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Wisconsin Focus on Energy
2017 TECHNICAL
REFERENCE MANUAL

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Executive Summary

Under its contract with the Public Service Commission of Wisconsin (the PSC) to evaluate the Wisconsin Focus on Energy programs, the Evaluation Team[1]—in coordination with the Program Administrator, the Program Implementers, and PSC staff—compiled this Technical Reference Manual (TRM). The information contained in this document summarizes the consensus calculations of the electric and natural gas energy savings, and the electric demand reductions, achieved from installing energy efficiency and renewable energy measures that are supported by Focus on Energy programs. This TRM is publicly available online at http://www.focusonenergy.com/about/evaluation-reports.

The values presented in this TRM fall into one of two categories:

- ***Deemed Savings*** are specific per-unit saving or demand reduction values that have been accepted by the Program Administrator, Program Implementers, Evaluator, and the PSC because the measures and the uses for the measures are consistent, and sound research supports the savings achieved.
- ***Savings Algorithms*** are equations for calculating savings or demand reductions based on project- and measure-specific details. This TRM makes these calculations transparent by identifying and justifying all relevant formulas, variables, and assumptions.

This TRM is also a reference guide as to how measures are classified in Focus on Energy's tracking database, SPECTRUM. This document is revised annually to account for changes to programs and measures.

The Evaluation Team leveraged many different primary and secondary sources to derive the calculation algorithms, variable assumptions, and measure descriptions contained in this TRM. These sources include available best practices and industry standards; on-site evaluation, measurement, and verification (EM&V) of savings from Focus on Energy projects; engineering reviews; and reviews of practices used in other jurisdictions. To best represent the Wisconsin climates and demographics, as well as program implementation practices, these energy-savings calculations account for state-specific factors such as climate zones, building codes, and market penetrations.

Update Process

The TRM is updated on a working basis throughout the year, and published each fall. The fall update incorporates savings updates from evaluation findings that will be effective for the following calendar year. The present edition presents deemed savings and inputs effective for calendar year 2017.

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[1] The Evaluation Team consists of Cadmus, St. Norbert College Strategic Research Institute, Apex Analytics, and REMI.

Annual updates keep the TRM relevant and useful by:

- Presenting validated savings calculations for any new measures Focus on Energy has begun offering through its programs since the last update;
- Eliminating measures that are no longer being offered through Focus on Energy programs; and
- Updating information on existing measures to reflect new research findings and technology changes.

Two processes are in place for updating the TRM and ensuring that those updates are timely, comprehensive, and accurate. All content updates are integrated into the existing document, with changes indicated in the Revision History table included for each measure entry.

1. Updates to savings calculations for existing measures are only made in the fall TRM revision. As part of the annual impact evaluation, the Evaluation Team identifies whether measures' recommended savings could be informed by evaluation findings and/or the presence of new research. The Evaluation Team works with the Program Administrator and the PSC to determine whether the findings are significant enough to merit a full review of the measure savings. Further review is typically pursued for those measure(s) that make a significant contribution to overall program savings, as well as when a lengthy period of time has elapsed since the measure was last reviewed, and/or if there is uncertainty regarding the accuracy of the existing savings calculations.

   In summer of each year, the Evaluation Team issues the results of its review, including any proposed revisions to savings calculations or other aspects of the existing TRM content. Program Implementation staff, the Program Administrator, and PSC staff review the proposed updates to achieve consensus on final revisions for publication in the fall TRM.

   By publishing all changes to existing measures in the fall update, the TRM is able to inform the Program Administrator and Program Implementers in program planning for the upcoming year.

2. Focus on Energy Program Implementers may propose adding new measures or revising the entries for existing measures at any time during the year, by preparing a workpaper that follows the structure of a TRM entry. These workpapers are reviewed by members of the Evaluation Team, the Program Administrator, and PSC staff to ensure that the proposed savings calculations are fully and adequately justified. Workpapers that meet this standard must have the following key criteria:
   a. A clear definition of the measure;
   b. A clear description of how the measure saves energy;
   c. A complete description of the calculation algorithms used to calculate savings, which identifies all variables and, where relevant, identifies the standard values to be used as inputs; and
   d. Citation of all data to valid sources.

The initial workpaper may be revised to ensure that all criteria are met and to achieve consensus on a final savings recommendation. Workpapers that pass all levels of the review receive formal approval from the PSC.

New measures and revised savings calculations take effect for the programs immediately after the workpaper is approved. Similarly, existing measures are deactivated as soon as they are no longer offered. As a result, the TRM does not have details for all active measures or savings calculations at every point during the year.

Navigating the TRM

Focus on Energy savings and demand reductions are calculated, and incentives are paid, by measure. Measures are defined as a specific product, technology, or service offered through one or more Focus on Energy programs, for which definable savings can be identified. Some TRM entries describe the savings for a single measure. Other entries address a group of related measures whose savings are calculated in a consistent way, such as measures that offer the same type of lighting product in different wattages.

TRM entries are grouped by technology and function, based on the group designations used to classify measures in SPECTRUM. Most groups are based on technology, including a lighting group with subcategories addressing CFLs, LEDs, and other specific lighting technologies. Some measures are grouped by technology end use, such as laundry or food service. These classifications are used for planning purposes and to categorize savings outcomes in evaluation reports.

Measure Detail Structure

Each entry describes the measure and its savings using the following format:

1. An introductory **Measure Detail Table** summarizes the measure savings and characteristics, including the formal measure name and any information necessary to include the measure in SPECTRUM. The measure detail table also identifies two key characteristics that guide how savings are calculated.

   First, the detail table identifies all <u>sectors</u> in which the measure is offered, which include:[2]

   a. Residential single-family homes;
   b. Residential multifamily dwellings (such as apartment buildings and condominiums);
   c. Commercial facilities;
   d. Industrial facilities;
   e. Agriculture facilities; and
   f. School and government facilities.

   In many cases, the energy savings calculated for a measure will be the same for each sector in which it is used. However, this can vary for measures that are used differently by different

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[2] Because measures that are incented through a markdown on the retail price at the store cannot be clearly assigned to a sector, they are assigned to the "upstream" sector based on the program design.

customer sectors. For example, research has confirmed that, on average, homeowners, commercial businesses, and industrial facilities use the same lighting product for different amounts of time and at different times of the day, resulting in different annual electricity savings and demand reductions.

2. Second, the table documents the measure type, which identifies the process by which savings are calculated. Each Focus on Energy measure is one of the following three measure types:
    a. *Prescriptive* measures have a specific deemed savings value that can be applied to each project within a given sector where the measure is used. This measure type is most commonly used for products that are manufactured and used consistently by all participants, such as light bulbs and appliances.
    b. *Custom* measure savings vary by project. This applies to more complex, multifaceted measures with different energy-use factors for each project, such as changes to industrial processes. TRM entries for custom measures do not identify savings values, but instead specify the savings algorithm that should be used to calculate savings and the source and calculation method used for algorithm inputs.
    c. *Hybrid* measure savings, like custom measure savings, vary by project, and are treated like custom measures in the TRM. The distinction between hybrid and custom measures is that the value of custom incentives also varies by project, while hybrid incentives are the same for each project.
3. The next three sections describe the measure(s) and how they achieve energy savings. The **Measure Description** defines the product, technology, or service. The **Description of Baseline Condition** identifies the less efficient product or service the customer could purchase in absence of Focus on Energy programs and incentives, while the **Description of Efficient Condition** identifies how the measure incented through Focus on Energy is more efficient than the baseline. Measures achieve energy savings and/or demand reductions based on the difference in energy use and demand between the baseline and efficient conditions.
4. Formulas are provided to specify the energy savings and demand reduction calculations. The **Annual Energy-Savings Algorithm** identifies how to calculate the electricity and/or natural gas savings achieved per year. The **Summer Coincident Peak Savings Algorithm** identifies the formula used to calculate reductions in electric demand, under the assumption that peak electric demand in Wisconsin occurs weekday afternoons (from 1:00 p.m. to 4:00 p.m.) in the months of June, July, and August. The **Lifecycle Energy-Savings Algorithm** identifies the formula used to convert annual electricity and/or natural gas savings to the lifecycle savings achieved over the expected useful life (EUL) of the measure. In addition to describing the algorithms used, all three sections specify the values of variables used in the calculation. These inputs may include assumptions about usage behavior or other details obtained through research. For custom and hybrid measures, the algorithms also note which inputs should be calculated on a project-by-project basis, from sources such as engineering reviews, modeling inputs, or on-site measurements.

5. Savings calculated through those formulas are often reported in the Measure Detail Table. However, in some cases—such as when there are calculations for multiple related measures—there is too much detail to concisely include in the Measure Detail Table. In those cases, a **Deemed Savings** section describes all completed savings calculations. In some cases, an **Assumptions** section may also be added to describe the process of selecting and/or calculating algorithm inputs in greater detail.
6. All factual statements and figures throughout the measure description include a superscript citation. The **Sources** section lists those citations numerically. For public sources such as published studies, hyperlinks and publication information are provided for the original source. More details on data cited to internal sources, such as historical Focus on Energy data or measure-specific market research, can be obtained from program staff. Initial inquiries can be directed to Joe Fontaine at the PSC, (608) 266-0910, joe.fontaine@wisconsin.gov.
7. The **Revision History Table** lists all the revision dates for that TRM entry and briefly describes the changes.

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Business (Nonresidential) Measures

Through the Business Portfolio, Wisconsin Focus on Energy delivers energy efficiency and renewable energy programs to nonresidential utility customers in the state. Customers who are eligible to participate in these programs include commercial and industrial firms, agricultural producers, schools, and local governments. With the programs, Focus on Energy aims to help nonresidential customers meet their unique and complex electricity and natural gas needs as efficiently as possible. Focus on Energy accomplishes this by providing information, financial incentives, and support for implementing energy-efficient technologies. These technologies include, but are not limited to, efficient lighting, heating and cooling systems, motors and drives, appliances, renewable energy systems, and custom products specific to key industries, such as food service and agricultural production.

The calendar year 2016 Business Portfolio includes seven programs designed to meet the needs of different types of nonresidential customers. Three programs serve nonresidential customers with different levels of energy use.

1. The **Small Business Program** serves small business customers with relatively low energy use, providing free direct installation of measures such as CFLs and exit signs, and offering incentives for the installation of additional measures.
2. The **Business Incentive Program** offers product-based and custom incentives for customers whose energy demand ranges between 100 kW and 1,000 kW per month.
3. The **Large Energy Users Program** serves customers with high energy use, such as large industrial firms and large commercial facilities, providing implementation support and incentives designed to meet each user’s specific energy needs.

In addition, two programs support markets with specialized needs.

1. The **Chains & Franchises Program** offers incentives and support designed for customers who have five or more facilities in the State of Wisconsin, such as retail businesses and restaurants.
2. The **Agriculture, Schools and Government Program** offers specialized incentives and support to address the needs of public facilities and agricultural producers.

Finally, two programs address areas not covered by other programs.

1. Nonresidential customers who are building new facilities can receive support from the **Design Assistance Program**, which connects customers, builders, and developers with experts who can provide energy-saving recommendations, then provides incentives to customers who incorporate those recommendations into their new construction.
2. Finally, the **Renewable Energy Competitive Incentive Program** offers incentives for installing a renewable energy technology through a competitive Request for Proposal.

Agriculture

Heat Recovery Tank, No Heating Element, Electric or Natural Gas

	Measure Details
Measure Master ID	Refrigeration Heat Recovery Unit, No Heating Element Electric, 3775 Natural Gas, 3774
Measure Unit	Per heat recovery tank
Measure Type	Hybrid
Measure Group	Agriculture
Measure Category	Energy Recovery
Sector(s)	Agriculture
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by measure
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	Varied by measure
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	$3,674.00[2]

Measure Description

A refrigeration heat recovery (RHR) unit captures waste heat from the refrigeration system and transfers some of that heat into water that is pre-heated before entering the water heater. The most popular units are comprised of a water tank with a heat exchanger wrapped around the outside of the tank. The hot refrigerant flows through the heat exchanger on its way to the condenser unit. The heat from the refrigerant is transferred through the tank wall into the water. Thermal buoyancy causes the warmest water to rise to the top of the tank. When hot water is used, water flows from the refrigeration heat recovery tank into the water heater, while well water flows into the heat recovery tank. These units can typically reduce the water heating by 50%.[3]

If a RHR unit and a plate cooler are both installed, the plate cooler may impact the savings effect of the RHR unit. A plate cooler will reduce the refrigeration load, diminishing the amount of heat rejection possible to the RHR system. As such, this measure may not improve energy savings with a dairy herd less than 100 cows that already has a plate cooler installed. Farms with dairy herds between 100 and 150[4] cows will not be able to maximize savings from both technologies, and an energy reduction factor must be applied to the RHR energy savings algorithm in this situation. Farms with greater than 150 cows should be able to maximize savings from both technologies.

Description of Baseline Condition

The baseline is existing farm refrigeration equipment, such as the milk bulk tank chilling system sized for the milk output requiring cooling, where no refrigeration heat recovery is being used and the water heater uses well water directly.

Description of Efficient Condition

The efficient condition is farm refrigeration equipment where a RHR unit (without additional heating element) is installed and heat is rejected from the refrigerant into a pre-heat water tank before continuing to the condensing unit. The RHR unit is assumed to consume no energy in order to function.

Annual Energy-Savings Algorithm

kWh savings are for electric measures, while therm savings are for natural gas water heaters. The savings for this measure are based on an average milk production of 70 pounds per cow, per professional experience and industry standard. When both a plate cooler and an RHR unit are installed, an energy reduction factor between 0.0 and 1.0 need to be applied when milk output is between 7,000 and 10,500 pound of milk per day.

$kWh_{SAVED} = Btu_{SAVED}/3{,}412$

$Therms_{SAVED} = Btu_{SAVED}/100{,}000$

$Btu_{SAVED} = (Btu_{RECOVERED}/day * 365)/EF$

$Btu_{RECOVERED}/day = Gal_{H20\ PREHEATED}/day * 8.34 * \Delta T * SH_{WATER} * ERF$

Where:

3,412 = Constant to covert Btu to kWh

100,000 = Contant to convert Btu to therm

365 = Number of milking days per year[8]

EF = Energy factor (= 90% electric standard efficiency; 59% natural gas standard efficiency)[5]

$Gal_{H20\ PREHEATED}/Day$ = Gallons per day preheated, determined from customer application (= varies)[6]

8.34 = Constant to covert pounds to gallon of water

ΔT = Difference between heated and groundwater temperature, given as: $Temp_{RHR\ AVG} - Temp_{GROUNDWATER}$

Where:

$Temp_{RHR\ AVG}$ = Temperature of heated water (= 125°F as approximate average of two sources)[3,9]

$Temp_{GROUNDWATER}$ = Temperature of groundwater (= 52.3°F)[7]

SH_{WATER} = Specific heat of water at 60°F (= 1.0 Btu/lb °F)

ERF = Error Function (= lb milk/day – 7,000 lb milk/day)/3,500 lb milk/day; = 0 if ERF < 0.0; = 1.0 if ERF > 1.0)

Summer Coincident Peak Savings Algorithm

There are no summer coincident peak savings for refrigeration heat recovery units. It is assumed that electric water heaters have a single element and the rating is unchanged when a RHR unit is added, resulting in no demand reduction.

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therms_{LIFECYCLE} = Therms_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[1]

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Revision History

Version Number	Date	Description of Change
01	10/01/2015	New measure

High Speed, High Efficiency Fan, Agriculture

	Measure Details
Measure Master ID	High Speed, High Efficiency Fan, Agriculture: Circulation Fan: 36 inches to 47 inches, 3767 48 inches to 52 inches, 3768 ≥ 53 inches, 3769 Ventilation Fan: 24 inches to 35 inches, 3770 36 inches to 47 inches, 3771 48 inches to 52 inches, 3772 ≥ 53 inches, 3773
Measure Unit	Per fan
Measure Type	Prescriptive
Measure Group	Agriculture
Measure Category	Fan
Sector(s)	Agriculture
Annual Energy Savings (kWh)	Varies
Peak Demand Reduction (kW)	Varies
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15 for circulation fans (MMIDs 3767-3769)[1] 16 for ventilation fans (MMIDs 3770-3773)[1]
Incremental Cost ($/unit)	$150.00[2]

Measure Description

Agriculture ventilation/exhaust fans are intended to provide minimum ventilation and maintain indoor air quality for livestock. Agriculture circulation fans are designed to help provide animal comfort, control insects in summer, and help maintain dry surfaces. Generally, agricultural-grade air circulating fans are corrosion resistant and designed for easy cleaning. This measure mainly applies to dairy barn fan installations, but can also be applicable for fans used in other livestock housing areas.

Description of Baseline Condition

The baseline condition is an air circulation fan used within an agricultural building. The baseline values for each fan grouping were determined from actual fan performance information supplied from the Bio-

Environmental and Structural System Lab (BESS) at the University of Illinois' certified fan test results (as shown when accessed on August 14, 2015).[4] The results were sorted into fan size groupings, with single and three phase fan power combined. The fan baseline (standard) efficiency and kilowatt consumption were determined as the simple average of each value for all respectively listed fan size groupings. The baseline comparison performance criteria for each of the fan size groupings are shown in the Standard and High Efficiency Fan Average Power Ratings table below.

Description of Efficient Condition

To qualify for a prescriptive incentive, each circulation or ventilation fan must undergo third-party testing and be rated by BESS or through an accredited Air Control and Movement Association testing facility. The 75th percentile of tested fan size grouping efficiency ratings for both circulation and ventilation fans tested at BESS labs were used as the initial minimum qualifying efficiency starting point. Then the actual minimum efficiency requirements were set by adjusting the 75th percentile base slightly up or down as needed to meet Wisconsin Focus on Energy program needs that these requirments be comparable to past years' fan qualifying standards.

Any single fan size minimum efficiency was not allowed to exceed more than 0.5 units higher than the previous year's minimum qualifying efficacies. Care was also taken not to raise the minimum standard high enough to exclude more than 25% of qualifying fans off the previous year's pre-qualified product fan list.

Energy Savings Minimum Qualifying Fan Efficiency Requirements

MMID	Fan Diameter (inches)	Minimum Efficiency for Exhaust and Ventilation Fans	Minimum Efficiency for Circulation Fans
3770	24 – 35	13.7 CFM/watt at 0.10 static pressure	N/A
3771, 3767	36 – 47	17.1 CFM/watt at 0.10 static pressure	18.7 pound force/kW
3772, 3768	48 – 52	20.3 CFM/watt at 0.10 static pressure	23.1 pound force/kW
3773,3769	≥ 53	20.3 CFM/watt at 0.10 static pressure	23.1 pound force/kW

Annual Energy-Savings Algorithm

Ventilation/Exhaust Fans

$KWh_{SAVED\_VENT} = (Fan_{kW\_BASELINE\_VENT} – Fan_{kW\_EFF\_VENT}) * HOURS$

Where:

$Fan_{kW\_BASELINE\_VENT}$ = Ventilation baseline efficiency fan average kW rating at 0.10 static pressure, average of all kW ratings reported from BESS lab results from testing fans in stated fan size groupings[4]

$Fan_{kW\_EFF\_VENT}$ = Ventilation high-efficiency fan average kW rating at 0.10 static pressure, average of all kW ratings at or above the minimum qualifying efficiencies, stated in Energy Savings Minimum Qualifying Fan Efficiency Requirements table above, from BESS lab results from testing fans in applicable fan size groupings[4]

HOURS = Annual hours of operation (= 7,446, or 8,760 * 0.85). Assumed that ventilation fans operate at least 85% of available yearly hours (conservative to account for likely fan downtime scenarios such as fan failures/maintenance, when barn is empty due to cow milking, or intentional shutting off a portion of fixed-speed exhaust fans to reduce the total exhaust CFM needs in winter times)

Circulation Fans

$kWh_{SAVED\_CIRC} = (Fan_{kW\_BASELINE\_CIRC} – Fan_{kW\_EFF\_CIRC}) * HOURS$

Where:

$Fan_{kW\_BASELINE\_CIRC}$ = Circulation baseline efficiency fan average kW rating, average of all kW ratings reported from BESS lab results from testing fans in stated fan size groupings[4]

$Fan_{kW\_EFF\_CIRC}$ = Circulation energy-efficient fan average kW rating, average of all kW ratings at or above the minimum qualifying efficiencies, stated in Energy Savings Minimum Qualifying Fan Efficiency Requirements table above, from BESS lab results from testing fans in applicable fan size groupings[4]

HOURS = Annual hours of operation (= 3,864)[5]

According to the professional judgment of experienced program subject matter expert, Terry Laube, farmers in Wisconsin typically turn their circulation fans on when it is 50°F or warmer to improve cow comfort. The HOURS shown above hold most true for dairy barn applications, and is deemed reasonable to hold true for other uses such as the control of animal comfort.

Standard and High-Efficiency Fan Average Power Ratings[4]

MMID	Diameter of Fan (inches)	Ventilation Fan kW Ratings Baseline / High-Efficiency	Circulation Fan kW Ratings Baseline / High-Efficiency
3770	24 - 35	0.5185 / 0.3989	N/A
3771, 3767	36 - 47	0.7434 / 0.5443	0.6217 / 0.5534
3772, 3768	48 - 52	1.2793 / 1.0033	1.0908 / 0.9896
3773,3769	≥ 53	1.3566 / 1.1276	1.2277 / 1.1515

Deemed kWh Savings[4]

MMID	Diameter of Fan (inches)	kWh Savings per Ventilation Fan	kWh Savings per Circulation Fan
3770	24 - 35	891	N/A
3771, 3767	36 - 47	1,482	264
3772, 3768	48 - 52	2,055	391
3773,3769	≥ 53	1,706	294

*All deemed savings values are rounded to the nearest integer.

Summer Coincident Peak Savings Algorithm

Ventilation/Exhaust Fans

$kW_{SAVED} = (Fan_{kW\_BASELINE\_VENT} - Fan_{kW\_EFF\_VENT}) * CF$

Circulation Fans

$kW_{SAVED} = (Fan_{kW\_BASELINE\_CIRC} - Fan_{kW\_EFF\_CIRC}) * CF$

Where:

CF = Coincidence factor (= 1.0)

It was assumed that for an overwhelming majority of the hours during the peak window for agriculture fans, it is at least 50°F before circulation or ventilation fans are run, and thus assumed that those fans are running during peak times (so a CF of 1.0 is justified to claim peak kW).

Deemed Demand kW Reduction[4]

MMID	Diameter of Fan (inches)	Demand kW Reduction per Ventilation Fan	Demand kW Reduction per Circulation Fan
3770	< 36	0.1196	N/A
3771, 3767	36 - 47	0.1991	0.0684
3772, 3768	48 - 52	0.2760	0.1012
3773,3769	≥ 53	0.2291	0.0762

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years for circulation fans; = 16 years for ventilation/exhaust fans)[1]

Deemed Lifecycle kWh Savings

MMID	Diameter of Fan (inches)	Demand kW Reduction per Ventilation Fan	Demand kW Reduction per Circulation Fan
3770	< 36	14,256	N/A
3771, 3767	36 - 47	23,712	3,960
3772, 3768	48 - 52	32,880	5,865
3773,3769	≥ 53	27,296	4,410

Lifecycle savings estimates are based on the assumption that agriculture fans and fan housing are cleaned regularly (at least once a year).

Sources

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5. Wisconsin Focus on Energy Technical Reference Manual, Appendix B: Common Variables, 'Outside Air Temperature Bin Analysis,' average hours for Wisconsin when ≥ 50°F, October 2015.

Revision History

Version Number	Date	Description of Change
01	01/2016	New measure

Energy Efficient Grain Dryer

	Measure Details
Measure Master ID	Energy Efficient Grain Dryer, 3386
Measure Unit	Bushels per hour
Measure Type	Hybrid
Measure Group	Agriculture
Measure Category	Grain Dryer
Sector(s)	Agriculture
Annual Energy Savings (kWh)	Varies
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies
Lifecycle Energy Savings (kWh)	Varies
Lifecycle Therm Savings (Therms)	Varies
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1,9]
Incremental Cost ($/unit)	$179 per bushel/hr of dryer capacity[2]

Measure Description

This incentive offering is for agricultural operations that replace their existing grain drying systems with a more energy efficient batch or continuous flow grain drying system with a ≤ 1,500 bushels per hour capacity. Although still operational, the efficiency of older equipment becomes obsolete in comparison to today's technology and can be more expensive to operate. Newer grain dryers generally have larger drying capacities, and can process loads faster and at a greater efficiency. Installing a new and more efficient grain dryer will effectively reduce the annual hours of operation by allowing for faster process of grain through increased efficiency. The purpose of drying grain is to reduce the amount of water contained in the crop after harvest to an acceptable level for marketing, storage, or processing. This incentive will be provided based on the bushel per hour processing capacity of the new grain dryer. In-bin drying and tower grain drying are excluded from this measure and should be handled as custom measures.

While this measure can apply to all types of grain, the main focus of this workpaper is on corn, which is the main use of grain dryers in the State of Wisconsin. This measure is not eligible for new construction, which should be handled as a custom project.

Description of Baseline Condition

The most accurate way to depict an existing grain dryer's previous overall baseline efficiency is to convert one to three years' of utility electric and natural gas usage (as metered for the grain dryer in operation) into Btus. This is then divided by the average number of bushels of grain dried in the given year and the initial and post-installation moisture content percentages. This calculates the pounds of water removed, leading to the historical Btu per pound of water removed.

As part of the application,one to three years' of grain dryer utility history will be requested and required as part of the supplied documentation for the applied measure.

- In the event that utility data for a grain dryer is not able to be provided for past years, a trade ally analysis of the existing grain dryer efficiency will also be accepted. Most trade ally's grain dryer analyses are propriety in nature, but they help determine an estimate of efficiency based on normal weather temperature/humidity data at the location of grain dryer installation during the time of harvest/drying. Their analysis should also account for the past harvested grain moisture contents, pre- and post-installation, as recorded by the customer, as well as the capacity ratings of the respective dryer (or a dryer similar to the existing dryer if specific information on the actual existing dryer cannot be obtained).
- If neither utility data nor a trade ally analysis can be provided, a default grain dryer efficiency value provided from USDA literature[10] will be used. This third option is a last resort and will most likely be the least accurate baseline comparison.

The efficiency of grain dryers is very dependent on the weather conditions and time of harvest for each year. Unfortunately, there is no simple way to depict this information for each individual project and many assumptions must be made. The several options for providing information to arrive at a baseline efficiency value are provided below to help ensure that the most accurate savings are calculated for Wisconsion Focus on Energy on a project by project basis.

Description of Efficient Condition

Per North Dakota State University Extension Service, the minimum energy required to evaporate water from corn is approximately 1,200 Btu/lb H_2O, and a realistic dryer maximum efficiency is about 1,500 Btu/lb H_2O.[3]

Since this measure is hybrid, the actual drying efficiency will be calculated for the specific efficient grain dryer that is installed, and to the best level possible based on the information provided by the customer and grain dryer specification sheet. To ensure that the efficient grain dryer is in fact more efficient than the previous dryer, before providing the incentive Wisconsin Focus on Energy requires that the efficient grain dryer use at least 250 Btu/lb H_2O less than the baseline dryer. The minimum level of grain dryer efficiency allowed for approval is ≤ 1,950 Btu/lb H_20 removed. This value was determined based on the USDA's typical grain dryer energy efficiency chart,[10] showing that the typical efficiency value for all high temperature grain dryers was at or above 2,000 Btu/lb H_20 removed. This 2,000 value was adjusted slightly downward to create a conservative baseline value.

The efficiency of a new grain dryer (Btu/lb H_20 removed) can be calculated using the formulas provided below in the Annual Energy-Savings Algorithm section, or the efficiency can be provided as trade ally analysis showing all of the inputs and outputs used.

The efficient grain dryer is also required to have at least one of the following features specific to being more energy efficient:

- Staged temperature (higher temperature for wettest grain, lower for nearly dry grain)
- Grain turners or inverters (rotate mostly dry grain away from plenum to move wetter grain near plenum)
- Differential grain speed (column designed to move grain next to the drying plenum faster to reduce excessive grain temperatures and provide a more uniform moisture content)
- Varied width of the drying column (narrower at top where the grain is wettest, allowing humid air to vent to the atmosphere faster)
- Some form of heat recovery (capturing excess heat from cooling section of a grain dryer, where applicable, and redirecting it to help preheat the incoming burner intake air)

Annual Energy-Savings Algorithm

Initial Calculations[4]

Moisture Shrink (%) = $(MC_{INIT} - MC_{FINAL})/(1 - MC_{FINAL})$

$lbs_{H2O\_REMOVED}$ = $Bushels_{INITIAL}$ * $lbs/bu_{INITIAL\_MC}$ * Moisture Shrink (%)

The formulas below are used as calculations for the proposed grain dryer only.

Grain Dryer Burner Capacity = 1.08 * Airflow CFM * (Plenum temp - Ambient temp)

Gas Usage Rate *(therm/hr)* = Grain Dryer Burner Capacity/100,000/burn_eff

Electric Usage Rate *(kWh/hr)* = Blower Fan hp * 0.746 * Load Factor/motor_eff

$GD_{PROPOSED\_EFF}$ *(BTU/lb H20)* = (Gas Usage Rate * 100,000) + (Electric Usage Rate * 3,412)/(Moisture Shrink % * Bu/hr * final bushel weight)

Where:

Moisture Shrink (%) = The weight reduction factor of wet grain as it is dried, derived from user-defined inputs

MC_{INIT} = Harvested grain moisture content percentage, derived from application

MC_{FINAL} = Dried grain moisture content percentage, derived from application

$lbs_{H2O\_REMOVED}$ = Pounds of water removed from harvest to post grain drying storage, derived from user-defined inputs

$Bushels_{INITIAL}$ = Number of wet bushels of grain to be dried per year, derived from user-defined inputs

$lbs/bu_{INITIAL\_MC}$ = Bushel weight, determined from grain moisture content percentage and weight per bushel reference tables[5]

1.08 = Constant for sensible heat equations

Airflow CFM = Rated blower CFM, derived from dryer specification sheet or user defined if spec sheet not available

Plenum temp = Temperature inside dryer at normal operation, derived from dryer specification sheet or user defined if spec sheet not available

Ambient temp = Average ambient temperature of outside air during typical drying times (= varies by city; see table below)

Average Ambient Temperatures in October and November in Various Wisconsin Cities[7]

Wisconsin Cities	October Average	November Average	Total Average
Eau Claire	46	33	40
Green Bay	47	34	41
LaCrosse	48	36	42
Madison	47	34	40.5
Milwaukee	50	38	44

100,000 = Constant to convert Btu to therm

burn_eff = Combustion efficiency of the grain dryer burner (= assumed to be 95%)[4]

Blower Fan hp = Main grain dryer blower fan hp rating, derived from dryer specification sheet or user defined if spec sheet not available

0.746 = Constant to convert horsepower to kilowatts

Load Factor = Assumed load factor of blower fan (= estimated as 85%)

motor_eff = Efficiency of motor, derived from NEMA rated fan efficiency tables based on motor hp[6]

Bu/hr = Bushels per hour of dryer capacity at 100% operation based on a 5% to 10% moisture content reduction, derived from dryer specification sheet or user defined if spec sheet not available

final bushel weight = Weight of final grain moisture content in lbs/bu[5]

<u>Energy-Savings Calculations:</u>

$$kWh_{SAVED} = (GD_{EXISTING\_EFF} * Lbs_{H2O\_REMOVED} * \text{kWh\%\_}_{EXIST}/3{,}412) – (GD_{PROPOSED\_EFF} * Lbs_{H2O\_REMOVED} * \text{kWh\%\_}_{PROP}/3{,}412)$$

$$Therms_{SAVED} = (GD_{EXISTING\_EFF} * Lbs_{H2O\_REMOVED} * \text{Therm\%\_}_{EXIST}/100{,}000) – (GD_{PROPOSED\_EFF} * Lbs_{H2O\_REMOVED} * \text{Therm\%\_}_{PROP}/100{,}000)$$

Where:

$GD_{EXISTING\_EFF}$ = Existing grain dryer efficiency, or Btu per pound of water removed, determined from customer utility data and user defined inputs of bushels dried at specific pre- and post-installation moisture contents

$Lbs_{H2O\_REMOVED}$ = Annual pounds of water removed from grain harvest during drying process (see Initial Calculations section above)

$\text{kWh\%\_}_{EXIST}$ = Existing electric use (=Average existing utility bill kWh consumption * 3,412 / (avgerage existing utility bill kWh consumption * 3,412 + average user existing utility bill therm consumption * 100,000)

3,412 = Contant to convert Btu to kilowatt-hours

$GD_{PROPOSED\_EFF}$ = Proposed grain dryer efficiency in Btu per pound of water removed (see Initial Calculations section above)

$\text{kWh\%\_}_{PROP}$ = Proposed electric use (= electric usage rate * 3,412 / (electric usage rate * 3,412 + gas usage rate * 100,000)

$\text{Therm\%\_}_{EXIST}$ = Existing gas use (= 1 - $\text{kWh\%\_}_{EXIST}$)

$\text{Therm\%\_}_{PROP}$ = Proposed gas use (= 1 - $\text{kWh\%\_}_{PROP}$)

Summer Coincident Peak Savings Algorithm

Grain drying does not occur during the summer peak time periods; therefore, no peak demand reduction can be claimed.

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 20 years; sources list measure life of 30 years[1] and 10 to 12 years,[9] so 20 years was selected as the midpoint)

Assumptions

The amount of energy savings from grain dryers is based on production, so farms that grow and dry more grain achieve more savings. The amount of grain harvested can be effected by the weather and the number of acres of grain planted in a particular year. The need for drying is also dependent on the weather at the time of harvest, with drier weather requiring less grain drying. To attempt to control for these variables, the number of bushels of grain dried over the past two to three years, as well as the expected future grain drying output, is collected on the application. This will help control for some of the variability in savings by using grain drying quantities based on past and future planned harvests.

The measure assumes that all grain drying takes place in the late fall months after grain harvest, typically around October and November.[8] While latent heat plays a role in the grain drying process, for purposes of simplification the air ‘sensible’ heat transfer formula is used for grain dryer efficiency calculations. The measure assumes blower/dryer fans are running at their full rated speed throughout the entire drying period, as well as that the burner plenum temperature stays constant throughout entire drying period. Specific electric use for grain dryer conveyors or augers/stirrers is not included in the calculation. Finally, grain dryer pricing is based on newer style grain dryers from one manufacturer that are more energy efficient than older models.

Incentive amount will be based on the bushels per hour of drying capacity at a 5% moisture content reduction.

Sources

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Revision History

Version Number	Date	Description of Change
01	10/2015	New measure

Plate Heat Exchanger and Well Water Pre-Cooler

	Measure Details
Measure Master ID	Plate Heat Exchanger and Well Water Pre-Cooler, 2491
Measure Unit	Per pound of milk
Measure Type	Hybrid
Measure Group	Agriculture
Measure Category	Heat Exchanger
Sector(s)	Agriculture
Annual Energy Savings (kWh)	Varies
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	$4,595.00[2]

Measure Description

A well water pre-cooler is a heat exchanger device used to partially cool milk without the need for energy intensive mechanical refrigeration. Cold well/ground water, around 52.3°F, is pumped through one side of a heat exchanger while cow's milk, at about 98°F, is pumped through the other side of the heat exchanger. Energy savings are calculated based on the amount of milk temperature reduction achieved from the heat exchanger, which is heat energy that does not have to be removed from mechanical refrigeration. This measure is only eligible for new pre-cooler installations, and not replacement pre-coolers. It is assumed that the warmed output water from the plate cooler is reused elsewhere on the farm, such as for washing general farm equipment or for animal watering. Little to no water waste should occur from the pre-cooler water output: farmers' will reuse this output water for general farm use to save from pumping additional water for those uses.

Description of Baseline Condition

The baseline condition is a dairy operation without the use of a milk pre-cooler, where milk cooling is achieved through the use of mechanical refrigeration compressors/chillers. Typically scroll or reciprocating compressors are used to drive the cooling process.

Description of Efficient Condition

The efficient condition is a dairy operation with a milk pre-cooler unit that allows for using colder well water to pre-cool milk prior to using mechanical refrigeration to cool the milk down to a final storage temperature of around 38°F.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{BASE} - kWh_{PROP}$

kWh_{BASE} = lbs of Milk * $C_{P,MILK}$ * ΔT * 365 / $COP_{COMPRESSOR}$ / 3,412

Where:

lbs of Milk = Estimated daily pounds of milk produced by the dairy farm (= user defined)

$C_{P,MILK}$ = Specific heat of milk (= 0.94 Btu/(lb-°F))[3]

ΔT = Temperature difference between warm milk coming into the plate cooler and the cooled milk leaving the plate cooler (= 25°F assumed for a single pass plate cooler; = 35°F assumed for a double/multi-pass plate cooler)[5]

365 = Number of milking days per year

$COP_{COMPRESSOR}$ = Coefficient of performance (= 2.46 (~8.4 EER) sssumed for a reciprocating compressor; = 3.08 (~10.5 EER) assumed for a scroll compressor)[5]

3,412 = Conversion factor from Btu to kWh

Summer Coincident Peak Savings Algorithm

There is not enough support to claim summer coincident peak kW savings for plate heat exchangers or well water pre-coolers.

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[1]

Assumptions

The savings calculation does not account for the energy needed to pump the cold well water through the plate cooler; since the plate cooler output of warmed well water is then used for animal watering, this water pumping would normally already occur for animal watering needs. The savings are based on the assumption that all plate cooler water output is reused elsewhere on the farm. Additional assumptions include:

- Milking operations are assumed to occur 365 days per year.[6]
- Savings associated from the reduced runtime of condenser/evaporator fans of the mechanical refrigeration system are not included, thus savings are more conservative. Such variables are not easy to predict based on the information available.

- Standard milk to water flow rate of 1:1 assumed, and the pipeline system pipe sizing, milk pump size, and flow rates are assumed to stay constant from pre-installation.
- All second use warmed water from the output of the well water plate cooler is assumed to be reused as general wash water to clean farm equipment or for animal watering (dairy cows consume at least three times more fluid (in water) then they produce as milk).[4]
- Milk directly from a cows teat is assumed to be 101°F, then arrives at the input of the pre-cooler around 98°F due to some natural minimum heat transfer in the milking system pipeline.[4]

Sources

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3. Journal of Food Engineering. "Determination of specific heat of milk at different fat content between 1C and 59C using micro DSC", Jin Hu. (Table 1) (Units converted from J/(g*K) to BTU/(lb-°F)) http://www.researchgate.net/publication/234102534_Determination_of_specific_heat_of_milk_at_different_fat_content_between_1C_and_59C_using_micro_DSC
4. Sanford, Scott. "Well Water Pre-Coolers." http://learningstore.uwex.edu/Assets/pdfs/A3784-03.pdf
5. Sanford, Scott (Senior Outreach Specialist Biological Systems Engineering at University of Wisconsin in Madison). "Energy Efficiency for Dairy Enterprises." Presentation to AgSG program. December 2014. Supporting slides available online: http://farmenergymedia.extension.org/sites/default/files/Dairy%20Energy%20Conservation-2013.pdf (Compressor EER default estimate values were stated in presentation and used in this workpaper calculation to account for a generic cooling system efficiency with each respective compressor type)
6. Wisconsin Milk Marketing Board. "Did You Know?: Milking Every Day." Accessed December 21, 2015. http://www.dairydoingmore.org/economicimpact/dairyfacts.

Revision History

Version Number	Date	Description of Change
01	09/2015	New measure

Energy Efficient or Energy Free Livestock Waterer

	Measure Details
Measure Master ID	Waterer, Livestock: < 250 Watts, 2660 Energy Free, 3018
Measure Unit	Per waterer
Measure Type	Prescriptive
Measure Group	Agriculture
Measure Category	Livestock Waterer
Sector(s)	Agriculture
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	0 (winter use only)
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	10[1]
Incremental Cost ($/unit)	MMID 2660 = $787.50;[3] MMID 3018 = $741.00[4]

Measure Description

Electrically heated waterers are commonly used to provide clean water for livestock during winter months when temperatures may drop below freezing. Baseline efficiency waterers typically have no insulation and require large heating elements to prevent water from freezing. Energy-efficient livestock waterers have at least two inches of insulation, which allows for the use of much smaller heating elements (less than 250 watts). Energy-free waterers have at least two inches of insulation and no heating element, as they use ground source water to prevent freezing.

Description of Baseline Condition

The heating element for a baseline unit is typically at least 750 watts, but may be 1,500 watts or larger. Retrofit waterer installations, both energy efficient and energy free, use a baseline of 1,100 watts. New construction waterer calculations use a baseline of 500 watts.

Description of Efficient Condition

Efficient or low energy livestock waterers must have a minimum of two inches of insulation. The heating element for an efficient unit will be a maximum of 250 watts. The energy-free unit may not have an electric heating element installed, but instead uses ground source heating. The new waterer must be able to serve the same herd size as the existing equipment. For new construction, the livestock waterer must be energy free.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1,000 * HOURS$

Where:

$Watts_{BASE}$ = Power consumption of baseline measure equipment (= 1,100 watts for retrofit; = 500 watts for new installation)[2]

$Watts_{EE}$ = Power consumption of efficient measure equipment (= 250 watts for energy-efficient retrofit; = 0 watts for energy-free installation)

1,000 = Kilowatt conversion factor

HOURS = Average annual run hours of heater (= 3,040; annual operation is used as a conservative estimate of the number of hours below 32°F annually throughout the State of Wisconsin, consistent with TMY3 bin data)

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1,000 * CF$

Where:

CF = Coincidence factor (= 0)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 10 years)[1]

Deemed Savings

Average Annual Deemed Savings

Type	MMID	Sector	kWh
Energy Efficient Livestock Waterer	2660	Agriculture	2,584
Energy Free Retrofit Livestock Waterer	3018	Agriculture	3,344
Energy Free New Construction Livestock Waterer	3018	Agriculture	1,520

Lifecycle Energy Savings

Type	MMID	Sector	kWh
Energy Efficient Livestock Waterer	2660	Agriculture	25,840
Energy Free Retrofit Livestock Waterer	3018	Agriculture	33,440
Energy Free New Construction Livestock Waterer	3018	Agriculture	15,200

Deemed Peak Demand Reduction

Type	MMIDs	kWh
All Livestock Waterers	2660 and 3018	0

Assumptions

No peak demand (kW) savings are associated with this measure because heaters are generally only used during winter months.

Source

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation: Business Programs: Measure Life Study." Final Report. August 25, 2009.
2. EnSave. Energy Efficient Stock Waterers. http://www.usdairy.com/~/media/usd/public/ensaveenergyefficientstockwaterers.pdf
3. Illinois Technical Reference Manual. 2013. Page 70. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf .
4. Historical Focus on Energy project data, 2012-2013. 196 waterers on 34 projects, average total cost of non-energy waterer is $741.00.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Circulation Fan, High Efficiency, Ag

	Measure Details
Measure Master ID	Circulation Fan, High Efficiency, Ag, 2253
Measure Unit	Per fan
Measure Type	Hybrid
Measure Group	Agriculture
Measure Category	Other
Sector(s)	Agriculture
Annual Energy Savings (kWh)	Varies
Peak Demand Reduction (kW)	Varies
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	$150.00[3]

Measure Description

Agriculture circulation fans are designed to destratify air, reduce animal heat stress, control insects, dry surfaces, and cool people and animals. Generally, agricultural-grade air circulating fans are corrosion resistant and designed for easy cleaning.

Description of Baseline Condition

The baseline condition is an air circulation fan used within an agricultural building. Calculations are performed using three separate fan diameter size groupings: 24-35 inches, 36-47 inches, and 48-71 inches. The baseline unit demand is based on the fan size groupings, at 450 watts, 620 watts, and 1,160 watts, respectively.

Description of Efficient Condition

To qualify for a prescriptive incentive, each circulation fan must undergo third-party testing and be rated through the Bioenvironmental and Structural System Lab at the University of Illinois or through the Air Control and Movement Association International Lab.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (CFM_{EE} / VER_{EE} – CFM_{BASE} / VER_{BASE}) * HOURS$

Where:

CFM_{EE} = New efficient unit flow at 0.10 static pressure in CFM[2]

VER_{EE} = New unit ventilating efficiency ratio in CFM/watt at 0.10 static pressure

CFM_{BASE} = Baseline unit flow at 0.10 static pressure in CFM

VER_{BASE} = Baseline unit ventilating efficiency ratio in CFM/watt at 0.10 static pressure

HOURS = Annual hours of operation (= 2,935)[2]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (CFM_{EE} / VER_{EE} – CFM_{BASE} / VER_{BASE}) * CF$

Where:

CF = Coincidence factor (= 1.0)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[1]

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation: Business Programs: Measure Life Study." Final Report. August 25, 2009.
2. Deemed savings from Illinois Technical Reference Manual Version 2.0 dated June 7, 2013, referencing Illinois Act On Energy Commercial TRM No. 2010-4 dated May 31, 2011.
3. Illinois Technical Reference Manual. 2013. Agriculture circulation or exhaust fan incremental cost (all sizes) is $150.00 each. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Dairy Refrigeration Tune-Up

	Measure Details
Measure Master ID	Dairy Refrigeration Tune-Up, 3796
Measure Unit	Per pound of milk per day
Measure Type	Prescriptive
Measure Group	Agriculture
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Agriculture
Annual Energy Savings (kWh)	0.07
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	0.7
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	10[2]
Incremental Cost ($/unit)	$260.86[1]

Measure Description

The tune-up is designed such that an EPA 608 Certified Service Provider assesses all refrigeration equipment associated with a commercial-grade dairy farm facility with the intention of reducing electrical consumption.

Description of Baseline Condition

The baseline condition is refrigeration equipment associated with a commercial-grade dairy farm facility that has not been inspected or tuned up in more than 24 months.

Description of Efficient Condition

The efficient condition is refrigeration equipment associated with a commercial-grade dairy farm facility that has been inspected and tuned up by an EPA 608 Certified Service Provider. The Service Provider must abide by all rules and regulations related to refrigerant testing and safety protocol and conduct the following: clean and inspect condenser and evaporator coils; clean drain pan; inspect/clean fans, screens, grills, filters and drier cores; inspect/adjust heat reclaim operation; tighten all line voltage connections; inspect/replace relays and capacitors as needed; and add/remove refrigerant charge as needed.

Annual Energy-Savings Algorithm

Energy savings are based on a 4% savings resulting from the refrigeration equipment tune-up.[3]

$kWh_{SAVED} = kWh_{SAVED}/day * 365\ days$

$kWh_{SAVED/DAY} = [lbs\ milk/day * 0.94 * \Delta T/(EER * 1{,}000)] * SF$

Where:

365 = Conversion factor, days per year[7]

lbs milk/day = Pounds of milk produced at farm facility per day (= 5,048 average)[1]

0.94 = Specific heat of milk (Btu/lb °F)[8]

ΔT = Change between starting temperature and final temperature (= 47.5°F Average)[1]

Starting Temperature = 98°F[4]

Final Temperature = Varies depending on amount of mechanical cooling required (see Assumptions)

EER = Energy efficiency ratio of the refrigeration system, in Btu/watt-hour (= varies by equipment; default values = 8.4 for systems with a reciprocating compressor and =10.5 for systems with a scroll compressor, for an average of 9.25)[5,1]

1,000 = Kilowatt conversion factor

SF = Savings factor (0.04)

As an example, when average values are used in the formula above: [[5,048 lbs milk/day * 0.94 * 47.5°F / (9.25 * 1,000)] * (0.04)] * 365 = 356 kWh_{SAVED}. Therefore, kWh savings will be based on 356 kWh_{SAVED} / 5,048 lbs milk/day = 0.07 kWh_{SAVED}/lb milk/day.

Summer Coincident Peak Savings Algorithm

There are no peak savings from this measure.

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 10 years)[2]

Assumptions

The savings factor is a conservative estimate based on a whole refrigeration system tune up. According to Scott Sanford from the University of Wisconsin-Madison, between 3% and 5% of electrical savings come from condenser cleaning alone.[3] In addition to cleaning the condenser, the refrigeration system tune up involves cleaning the evaporator coils, fans, filters, screens, and grills, as well as inspecting and adjusting/replacing relays, capacitors, and refrigerant charge.

There are a number of scenarios to consider when determining the change in temperature. Based on a review of 54 completed projects, 56% had no plate cooler or VFD, 35% had a plate cooler installed, and 9% had a plate cooler and VFD installed on the milk pump. If there is no plate cooler, the milk needs to be mechanically cooled from 98°F to 38°F (ΔT = 60°F). A single-pass and double-pass plate cooler typically drops the milk to an average temperature of 73°F and 63°F, respectively (35°F and 25°F of mechanical cooling needed to drop to 38°F respectively, for a ΔT = 25°F - 35°F). Adding a VFD to the milk transfer pump allows for up to an additional 15°F of free cooling. When installed in addition to a single-pass plate cooler, the milk temperature would drop to approximately 58°F (20°F of mechanical cooling needed to drop temperature to 38°F, for ΔT = 20°F).[6] Based on the historical project data, the average change in temperature is 47.5°F.

Sources

1. Historical Data (54 projects), average of May 2013 – July 2015 approved application kWh savings. Refer to the 'Dairy Refrigeration System Tune Up Support Doc'.
2. 2014 Database for Energy Efficiency Resources (DEER). EUL listing showing a 10-year measure life for refrigerant charging (commercial). http://www.deeresources.com.
3. Sanford, Scott. "Energy Efficiency for Dairy Enterprises Presentation." University of Wisconsin-Madison. 2005. Slides 16, 18, 21, 25, and 26. Accessed October 7, 2015.
4. Wisconsin Milk Marketing Board. "Did You Know? Milking Every Day." Accessed December 21, 2015. http://www.dairydoingmore.org/economicimpact/dairyfacts.
5. Journal of Food Engineering. "Determination of specific heat of milk at different fat content between 1C and 59C using micro DSC." Jin Hu. (Table 1) (Units converted from J/(g*K) to BTU/(lb*°F)) http://www.researchgate.net/publication/234102534_Determination_of_specific_heat_of_milk_at_different_fat_content_between_1C_and_59C_using_micro_DSC

Revision History

Version Number	Date	Description of Change
01	10/2015	New measure

Boilers & Burners

Steam Fittings and Pipe Insulation

	Measure Details
Measure Master ID	Insulation, Steam Fitting, Removable, Natural Gas, 2429 Insulation, Steam Piping, Natural Gas, 2430
Measure Unit	Per linear foot (pipe insulation) Per fitting (fitting insulation)
Measure Type	Prescriptive
Measure Group	Boilers & Burners
Measure Category	Insulation
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	11.38 (per linear foot pipe insulation) 40.44 (per fitting insulation)
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	113.8 (per linear foot pipe insulation) 404.4 (per fitting insulation)
Water Savings (gal/yr)	0
Effective Useful Life (years)	10[1]
Incremental Cost ($/unit)	MMID 2429 = $37.63/fitting;[4] MMID 2430 = $8.40/ft [5]

Measure Description

Uninsulated steam lines and fittings are a constant source of wasted energy. Adding insulation can typically reduce energy losses by 90% and will help ensure proper steam pressure and temperatures where needed. This measure is only for steam pipes in unconditioned spaces, including unconditioned basements and crawlspaces that are insulated from the conditioned space of the building.

Description of Baseline Condition

The baseline measure is an existing, non-insulated steam pipe or fittings that is part of an HVAC steam distribution system, with 80% boiler efficiency.

Description of Efficient Condition

Insulation must meet all federal and local safety standards and be rated for the temperature of the pipe on which it will be applied. Incentives are not intended for replacing existing pipe, insulation but only for insulating existing bare pipe.

The pipe being insulated must be at least 0.5-inches in diameter and must carry steam as part of an HVAC steam distribution system. The insulation thickness must meet 2009 IECC standards,[2] as outlined in section 5.3.2.8. For steam pipe with a 1.5-inch NPS or smaller, insulation must be at least 1.5 inches thick. For steam pipe with an NPS greater than 1.5 inches, insulation must be at least 3.0-inches thick. This is based on insulation with a K-value that does not exceed 0.27 Btu per inch/h*ft^2*°F. Installation must include a protective jacket around the insulation.

Annual Energy-Savings Algorithm

Savings were calculated using the assumptions listed below and 3E Plus v4.0 software, distributed by NAIMA (North American Insulation Manufacturers Association).[3] The 3E Plus software was used to calculate heat loss rates for bare and insulated pipe thickness per foot. The difference in heat loss is multiplied by the assumed hours of operation and divided by the boiler efficiency and Btu to therm conversion to calculate annual natural gas therm savings.

$\text{Therm}_{\text{SAVED\_PIPE}} = \text{PipeInsul}_{\text{SAVED}} * \text{LF}$

$\text{PipeInsul}_{\text{SAVED}} = \text{Pipe}_{\text{BARE}} - \text{Pipe}_{\text{INSUL}}$

Where:

$\text{PipeInsul}_{\text{SAVED}}$ = Annual energy savings through insulating in therms per linear foot of pipe (= 11.38)

LF = Total linear feet of pipe (= 1)

$\text{Pipe}_{\text{BARE}}$ = Annual energy consumption for uninsulated pipe calculated with 3E Plus software

$\text{Pipe}_{\text{INSUL}}$ = Annual energy consumption for insulated pipe calculated with 3E Plus software

$\text{Therm}_{\text{SAVED\_FITTING}} = \text{FittingInsul}_{\text{SAVED}} * \text{NF}$

$\text{FittingInsul}_{\text{SAVED}} = \text{Fitting}_{\text{BARE}} - \text{Fitting}_{\text{INSUL}}$

Where:

$\text{FittingInsul}_{\text{SAVED}}$ = Annual energy savings through insulating in therms per fitting (= 40.44)

NF = Number of fittings (= 1)

$\text{Fitting}_{\text{BARE}}$ = Annual energy consumption for uninsulated fitting calculated with 3E Plus software

$\text{Fitting}_{\text{INSUL}}$ = Annual energy consumption for uninsulated fitting calculated with 3E Plus software

Summer Coincident Peak Savings Algorithm

There are no peak savings for this measure.

Lifecycle Energy-Savings Algorithm

$\text{Therm}_{\text{LIFECYCLE}} = \text{Therm}_{\text{SAVED}} * \text{EUL}$

Where:

EUL = Effective useful life (= 10 years)[1]

Assumptions

The pipe or fitting will be hot for 4,000 hours per year.

The NPS is 2 inches. A fitting is equivalent to approximately 3.55 feet of 2-inch pipe.

The system application for this calculation is Pipe – Horizontal/Vertical, with the dimensional standard of ASTM C 585 Rigid/Flexible.

Sources

1. PA Consulting Group Inc. Public Service Commission of Wisconsin Focus on Energy Evaluation, Business Programs: Deemed Savings Manual, Final Report. March 22, 2010.
2. 2009 IECC standards.
3. This program is available through NAIMA (North American Insulation Manufacturers Association) at http://www.pipeinsulation.org/.
4. Actual Program Data, 2015-2016. 20 projects with average actual cost of $37.63 per fitting.
5. Actual Program Data, 2015-2016. 18 projects with average actual cost of $8.40 per foot

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Building Shell

Spring-Loaded Garage Door Hinge

	Measure Details
Measure Master ID	Spring-Loaded Garage Door Hinge: 55 Degree Indoor Temperature Setpoint, 3680 60 Degree Indoor Temperature Setpoint, 3681 65 Degree Indoor Temperature Setpoint, 3682 70 Degree Indoor Temperature Setpoint, 3683
Measure Unit	Per garage door
Measure Type	Hybrid
Measure Group	Building Shell
Measure Category	Air Sealing
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by measure
Life-cycle Energy Savings (kWh)	0
Life-cycle Therm Savings (Therms)	Varies by measure
Water Savings (gal/Year)	0
Effective Useful Life (years)	20[1]
Incremental Cost ($/unit)	$228.00[9]

Measure Description

Overhead doors do not always seal well against weather stripping and gaps may occur that lead to the loss of energy if the inside space is heated. These gaps can be exacerbated by wind and/or deterioration of weather stripping with age.

Spring-loaded garage door hinges reduce air infiltration around overhead doors by employing spring-loaded assemblies that keep overhead door sections pressed tightly against the seals. This eliminates the loss of energy.

The heavy-duty 12-gauge steel hinges fit most existing commercial doors. Individual door panels can be custom-adjusted to overcome poor track positioning and warped walls. The measure can be installed as a retrofit or on new construction.

Description of Baseline Condition

Infiltration is the uncontrolled leakage of air into a building. Air leaking can increase both heating and cooling costs. The rate of infiltration is driven by how well a building is sealed, the difference in temperature between the inside of the building and outside air, and the wind speed. Generally, the greatest temperature differences and wind speeds occur in winter. Sealed leaks will produce heating savings. The calculations below estimate heating savings.

The baseline condition is a 1/8-inch gap between the door and the weather stripping on the two vertical dimensions and one horizontal dimension. The bottom of the door is assumed sealed.

Description of Efficient Condition

The efficient condition is having installed the spring-loaded hinges, and the gap is assumed to be zero resulting in a net sealed dimension of 1/8 inch.

Annual Energy-Savings Algorithm

Reduced Infiltration (CFM) = $A_L * [(C_s * \Delta T) + (C_w * W_s^2)]^{0.5}$

Where:

A_L = Effective leakage area reduced, in square inches (= 51; average door assumed to be 10 feet wide and 12 feet tall; perimeter of top and two sides is 408 inches; with 1/8-inch gap reduced)

C_s = Stack coefficient (= 0.0299 $CFM^2/(in^4 * {}^oF$; determined from building height in stories with average of 2 stories assumed)[3]

ΔT = Indoor temperature setpoint minus average outside temperature during heating season (= 35°F; average outside temperature across Wisconsin during the heating season, for four locations)[4]

C_w = Wind coefficient (= 0.0086 CFM^2/ in^4 mph^2; determined from how sheltered the building is from the wind)[5]

W_s = Average heating season wind speed (= 11 mph)[2,6]

Hourly Heat Load Reduced (Btu/hour) = Reduced Infiltration (CFM) * (60 Min/Hr) * (0.08 Lb/CF) * (0.24 BTU/lb) * ΔT

Where:

0.08 = Average heating season air density in Wisconsin (lb/CF)[7]

0.24 = Specific heat of air (BTU/lb)[8]

Hourly Natural Gas Reduced (therms/hour) = (Reduced Heat Load Btu/hour)/(Heating Efficiency)/(100,000 Btu/therm)

Where:

Heating Efficiency = Typical non-condensing heating efficiency (= 0.80)[9]

Annual Natural Gas Use Reduced (therms/year) = Hourly Natural Gas Reduced (therms/Hrhour) * (Heating hours/year)

Where:

Heating Hr/Yr = Hours in typical September to April heating season(= 5,840)

Deemed Savings Results

MMID	Indoor Temperature Setpoint (°F)	Deemed Savings/Door (Therms/Year)
3680	55	110
3681	60	143
3682	65	179
3683	70	217

Summer Coincident Peak Savings Algorithm

There are no summer coincident peak savings for this measure.

Lifecycle Energy-Savings Algorithm

$\text{therms}_{\text{LIFECYCLE}}$ = therms/year * EUL

Where:

EUL = Effective useful life (= 20 years)[1]

Assumptions

The baseline condition is having a 1/8-inch gap between the garage door and the weather stripping on the two vertical dimensions and one horizontal dimension. The bottom of the door is assumed to be sealed. After installing the spring-loaded hinges, the gap is assumed to be zero resulting in a net sealed dimension of 1/8 inch. Interior space must be heated with natural gas.

The infiltration calculation is based on an ASHRAE model noted in the sources.

Infiltration in residential buildings has been studied extensively, and several calculation techniques have been produced to estimate annual infiltration rates. However, infiltration in commercial buildings has not been studied to the same detail, and standard calculations have not been developed for annual commerical infiltration rates. Therefore, the calculations assume residential-like infiltration.

The interior temperature setpoint is based on individual customer, and will be input by the customer who selects one of the four options (55°F, 60°F, 65°F, or 70°F). Deemed energy savings will vary according to the Deemed Savings Results table above. The incentive will not vary by setpoint, so there is no gain for a customer to report an inaccurate number.

The average garage door is 10 feet wide by 12 feet tall, based on Wisconsin Focus on Energy installations done to date.

The EUL is 20 years.[1] Initial installations of the Green Hinge product have been in the market for at least fiveyears, and the trade ally claims there have been no failures in that time. The company provides a lifetime guarantee thus if there is a failure, the customer would likely replace it in kind. The spring supplier certifies that the spring is good for > 10,000,000 cycles. Conventional garage door hinges routinely last 20+ years.

The average installation cost is based on the average door size of 10 feet wide by 12 feet tall, with six panels and five sets of hinges at $28.00/set (trade ally website quote) plus an estimated installation of $200.00 per door.

Sources

1. Focus on Energy. Evaluation – Business Program: Measure Life Study. 2009.
2. 2009 ASHRAE Handbook – Fundamentals. pg. 16.23.
3. 2001 ASHRAE Handbook – Fundamentals. pg. 26.21 (40).
4. U.S. Climate Data. "U.S. climate data." Last updated 2016. http://www.usclimatedata.com.
5. Graphiq Inc. "Find Average Wind Speed for US Cities." Last updated 2016. http://average-wind-speed.findthebest.com/
6. The Engineering ToolBox. "Air Density and Specific Weight." http://www.engineeringtoolbox.com/air-density-specific-weight-d_600.html
7. The Engineering ToolBox. "Properties of Air - temperatures ranging -100 to 1000 °F." http://www.engineeringtoolbox.com/air-properties-viscosity-conductivity-heat-capacity-d_1509.html
8. The Engineering Toolbox. Available online: http://www.engineeringtoolbox.com/specific-heat-capacity-gases-d_159.html
9. 2015 Vendor Feedback. The average installation cost is based on the average door size of 10 feet wide by 12 feet tall, with six panels and five sets of hinges at $28.00 per set (trade ally feedback /web quote) plus an estimated installation of $200.00 per door.

Revision History

Version Number	Date	Description of Change
01	8/2016	Added workpaper

Compressed Air, Vacuum Pumps

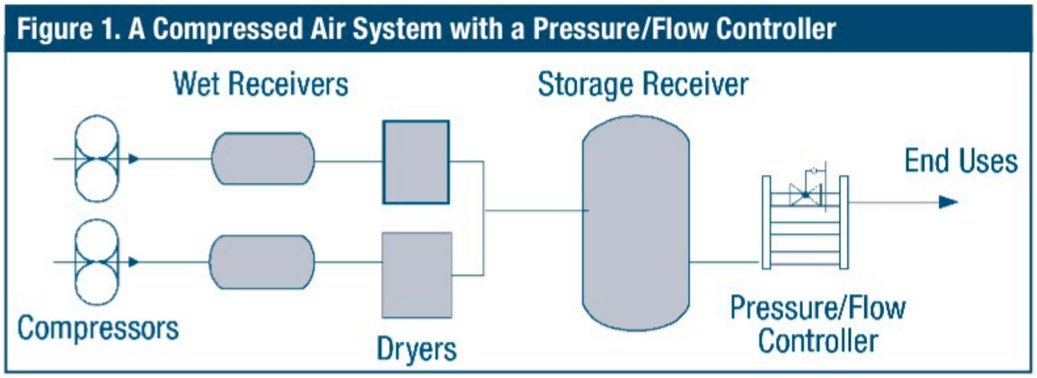
Compressed Air Controller, Pressure/Flow Controller

	Measure Details
Measure Master ID	Compressed Air Controller, Pressure/Flow Controller, 2255
Measure Unit	Per Compressed Air System
Measure Type	Hybrid
Measure Group	Compressed Air, Vacuum Pumps
Measure Category	Controls
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	178
Peak Demand Reduction (kW)	0.035
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	2,670
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	$27.15/hp[7]

Measure Description

A pressure/flow controller can greatly increase the control of an air storage system. These units, also called demand valves, precision flow controllers, or pilot-operated regulators, are precision pressure regulators that allow the airflow to fluctuate while maintaining a constant pressure to the facility's air distribution piping network.

Compressed Air System with a Pressure/Flow Controller[2]



Installing a pressure/flow controller on the downstream side of an air storage receiver creates a pressure differential entering and leaving the vessel. This pressure differential stores energy in the form of readily available compressed air, which can be used to supply the peak air demand for short-duration events, in place of using more compressor horsepower to feed this peak demand.

The benefits of having a pressure/flow controller include:

- Reducing kW of peak demand, especially with multiple compressor configurations.
- Saving kWh by allowing the compressor to run at most efficient loads, then turn itself off in low/no demand periods.
- Saving kWh by reducing plant air pressure to the minimum allowable. This leads to reduced loads on the electric motors and greater system efficiency. For every 2 psi reduced in the system, 1% of energy is saved.
- Maintaining a reduced, constant pressure in the facility wastes less air due to leakage, and less volume is required by the compressor.
- Ensuring quality control of the process by the constant pressure: machines can produce an enhanced product quality when the pressure is allowed to fluctuate.

Description of Baseline Condition

The baseline conditioning is having no existing pressure/flow controller and an existing compressed air system with a total compressor motor capacity ≥ 50 hp.

Description of Efficient Condition

To qualify for an incentive, the facility must have a compressed air system with motor capacity ≥ 50 hp, and a pressure/flow controller must be installed on the main pressure header. This measure is not replacing drop-line regulators or filter-regulator lubricators.

Annual Energy-Savings Algorithm

kWh_{SAVED} = HP * 0.746 / Motor Eff. * Load Factor * HOURS * % decrease

Where:

HP = Compressor motor size in horsepower

0.746 = Conversion factor from kilowatts to horsepower

Motor Eff. = Compressor motor efficiency (= 95%)[3]

Load Factor = Average load on compressor motor (= 89%)[3]

HOURS = Average annual run hours (= 5,083)[4]

% decrease = Percentage decrease in power input (= 5%)[5]

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = HP * 0.746 / Motor Eff. * Load Factor * % decrease * CF

Where:

CF = Coincidence factor (= 1)[6]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE}$ = kWh_{SAVED} * EUL

Where:

EUL = Effective useful life (= 15 years)[1]

Sources

1. Estimate from product representative.
2. Industrial Technologies Program. *Compressed Air Tip Sheet #9.* August 2004.
3. Cascade Energy. Proposed Standard Savings Estimation Protocol for Ultra-Premium Efficiency Motors. November 5, 2012.
4. United States Department of Energy Office of Energy Efficiency & Renewable Energy. *United States Industrial Electric Motor Systems Market Opportunities Assessment*. Pg. 42. December 2002.
5. United States Department of Energy. Improving Compressed Air System Performance: A Sourcebook for Industry. Pg. 20. November 2003.
6. Army Corps of Engineers. *Compressed Air System Survey at Sierra Army Depot, CA*. Mike C.J. Lin, Ahmad R. Ganji, Shy-Sheng Liou, and Bryan Hackett. November 2000. www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA384166
7. 71 past projects since 2012, with average cost of $27.15 per hp.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Compressed Air, Cycling Thermal Mass Air Dryers

	Measure Details
Measure Master ID	Compressed Air, Cycling Thermal Mass Air Dryers, 2264
Measure Unit	Per CFM
Measure Type	Prescriptive
Measure Group	Compressed Air, Vacuum Pumps
Measure Category	Dryer
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	1,430 per 100 CFM
Peak Demand Reduction (kW)	0.281 per 100 CFM
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	21,450 per 100 CFM
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	$6.00/CFM[7]

Measure Description

When air is compressed, it is typically saturated with moisture, which may cause corrosion or contamination if it condenses in a compressed air system. Compressed air dryers remove moisture from the compressed air system. Refrigerated dryers are the most common,[2] which remove moisture by cooling the air and causing water vapor to condense. Cycled refrigerated dryers turn on and off, or use a VFD to operate only as needed. Non-cycling dryers will continue to consume energy when drying is not needed.

Description of Baseline Condition

The baseline for this measure is a non-cycling refrigerated thermal mass air dryer.

Description of Efficient Condition

New dryers must be properly sized to meet the needs of the compressed air system in order to qualify. New dryers must be cycling or VFD-controlled refrigerated dryers. This measure is only for the replacement of non-cycled refrigerated dryers with cycled refrigerated dryers. The addition of controls to existing dryers does not qualify. The replacement of desiccant, deliquescent, heat-of-compression, membrane, or other types of dryers does not qualify.

Annual Energy-Savings Algorithm

kWh_{SAVED} = SF * LF * CFM * HOURS

Where:

SF = Savings factor in kW/CFM (= varies by dryer capacity; see table below)

LF = Load factor (= 89%)[4]

CFM = Cubic feet per minute; the actual rated capacity of air dryer

HOURS = Average annual run hours (= 5,083)[5]

Savings Factor by Dryer Capacity

Dryer Capacity in CFM	Savings Factor (kW/CFM)[3]
< 100	0.00474
≥ 100 and < 200	0.00359
≥ 200 and < 300	0.00316
≥ 300 and < 400	0.00290
≥ 400	0.00272

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = SF * LF * CFM * CF

Where:

CF = Coincidence factor (= 1)[6]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE}$ = kWh_{SAVED} * EUL

Where:

EUL = Effective useful life (= 15 years)[1]

Sources

1. Energy and Resource Soultions. Measure Life Study prepared for The Massachusetts Joint Utilities. 2005. http://rtf.nwcouncil.org/subcommittees/nonreslighting/Measure%20Life%20Study_MA%20Joint%20Utilities_2005_ERS-1.pdf
2. United States Department of Energy. Compressed Air Challenge, Improving Compressed Air System Performance: a Sourcebook for Industry. Pg. 11. November 2003.
3. Massachusetts Technical Resource Manual for Estimating Savings from Energy Efficiency Measures. Average of values, pg. 217. October 2010.

4. Cascade Energy. Proposed Standard Savings Estimation Protocol for Ultra-Premium Efficiency Motors. November 5, 2012.
5. United States Department of Energy Office of Energy Efficiency & Renewable Energy. *United States Industrial Electric Motor Systems Market Opportunities Assessment*. Pg 42. December 2002.
6. Army Corps of Engineers. *Compressed Air System Survey at Sierra Army Depot, CA.* Mike C.J. Lin, Ahmad R. Ganji, Shy-Sheng Liou, and Bryan Hackett. November 2000. www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA384166
7. Illinois Statewide Technical Reference Manual for Energy Efficiency, Version 5.0, Volume 2. (2016). Page 476. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_5/Final/IL-TRM_Effective_060116_v5.0_Vol_2_C_and_I_021116_Final.pdf

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Compressed Air Heat Recovery, Space Heating

	Measure Details
Measure Master ID	Compressed Air Heat Recovery, Space Heating, 2257
Measure Unit	Per horsepower
Measure Type	Hybrid
Measure Group	Compressed Air, Vacuum Pumps
Measure Category	Energy Recovery
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	58 per HP
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	870 per HP
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	Varies by project

Measure Description

The majority of the energy consumed by industrial air compressors is converted to heat, which can be recovered. Air compressor heat recovery systems are designed to capture waste heat and use it for space heating, water heating, or process heating. These systems can be installed on both air- and water-cooled compressors. For air-cooled compressors, ductwork and fans may be installed to send cool air across the compressor's after-cooler and oil cooler. The cool air absorbs heat from the compressor and gets ducted to where it is needed. For water-cooled compressors, a water-to-air or water-to-water heat exchanger may be used.

Heat recovery systems installed for backup or redundant air compressors do not qualify. The project must result in an estimated net reduction in facility Btus to be eligible. The static pressure in the area where the compressor is enclosed must remain the same, since a reduction in static pressure may reduce compressor efficiency. If outside air is used, anti-freeze protection must be considered.

Description of Baseline Condition

The baseline condition is a compressor without a heat recovery system.

Description of Efficient Condition

The efficient condition is a compressor with a heat recovery system.

Annual Energy-Savings Algorithm

$\text{Therm}_{\text{SAVED}}$ = HR * BHP * 2,545 * HOURS * Load Factor / 100,000

Where:

HR = Heat recoverable as a percentage of brake horsepower (= 50%)[2]

BHP = Compressor motor size, brake horsepower

2,545 = Conversion factor from Btu to BHP/hour

HOURS = Average annual run hours (= 5,083)[3]

Load Factor = Average load on compressor motor (= 89%)[4]

100,000 = Conversion from Btus to therms

Summer Coincident Peak Savings Algorithm

There are no peak savings for this measure.

Lifecycle Energy-Savings Algorithm

$\text{Therm}_{\text{LIFECYCLE}}$ = $\text{Therm}_{\text{SAVED}}$ * EUL

Where:

EUL = Effective useful life (= 15 years)[1]

Sources

1. PA Consulting Group Inc. Public Service Commission of Wisconsin Focus on Energy Evaluation, Business Programs: Deemed Savings Manual, Final Report. March 22, 2010.
2. Bonneville Power Administration. Compressed Air System Energy Efficiency Measure Information Sheet. May 2006.
3. United States Department of Energy Office of Energy Efficiency & Renewable Energy. *United States Industrial Electric Motor Systems Market Opportunities Assessment*. Pg 42. December 2002.
4. Cascade Energy. Proposed Standard Savings Estimation Protocol for Ultra-Premium Efficiency Motors. November 5, 2012.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Compressed Air Mist Eliminators

	Measure Details
Measure Master ID	Compressed Air Mist Eliminators, 2258
Measure Unit	Per horsepower
Measure Type	Hybrid
Measure Group	Compressed Air, Vacuum Pumps
Measure Category	Filtration
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	71
Peak Demand Reduction (kW)	0.014
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	710
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	5 (new construction), 3 (retrofit)[1]
Incremental Cost ($/unit)	$21.55/hp[7]

Measure Description

Large compressed air systems require air filtration for proper operation. These filters remove oil mist from the supply air of lubricated compressors, protecting the distribution system and end-use devices. While these filters are important to the operation of the system, they do have a pressure drop across them, and thus require a slightly higher operating pressure. Typical coalescing oil filters will operate with a 2 psig to 10 psig pressure drop. Mist eliminator air filters operate at a 0.5 psig pressure drop that increases to 3 psig over time before replacement is recommended.

This reduction in pressure drop allows the compressed air system to operate at a reduced pressure and, in turn, reduces the energy consumption of the system. In general, the energy consumption will decrease by 1% for every 2 psig the operating pressure is reduced.[2] Lowering the operating pressure has the secondary benefit of decreasing the demand of all unregulated usage, such as leaks and open blowing.

The equipment is mist eliminator air filters. The compressed air system must be greater than 50 hp to qualify, and the mist eliminator must have less than a 1 psig pressure drop and replace a coalescing filter.

Description of Baseline Condition

The baseline measure is a standard coalescing filter.

Description of Efficient Condition

The efficient condition is a mist eliminator air filter that replaces a standard coalescing filter.

Annual Energy-Savings Algorithm

kWh_{SAVED} = HP * 0.746 / Motor Eff. * Load Factor * HOURS * % Savings

% Savings = $Total_{PR}$ * RS

Where:

HP = Compressor motor size horsepower
0.746 = Conversion factor from HP to kW
Motor Eff. = Compressor motor efficiency (= 95%)[2]
Load Factor = Average load on compressor motor (= 89%)[2]
HOURS = Average annual run hours (= 5,083)[3]
% Savings = Percentage of energy saved (= 2%)[4]
$Total_{PR}$ = Total pressure reduction from replacing filter (= 4 psig)[4]
RS = Percentage of energy saved for each psig reduced (= 0.5%)[5]

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = HP * 0.746 / Motor Eff. * Load Factor * % Savings * CF

Where:

CF = Coincidence factor (= 1; compressed air systems run during peak demand)[6]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE}$ = kWh_{SAVED} * EUL

Where:

EUL = Effective useful life (= 10 years)[1]

Sources

1. Massachussetts TRM 2013. http://ma-eeac.org/wordpress/wp-content/uploads/TRM_PLAN_2013-15.pdf .Savings based on low pressure "mist eliminator" filters; Based on typical replacement schedules for low pressure filters (NSTAR staff estimates)
2. Cascade Energy. Proposed Standard Savings Estimation Protocol for Ultra-Premium Efficiency Motors. November 5, 2012.

3. United States Department of Energy Office of Energy Efficiency & Renewable Energy. *United States Industrial Electric Motor Systems Market Opportunities Assessment*. Pg. 42. December 2002.
4. Sullair Corporation. *Compressed Air Filtration and Mist Eliminators Datasheet*. Available online: http://www.amcompair.com/products/brochures/sullair_brochures/_Sullair%20filtration.pdf.
5. United States Department of Energy. Improving Compressed Air System Performance: A Sourcebook for Industry. Pg. 20. November 2003.
6. Army Corps of Engineers. *Compressed Air System Survey at Sierra Army Depot, CA.* Mike C.J. Lin, Ahmad R. Ganji, Shy-Sheng Liou, and Bryan Hackett. November 2000. www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA384166
7. Actual Program Data, 2014-2015. 24 projects, average cost of $21.55 per hp installed.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Compressed Air Nozzles, Air Entraining

	Measure Details
Measure Master ID	Compressed Air Nozzles, Air Entraining, 2259
Measure Unit	Per nozzle
Measure Type	Prescriptive
Measure Group	Compressed Air, Vacuum Pumps
Measure Category	Nozzle
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	4,800
Peak Demand Reduction (kW)	1.8
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	72,000
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	$36.42/nozzle[6]

Measure Description

Engineered nozzles, also known as air entraining nozzles, reduce the amount of compressed air required for cleaning, cooling, drying, and blowoff applications. These nozzles use the coanda effect to pull in free air and accomplish tasks with up to 70% less compressed air. Engineered nozzles often replace simple copper tubes, and have the added benefits of reducing noise due to the use of laminar airflow and producing a safer workplace due to the elimination of potential skin contact with high pressure air.

Description of Baseline Condition

The baseline condition is a standard efficiency compressed air system operating at an efficiency of 0.16 kW/scfm[2] for a minimum of 2,000 hours per year. Compressed air pipe flow rates are standard.[3]

Description of Efficient Condition

Nozzles must be engineered and usage must be 2,000 hours or greater to qualify.

Annual Energy-Savings Algorithm

kWh_{SAVED} = Eff * (Open Flow – Eng. Flow) * HOURS

Where:

Eff = Efficiency of standard air compressor (= 0.16 kW/scfm)

Open Flow = Flow of copper pipe nozzle (= 21 scfm)

Eng. Flow = Flow of engineered nozzle (= 6 scfm)
HOURS = Average annual run hours (= 2,000)

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = Eff * (Open Flow – Eng. Flow) * CF

Where:

CF = Coincidence factor (= 0.75)[4]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE}$ = kWh_{SAVED} * EUL

Where:

EUL = Effective useful life (= 15 years)[1]

Assumptions

The nozzle flow rates are averages based on available published data from engineered nozzle manufacturers. The savings assume a 1/8-inch diameter open tube.[3]

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation: Business Programs: Measure Life Study." Final Report. August 25, 2009.
2. United States Department of Energy. *Improving Compressed Air System Performance*. Pgs. 48-49.
3. Franklin Energy Services, LLC. Personal communications regarding engineering approximation based on field observation.
4. Technical Reference Manual for Ohio Senate Bill 221 Energy Efficiency and Conservation Program and 09-512-GE-UNC. October 15, 2009.
5. The 2,000 hours is the minimum (and most conservative) run hours needed to qualify for this measure and agreed upon by the PSC, Cadmus, Administrator, and Implmenters.
6. Focus on Energy Historical Project Data. 2013.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Compressed Air System Leak Survey and Repair

	Measure Details
Measure Master ID	Compressed Air System Leak Survey and Repair: Year 1, 2261 Year 2, 2262 Year 3, 2263 Year 4 and Beyond, 3598
Measure Unit	Per CFM
Measure Type	Hybrid
Measure Group	Compressed Air, Vacuum Pumps
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by capacity and leak size
Peak Demand Reduction (kW)	Varies by capacity and leak size
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by capacity and leak size
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	2[1]
Incremental Cost ($/unit)	Varies by measure, see Appendix D

Measure Description

For the compressed air system survey and repair measure, the facility's compressed air system is analyzed and areas are identified with opportunity to reduce leakage and energy consumption and gain efficiency through an improved equipment control strategy or equipment replacement.

Description of Baseline Condition

The baseline condition is determined by surveying the existing compressed air system. This involves identifying the number and types of compressors used; their nominal hp, scfm, or psig; and the controls associated with each compressor.

Description of Efficient Condition

In order to qualify for an incentive, the customer must repair one leak for every five connected compressor horsepower. If less than one leak per every five horsepower is identified, then all identified leaks must be repaired. The customer may provide a written explanation for a leak that cannot be repaired and may still qualify for an incentive. The customer must provide a leak log in the form of a spreadsheet so that the number of repairs and associated savings can be checked and calculated using the method outlined below.

Annual Energy-Savings Algorithm

This hybrid measure is designed to determine the kWh losses associated with the distribution of air system leaks. The required calculation inputs provide the estimated system CFM capacity and the associated CFM losses associated with the number of identified leaks. A leak survey will results in the input values for the leak sizes and quantities. The annual energy savings and percentage of existing system losses, along with the grant calculations, are provided as outputs.

The general calculation methodology is:

kWh_{SAVED} = (10,655 * [($/kWh) / 0.06] / 104 * OpPressure * (HOURS / 8,760) * ΔCFM Loss) / ($/kWh)))

ΔCFM Loss = #ofLeaks * (CFM/leak)

Where:

10,655 = Cost of 104 CFM compressed air leak at $0.06/kWh operating for 8,760 hours

$/kWh = Unit rate for electricity (= $0.06 or participant input)

0.06 = kWh $ rate

104 = Total CFM loss from 1/4-inch leak at 100 psig

OpPressure = Adjustment factor for current operating pressure (= varies by operating pressure; see table below)

HOURS = Average annual run hours (= user input)

8,760 = Total hours per year

ΔCFM Loss = Total CFM lost in whole system (=varies by leak size; see table below)

#ofLeaks = Number of leaks at each orifice size

CFM/leak = CFM of air lost at particular orifice size from decibel reading (= varies by decibels; see table below)

Adjustment Factor for Operating Pressure (100 psig = 1.0)[3]

OpPressure (psig)	70	75	80	85	90	95	100	110	125
Factor	0.725	0.7625	0.8	0.85	0.90	0.95	1.00	1.10	1.20

CFM Look-Up by Leak Orifice Size[3]

Leak Orifice Size	70	75	80	85	90	95	100	110	125
1/64”	0.29	0.31	0.32	0.34	0.36	0.38	0.40	0.44	0.48
1/32”	1.16	1.21	1.26	1.36	1.46	1.51	1.55	1.75	1.94
1/16”	4.66	4.95	5.24	5.48	5.72	6.02	6.31	6.99	7.66
1/8”	18.62	19.69	20.76	21.93	23.10	24.16	25.22	27.94	30.65
1/4”	74.40	78.75	83.10	87.55	92.00	96.45	100.90	111.55	122.20
3/8”	167.80	177.50	187.20	196.90	206.60	216.80	227.00	251.25	275.50
1/2”	296.00	309.00	322.00	350.50	379.00	397.00	415.00	460.50	506.00

Decibel Readings vs. CFM[2]

Digital Reading	100 PSIG	75 PSIG	50 PSIG	25 PSIG	10 PSIG
10 dB	0.5	0.3	0.2	0.1	0.05
20 dB	0.8	0.9	0.5	0.3	0.15
30 dB	1.4	1.1	0.8	0.5	0.4
40 dB	1.7	1.4	1.1	0.8	0.5
50 dB	2.0	2.8	2.2	2.0	1.9
60 dB	3.6	3.0	2.8	2.6	2.3
70 dB	5.2	4.9	3.9	3.4	3.0
80 dB	7.7	6.8	5.6	5.1	3.6
90 dB	8.4	7.7	7.1	6.8	5.3
100 dB	10.6	10.0	9.6	7.3	6.0

Summer Coincident Peak Savings Algorithm

There are no peak savings for this measure.

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 2 years)[1]

Assumptions

Efficiency of Compressor Types:

- Single-Stage: 3.8 CFM/hp
- Two-stage: 4.8 CFM/hp
- Rotary: 5.2 CFM/hp

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation: Business Programs: Measure Life Study." Final Report. August 25, 2009. Each year's tune-up should last two years.
2. UE Systems, Inc. *Compressed Air Ultrasonic Leak Detection Guide*. Available online: http://www.plantsupport.com/download/UCAGuide.pdf.
3. U.S. Department of Energy. http://www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/compressed_air3.pdf (originally from: Used with permission from Fundamentals of Compressed Air Systems Training offered by the Compressed Air Challenge®.)"

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Compressed Air Condensate Drains, No Loss Drain

	Measure Details
Measure Master ID	Compressed Air Condensate Drains, No Loss Drain, 2254
Measure Unit	Per drain
Measure Type	Prescriptive
Measure Group	Compressed Air, Vacuum Pumps
Measure Category	Other
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	1,525
Peak Demand Reduction (kW)	0.24
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	30,500
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Incremental Cost ($/unit)	$42.00/ton[5]

Measure Description

Air condensate drains, also referred to as traps, allow for water in the form of condensation to be removed from compressed air systems. Undrained water may interfere with the flow of compressed air and may also corrode the piping or tank.

Manual or automatic drains may be used. A manual drain is typically a simple valve that is opened by an operator. Level-operated mechanical drains are automatic and should not waste air if properly maintained, but they do require maintenance. Electrically operated solenoid drains use a timing device to open an orifice for a programmed amount of time, regardless of the level of condensate. Each of these types of drains may waste compressed air, and each can be replaced with no air-loss drains that automatically remove condensate without waste.

Description of Baseline Condition

The baseline measure is a timed solenoid drain.

Description of Efficient Condition

The efficient condition is a no loss air drain used in a system with load/no-load, variable speed, variable displacement, or centrifugal compressors. Load/no-load compressors must have adequate storage for drains to be eligible. Manual drains, lever-operated mechanical drains, and solenoid drains are not eligible for incentives. No loss drains must be rated to remove the necessary amount of condensate without any loss of compressed air.

Annual Energy-Savings Algorithm

kWh_{SAVED} = SF * HOURS

Where:

SF = Saving factor in kilowatts per drain (= 0.3)[2]

HOURS = Average annual run hours (= 5,083)[3]

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = SF * CF

Where:

CF = Coincidence factor (= 0.80)[2]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE}$ = kWh_{SAVED} * EUL

Where:

EUL = Effective useful life (= 20 years)[1]

Sources

1. 2011 Xcel Colorado DSM Plan. https://www.xcelenergy.com/staticfiles/xe/Regulatory/Regulatory%20PDFs/2011-CO-DSM-Plan.pdf.
2. TecMarket Works. New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs. Pgs. 193 and 194. October 15, 2010.
3. U. S. Department of Energy Office of Energy Efficiency & Renewable Energy. *United States Industrial Electric Motor Systems Market Opportunities Assessment*. Pg. 42. December 2002.
4. TecMarket Works, New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs, October 15, 2010, page 13.
5. Costs in Six Northeast and Mid-Atlantic Markets. $42.00 is cost of 150 Ton Water-Cooled Scroll/Screw Chiller Incremental Cost/Ton. Baseline Efficiency= 0.78 kW per ton and Efficient Condition = 0.68 kW per ton. Available online: http://www.neep.org/incremental-cost-study-phase-2

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Domestic Hot Water

Water Heater, High Usage, ≥ 90% TE Gas Storage / ≥ 2 EF Electric Heat Pump

	Measure Details
Measure Master ID	Water Heater, High Usage: ≥ 90% TE, K-12 School, 3684 ≥ 90% TE, Natural Gas, 3045 ≥ 0.82 EF, Tankless, Natural Gas, 3046 ≥ 2 EF, Heat Pump Storage, Electric, 3047
Measure Unit	Per heater
Measure Type	Hybrid
Measure Group	Domestic Hot Water
Measure Category	Water Heater
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by facility type
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by facility type
Lifecycle Energy Savings (kWh)	Varies by facility type
Lifecycle Therm Savings (Therms)	Varies by facility type
Water Savings (gal/yr)	0
Effective Useful Life (years)	13 (MMIDs 3684 and 3045)[1] 15 (MMIDs 3046 and 3047)[2]
Incremental Cost ($/unit)	Varies by measure, see Appendix D

Measure Description

This measure is installing a new high-efficiency water heater unit in new construction or in place of an older existing water heater. The new high-efficiency water heater delivers the same amount of hot water at the same temperature as the existing or baseline unit.

Description of Baseline Condition

The baseline condition is a new conventional electric or natural gas storage water heater intended for service in commercial and industrial buildings (as new DHW heaters are only installed when the existing unit has failed, or is judged to have reached its end-of-life condition). Per the ACEE "Market

Transformation Efforts for Water Heating Efficiency" report,[3] the following efficiency ratings are assumed:

- Electric DHW Heater: 0.90 EF
- Natural Gas DHW Heater: 0.59 EF
- Natural Gas DHW Heater: ≥ 0.67 EF

High usage applications are required to meet the annual operation and usage requirements for one or more of the categories shown in the table below.

Annual Operation and Usage in High Usage Applications

Category	Subcategory	Annual Operation (Minimum Days/Year)	Usage (Minimum)
Food Service	Full Service Restaurant Fast Food	≥ 300	Meals/Day (≥ 300)
	Cafeteria	≥ 175	Meals/Day (≥ 300)
Lodging	Dormitory	≥ 200	Beds (≥ 50)
	Hotel/Motel	≥ 300	Rooms or Beds (≥ 30)
Healthcare	Hospital	≥ 300	Beds (≥ 30)
	Nursing Home	≥ 300	Beds (≥ 30)
Laundry	Laundromat	≥ 300	Washes/Day (≥ 30)
Food Sales	Super Market	≥ 300	N/A
Education	K-12 Schools	≥ 180	Students/Building (≥ 300)
Prisons	Housing	≥ 200	Housed Inmates (≥ 50)

Description of Efficient Condition

The efficient condition is one of the following types of new energy-efficient DHW heaters:

Qualifying Natural Gas Equipment:

- ***0.82 EF Natural Gas Tankless Water Heaters:*** To be able to heat water 70°F or more virtually instantaneously, most natual gas tankless water heaters have an input of 100,000 Btu/hour or higher. Their major advantage is having no standby heat losses, which have to be made up by the heater firing whenever the water temperature drops below a set point. In addition, these heaters are typically installed close to the location where hot water is needed, which minimizes losses from the hot-water delivery piping.
- ***90% Thermal Efficiency[8] Condensing Natural Gas Storage Water Heaters:*** Condensing natural gas storage water heaters are designed to capture the latent heat from water vapor created when natural gas is burned. Conventional natural gas storage water heaters allow water vapor to leave the device, and therefore the latent heat is not captured; this means condensing

natural gas heaters have a higher efficiency. Because flue gases have been significantly cooled, condensing natural gas water heaters require the use of a fan to propel combustion products gases through the exhaust flue.

Qualifying Electric Equipment:

- 2.0 EF ENERGY STAR-Qualified Integrated Heat Pump Water Heaters
- 2.0 EF Add-On Heat Pump Water Heaters

The EF rating for residential water heaters was developed per a U.S. DOE rulemaking process, and is therefore based on a test profile that represents the water usage pattern in a typical residence. There is a general consensus that this profile is not appropriate for rating the newer types or storage types of DHW heaters, and a U.S. DOE-sponsored committee is developing a better test procedure and profile.

High usage, condensing, natural gas storage water heaters are not EF rated. For calculation purposes, an EF of 0.8 is used for condensing storage water heaters in high usage applications.[8]

Annual Energy-Savings Algorithm

$Btu_{SAVED} = GPY * 8.33 * 1.0 * \Delta T * [(1/EF_{BASELINE}) - (1/EF_{EFFICIENT})]$

For electric water heaters: $kWh_{SAVED} = Btu_{SAVED} / 3,412$

For gas water heaters: $Therms_{SAVED} = Btu_{SAVED} / 100,000$

Where:

GPY = Gallons per year of DHW usage (= derived from days per year of operation and gallons per day shown in table below)

8.33 = Density of water in pounds per gallon

1.0 = Specific heat of water in Btu per (pound-°F temperature change)

ΔT = Water temperature change produced by the DHW heater (= water heater setpoint temperature as user-defined on application - 52.3°F)[5]. If actual water heater setpoint temperature is unknown, use 125°F as the default

$EF_{BASELINE}$ = Efficiency metric for baseline DHW heater

$EF_{EFFICIENT}$ = Efficiency metric for efficient DHW heater

3,412 = Conversion factor for Btu per kWh

100,000 = Conversion factor for Btu per therm

Average Daily Gallons by Facility Type

Facility Type	Avg Daily Gallons	Source[4]
Schools Elementary School Jr./Sr. High School	0.6 gal/student 1.8 gal/student	ASHRAE HVAC Applications 2011, Chapter 50, Table 7
Motels and Hotels ≤ 20 rooms/suites 21 to 99 rooms/suites ≥ 100 rooms/suites	20 per room 14 per room 10 per room	ASHRAE HVAC Applications 2011, Chapter 50, Table 7
Dormitories	12.7 per student	ASHRAE HVAC Applications 2011, Chapter 50, Table 7 (average of 13.1 for male dormitory and 12.3 for female dormitory)
Prison Housing	12.7 per housed inmate	ASHRAE HVAC Applications 2011, Chapter 50, Table 7 (average of 13.1 for male dormitory and 12.3 for female dormitory; *prison housing water usage is assumed to be similar to the dormitories category)*
Hospital	50 per bed	http://smud.apogee.net/comsuite/content/ces/?id=971 (lists a range of 25 to 90 gallons/day/bed, used 50, which is conservative of 57.5 midpoint)[5]
Nursing Homes	18.4 per bed	ASHRAE HVAC Applications 2011, Chapter 50, Table 7
Food Service Full Service Restaurant Cafeteria Fast Food	2.4 per meal 2.4 per meal 350 per day	Full Service and cafeteria: ASHRAE HVAC Applications 2011, Chapter 50, Table 7 Fast food: ASHRAE HVAC Applications 2011, Chapter 50, page 50.15 (lists range of 250 to 500, use 350 as under midpoint of the range)
Supermarket	650 per day	ASHRAE HVAC Applications 2011, Chapter 50, page 50.15 (lists range of 300 to 1,000, use average of 650)
Laundry	21 per wash	ASHRAE HVAC Applications 2011, Chapter 50, page 50.12 (for low-flow clothes washer)

Summer Coincident Peak Savings Algorithm

Demand reduction is a function of building type, because it is a function of whether—at the time of interest—the units are operating intermittently to compensate for heat losses through the tank and surrounding insulation, or if they are operating at a constant level to heat the incoming water that is replacing hot water being used at a high rate. A careful study to analyze demand reduction in various facility types has not been performed, largely because it is recognized that the amount of reduction will be quite small. For this reason, and because the power rating of storage type electric water heaters is the same for the baseline and efficient models, zero demand reduction is assumed for all storage type heaters. For heat pump DHW heaters, there will be savings due to different power ratings.

Electric and Natural Gas Storage DHW Heaters

There are no summer coincident peak savings for storage DHW heaters.

Electric Heat Pump DHW Heaters

$kW_{SAVED} = CF * FUF * kW_{BASELINE} * [(1/EF_{BASELINE}) – (1/EF_{EFFICIENT})]$

Where:

CF = Coincidence factor (ratio of expected power demand at utility peak system demand to the maximum connected load of an item of equipment; = varies by facility type, see table below)

FUF = Facility utilization factor (ratio of facility utilization at the time of utility peak system demand to the maximum facility utilization). This parameter is a function of facility type. For dormitories, it should reflect summer occupancy relative to maximum occupancy. Similarly for other facility types, it should account for summer weekday occupancy factors that affect DHW usage (= project-specific values; otherwise use the set of typical FUF values shown in table below)

$kW_{BASELINE}$ = Power rating of the baseline DHW heater

Coincidence Factors and Facility Utilization Factors[7]

Facility Type	CF	FUF
Dormitories	0.25	0.30
Schools		
Elementary	0.10	0.10
Junior / Middle / High	0.25	0.40
Motels and Hotels*	0.25	1.00
Nursing Homes	0.35	1.00
Hospital (assume same values as nursing home)	0.35	1.00
Office Buildings	0.15	0.90
Food Service	0.40	1.00
Apartment Houses	0.25	0.90
Supermarkets	0.15	1.00
Laundry	0.50	1.00

* Excludes restaurants, kitchens, and laundries.

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therms_{LIFECYCLE} = Therms_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 13 years for natural gas storage, freestanding water heaters; = 15 years for natural gas tankless and electric heat pump)[1,2]

Sources

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2. MMID 3046 and 3047: California Public Utility Commission. *CALMAC 2000 workshop report.* Available online: http://www.cpuc.ca.gov/NR/rdonlyres/7E3A4773-6D35-4D21-A7A2-9895C1E04A01/0/EEPolicyManualV5forPDF.pdf and PA Consulting Group Inc. *State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation: Business Programs: Measure Life Study*. Final Report. August 25, 2009.
3. American Council for an Energy-Efficient Economy (Jacob Talbot). “Market Transformation Efforts for Water Heating Efficiency.” ACEEE Report A121. January 2012.
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6. Sacramento Municipal Utility District. “Energy Library / Facility Types / Healthcare / Hospitals.” Accessed November 12, 2014. http://smud.apogee.net/comsuite/content/ces/?id=971,
7. Coincidence Factors and Facility Utilization Factors were “developed by seeking consensus among a small group of engineers having experience performing energy audits in C&I facilities.” Seven experienced engineers were surveyed.
8. Title 10 Code of Federal Regulations, Part 431 sets minimum efficiency standards for gas-fired commercial storage water heaters at an EF=0.80.
9. “2015 Michigan Energy Measures Database.” Accessed December 28, 2015. http://www.michigan.gov/mpsc/0,4639,7-159-52495_55129---,00.html. (MMIDs 3045 and 3684 = Michigan measure N-CO-WH-000160-G-XX-XX-XX-XX-02, MMID 3046 = Michigan measure N-CO-WH-000162-G-XX-XX-XX-XX-02, MMID 3047 = N-CO-WH-000507-G-XX-XX-XX-XX-01).

Revision History

Version Number	Date	Description of Change
01	01/01/2013	Revised measure
02	11/07/2014	Added building categories
03	09/25/2015	Added categories for K-12 schools and prisons
04	12/29/2015	Updated incremental cost data

Food Service

Dishwasher, ENERGY STAR Commercial

	Measure Details
Measure Master ID	Dishwasher: Low Temp: Door Type, ENERGY STAR, 2280 (Electric) and 2293 (Natural Gas) Multi Tank Conveyor, ENERGY STAR, 2294 (Electric) and 2295 (Natural Gas) Single Tank Conveyor, ENERGY STAR, 2296 (Electric) and 2297 (Natural Gas) Under Counter, ENERGY STAR, 2298 (Electric) and 2299 (Natural Gas) Pots/Pans Type, ENERGY STAR, 3140 (Natural Gas) High Temp: Electric Booster, Door Type, ENERGY STAR, 2281 (Electric) and 2282 (Natural Gas) Electric Booster, Multi Tank Conveyor, ENERGY STAR, 2283 (Electric) and 2284 (Natural Gas) Electric Booster, Single Tank Conveyor, ENERGY STAR, 2285 (Electric) and 2286 (Natural Gas) Electric Booster, Under Counter, ENERGY STAR, 2287 (Electric) and 2288 (Natural Gas) Electric Booster, Pots/Pans Type, ENERGY STAR, 3137 (Natural Gas) Natural Gas Booster, Door Type, ENERGY STAR, 2289 (Natural Gas) Natural Gas Booster, Multi Tank Conveyor, ENERGY STAR, 2290 (Natural Gas) Natural Gas Booster, Single Tank Conveyor, ENERGY STAR, 2291 (Natural Gas) Natural Gas Heat, Natural Gas Booster, Under Counter, ENERGY STAR, 2292 (Natural Gas) Natural Gas Booster, Pots/Pans Type, ENERGY STAR, 3138 (Natural Gas)
Measure Unit	Per dishwasher
Measure Type	Prescriptive
Measure Group	Food Service
Measure Category	Dishwasher, Commercial
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	Varies by measure
Annual Therm Savings (Therms)	Varies by measure
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	Varies by measure
Water Savings (gal/yr)	Varies by measure
Effective Useful Life (years)	10[1]
Incremental Cost ($/unit)	Varies by measure, see Appendix D

Measure Description

On average, ENERGY STAR-qualified commercial dishwashers are 25% more efficient than conventional dishwashers in both energy and water use. The reduction in water use results in additional water-heating energy savings.

The ENERGY STAR rating applies to commercial under-counter dishwashers; single-tank door type dishwashers; pot, pan, and utensil dishwashers; single- and multiple-tank conveyor dishwashers; and flight-type dishwashers. To meet ENERGY STAR criteria, commercial dishwashers must meet certain idle energy use rates and volume of water consumed per rack.

Dishwasher measures are for higher temperature and lower temperature machines in door type, multitank conveyor, single-tank conveyor, and under-counter machines. Water heater configurations are for electric water heaters with an electric booster heater, natural gas water heaters with an electric booster heater, and natural gas water heaters with a natural gas booster heater. This measure does not apply to flight-type dishwashers, as these units are custom.

Description of Baseline Condition

The baseline condition for commercial dishwashers is based on values in the ENERGY STAR commercial kitchen equipment calculator;[2] these values were based on the U.S. EPA 2013 FSTC research on available commercial dishwasher models.[3]

Description of Efficient Condition

The efficient condition for commercial dishwashers is defined by the ENERGY STAR v2.0 *Requirements for Commercial Dishwashers*.[2]

Annual Energy-Savings Algorithm

$$\text{kWh}_{\text{SAVED}} = \Delta\text{kWh/yr}_{\text{WATER HEATER}} + \Delta\text{kWh/yr}_{\text{BOOSTER HEATER}} + \Delta\text{kWh/yr}_{\text{IDLE}}$$

$$\text{Therm}_{\text{SAVED}} = \Delta\text{Therms/yr}_{\text{WATER HEATER}} + \Delta\text{Therms/yr}_{\text{BOOSTER HEATER}}$$

$$\text{Gallons}_{\text{SAVED}} = \text{Gallons/yr}_{\text{BASE}} - \text{Gallons/yr}_{\text{EE}}$$

Energy-Savings Algorithms by Fuel and Machine Type

Fuel Type	Machine Type	Algorithm
Electric	Water Heater	$\Delta\text{kWh/yr}_{\text{WATER HEATER}} = \text{Gallons}_{\text{SAVED}} * \text{kWh/gallon}_{\text{WATER HEATER}}$
	Booster Heater	$\Delta\text{kWh/yr}_{\text{BOOSTER HEATER}} = \text{Gallons}_{\text{SAVED}} * \text{kWh/gallon}_{\text{BOOSTER HEATER}}$
Natural Gas	Water Heater	$\Delta\text{Therms/yr}_{\text{WATER HEATER}} = \text{Gallons}_{\text{SAVED}} * \text{Therms/gallon}_{\text{WATER HEATER}}$
	Booster Heater	$\Delta\text{Therms/yr}_{\text{BOOSTER HEATER}} = \text{Gallons}_{\text{SAVED}} * \text{Therms/gallon}_{\text{BOOSTER HEATER}}$

Energy Usage by Fuel and Machine Type

Fuel Type	Machine Type	Energy Use
Electric	Water Heater	$kWh/gallon_{WATER\ HEATER} = \Delta T_{WH} * C_{WATER} * \rho_{WATER} / \eta_{ELECTRIC} / 3{,}412$
	Booster Heater	$kWh/gallon_{WATER\ HEATER} = \Delta T_{BH} * C_{WATER} * \rho_{WATER} / \eta_{ELECTRIC} / 3{,}412$
Natural Gas	Water Heater	$Therms/gallon_{WATER\ HEATER} = \Delta T_{WH} * C_{WATER} * \rho_{WATER} / \eta_{GAS} / 100{,}000$
	Booster Heater	$Therms/gallon_{BOOSTER\ HEATER} = \Delta T_{WH} * C_{WATER} * \rho_{WATER} / \eta_{GAS} / 100{,}000$

Where:

ΔT_{WH} = Temperature rise delivered by water heater (= 70°F)[2]

C_{WATER} = Specific heat of water (= 1 Btu/pound/°F)

ρ_{WATER} = Density of water (= 8.33 lbs/cubic foot)

$\eta_{ELECTRIC}$ = Electric conversion efficiency (= 98%)[4]

3,412 = Conversion factor from Btu to kWh

ΔT_{BH} = Temperature rise delivered by booster heater (= 40°F)[2]

η_{GAS} = Natural gas conversion efficiency (= 76%)[4]

100,000 = Conversion factor from Btu to therms

$$\Delta kWh/yr_{IDLE} = (kW_{BASE\ IDLE} * DY * (HD - RD * WT_{BASE} / 60)) - (kW_{EE\ IDLE} * DY * (HD - RD * WT_{EE} / 60))$$

$$Gallons/yr_{BASE} = GPR_{BASE} * DY * RD$$

$$Gallons/yr_{EE} = GPR_{EE} * DY * RD$$

Where:

$kW_{BASE\ IDLE}$ = Baseline consumption when on but not in wash cycle (= varies by measure; see table below)[2]

DY = Days per year of dishwasher operation (= 365)[2]

HD = Hours per day of dishwasher operation (= 18)[2]

RD = Number of racks of dishes washed each day (= varies by measure; see table below)[2]

WT_{BASE} = Washtime (= length of wash cycles in minutes; varies by measure, see table below)[2]

60 = Minutes per hour

$kW_{EE\ IDLE}$ = Efficient equipment consumption when on but not in wash cycle (= varies by measure; see table below)[2]

WT_{EE} = Washtime efficient equipment (= varies by measure; see table below)

GPR_{BASE} = Gallons per rack of baseline equipment (= varies by measure; see table below)[2]

GPR_{EE} = Gallons per rack of ENERGY STAR equipment (= varies by measure; see table below)[2]

Variable Values by Measure Type

Measure Type	GPR_{BASE}	GPR_{EE}	$kW_{BASE\ IDLE}$	$kW_{EE\ IDLE}$	WT_{BASE}	WT_{EE}	RD
Low Temperature							
Under Counter	1.73	1.19	0.50	0.50	2.0	2.0	75
Stationary Single-Tank Door	2.10	1.18	0.60	0.60	1.5	1.5	280
Single-Tank Conveyor	1.31	0.79	1.60	1.50	0.3	0.3	400
Multiple Tank Conveyor	1.04	0.54	2.00	2.00	0.3	0.3	600
High Temperature							
Under Counter	1.09	0.86	0.76	0.50	2.0	2.0	75
Stationary Single-Tank Door	1.29	0.89	0.87	0.70	1.0	1.0	280
Single-Tank Conveyor	0.87	0.70	1.93	1.50	0.3	0.3	400
Multiple Tank Conveyor	0.97	0.54	2.59	2.25	0.2	0.2	600
Pot, Pan, and Utensil	0.70	0.58	1.20	1.20	3.0	3.0	280

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = DRed_{DW} * CF$

Where:

$DRed_{DW}$ = Summer demand reduction per purchased ENERGY STAR dishwasher (= 0.0225)[5]

CF = Coincident factor (= 1; this is already embedded in the summer peak demand reduction estimate as $DRed_{DW}$)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

$Gallons_{LIFECYCLE} = Gallons_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 10 years)[1]

Deemed Savings

Savings With Electric Water Heater and Booster Heater

	MMID	Baseline		ENERGY STAR		Savings	
		Electric (kWh)	Natural Gas (therm)	Electric (kWh)	Natural Gas (therm)	Electric (kWh)	Natural Gas (therm)
Low Temperature							
Under Counter	2298 (Electric) 2299 (Natural Gas)	11,085	0	8,508	0	2,577	0
Stationary Single-Tank Door	2280 (Electric) 2293 (Natural Gas) 3140 (Pots/Pans)	39,824	0	23,433	0	16,392	0
Single-Tank Conveyor	2296 (Electric) 2297 (Natural Gas)	42,687	0	28,868	0	13,819	0
Multitank Conveyor	2294 (Electric) 2295 (Natural Gas)	50,656	0	31,567	0	19,090	0
High Temperature (with electric booster heater)							
Under Counter	2287 (Electric) 2288 (Natural Gas)	12,474	0	9,278	0	3,196	0
Stationary Single-Tank Door	2281 (Electric) 2282 (Natural Gas) 2761 (Pots/Pans)	40,351	0	28,325	0	12,027	0
Single-Tank Conveyor	2285 (Electric) 2286 (Natural Gas)	46,069	0	36,758	0	9,311	0
Multitank Conveyor	2283 (Electric) 2284 (Natural Gas)	73,321	0	45,538	0	27,784	0
Pot, Pan, and Utensil	3137	21,351	0	17,991	0	3,360	0

	MMID	Baseline		ENERGY STAR		Savings	
		Electric (kWh)	Natural Gas (therm)	Electric (kWh)	Natural Gas (therm)	Electric (kWh)	Natural Gas (therm)
High Temperature (with natural gas booster heater)							
Under Counter	2292	9,502	131	6,933	103	2,569	28
Stationary Single-Tank Door	2289	27,218	578	19,264	399	7,954	179
Single-Tank Conveyor	2291	33,415	557	26,577	448	6,838	109
Multitank Conveyor	2290	52,159	931	33,757	518	18,403	413
Pot, Pan, and Utensil	3138	14,224	314	12,086	260	2,138	54

Savings With Natural Gas Water Heater and Booster Heater

	MMID	Baseline		ENERGY STAR		Savings	
		Electric (kWh)	Natural Gas (therm)	Electric (kWh)	Natural Gas (therm)	Electric (kWh)	Natural Gas (therm)
Low Temperature							
Under Counter	2298 (Electric) 2299 (Natural Gas)	2,829	363	2,829	250	0	113
Stationary Single-Tank Door	2280 (Electric) 2293 (Natural Gas) 3140 (Pots/Pans)	2,409	1,647	2,409	925	0	721
Single-Tank Conveyor	2296 (Electric) 2297 (Natural Gas)	9,344	1,467	8,760	885	584	582
Multitank Conveyor	2294 (Electric) 2295 (Natural Gas)	10,950	1,747	10,950	907	0	840
High Temperature (with electric booster heater)							
Under Counter	2287 (Electric) 2288 (Natural Gas)	7,272	229	5,174	181	2,098	48
Stationary Single-Tank Door	2281 (Electric) 2282 (Natural Gas) 2761 (Pots/Pans)	17,368	1,012	12,468	698	4,900	314
Single-Tank Conveyor	2285 (Electric) 2286 (Natural Gas)	23,925	975	18,941	784	4,984	190

Multitank Conveyor	2283 (Electric) 2284 (NG)	36,288	1,630	24,921	907	11,367	723
Pot, Pan, and Utensil	3137	8,879	549	7,657	455	1,222	94
High Temperature (with natural gas booster heater)							
Under Counter	2292	4,300	360	2,829	284	1,471	76
Stationary Single-Tank Door	2289	4,234	1,590	3,407	1,097	827	493
Single-Tank Conveyor	2291	11,271	1,531	8,760	1,232	2,511	299
Multitank Conveyor	2290	15,126	2,561	13,140	1,426	1,986	1,135
Pot, Pan, and Utensil	3138	1,752	863	1,752	715	0	148

Annual Water Savings

	MMID	Baseline (Gallons/yr)	ENERGY STAR (Gallons/yr)	Savings (Gallons/yr)
Low Temperature				
Under Counter	2298 (Electric) 2299 (Natural Gas)	47,359	32,576	14,783
Stationary Single-Tank Door	2280 (Electric) 2293 (Natural Gas) 3140 (Pots/Pans)	214,620	120,596	94,024
Single-Tank Conveyor	2296 (Electric) 2297 (Natural Gas)	191,260	115,340	75,920
Multitank Conveyor	2294 (Electric) 2295 (Natural Gas)	227,760	118,260	109,500
High Temperature				
Under Counter	Electric Booster Heater: 2287 (Electric) 2288 (Natural Gas) Natural Gas Booster Heater: 2292	29,839	23,543	6,296
Stationary Single-Tank Door	2281 (Electric) 2282 (Natural Gas) 2761 (Pots/Pans)	131,838	90,958	40,880
Single-Tank Conveyor	Electric Booster Heater: 2285 (Electric) 2286 (Natural Gas) Natural Gas Booster Heater: 2291	127,020	102,200	24,820
Multitank Conveyor	Electric Booster Heater: 2283 (Electric) 2284 (Natural Gas)	212,430	118,260	94,170
Pot, Pan, and Utensil	Electric Booster Heater: 3137 Natural Gas Booster Heater: 3138	71,540	59,276	12,264

Assumptions

For peak demand reduction, the HOU is assumed to be the total HOU and is not differentiated from the percentage of time during idle state versus washing.

Sources

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2. United States Department of Energy. “ENERGY STAR Commercial Kitchens Calculator.” www.energystar.gov.
3. United State Environmental Protection Agency, Food Service Technology Center. http://www.fishnick.com/
4. Air Conditioning, Heating, and Refrigeration Institute. RWH research. Most common RE for non-heat pump water heaters: http://www.ahridirectory.org/ahridirectory/pages/rwh/defaultSearch.aspx
5. Pennsylvania Public Utilities Commission. *Pennsylvania PUC Technical Reference Manual.* June 2013. Demand reduction was derived using dishwasher load shape.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

CEE Tier 2 Ice Machines

	Measure Details
Measure Master ID	Ice Machine, CEE Tier 2: Air Cooled: Self Contained, 0-499 lbs/day, 3414 Ice Making Head, 0-499 lbs/day, 3416 Ice Making Head, 500-999 lbs/day, 3417 Ice Making Head, ≥ 1,000 lbs/day, 3418 Remote Condensing, 0-499 lbs/day, 3422 Remote Condensing, 500-999 lbs/day, 3423 Remote Condensing, ≥ 1,000 lbs/day, 3424 Water Cooled: Self Contained, 0-499 lbs/day, 3415 Ice Making Head, < 500 lbs/day, 3419 Ice Making Head, 500-999 lbs/day, 3420 Ice Making Head, ≥ 1,000 lbs/day, 3421
Measure Unit	Per ice machine
Measure Type	Prescriptive
Measure Group	Food Service
Measure Category	Ice Machine
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by machine type and size
Peak Demand Reduction (kW)	Varies by machine type and size
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by machine type and size
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	53[1]
Effective Useful Life (years)	10[2]
Incremental Cost ($/unit)	$981.00[7]

Measure Description

Commercial ice machines are used in restaurants, hospitals, hotels, schools, offices, and grocery stores. CEE Tier 2 ice machines are, on average, 10% more energy efficient and use approximately 25% less water than standard models. These machines are designed with more efficient compressors. Investing in more energy-efficient ice machines can save hundreds of dollars per year.

Description of Baseline Condition

The baseline is a standard ice machine that meets the Energy Policy Act of 2005.

Description of Efficient Condition

New units must be CEE Tier 2 ice machines with a harvest rate based on operation at standard rating conditions per AHRI Standard 810.

Annual Energy-Savings Algorithm

Based on the harvest rate for various CEE categories of ice machines, each qualifying ice machine must meet an energy use limit based on kWh/100 lbs of ice. The savings are derived by subtracting the CEE Tier 2 energy limits from the baseline Energy Policy Act of 2005 ice machine energy usage. The savings based on each harvest rate category are weighted based on the number of qualifying CEE Tier 2 units from the January 2014 *Qualified Products List* to provide an overall measure savings for the measure descriptions listed above.

$kWh_{SAVED} = (\Delta kWh/100 \text{ lb of ice})/100 * (H * DutyCycle) * 365$

$\Delta kWh/100 \text{ lb of ice} = \Delta B + (\Delta A * H * DutyCycle)$

$\Delta B = B_{BASE} - B_{CEE\ TIER\ 2}$

$\Delta A = A_{BASE} - A_{CEE\ TIER\ 2}$

Where:

100 = Factor to normalize from 100 pounds of ice to 1 pound of ice

H = Harvest rate of ice in pounds

DutyCycle = Percentage of annual average ice machine duty cycle[3]

365 = Number of days per year

ΔB = Constant to calculate kWh consumption per 100 pounds of ice as a function of harvest rate (algorithm represents maximum energy consumption for the category)

ΔA = Coefficient to calculate kWh consumption per 100 pounds of ice as a function of harvest rate (algorithm represents maximum energy consumption for the category)

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED}/HOURS$

Where:

HOURS = Annual hours per year (= 8,760)[5]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 10 years)[1]

Deemed Savings

Annual Deemed Savings

Measure	MMID	kWh	kW
Ice Machine, CEE Tier 2, Air Cooled, Self Contained, 0-499 lbs/day	3414	853	0.0974
Ice Machine, CEE Tier 2, Water Cooled, Self Contained, 0-499 lbs/day	3415	856	0.0977
Ice Machine, CEE Tier 2, Air Cooled, Ice Making Head, 0-499 lbs/day	3416	543	0.0619
Ice Machine, CEE Tier 2, Water Cooled, Ice Making Head, < 500 lbs/day	3419	839	0.0957
Ice Machine, CEE Tier 2, Air Cooled, Remote Condensing, 0-499 lbs/day	3422	2,752	0.3141
Ice Machine, CEE Tier 2, Air Cooled, Ice Making Head, 500-999 lbs/day	3417	2,266	0.2590
Ice Machine, CEE Tier 2, Water Cooled, Ice Making Head, 500-999 lbs/day	3420	1,686	0.1925
Ice Machine, CEE Tier 2, Air Cooled, Remote Condensing, 500-999 lbs/day	3423	2,735	0.3141
Ice Machine, CEE Tier 2, Air Cooled, Ice Making Head, ≥ 1,000 lbs/day	3418	1,427	0.1631
Ice Machine, CEE Tier 2, Water Cooled, Ice Making Head, ≥ 1,000 lbs/day	3421	1,686	0.1920
Ice Machine, CEE Tier 2, Air Cooled, Remote Condensing, ≥ 1,000 lbs/day	3424	2,164	0.2469

Lifecycle Deemed Savings

Measure	MMID	Lifecycle kWh
Ice Machine, CEE Tier 2, Air Cooled, Self Contained, 0-499 lbs/day	3414	8,529
Ice Machine, CEE Tier 2, Water Cooled, Self Contained, 0-499 lbs/day	3415	8,560
Ice Machine, CEE Tier 2, Air Cooled, Ice Making Head, 0-499 lbs/day	3416	5,425
Ice Machine, CEE Tier 2, Water Cooled, Ice Making Head, < 500 lbs/day	3419	8,387
Ice Machine, CEE Tier 2, Air Cooled, Remote Condensing, 0-499 lbs/day	3422	27,517
Ice Machine, CEE Tier 2, Air Cooled, Ice Making Head, 500-999 lbs/day	3417	22,660
Ice Machine, CEE Tier 2, Water Cooled, Ice Making Head, 500-999 lbs/day	3420	16,862
Ice Machine, CEE Tier 2, Air Cooled, Remote Condensing, 500-999 lbs/day	3423	27,346
Ice Machine, CEE Tier 2, Air Cooled, Ice Making Head, ≥ 1,000 lbs/day	3418	14,267
Ice Machine, CEE Tier 2, Water Cooled, Ice Making Head, ≥ 1,000 lbs/day	3421	16,860
Ice Machine, CEE Tier 2, Air Cooled, Remote Condensing, ≥ 1,000 lbs/day	3424	21,643

Assumptions

The harvest rates are determined based on the *High Efficiency Specifications for Commercial Ice Machines* category for various types of air cooled and water cooled units for CEE Tier 2 specifications.[4,6]

Sources

1. Consortium for Energy Efficiency. *Average Daily Potable Water Consumption at CEE Tiers*. Provided by Kim Erickson, CEE.
2. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0. Updated March 22, 2010. (24 hours/day * 7 days/week * 52 weeks/year = 8,760 hours)
3. Consortium for Energy Effiency. *Commercial Ice Machines: The Potential for Energy Efficiency and Demand Response.* Don Fisher, David Cowen and Angelo Karas, Fisher–Nickel, Inc. Charlene Spoor, Pacific Gas & Electric Company. 2012. http://aceee.org/files/proceedings/2012/data/papers/0193-000289.pdf
4. Consortium for Energy Efficiency. Commercial Kitchens Initiative. High Efficiency Specifications for Commercial Ice Machines. Effective Date July 1, 2011.
5. PA Consulting Group Inc. State of Wisconsin Public Service Commission Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study Final Report. August 25, 2009.

6. Consortium for Energy Efficiency. Commercial Ice Machines Specification Revision Technical Analysis. Data obtained from Autoquotes.® July 2010.
7. Illinois Technical Reference Manual. 2013. Page 103. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf .

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

ENERGY STAR Commercial Combination Ovens (Natural Gas or Electric)

	Measure Details
Measure Master ID	Oven, Combination, ENERGY STAR, Electric, 3118 Oven, Combination, ENERGY STAR, Natural Gas, 3119
Measure Unit	Per oven
Measure Type	Prescriptive
Measure Group	Food Service
Measure Category	Oven
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	15,096
Peak Demand Reduction (kW)	3.446
Annual Therm Savings (Therms)	1,103
Lifecycle Energy Savings (kWh)	181,146
Lifecycle Therm Savings (Therms)	13,237
Water Savings (gal/yr)	0
Effective Useful Life (years)	12[1]
Incremental Cost ($/unit)	$0.00[6]

Measure Description

A combination oven is a self-contained device that functions as a hot air convection (oven mode), saturated and superheated steam heating (steam mode), and combination convection/steam mode for moist heating. The convection/stem mode performs steaming, baking, roasting, rethermalizing, and proofing of various food products. The combination oven can also be referred to as a combination oven/steamer, combi, or combo.

Description of Baseline Condition

Baseline equipment is assumed to be a new combination oven that does not meet ENERGY STAR v2.0 performance specification. Data analysis were provided by the CEE and a dataset was provided by the EPA FSTC and manufacturers from December 2011 through July 2012.

Description of Efficient Condition

The efficient condition is any commercial combination oven that is on the ENERGY STAR Commercial Combination Ovens qualified products list,[2] per the ENERGY STAR v2.0 performance specifications for natural gas and electric combination ovens.[2]

Annual Energy-Savings Algorithms

Electric Combination Oven:

$$kWh_{\text{SAVED}} = (Wh/day_{\text{BASELINE}} - Wh/day_{\text{EE}}) * DPY / 1{,}000$$

$$Wh/day_{\text{BASELINE}} = Wh/day_{\text{CONVECTION, BASELINE}} + Wh/day_{\text{STEAM, BASELINE}} + Wh/day_{\text{PREHEAT, BASELINE}}$$

$$Wh/day_{\text{CONVECTION, BASELINE}} = (1\text{-}\%_{\text{STEAM}}) *\{(m * E_{\text{CONVECTION}}) / \eta_{\text{CONVECTION, BASELINE}} + [E_{\text{IDLE-CONVECTION, BASELINE}} * (t_{\text{DAY}} - m/PC_{\text{CONVECTION, BASELINE}} - nP * t_{\text{PREHEAT}}/60)]\}$$

$$Wh/day_{\text{STEAM, BASELINE}} = \%_{\text{STEAM}} * \{(m* E_{\text{STEAM}}) / \eta_{\text{STEAM,BASELINE}} + [E_{\text{IDLE-STEAM, BASELINE}} * (t_{\text{DAY}} - m/PC_{\text{STEAM,BASELINE}} - nP * t_{\text{PREHEAT}}/60)]\}$$

$$Wh/day_{\text{PREHEAT, BASELINE}} = E_{\text{PREHEAT, BASELINE}} * nP$$

$$Wh/day_{\text{EE}} = Wh/day_{\text{CONVECTION, EE}} + Wh/day_{\text{STEAM, EE}} + Wh/day_{\text{PREHEAT, EE}}$$

$$Wh/day_{\text{CONVECTION, EE}} = (1\text{-}\%_{\text{STEAM}}) * \{(m * E_{\text{CONVECTION}}) / \eta_{\text{CONVECTION, EE}} + [E_{\text{IDLE-CONVECTION, EE}} * (t_{\text{DAY}} - m/PC_{\text{CONVECTION, EE}} - nP * t_{\text{PREHEAT}}/60)]\}$$

$$Wh/day_{\text{STEAM, EE}} = \%_{\text{STEAM}} * \{(m * E_{\text{STEAM}}) / \eta_{\text{STEAM,EE}} + [E_{\text{IDLE-STEAM, EE}} * (t_{\text{DAY}} - m/PC_{\text{STEAM, EE}} - nP * t_{\text{PREHEAT}}/60)]\}$$

$$Wh/day_{\text{PREHEAT, EE}} = E_{\text{PREHEAT, EE}} * nP$$

Natural Gas Combination Oven:

$$Therm_{\text{SAVED}} = (Btu/day_{\text{BASELINE}} - Btu/day_{\text{EE}}) * DPY / 100{,}000$$

$$Btu/day_{\text{BASELINE}} = Btu/day_{\text{CONVECTION, BASELINE}} + Btu/day_{\text{STEAM,BASELINE}} + Btu/day_{\text{PREHEAT, BASELINE}}$$

$$Btu/day_{\text{CONVECTION, BASELINE}} = (1\text{-}\%_{\text{STEAM}}) * \{(m * E_{\text{CONVECTION}}) / \eta_{\text{CONVECTION, BASELINE}} + [E_{\text{IDLE-CONVECTION, BASELINE}} * (t_{\text{DAY}} - m/PC_{\text{CONVECTION, BASELINE}} - nP * t_{\text{PREHEAT}}/60)]\}$$

$$Btu/day_{\text{STEAM, BASELINE}} = \%_{\text{STEAM}} * \{(m* E_{\text{STEAM}}) / \eta_{\text{STEAM, BASELINE}} + [E_{\text{IDLE-STEAM, BASELINE}} * (t_{\text{DAY}} - m/PC_{\text{STEAM,BASELINE}} - nP * t_{\text{PREHEAT}}/60)]\}$$

$$Btu/day_{\text{PREHEAT, BASELINE}} = E_{\text{PREHEAT,BASELINE}} * nP$$

$$Btu/day_{\text{EE}} = Wh/day_{\text{CONVECTION, EE}} + Wh/day_{\text{STEAM, EE}} + Wh/day_{\text{PREHEAT, EE}}$$

$$Wh/day_{\text{CONVECTION, EE}} = (1\text{-}\%_{\text{STEAM}}) * \{(m* E_{\text{CONVECTION}}) / \eta_{\text{CONVECTION, EE}} + [E_{\text{IDLE-CONVECTION, EE}} * (t_{\text{day}} - m/PC_{\text{CONVECTION, EE}} - nP * t_{\text{PREHEAT}}/60)]\}$$

$Wh/day_{STEAM,\ EE} = \%_{STEAM} * \{(m * E_{STEAM}) / \eta_{STEAM,\ EE} + [E_{IDLE\text{-}STEAM,\ EE} * (t_{DAY} - m/PC_{STEAM,\ EE} – nP * t_{PREHEAT}/60)]\}$

$Wh/day_{PREHEAT,\ EE} = E_{PREHEAT,EE} * nP$

Where:

DPY = Days of operation per year (= 365)[3]

1,000 = Kilowatt conversion factor

$\%_{STEAM}$ = Percentage of time in steam mode (= 50%)[3]

m = Estimated mass of food cooked per day, in pounds (= 250)[3]

$E_{CONVECTION}$ = Energy absorbed by food product: cooking by convection (= 73.2 Wh/lb; = 250 Btu/lb)[4]

$E_{IDLE\text{-}CONVECTION,\ BASELINE}$= Baseline idle energy rate (= varies by unit type; see table below)[3]

t_{DAY} = Estimated operating time per day, in hours (= 12)[3]

$PC_{CONVECTION,\ BASELINE}$= Production capacity of baseline equipment in pounds per hour (= varies by unit type; see table below)[3]

nP = Estimated number of preheats per day (= 1)[3]

$t_{PREHEAT}$ = Estimated preheat time in minutes per preheat (= 15)[3]

60 = Minutes in an hour

E_{STEAM} = Energy absorbed by food product: cooking by steam (= 30.8 Wh/lb; = 105 Btu/lb)[4]

100,000 = Conversion factor from Btu to therms

$\eta_{STEAM,BASELINE}$ = Cooking energy efficiency of baseline unit (= varies by unit type; see table below)[4]

$\eta_{CONVECTION,\ BASELINE}$= Energy efficiency of baseline unit (= varies by unit type; see table below)[4]

$E_{IDLE\text{-}STEAM,\ BASELINE}$ = Baseline energy absorbed by food product: cooking by by steam (= varies by unit type; see table below)[3]

$PC_{STEAM,BASELINE}$ = Production capacity of baseline cooking by steam

$E_{PREHEAT,\ BASELINE}$ = Measured energy used per preheat for baseline unit (= varies by unit type; see table below)[3]

$\eta_{CONVECTION,\ EE}$ = Cooking energy efficiency of efficient unit

$E_{IDLE\text{-}CONVECTION,\ EE}$ = ENERGY STAR idle rate of efficient equipment (= varies by unit type; see table below)[4]

$PC_{CONVECTION,\ EE}$ = Production capacity of efficient equipment in pounds per hour (= varies by unit type; see table below)[3]

$\eta_{STEAM,\ EE}$ = Cooking energy efficiency of efficient unit, cooking by steam (= varies by unit type; see table below)[4]

$E_{IDLE\text{-}STEAM,\ EE}$ = ENERGY STAR idle rate of efficient equipment, cooking by steam (= varies by unti type; see table below)[4]

$PC_{STEAM,EE}$ = Production capacity of energy efficient equipment, cooking by steam

$E_{PREHEAT,\ EE}$ = Measured energy used per preheat from efficient equipment (= varies by unti type; see table below)[3]

Production Capacity by Unit Type

	Baseline	EE
$PC_{CONVECTION}$	100	125
PC_{STEAM}	150	200

Cooking Energy Efficiency by Unit Type

	Electric		Natural Gas	
	Baseline	EE	Baseline	EE
$\eta_{CONVECTION}$	65%	70%	35%	44%
η_{STEAM}	40%	50%	20%	38%

Measured Energy Used per Preheat by Unit Type

	Baseline	EE
$E_{PREHEAT,\ ELECTRIC}$ (Watts)	3,750	2,000
$E_{PREHEAT,\ STEAM}$ (Btu)	22,000	16,000

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} * (CF / HOU)$

Where:

CF = Coincidence factor (= 1)[5]

HOU = Annual hours-of-use (= 4,380)[3]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 12 years)[1]

Assumptions

The default values given in calculators from the ENERGY STAR FSTC were used for savings calculation variables.

Sources

1. Similar MMIDs 2485-2488. EUL derived from Food Service Technology Center. Gas Convection Oven Life-Cycle Cost Calculator.
2. United States Department of Energy. ENERGY STAR Product Finder: Commercial Combination Ovens.
3. United States Department of Energy. Version 2.0 ENERGY STAR Performance Specification for Gas and Electric Combination Ovens.
4. Food Service Technology Center. “Life-Cycle & Energy Cost Calculator: Combination Ovens.” http://www.fishnick.com/saveenergy/tools/calculators/
5. The Summer Peak Coincidence Factor is assumed to equal 1.0, since the annual kWh savings is divided by the total annual hours (8760), effectively resulting in the average kW reduction during the peak period.
6. ENERGY STAR® Commercial Kitchen Savings Calculator. Accessed 03/11/2016. All Rack Ovens Incremental Cost=$0.00. Available online: https://www.energystar.gov/products/commercial_food_service_equipment

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Oven, Convection, ENERGY STAR, Electric

	Measure Details
Measure Master ID	Oven, Convection, ENERGY STAR, Electric, 2485
Measure Unit	Per oven
Measure Type	Prescriptive
Measure Group	Food Service
Measure Category	Oven
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	2,083
Peak Demand Reduction (kW)	0.48
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	24,998
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	12[1]
Incremental Cost ($/unit)	$0.00[5]

Measure Description

A convection oven is a self-contained device that functions as a hot air convection (oven mode), saturated and superheated steam heating (steam mode), and combination convection/steam mode for moist heating. The convection/stem mode performs steaming, baking, roasting, rethermalizing, and proofing of various food products. Savings adjustment for existing active measure based on ENERGY STAR Version 2.1 specification taking effect January 1, 2014.[3]

Description of Baseline Condition

The baseline condition is an electric full-size convection ovens that has an average cooking energy efficiency of 65% and an average idle rate of 2 kW.[4]

Description of Efficient Condition

The efficient condition is the minimum cooking energy efficiency of an ENERGY STAR electric full-size convection ovens of 71%, with a maximum idle rate of 1.6 kW.[4]

Annual Energy-Savings Algorithm

Per the energy formula on page 4-48 of the Deemed Savings Manual 1.0:[2]

$kWh_{SAVED} = (E_{DAY,\ BASELINE} - E_{DAY,\ ENERGY\ STAR}) * OpDay$

$E_{DAY} = [(LB_{FOOD} * E_{FOOD})/Efficiency] + IdleRate * [OpHrs - (LB_{FOOD}/PC) - (T_{PREHT}/60)] + E_{PREHT}$

Where:

$OpDay$ = Operating days per year (= varies by model and fuel type; see table below)

E_{DAY} = Daily energy consumption (kWh or Btu)

LB_{FOOD} = Pounds of food cooked per day (= varies by model and fuel type; see table below)

E_{FOOD} = ASTM Energy to Food (kWh/lb or Btu/lb; = varies by model and fuel type, see table below)

$Efficiency$ = ASTM Heavy Load Cooking Energy Efficiency percentage (= varies by model and fuel type; see table below)

$IdleRate$ = Idle energy rate (kW or Btu/hr; = varies by model and fuel type, see table below)

$OpHrs$ = Operating hours per day (= varies by model and fuel type; see table below)

PC = Production capacity in pounds per hour (= varies by model and fuel type; see table below)

T_{PREHT} = Preheat time in minutes (= varies by model and fuel type; see table below)

60 = Conversion from minutes to hours

E_{PREHT} = Preheat energy (kWh or Btu; = varies by model and fuel type, see table below)

Parameter Values by Model and Oven Fuel

Oven Fuel	Parameter	Baseline Model	ENERGY STAR Model	Source
Electric or Natural Gas	Preheat Time (min)	15	15	Deemed
	Operating Hrs/Day	12	12	4
	Operating Days/Year	365	365	4
	Pounds of Food Cooked per Day	100	100	4
Electric	Production Capacity (lb/h)	90	90	4
	Preheat Energy (kWh)	1.5	1	4
	Idle Energy Rate (kW)	2	1.6	4
	Cooking Energy Efficiency (%)	65%	71%	4
	ASTM Energy to Food (kWh/lb)	0.0732	0.0732	4
Natural Gas	Production Capacity (lb/h)	83	86	4
	Preheat Energy (Btu)	19,000	11,000	4
	Idle Energy Rate (Btu/h)	15,100	12,000	4
	Cooking Energy Efficiency (%)	44%	46%	4
	ASTM Energy to Food (Btu/lb)	250	250	4

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (E_{DAY, BASELINE} - E_{DAY, ENERGY\ STAR}) / OpHrs$

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 12 years)[4]

Sources

1. Food Service Technology Center. Convection Oven Life-Cycle Cost Calculator.
2. Business Programs, Deemed Savings Manual V1.0, March 22, 2010.
3. ENERGY STAR Commercial Ovens Program Requirements, Version 2.1.
4. ENERGY STAR Commercial Kitchen Equipment Calculator.
5. ENERGY STAR® Commercial Kitchen Savings Calculator. Accessed 03/11/2016. All Ovens Incremental Cost = $0.00. Available online: https://www.energystar.gov/products/commercial_food_service_equipment.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

Oven, Convection, ENERGY STAR, Natural Gas

	Measure Details
Measure Master ID	Oven, Convection, ENERGY STAR, Natural Gas, 2486
Measure Unit	Per full size oven
Measure Type	Prescriptive
Measure Group	Food Service
Measure Category	Oven
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	156
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	1,872
Water Savings (gal/yr)	0
Effective Useful Life (years)	12[1]
Incremental Cost ($/unit)	$0.00[5]

Measure Description

A convection oven is a self-contained device that functions as a hot air convection (oven mode), saturated and superheated steam heating (steam mode), and combination convection/steam mode for moist heating. The convection/stem mode performs steaming, baking, roasting, rethermalizing, and proofing of various food products.

Description of Baseline Condition

The average cooking energy efficiency of a natural gas full-size convection oven is 44%, with an average idle rate of 15,100 Btu per hour.[4]

Description of Efficient Condition

The minimum cooking energy efficiency of ENERGY STAR full-size convection ovens is 46%, with a maximum idle rate of 12,000 Btu per hour.[4]

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (E_{DAY,\ BASELINE} – E_{DAY,\ ENERGY\ STAR}) * OpDay * (1/100{,}000)$

$E_{DAY} = [(LB_{FOOD} * E_{FOOD})/Efficiency] + IdleRate * [OpHrs – (LB_{FOOD}/PC) – (T_{PREHT}/60)] + E_{PREHT}$

Where:

E_{DAY} = Daily energy consumption (kWh or Btu)

OpDays = Operating days per year (= varies by model and fuel type; see table below)

1/100,000 = Btu to therms conversion

LB_{FOOD} = Pounds of food cooked per day (= varies by model and fuel type; see table below)

E_{FOOD} = ASTM Energy to Food (kWh/lb or Btu/lb; = varies by model and fuel type, see table below)

Efficiency = ASTM Heavy Load Cooking Energy Efficiency percentage (= varies by model and fuel type; see table below)

IdleRate = Idle energy rate (kW or Btu/hr; = varies by model and fuel type, see table below)

OpHrs = Operating hours per day (= varies by model and fuel type; see table below)

PC = Production capacity (lb/hr; = varies by model and fuel type, see table below)

T_{PREHT} = Preheat time in minutes (= varies by model and fuel type; see table below)

60 = Conversion from minutes to hours

E_{PREHT} = Preheat energy (kWh or Btu; = varies by model and fuel type, see table below)

Parameter Values by Model and Oven Fuel

Oven Fuel	Parameter	Baseline Model	ENERGY STAR Model	Source
Electric or Natural Gas	Preheat Time (min)	15	15	Deemed
	Operating Hrs/Day	12	12	3
	Operating Days/Year	365	365	3
	Pounds of Food Cooked per Day	100	100	3
Electric	Production Capacity (lb/h)	90	90	3
	Preheat Energy (kWh)	1.5	1	4
	Idle Energy Rate (kW)	2	1.6	3
	Cooking Energy Efficiency (%)	65%	71%	3
	ASTM Energy to Food (kWh/lb)	0.0732	0.0732	3

Oven Fuel	Parameter	Baseline Model	ENERGY STAR Model	Source
Natural Gas	Production Capacity (lb/h)	83	86	3
	Preheat Energy (Btu)	19,000	11,000	4
	Idle Energy Rate (Btu/h)	15,100	12,000	3
	Cooking Energy Efficiency (%)	44%	46%	3
	ASTM Energy to Food (Btu/lb)	250	250	3

Summer Coincident Peak Savings Algorithm

There are no peak savings for this measure.

Lifecycle Energy-Savings Algorithm

$\text{Therm}_{\text{LIFECYCLE}} = \text{Therm}_{\text{SAVED}} * \text{EUL}$

Where:

EUL = Effective useful life (= 12 years)[1]

Sources

1. Food Service Technology Center. Gas Convection Oven Life-Cycle Cost Calculator.
2. ENERGY STAR Commercial Ovens Program Requirements, Version 2.1.
3. ENERGY STAR Commercial Kitchen Equipment Calculator.
4. Food Service Technology Center. Electric Convection Oven Life-Cycle Cost Calculator.
5. ENERGY STAR® Commercial Kitchen Savings Calculator. Accessed 03/11/2016. All Ovens Incremental Cost = $0.00. Available online: https://www.energystar.gov/products/commercial_food_service_equipment

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

Oven, Rack Type, ENERGY STAR, Natural Gas

	Measure Details
Measure Master ID	Oven, Rack Type, ENERGY STAR, Natural Gas: Single Compartment, 2488 Double Compartment, 2487
Measure Unit	Per oven
Measure Type	Prescriptive
Measure Group	Food Service
Measure Category	Oven
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	Varies by measure
Annual Therm Savings (Therms)	Varies by measure
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	Varies by measure
Water Savings (gal/yr)	0
Effective Useful Life (years)	12[1,2]
Incremental Cost ($/unit)	$0.00[3]

Measure Description

Rack ovens have a high capacity, are able to produce steam internally, and are fitted with a motor-driven mechanism for rotating multiple pans inserted into one or more removable or fixed pan racks within the oven cavity. A single rack oven is able to accommodate one removable single rack of standard sheet pans measuring 18 x 26 x 1-inch, while a double rack oven is able to accommodate two removable single racks of standard sheet pans measuring 18 x 26 x 1-inch, or one removable double-width rack.

Description of Baseline Condition

The baseline condition is an average natural gas single rack oven with cooking energy efficiency of 43.5% and an average idle rate of 24,451 Btu per hour.[4]

The baseline condition could also be an average natural gas double rack oven with cooking energy efficiency of 50.5% and an average idle rate of 37,971 Btu per hour.[4]

Description of Efficient Condition

The minimum cooking energy efficiency for a single rack oven to qualify for ENERGY STAR is 48%, with a maximum idle rate of 25,000 Btu per hour.[5] The average cooking energy efficiency of available ENERGY STAR-qualified natural gas single rack ovens is 48.9% with an average idle rate of 21,009 Btu per hour.[4]

The minimum cooking energy efficiency for a double rack oven to qualify for ENERGY STAR is 52%, with a maximum idle rate of 30,000 Btu per hour.[5] The average cooking energy efficiency of available ENERGY STAR-qualified natural gas double rack ovens is 53.9% with an average idle rate of 24,128 Btu per hour.[4]

Annual Energy-Savings Algorithm

$\text{Therms}_{\text{SAVED}} = (E_{\text{DAY, BASELINE}} - E_{\text{DAY, ENERGY STAR}}) * \text{OpDay} * (1/100{,}000)$

$E_{\text{DAY}} = [(LB_{\text{FOOD}} * E_{\text{FOOD}})/\text{Efficiency}] + \text{GasIdleRate} * [\text{OpHrs} - (LB_{\text{FOOD}}/PC) - (T_{\text{PREHT}}/60)] + E_{\text{PREHT}}$

$\text{kWh}_{\text{SAVED}} = \text{kWh}_{\text{ANNUAL, BASELINE}} - \text{kWh}_{\text{ANNUAL, ENERGY STAR}}$

$\text{kWh}_{\text{ANNUAL}} = \text{ElecIdleRate} * \text{OpDay} * [\text{OpHrs} - (LB_{\text{FOOD}}/PC)]$

Where:

E_{DAY} = Daily energy consumption (Btu)

OpDays = Operating days per year (= varies by model; see table below)

1/100,000 = Btu to therms conversion

LB_{FOOD} = Pounds of food cooked per day (= varies by model; see table below)

E_{FOOD} = ASTM Energy to Food (Btu/lb; = varies by model, see table below)

Efficiency = ASTM Heavy Load Cooking Energy Efficiency (%; = varies by model, see table below)

GasIdleRate = Gas Idle energy rate (Btu/hr; = varies by model, see table below)

OpHrs = Operating hours per day (= varies by model; see table below)

T_{PREHT} = Preheat time in minutes (= varies by model; see table below)

60 = Conversion from minutes to hours

E_{PREHT} = Preheat energy (Btu; = varies by model, see table below)

ElecIdleRate = Electric Idle energy rate (kW; = varies by model, see table below)

PC = Production capacity (lb/hr; = varies by model, see table below)

Parameter Values by Model

Parameter	Single Rack		Double Rack		Source
	Baseline	ENERGY STAR	Baseline	ENERGY STAR	
Preheat Energy (Btu; E_{PREHT})	50,000	44,000	100,000	85,000	4
Gas Idle Energy Rate (Btu/hr; GasIdleRate)	24,451	21,009	37,971	24,128	4
Electric Idle Energy Rate (kW; ElecIdleRate)	0.80	0.51	1.55	1.14	4
Heavy-Load Energy Efficiency (%; Efficiency)	43.5%	48.9%	50.5%	53.9%	4
ASTM Energy to Food (Btu/lb; E_{FOOD})	250	250	250	250	6
Production Capacity (lbs/hr; PC)	141	137	268	281	4
Operating Hours per Day (OpHrs)	12	12	12	12	4
Operating Days per Year (OpDays)	365	365	365	365	4
Preheat time in minutes (T_{PREHT})	15	15	15	15	7
Lbs of Food Cooked per Day (LB_{FOOD})	600	600	1,200	1,200	4

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = ElecIdleRate_{BASELINE} – ElecIdleRate_{ENERGY\ STAR}$

Where:

$ElecIdleRate_{BASELINE}$ = Electric Idle energy rate (kW; = varies by model, see table above)

$ElecIdleRate_{ENERGY\ STAR}$ = Electric Idle energy rate (kW; = varies by model, see table above)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therms_{LIFECYCLE} = Therms_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 12 years)[1,2]

Deemed Savings

Natural Gas and Eelectricity Deemed Savings per ENERGY STAR, Natural Gas, Rack Type Oven

Measure	MMID	Annual kWh	Annual Therms	Peak kW	Lifecycle kWh	Lifecycle Therms
Single Compartment	2488	828	255	0.29	9,936	3,060
Double Compartment	2487	1,002	529	0.41	12,024	6,348

Sources

1. Food Service Technology Center. *Gas Rack Oven Life-Cycle Cost Calculator.* www.fishnick.com/saveenergy/tools/calculators/grackovencalc.php
2. California Energy Commission and California Public Utilities Commission. *Database for Energy Efficient Resources*. 2008. www.energy.ca.gov/deer
3. ENERGY STAR® Commercial Kitchen Savings Calculator. Accessed 03/11/2016. All Rack Ovens Incremental Cost = $0.00. Available online: https://www.energystar.gov/products/commercial_food_service_equipment
4. Commercial Ovens Draft 2 Version 2.2 Plots, ENERGY STAR website for development of Commercial Ovens Specification Version 2.2. http://www.energystar.gov/products/spec/commercial_ovens_specification_version_2_2_pd. *(Implementer had personal communication with Consortium for Energy Efficiency staff to obtain the data tables used to generate these public plots of rack oven performance).*
5. ENERGY STAR Commercial Ovens Program Requirements, Version 2.2. www.energystar.gov/sites/default/files/Commercial%20Ovens%20Final%20Version%202.2%20Specification.pdf
6. ENERGY STAR Commercial Kitchen Equipment Calculator (used convection ovens value since a separate value for rack ovens is not yet available). www.energystar.gov/buildings/sites/default/uploads/files/commercial_kitchen_equipment_calculator.xlsx
7. *Wisconsin Focus on Energy Technical Reference Manual.* October 22, 2015. (Preheat time listed as 15 minutes and "deemed" for convection ovens (MMID 2485, 2486) and combination ovens (MMID 3118, 3119).

Revision History

Version Number	Date	Description of Change
01	11/11/2015	Updated from Wisconsin Focus on Energy QPL to ENERGY STAR
04	01/22/2016	Updated per comments

Commercial Refrigerator, ENERGY STAR

	Measure Details
Measure Master ID	Refrigerator, Chest, Glass Door: < 15 cu ft, ENERGY STAR, 2521 15-29 cu ft, ENERGY STAR, 2522 30-49 cu ft, ENERGY STAR, 2523 50+ cu ft, ENERGY STAR, 2524 Refrigerator, Chest, Solid Door: < 15 cu ft, ENERGY STAR, 2525 15-29 cu ft, ENERGY STAR, 2526 30-49 cu ft, ENERGY STAR, 2527 50+ cu ft, ENERGY STAR, 2528 Refrigerator, Vertical, Glass Door: < 15 cu ft, ENERGY STAR, 2529 15-29 cu ft, ENERGY STAR, 2530 30-49 cu ft, ENERGY STAR, 2531 50+ cu ft, ENERGY STAR, 2532 Refrigerator, Vertical, Solid Door: < 15 cu ft, ENERGY STAR, 2533 15-29 cu ft, ENERGY STAR, 2534 30-49 cu ft, ENERGY STAR, 2535 50+ cu ft, ENERGY STAR, 2536
Measure Unit	Per refrigerator
Measure Type	Prescriptive
Measure Group	Food Service
Measure Category	Refrigerator / Freezer - Commercial
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by size and door type
Peak Demand Reduction (kW)	Varies by size and door type
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by size and door type
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	12[1]
Incremental Cost ($/unit)	$0.00 (for all)[6]

Measure Description

This measure is installing refrigeration equipment that meets ENERGY STAR Version 3.0 performance specification, effective October 1, 2014.[2] ENERGY STAR commercial solid and glass door refrigerators are designed to be more energy efficient than standard units and use higher efficiency ECM evaporator and condenser fan motors, a hot natural gas anti-sweat heater, or high-efficiency compressors.

Description of Baseline Condition

The baseline condition is a unit meeting U.S. Department of Energy commercial refrigeration equipment standards effective January 10, 2010.[3]

Description of Efficient Condition

The efficient equipment is a certified ENERGY STAR Version 3.0 vertical and horizontal closed door.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (kWh_{BASELINE} – kWh_{ENERGY\ STAR}) * Days$

Where:

$kWh_{BASELINE}$ = Daily baseline unit consumption (= varies by unit; see table below)[4]
$kWh_{ENERGY\ STAR}$ = Daily qualifying unit consumption (=varies by unit; see table below)[4]
Days = Annual days of operation, deemed (= 365)

Parameter Values by Unit Type

Unit Type	Door Type	Size (cu. ft.)	Daily Baseline Consumption	Daily Qualifying Consumption	Annual Savings (kWh)	On Peak Savings (kW)	Lifecycle Savings (kWh)
Vertical Closed Refrigerators	Solid	0 < V < 15	0.10V + 2.04	0.02V + 1.60	430	0.0491	5,160
		15 ≤ V < 30	0.10V + 2.04	0.09V + 0.55	620	0.0708	7,440
		30 ≤ V < 50	0.10V + 2.04	0.01V + 2.95	1,063	0.1214	12,756
		50 ≤ V	0.10V + 2.04	0.06V + 0.45	1,564	0.1785	18,768
	Transparent	0 < V < 15	0.12V + 3.34	0.10V + 1.07	890	0.1016	10,680
		15 ≤ V < 30	0.12V + 3.34	0.15V + 0.32	865	0.0987	10,380
		30 ≤ V < 50	0.12V + 3.34	0.06V + 3.02	1,031	0.1177	12,372
		50 ≤ V	0.12V + 3.34	0.08V + 2.02	1,461	0.1668	17,532
Horizontal Closed Refrigerators*	Solid	All volumes	0.10V + 2.04	0.06V + 0.60	726	0.0828	8,712
	Transparent		0.12V + 3.34				

* The U.S. EPA provided a masked data set for the horizontal closed refrigerators and freezers that did not distinguish solid door units from transparent door horizontal units. The solid door daily baseline consumption was used as a conservative savings estimate for the horizontal closed unit type.

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} * (CF / HOU)$

Where:

CF = Coincidence factor (= 1)[5]

HOU = Hours-of-use, deemed (= 8,760)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 12 years)[4]

Deemed Savings

Deemed Savings Values by Measure

Measure Master Name	MMID	Deemed Savings Values		
		kWh - Annual	kWh - Lifecycle	kW
Refrigerator, Chest, Glass Door, < 15 cu ft, ENERGY STAR	2521	726	8,712	0.0828
Refrigerator, Chest, Glass Door, 15-29 cu ft, ENERGY STAR	2522	726	8,712	0.0828
Refrigerator, Chest, Glass Door, 30-49 cu ft, ENERGY STAR	2523	726	8,712	0.0828
Refrigerator, Chest, Glass Door, 50+ cu ft, ENERGY STAR	2524	726	8,712	0.0828
Refrigerator, Chest, Solid Door, < 15 cu ft, ENERGY STAR	2525	726	8,712	0.0828
Refrigerator, Chest, Solid Door, 15-29 cu ft, ENERGY STAR	2526	726	8,712	0.0828
Refrigerator, Chest, Solid Door, 30-49 cu ft, ENERGY STAR	2527	726	8,712	0.0828
Refrigerator, Chest, Solid Door, 50+ cu ft, ENERGY STAR	2528	726	8,712	0.0828
Refrigerator, Vertical, Glass Door, < 15 cu ft, ENERGY STAR	2529	890	10,680	0.1016
Refrigerator, Vertical, Glass Door, 15-29 cu ft, ENERGY STAR	2530	865	10,380	0.0987
Refrigerator, Vertical, Glass Door, 30-49 cu ft, ENERGY STAR	2531	1,031	12,372	0.1177
Refrigerator, Vertical, Glass Door, 50+ cu ft, ENERGY STAR	2532	1,461	17,532	0.1668
Refrigerator, Vertical, Solid Door, < 15 cu ft, ENERGY STAR	2533	430	5,160	0.0491
Refrigerator, Vertical, Solid Door, 15-29 cu ft, ENERGY STAR	2534	620	7,440	0.0708
Refrigerator, Vertical, Solid Door, 30-49 cu ft, ENERGY STAR	2535	1,063	12,756	0.1214
Refrigerator, Vertical, Solid Door, 50+ cu ft, ENERGY STAR	2536	1,564	18,768	0.1785

Sources

1. ENERGY STAR Program Calculator for Commercial Refrigerators and Freezers http://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx
2. ENERGY STAR Program Requirements for Commercial Refrigerators and Freezers, Version 3.0.
3. U.S. Department of Energy. Commercial Refrigeration Equipment Standards. Effective January 20, 2010.
4. U.S. Environmental Protection Agency. Masked data set for commercial refrigerators and freezers, provided May 2013.
5. The Summer Peak Coincidence Factor is assumed to equal 1.0, since the annual kWh savings is divided by the total annual hours (8760), effectively resulting in the average kW reduction during the peak period.
6. ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 03/2016. "Commercial refrigerator" incremental cost is $0.00 for all. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

Commercial Freezers, ENERGY STAR

	Measure Details
Measure Master ID	Freezer, Chest, Glass Door: < 15 cu ft, ENERGY STAR, 2321 15-29 cu ft, ENERGY STAR, 2322 30-49 cu ft, ENERGY STAR, 2323 50+ cu ft, ENERGY STAR, 2324 Freezer, Chest, Solid Door: < 15 cu ft, ENERGY STAR, 2325 15-29 cu ft, ENERGY STAR, 2326 30-49 cu ft, ENERGY STAR, 2327 50+ cu ft, ENERGY STAR, 2328 Freezer, Vertical, Glass Door: < 15 cu ft, ENERGY STAR, 2329 15-29 cu ft, ENERGY STAR, 2330 30-49 cu ft, ENERGY STAR, 2331 50+ cu ft, ENERGY STAR, 2332 Freezer, Vertical, Solid Door: < 15 cu ft, ENERGY STAR, 2333 15-29 cu ft, ENERGY STAR, 2334 30-49 cu ft, ENERGY STAR, 2335 50+ cu ft, ENERGY STAR, 2336
Measure Unit	Per freezer
Measure Type	Prescriptive
Measure Group	Food Service
Measure Category	Refrigerator / Freezer - Commercial
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by size and door type
Peak Demand Reduction (kW)	Varies by size and door type
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by size and door type
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	12[1]
Incremental Cost ($/unit)	Varies by measure, see Appendix D

Measure Description

This measure is installing refrigeration equipment that meets ENERGY STAR Version 3.0 performance specification, effective October 1, 2014.[2] ENERGY STAR commercial solid door and glass door freezers are more energy efficient than standard units, and use higher efficiency ECM evaporator and condenser fan motors, hot natural gas anti-sweat heater, or high-efficiency compressors.

Description of Baseline Condition

The baseline condition is a unit meeting U.S. Department of Energy commercial refrigeration equipment standards effective January 10, 2010.[3]

Description of Efficient Condition

The efficient condition is certified ENERGY STAR Version 3.0 vertical and horizontal closed freezers.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (kWh_{BASELINE} – kWh_{ENERGY\ STAR}) * Days$

Where:

$kWh_{BASELINE}$ = Daily baseline unit consumption (= varies by unit; see table below)

$kWh_{ENERGY\ STAR}$ = Daily qualifying unit consumption (= varies by unit; see table below)

Days = Annual days of operation, deemed (= 365)

Parameter Values by Unit Type[4]

Unit Type	Door Type	Size (cu. ft.)	Daily Baseline Consumption	Daily Qualifying Consumption	Annual Savings (kWh)	On Peak Savings (kW)	Lifecycle Savings (kWh)
Vertical Closed Freezers	Solid	0 < V < 15	0.4V + 1.38	0.25V + 1.55	447	0.051	5,364
		15 ≤ V < 30	0.4V + 1.38	0.20V + 2.30	1,204	0.1374	14,448
		30 ≤ V < 50	0.4V + 1.38	0.25V + 0.80	2,557	0.2919	30,684
		50 ≤ V	0.4V + 1.38	0.14V + 6.30	4,602	0.5254	55,224
	Transparent	0 < V < 15	0.75V + 4.10	0.56V + 1.61	1,266	0.1445	15,192
		15 ≤ V < 30	0.75V + 4.10	0.30V + 5.50	3,134	0.3578	37,608
		30 ≤ V < 50	0.75V + 4.10	0.55V - 2.00	5,422	0.6189	65,064
		50 ≤ V	0.75V + 4.10	0.32V + 9.49	8,351	0.9533	100,212
Horizontal Closed Freezers*	Solid	All volumes	0.4V + 1.38	0.10V + 0.20	672	0.0767	8,064
	Transparent		0.75V + 4.10				

* The U.S. EPA provided a masked data set for the horizontal closed refrigerators and freezers that did not distinguish solid door units from transparent door horizontal units. The solid door daily baseline consumption was used as a conservative savings estimate for the horizontal closed unit type.

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} / HOURS$

Where:

HOURS = Hours-of-use, deemed (= 8,760)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 12 years)[1]

Deemed Savings

Deemed Savings Values by Measure

Measure Master Name	MMID	Deemed Savings		
		kWh - Annual	kWh - Lifecycle	kW
Freezer, Chest, Glass Door, < 15 cu ft, ENERGY STAR	2321	672	8,064	0.0767
Freezer, Chest, Glass Door, 15-29 cu ft, ENERGY STAR	2322	672	8,064	0.0767
Freezer, Chest, Glass Door, 30-49 cu ft, ENERGY STAR	2323	672	8,064	0.0767
Freezer, Chest, Glass Door, 50+ cu ft, ENERGY STAR	2324	672	8,064	0.0767
Freezer, Chest, Solid Door, < 15 cu ft, ENERGY STAR	2325	672	8,064	0.0767
Freezer, Chest, Solid Door, 15-29 cu ft, ENERGY STAR	2326	672	8,064	0.0767
Freezer, Chest, Solid Door, 30-49 cu ft, ENERGY STAR	2327	672	8,064	0.0767
Freezer, Chest, Solid Door, 50+ cu ft, ENERGY STAR	2328	672	8,064	0.0767
Freezer, Vertical, Glass Door, < 15 cu ft, ENERGY STAR	2329	1,266	15,192	0.1445
Freezer, Vertical, Glass Door, 15-29 cu ft, ENERGY STAR	2330	3,134	37,608	0.3578
Freezer, Vertical, Glass Door, 30-49 cu ft, ENERGY STAR	2331	5,422	65,064	0.6189
Freezer, Vertical, Glass Door, 50+ cu ft, ENERGY STAR	2332	8,351	100,212	0.9533
Freezer, Vertical, Solid Door, < 15 cu ft, ENERGY STAR	2333	447	5,364	0.051
Freezer, Vertical, Solid Door, 15-29 cu ft, ENERGY STAR	2334	1,204	14,448	0.1374
Freezer, Vertical, Solid Door, 30-49 cu ft, ENERGY STAR	2335	2,557	30,684	0.2919
Freezer, Vertical, Solid Door, 50+ cu ft, ENERGY STAR	2336	4,602	55,224	0.5254

Sources

1. ENERGY STAR Program Calculator for Commercial Refrigerators and Freezers http://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx
2. ENERGY STAR Program Requirements for Commercial Refrigerators and Freezers, Version 3.0.

3. U.S. Department of Energy. Commercial Refrigeration Equipment Standards. Effective January 20, 2010.
4. U.S. Environmental Protection Agency. Masked data set for commercial refrigerators and freezers, provided May 2013.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

HVAC

Demand Control Ventilation for Air Handling Units

Measure Master ID	Demand Control Ventilation for Air Handling Units, 2853
Measure Unit	Per CFM of outside air controlled
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Controls
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Calculated
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Calculated
Lifecycle Energy Savings (kWh)	Calculated
Lifecycle Therm Savings (Therms)	Calculated
Water Savings (gal/yr)	0
Effective Useful Life (years)	10[1]
Incremental Cost ($/unit)	$1.00/CFM[2]

Measure Description

Commercial spaces are required to provide ventilation based on a minimum flow rate of outside air, as calculated using the area of conditioned space and number of occupants. Standard systems are unable to measure the number of occupants and must default to a maximum occupancy based ventilation rate. Demand control ventilation measures that carbon dioxide is in the space as a proxy for occupants, and allows the occupant-based portion of ventilation to be reduced below the maximum, resulting in heating and cooling savings.

Description of Baseline Condition

The baseline equipment is a packaged, split, or built-up air handler with an economizer that does not provide ventilation during unoccupied operation. Heating is assumed to be provided by natural gas equipment with an operating efficiency of 80%. Cooling efficiencies are estimated at code requirements according to the table below.

Cooling Efficiency Code Requirements

IECC 2009 Table 503.2.3(1)	Minimum Efficiency
Standard AC Unit < 65 kBtu/h (5.42 tons)	13.0 SEER
Standard AC Unit ≥ 65 and < 135 kBtu/h (5.42 to 11.25 tons)	11.0 EER
Standard AC Unit ≥ 135 and < 239 KBtu/h (11.25 to 20 tons)	10.8 EER
Standard AC Unit ≥ 240 and < 759 kBtu/h (20 to 63.33 tons)	9.8 EER
Standard AC Unit ≥ 760 kBtu/h (63.33 tons)	9.5 EER

Description of Efficient Condition

The efficient equipment includes packaged, split, or built up air handlers that control outside air by monitoring carbon dioxide conditions in the space and adjusting ventilation to meet the occupancy based space requirement while not falling below the conditioned area requirement.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (4.5 * CFM * \Delta h) * (EFLH_{COOL} * 12 / EER) * SF_{COOL} / 3{,}412 * (HOURS/HOURS_{COOL})$

$Therm_{SAVED} = (1.08 * CFM) * HOURS * HDD / \eta / 100{,}000 * SF_{HEAT}$

Where:

4.5 = Conversion factor for flow rate and specific volume of air for enthalpy based cooling calculation

CFM = Outside airflow in cubic feet per minute, provided by customer

Δh = Difference in enthalpy (Btu/lbm) between the design day outside air conditions and the return air conditions; lbm is pounds per mass.

$EFLH_{COOL}$ = Equivalent full-load cooling hours (= varies by building type; see table below)[6]

12 = Conversion factor from EER to kW/ton

EER = Energy efficiency ratio of the existing equipment, assumed to be code (= varies by unit size; see table above)

SF_{COOL} = Deemed cooling savings factor (= varies by building type; see table below)[6]

3,412 = Conversion factor from BTU to kWh

HOURS = Hours of operation per day, provided by customer

$HOURS_{COOL}$ = Default hours of operation per day used in $EFLH_{COOL}$ (= varies by building type; see table below)[6]

1.08 = Conversion factor for flow rate and specific volume of air for dry bulb heating calculation

HDD = Heating degree days (using base 65; = see table below)

η = Heating efficiency (= assumed to be 0.83)

SF_{HEAT} = Deemed heating savings factor (= varies by building type; see table below)[6]

Enthalpies, HDD, and Incremental Costs

	Design Cooling h (Btu/lbm)	Cooling Return h (Btu/lbm)	HDD
Weighted Wisconsin Average	32.15	28.86	7,616

Cooling and Heating Savings Factors and Equivalent Full-Load Hours by Building Type

Building Type	SF_{COOL}	SF_{HEAT}	$EFLH_{COOL}$	$HOURS_{COOL}$
Food Sales	0.34	0.40	749	17.25
Food Service	0.34	0.40	578	11.50
Health Care	0.34	0.40	803	24.00
Hotel/Motel	0.15	0.18*	663	24.00
Office	0.15	0.18	578	11.50
Public Assembly	0.34	0.40	535	11.50
Public Services (non-food)	0.34	0.40	535	11.50
Retail	0.34	0.40	567	11.50
Warehouse	0.31	0.36	358	11.50
School	0.34	0.40	439	13.00
College	0.34	0.40	877	13.20
Other	0.15	0.18	589	11.50

* This value is applicable to common areas and conference rooms, but not to sleeping areas.

Summer Coincident Peak Savings Algorithm

There are no peak savings associated with this measure.

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[1]

Assumptions

$EFLH_{COOL}$ data based on DOE2/Equest building simulation. The prototype building models are based on the California DEER study prototypes, modified for local construction practices and code. Simulations were run using TMY3 weather data.

Assumed ventilation rates complied following the requirements of ASHRAE standard 62.1 - 2004.

Incremental costs include controls and programming, and assumes a similar cost between Direct Expansion and water cooled equipment.

Savings assume a constant volume air system.

Savings assume existing economizer operation, and that economizer operation is given preference over a demand control ventilation strategy.

Assumes savings in hospitals and clinics is limited to areas without a code required ACH of fresh air.

Sources

1. 2013 Conneticut TRM. http://www.energizect.com/sites/default/files/2013%20PSD_ProgramSavingsDocumentation-Final110112.pdf
2. Historical data (1/1/14 - 8/10/16)
3. "ANSI/AHRI 210/240-2008: 2008 Standard for Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment."
4. Trane. "Psychometric Chart at Barometric Pressure 29.921 Inches of Mercury." and ASHRAE 2009 Fundamentals. Cooling DB/MCWB @ 0.4% averaged for state.
5. Franklin Energy Services. Assumed cooling setpoint of 74°F with 50% relative humidity and a 2°F temperature rise in the return plenum.
6. Focus on Energy Deemed Savings Manual.
7. Franklin Energy Services. Calculated through energy modeling with certain building type square footage modified based on economizer operation hours. Savings limited to 40% based on professional experience due to concerns for negative building pressurization and minimum outside air requirements per square footage of occupied facility. Higher values may be obtained, requiring custom calculations.

Revision History

Version Number	Date	Description of Change
01	01/01/2013	Revised measure

Parking Garage Ventilation Controls

	Measure Details
Measure Master ID	Parking Garage Ventilation Controls, 3493
Measure Unit	Per exhaust fan system
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Controls
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by fan horsepower
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by fan horsepower
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Incremental Cost ($/unit)	$607.00[2]

Measure Description

The proposed measure requires controlling ventilation airflow in enclosed parking garages based on carbon monoxide concentrations, while maintaining code required run hours.[3] By controlling airflow based on need rather than running constantly, the system will save energy and maintain a safe environment.

Description of Baseline Condition

The baseline condition is 24-hour garage exhaust fan operation.

Description of Efficient Condition

The efficient condition is garage exhaust fan(s) controlled by carbon monoxide sensor(s) with a minimum five hours of daily operation.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{B} - kWh_{CO}$

$kWh_{B} = HP_{FAN} * 0.746 * 24 * 365$

$kWh_{CO} = HP_{FAN} * 0.746 * HOURS_{RUN} * 365$

Where:

kWh_B = Annual electricity consumption of baseline fan control system

kWh_{CO} = Annual electricity consumption of CO fan control system

HP_{FAN} = Total horsepower of garage ventilation fan motor(s)

0.746 = Kilowatts per horsepower

24 = Hours per day

365 = Days per year

$HOURS_{RUN}$ = Average daily exhaust fan run hours with CO control system (=7 to account for 5 hour minimum plus additional CO sensing run time)

Summer Coincident Peak Savings Algorithm

There are no coincident peak savings associated with this measure.

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = (kWh_B - kWh_{CO}) * EUL$

Where:

EUL = Effective useful life (= 5 years)[1]

Sources

1. State of Wisconsin Public Service Commission of Wisconsin. Focus on Energy Evaluation Business Programs: Measure Life Study – Ventilation Controls Installed - Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. Actual Program Data for MMID 3016, 2014-2016. 2 multifamily projects average actual cost of $607.00.
3. Wisconsin Legislature SPS 364.0404 - minimum enclosed garage ventilation https://docs.legis.wisconsin.gov/code/admin_code/sps/safety_and_buildings_and_environment/361_366/364/II/0404

Revision History

Version Number	Date	Description of Change
01	12/31/2012	New measure

Surgery Occupancy, HVAC Controls

	Measure Details
Measure Master ID	HVAC Controls, Surgery Occupancy, 3632
Measure Unit	Per upgrade
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Controls
Sector(s)	Commercial, Schools & Government
Annual Energy Savings (kWh)	Varies by type of savings
Peak Demand Reduction (kW)	Varies by type of savings
Annual Therm Savings (Therms)	Varies by type of savings
Lifecycle Energy Savings (kWh)	Varies by type of savings
Lifecycle Therm Savings (Therms)	Varies by type of savings
Water Savings (gal/yr)	0
Effective Useful Life (years)	10[7]
Incremental Cost ($/unit)	$5,500.00[6]

Measure Description

The savings expected to be realized in the business commercial sector, specifically within hospital air handlers serving surgery spaces. These air handlers currently operate continuously at a minimum of 20 Air Changes per Hour (ACH), and 4 ACH of outside air. After Building Automation Systems are upgraded to an extended architecture, the capability to reduce airflow to operating rooms when unoccupied may be obtained. However, space pressure relationships between an operating room and adjoining spaces are critical and steps must be taken to prevent an operating room from having negative pressure when airflow is reduced. Typically, these steps involve installing additional equipment on the return and/or supply ductwork serving the operating room. Once the equipment and controls changes have been made, an airflow reduction to 6 ACH, 1.6 ACH OA is feasible. The cost of these upgrades varies widely, depending on the existing equipment. However, if a base system of building automation system is present, the additional controls and possible VFD cost is within expected program range of one to 10 years.

Description of Baseline Condition

Baseline equipment includes an air handler with Supply/Return fans served by Variable Speed Drives, chilled water cooling coils, hot water heating coils, and economizer operation. Cooling energy is provided by a chilled water loop, typically served by a chiller paired with a cooling tower. Heating energy is provided by a hot water loop, typically served by an atmospheric boiler.

Air handlers typically serve multiple spaces, so the portion of air flow and Supply/Return Fan HP energy that should be attributed to the surgery rooms is calculated by the following inputs:

- Number of surgery rooms
- Total square footage of surgery rooms
- Total square footage of non-surgery rooms served by associated AHU
- Average volume of rooms
- Reheat Type, Natural Gas or Electric
- Existing air changes per hour
- Surgery room temperature and humidity requirements during occupied and unoccupied modes
- Estimated schedule of unoccupied controls to be implemented (e.g. 6pm to 6am, 7 days/week)
- Surgery Room space pressure setpoint relative to adjacent spaces
- Proposed Control Strategy Type (described in description of efficient condition)

Based on these inputs, a baseline condition of Supply CFM, OA CFM, and Fan Power kW is calculated. CFM calculations are based on the size of the room and assumptions of 20 ACH Supply, 4 ACH OA Supply. Fan power is calculated as CFM*Static Pressure/(6356*Total Fan Efficiency).

With these calculated values, BIN Data and typical AHU setpoints are used to calculate savings on cooling kWh, heating therms, reheat therms, and fan kWh. Assumptions are used for Cooling kW/Ton, Boiler efficiency, Return Air Temperature, Supply Air Temperature, Fan efficiency, fan static pressure, and return/exhaust fan load relative to supply fan.

Description of Efficient Condition

The Efficient Condition allows for operation in a similar manner to the proposed condition, except the total supply CFM has been reduced to 6 ACH with proportional OA cfm reduction. The Efficient Condition is expected to operate as one of the three possible controls strategies:

- A two-position (min/max) variable air volume (VAV) box is installed on the supply air source. Supply airflow is controlled to setpoint. Shut-off dampers are installed in the return ductwork equal to the amount of the setback volume. The VAV box and dampers are balanced to the maximum and minimum volumes for occupied and unoccupied modes. When the VAV box switches to the unoccupied mode, the return dampers (controlling the setback volume) close.
- Pressure-independent valves are placed on the supply and return ductwork (and potentially on ductwork serving surrounding spaces). The supply airflow is controlled to setpoint. The valves,

calibrated to the maximum and minimum volumes for occupied and unoccupied modes, maintain the desired offset.

- A modulating control dampers is installed in the return duct and controlled by a room pressure sensor. The damper modulates to maintain a positive relative room pressure during both occupied and unoccupied modes. A standard terminal box controls the supply airflow to setpoint for each sequence.

Annual Energy-Savings Algorithm

Heating Load Savings (therms/yr)

If bin data recorded is between schedule of unoccupied controls: (Total CFM Existing - Total CFM Proposed) * Sensible Heat Constant * (T_supply - T_MA)

Cooling Load Savings (kWh/yr)

Total Energy Cooling Load of outside Air: (Outside Air CFM Existing-Outside Air CFM Proposed) * Total Heat Constant * (Enthalpy_OA - Enthalpy_DA)

Sensible Energy Cooling Load of Return Air: If T_OA > T_supply: (Return Air CFM Existing - Return Air CFM Proposed) * Sensible Heat Constant * (T_return - T_supply)

Fan Power Savings (kWh/yr)

(Total Air CFM Existing - Total AIR CFM Proposed) * (Pressure_fan static / 6,356 / Efficiency_fan) * kW/bHP * RF + EF_Multiplier * hours/yr unoccupied

Reheat Savings (therms/yr)

Sensible Heat Constant * (Total CFM Existing - Total CFM Proposed) * (T_VAV_Supply_Existing - T_VAV_Supply_Proposed) * (Total Hours - Occupied Hours)

Where:

Total CFM Existing = Actual total building airflow

Total CFM Proposed = Proposed total building airflow

Sensible Heat Constant = (lb/cubic feet air * Btu/lb air * minute/hour = 1.08

T_supply = Supply temperature of air handling unit (= 52°F)

T_MA = Mixed air temperature, calculated based on percentage of outside air vs. return air (based on ideal economizer schedule)

Outside Air CFM Existing = Actual outside air supply airflow

Outside Air CFM Proposed = Proposed outside air supply airflow

Total Heat Constant = (60 min/hr) / (density of standard air = 0.075) = 4.5

Enthalpy_OA = Enthlapy of outside air= [A * RH_OA + B (Curve fit equation to psych chart, accurate within 0.7% between 40°F ≤ T_OA ≤ 80°F)]

A = 0.007468 * DB^2 - 0.4344 * DB + 11.1769

RH_OA = Outside air relative humidity, TMY3 bin data B = 0.2372 * DB + 0.1230

Enthalpy_DA = Enthalpy of discharge air, 52°F at saturated conditions in 0-foot elevation (= 21.45)

Return Air CFM Existing = Actual return air supply airflow

Return Air CFM Proposed = Proposed return air supply airflow

T_return = Return temperature of air handling unit (= assumed 3°F above T_setpoint)

Total Air CFM Existing = Actual total airflow

Total AirCFM Proposed = Proposed total airflow

Pressure_fan static = Total static pressure of supply fan (= assumed 4 inches Water Guage)

6,356 = Horsepower conversion factor

Efficiency_fan = Overall supply fan efficiency (= assumed 75, including fan, motor, and VFD efficiencies)

kW/bHP = Conversion HP to watts (= 0.746)

RF+ EF_Multiplier = Total energy consumption of all fans is 175% of the energy consumption of just the supply fan. (= assumed 1.75)

hours/yr unoccupied = Unoccupied hours/yr (=6,140)

T_VAV_Supply_Existing = Actual supply temperature of the air after passing through the VAV box

T_VAV_Supply_Proposed = Proposed supply temperature of the air after passing through the VAV box

Total Hours = Number of hours per year, per bin

Occupied Hours = Number of hours facility is occupied

Summer Coincident Peak Savings Algorithm

There are no peak savings from this measure.

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 10 years)

Sources

1. Grumman Butkus. "Greening the OR Symposium." Presentation. September 11, 2014.
2. The American Society for Healthcare Engineering. Operating Room HVAC Setback Strategies. 2011. Available online: http://www.ashe.org/resources/management_monographs/pdfs/mg2011love.pdf
3. ANSI/ASHRAE/ASHE 170-2008 Ventilation of Healthcare Facilities
4. ASHRAE 90.1-2007 Energy Standard for Buildings Except Low-Rise Residential Buildings
5. ASHRAE 62.1-2007 Ventilation for Acceptable Indoor Air Quality
6. Historical Program Data- 4 similar projects done under other measure names

Historical Focus on Energy Surgery HVAC Projects

App ID	Project Cost	Square Footage
249844	$29,980.00	1,800
74147	$25,050.00	3,912
118592	$29,514.00	3,600
199725	$75,640.00	4,520

7. Previous projects were performed under the "HVAC Controls, Scheduling/Setpoint Optimization" measure (EUL = 15 years) and standard retrocommissioning measure (EUL = 5 years) - used an average of 10 year EUL.

Revision History

Version Number	Date	Description of Change
01	03/2015	Initial TRM entry

Economizer, RTU Optimization

	Measure Details
Measure Master ID	Economizer, RTU Optimization, 3066
Measure Unit	Per ton
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Economizer
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by location
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by location
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	10[1]
Incremental Cost ($/unit)	$108.00[4]

Measure Description

A majority of commercial spaces are heated and cooled by packaged rooftop units. This measure is installing an air side economizer that offsets or reduces the need for mechanical cooling.

Description of Baseline Condition

The baseline equipment is a packaged rooftop unit with a fixed ventilation rate (fixed damper; no economizer).

Description of Efficient Condition

The efficient equipment is a packaged rooftop unit that includes an economizer controller, actuator, and sensor that provide air-side economizing.

Annual Energy-Savings Algorithm

The following algorithm is iterated for and summed over every hour (from April to October, inclusive) that has an outside air dry-bulb temperature greater than or equal to 55°F, with the estimated average balance point of the buildings addressed.

$kWh_{SAVED} = kWh/year_{BASELINE} – kWh/year_{ECONOMIZER}$

$kWh/year_{BASELINE} = \Sigma(kW_{HOUR\text{-}INTERVAL\text{-}BASELINE} * 1 \text{ hour})$

$kW_{HOUR\text{-}INTERVAL\text{-}BASELINE} = CAP * R_{CAP} * (12 / EER)$

$kWh/year_{ECONOMIZER} = \Sigma(kW_{HOUR\text{-}INTERVAL\text{-}ECONOMIZER} * 1\ hour)$

$kW_{HOUR\text{-}INTERVAL\text{-}ECONOMIZER} = CAP * R_{CAP} * (12 / EER) * Econ_{OPERATING}$

Where:

1 hour = Duration of time for each hour-long interval

CAP = Cooling capacity of equipment in tons (= varies by equipment; actual equipment values should be used; 1 ton is used for per-ton deemed savings value provided in this workpaper)

R_{CAP} = The cooling load at which the air conditioning compressor is operating, as a percentage of the full load capacity CAP; interpolated for every hour between (55°F, 0%) and (95°F, 90%)

12 = Conversion factor from EER to kW/ton

EER = Energy efficiency ratio of the rooftop air handling unit, in Btu/(W*hr) (= varies by equipment; default 9.675 used for deemed savings)[2]

$Econ_{OPERATING}$ = Binary variable (1 or 0) that indicates whether the economizer is in operation; economizer operates when outside air (dry-bulb) temperature is between 55°F and 65°F, inclusive

Summer Coincident Peak Savings Algorithm

The peak demand reduction for economizers is assumed to be zero, as economizers are not expected to operate during peak hours due to the outside air temperature constraints. Economizers, in this savings algorithm, are defined to operate between the outside air dry-bulb temperature of 55°F (the estimated building balance point) and the assumed dry bulb equivalent set point temperature of 65°F, and peak demand hours are likely to be characterized by higher outside air temperatures.

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 10 years)[1]

Deemed Savings

The deemed savings were calculated as shown in the table below. The city nearest the participant location should be applied.

Deemed Savings by Location

City	Annual Savings (kWh/yr/ton)	Peak Demand Reduction (kW)	Lifecycle Electric Energy Savings (kWh/ton)
Madison	177	0	1,761
Milwaukee	222	0	2,220
Green Bay	229	0	2,293
La Crosse	167	0	1,674
Minocqua	215	0	2,150
Wausau	175	0	1,748
Rice Lake	202	0	2,019

Assumptions

The economizer operates between 55°F and 65°F.

Economizer modulation (mixing of outside air and inside air to match the set point temperature) is not taken into account with the savings analysis.

The fraction of the full capacity where the air conditioning compressor is operating is assumed to be a linear function of outside air dry-bulb temperature (0% at 55°F and 90% at 95°F). This assumes correct sizing of the air conditioning unit when installed, including some extra capacity for cooling beyond 95°F.

The hourly interval weather data for Green Bay, La Crosse, Madison, Milwaukee, Minocqua, Rice Lake, and Wausau were obtained from TMY 3 data.[3]

Sources

1. California Energy Commission and California Public Utilities Commission. Database for Energy Efficient Resources (DEER) 2008. http://www.energy.ca.gov/deer/ .
2. International Energy Conservation Code. Table 503.2.3(1). 2009. Straight unweighted average of minimum EER standards for RTUs of cooling capacities greater than 11.25 tons.
3. National Renewable Energy Laboratory. "TMY3 Weather Data: National Solar Radiation Data Base." http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html.
4. RSMeans. Facilities Construction Cost Data. 29th Edition. 2013. Assumed $54.00 per hour labor rate for work performed on air cooling equipment. Estimated 2 hours for completion based on project experience.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Energy Recovery Ventilator

	Measure Details
Measure Master ID	Energy Recovery Ventilator, 2314
Measure Unit	Per CFM
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Energy Recovery
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	72
Peak Demand Reduction (kW)	9.43
Annual Therm Savings (Therms)	13,576
Lifecycle Energy Savings (kWh)	1,080
Lifecycle Therm Savings (Therms)	203,640
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[3]
Incremental Cost ($/unit)	$6.14/CFM[4]

Measure Description

This measure is installing an Energy Recovery Ventilator (ERV) on an HVAC system that provides both heating and cooling to occupied space. ERV systems exchange heat (often both sensible heat and water vapor) between outgoing exhaust air and incoming ventilation air. Under appropriate conditions, this allows for reducing the capacity of the HVAC system, which creates energy savings. Heat and energy recovery wheels are the most commonly applied ERV systems.

Description of Baseline Condition

The baseline is determined from the facility operating hours, current heating/cooling equipment efficiencies, and ERV supply airflow CFM.

Description of Efficient Condition

The efficient condition is an ERV installed on the HVAC system. The system must both heat and cool the space, with minimum cooling hours from 1:00 p.m. to 4:00 p.m., June through August, and with heating occurring in the winter. In addition, the following specifications must be met:

- The leaving supply airflow matches AHRI standard 1060-2005.
- Equipment is AHRI certified to standard 1060-2005 and bear the AHRI certification symbol for the air-to-air recovery ventilation equipment certification program based on AHRI 106.
- Qualifying equipment is independently tested and reported per ASHRAE standard 84-1991.

Annual Energy-Savings Algorithm

Savings were calculated as the sum of iterations over the full range of temperatures (-30°F to 100°F), broken into five-degree intervals. The total savings account for the distribution of the number of hours for each temperature interval.

When in cooling, the savings for each temperature interval are calculated as:[1]

$$kWh_{SAVED} = \Sigma\ (\Delta kWh_{TEMP\text{-}INTERVAL})$$

$$\Delta kWh_{TEMP\text{-}INTERVAL} = [(1/\rho_{AIR} * 60 * V_{SUPPLY} * \eta_{HX\text{-}SUMMER} * (H_{OUT} - H_{RETURN}) / 12{,}000 * \eta_{COOLING}\ ) - kW_{FAN}] * t_{TEMP\text{-}INTERVAL}$$

$$kW_{FAN} = V_{SUPPLY} * (\Delta P_{HX} + \Delta P_{OTHERS}) / (33{,}013 / 5.202) / \eta_{FANMECH.} / \eta_{FANMOTOR} * 0.746$$

When in heating, the savings for each temperature interval are calculated as:

$$Therm_{SAVED} = \Sigma\ (\Delta Therms_{TEMP\text{-}INTERVAL})$$

$$\Delta Therm_{TEMP\text{-}INTERVAL} = ((1.08 * V_{SUPPLY} * \eta_{HX\text{-}WINTER} * (T_{HEATED\ SPACE} - T_{OUTSIDE}) / 100{,}000) / \eta_{HEATING}) * t_{TEMP\text{-}INTERVAL}$$

Where:

$1/\rho_{AIR}$ = Specific volume of air (ρ_{AIR} = 0.075 lb/cubic foot at 1 atm and 68°F)

60 = Conversion factor from hours to minutes

V_{SUPPLY} = Volume of supply air (= actual; otherwise use default value of 7,200 CFM)

$\eta_{HX\text{-}SUMMER}$ = Efficiency of summer heat exchanger (= actual; otherwise use default value of 74%)

H_{OUT} = Enthalpy of outside air in Btu per pound, based on temperature interval

H_{RETURN} = Enthalpy of inside air at 75°F, 50% RH (= 28.3 Btu/lb)

12,000 = Conversion from Btu to tons (of cooling)

$\eta_{COOLING}$ = Efficiency of cooling system (= 1.20 kW/ton)

$t_{TEMP\text{-}INTERVAL}$ = Number of hours the system operates in the particular temperature interval

ΔP_{HX} = Pressure drop across the heat exchanger (= 0.29 inches of water)

ΔP_{OTHERS} = Pressure drop across the filter, louver, inlet, and outlet (= 0.80 inches of water)

33,013 = Conversion factor from HP to foot pounds per minute

5.202 = Conversion factor from inches of water to pounds per square foot

$\eta_{FANMECH}$ = Fan mechanical efficiency (= actual; otherwise use default value of 65%)

$\eta_{FANMOTOR}$ = Fan motor efficiency (= actual; otherwise use default value of 89.5% for 5 HP fan motor)

0.746 = Conversion factor from horsepower to kilwatts

1.08 = Conversion factor of pounds of air per hour multiplied by heat capacity of air in Btu per pound, whichallows the enthalpy to be determined using the volumetric flowrate of air in CFM and the temperature difference

$\eta_{HX\text{-}WINTER}$ = Efficiency of summer heat exchanger (= actual; otherwise use default value of 73%)

$T_{HEATED\ SPACE}$ = Temperature inside heated space (= 68°F)

$T_{OUTSIDE}$ = Midpoint of the temperature interval outside in Fahrenheit, based on temperature interval

100,000 = Btu to therm conversion

$\eta_{HEATING}$ = Efficiency of heating system (= 85%)

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} / HOURS_{COOLING}$

Where:

kWh_{SAVED} = Annual savings during cooling season, based on temperature interval (= 9,615 kWh)

$HOURS_{COOLING}$ = Number of operating hours during cooling (= 1,258)[2]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[3]

Deemed Savings

Deemed Energy Savings by Heating or Cooling

	Annual Energy Savings	Peak Demand Reduction	Lifecycle Energy Savings
Yearlong	72 kWh	-	1,080 kWh
	13,576 therms	-	203,640 rherms
Cooling	11,867 kWh	9.43 kW	178,005 kWh
	-	-	-
Heating	-11,795 kWh	-	176,925 kWh
	13,576 therms	-	203,640 therms

There are negative kWh savings from operating the fan (kWh_{FAN}); when the system is in heating mode, heating savings come from natural gas savings, whereas the electric energy use increases due to the kWh consumed by the fan. However, the overall Btu savings is net positive.

Assumptions

Deemed savings values were calculated for a system with a 7,200 CFM supply fan.

All of the assumptions used in the savings calculations, as listed in the definition of terms, are from the Focus on Energy Program Energy Recovery Ventilator Calculation input.[1]

The weather intervals and corresponding operating hours in the following tables were used to calculate the deemed savings values.[2]

Weather Intervals and Corresponding Operating Hours

	Temperature Range (°F)	Range Midpoint (°F)	Hours Operating in Each Temperature Interval (hours)	Enthalpy (Btu/lb)
Cooling	95 to 100	97.5	4.18	42.12
	90 to 95	92.5	20.56	40.57
	85 to 90	87.5	70.72	39.45
	80 to 85	82.5	266.68	35.13
	75 to 80	77.5	421.24	32.40
	70 to 75	72.5	474.69	30.69
Heating	65 to 70	67.5	698.74	28.33
	60 to 65	62.5	877.28	25.22
	55 to 60	57.5	574.89	21.97
	50 to 55	52.5	642.02	19.17
	45 to 50	47.5	466.10	17.11

	Temperature Range (°F)	Range Midpoint (°F)	Hours Operating in Each Temperature Interval (hours)	Enthalpy (Btu/lb)
	40 to 45	42.5	639.90	15.06
	35 to 40	37.5	859.58	12.95
	30 to 35	32.5	730.96	10.99
	25 to 30	27.5	429.07	9.13
	20 to 25	22.5	507.80	7.61
	15 to 20	17.5	388.02	5.87
	10 to 15	12.5	229.07	4.04
	5 to 10	7.5	147.38	2.53
	0 to 5	2.5	95.69	1.30
	-5 to 0	-2.5	93.43	0.08
	-10 to -5	-7.5	79.95	-1.39
	-15 to -10	-12.5	27.69	-2.52
	-20 to -15	-17.5	9.57	-3.90
	-25 to -20	-22.5	3.49	-4.86
	-30 to -25	-27.5	1.31	-6.22

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. Focus on Energy Program, Energy Recovery Ventilator Calculator prepared by Franklin Energy..
3. Wisconsin PSC EUL Database. 2013. See Appendix C.
4. Historical Focus on Energy project data, 2012-2013. 86 projects, excluded high cost per CFM that may be for complete AHU replacement, average cost of ERV is $6.14 per CFM.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

High Volume, Low Speed Fans

	Measure Details
Measure Master ID	Fans, High Volume, Low Speed (HVLS): 20-foot diameter, 2316 22-foot diameter, 2317 24 foot diameter, 2318
Measure Unit	Per fan
Measure Type	Prescriptive
Measure Group	HVAC
Measure Category	Fan
Sector(s)	Agriculture
Annual Energy Savings (kWh)	Varies by fan diameter
Peak Demand Reduction (kW)	Varies by fan diameter
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by fan diameter
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15 (20-foot and 22-foot diameter fans), 13 (24-foot diameter fans)[1]
Incremental Cost ($/unit)	$4,689.88(All diameters)[2]

Measure Description

It is important to keep livestock cool during the summer months for breeding, milk production, and general good health. Traditionally, farms use a number of high speed circulation fans (typically < 54-inch diameter) with a 1 HP to 1.5 HP motor per fan that moves approximately 29,000 CFM to cool livestock. High volume, low speed (HVLS) fans with diameters of 8-feet to 24-feet use anywhere from 1 HP to 2 HP motors per fan and move between 140,000 CFM up to 300,000+ CFM.[3]

Description of Baseline Condition

The baseline condition is a dairy farm with a freestall barn with one or two rows of high speed fans per group of animals: one row along the feed alley blowing over the animals’ backs and one row over the cow beds in the center of the group. Usually, 48-foot to 50-foot high speed fans are installed every 30 feet or 40 feet, respectively. The baseline condition for other types of livestock barns is similar in using multiple high speed fans to keep the animals cool.

Description of Efficient Condition

The efficient condition for dairy farms is a freestall barn with one row of HVLS fans installed approximately every 60 feet down the center of the barn over the feed alley. The efficient condition for other livestock barns is similar in using fewer HVLS fans compared to the baseline high speed fans to achieve the same or a similar amount of airflow.

- Five 48-inch fans could be replaced by one 20-foot HVLS[3]
- Five fans in a mix of 48-inch and 50-inch sizes could be replaced by one 22-foot HVLS
- Six 50-inch fans could be replaced by one 24-foot HVLS[4]

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{HIGH\ SPEED} * \#\ of\ HS\ Fans - Watts_{HVLS}) / 1{,}000 * HOU$

Deemed HVLS Fan kWh Savings

MMID	Fan Size	kWh_{SAVED}
2316	20 feet	16,074
2317	22 feet	17,427
2318	24 feet	20,784

Where:

$Watts_{HIGH\ SPEED}$ = Power consumption of a single baseline high speed fan (= 1,020 watts for 48-inch fans; = 1,090 watts for fans between 48-inches and 50-inches; = 1,143 watts for 50-inch fans)[5]

\# of HS Fans = Equivalent number of high speed fans needed to achieve similar airflow, in CFM, of one HVLS fan (= 5 for 20-foot and 22-foot HVLS; = 6 for 24-foot HVLS)[3,4]

$Watts_{HVLS}$ = Power consumption of HVLS fan (= 940 watts for 20-foot and 22-foot HVLS; = 1,119 watts for 24-foot HVLS)[6]

1,000 = Kilowatt conversion factor

HOU = Average annual run hours (= 3,864; see assumptions)[7]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{HIGH\ SPEED} * \#\ of\ HS\ Fans - Watts_{HVLS}) / 1{,}000 * CF$

Where:

CF = Coincidence factor (1.0)

Deemed HVLS Fan kW Savings

MMID	Fan Size	kW_{SAVED}
2316	20 feet	4.160
2317	22 feet	4.510
2318	24 feet	5.739

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years for 20-foot and 22-foot HVLS fans; = 13 years for 24-foot HVLS fans)[1]

Deemed HVLS Fan kWh Lifecycle Savings

MMID	Fan Size	$kWh_{LIFECYCLE}$
2316	20 feet	241,114
2317	22 feet	261,400
2318	24 feet	270,192

Deemed Savings

Deemed Savings Values for High Volume, Low Speed Fans

Fan Size	MMID	Annual Energy Savings (kWh)	Peak Demand Reduction (kW)	Lifecycle Energy Savings (kWh)
20 feet	2316	16,074	4.160	24,1114
22 feet	2317	17,427	4.510	26,1400
24 feet	2318	20,784	5.739	27,0192

Assumptions

The savings for this measure are based on the assumption that one 20-foot HVLS fan replaces five high speed circulating fans and one 24-foot HVLS fan can replace six high speed circulating fans (based on square footage served by both fan types).[3,4] HVLS calculations were compared against multiples high speed fans of sizes from 48 feet to 50 feet based on cited sources stating those sizes.[3,4] Historical AgSG program application data submitted from January 1, 2015 through December 8, 2015 also reveals that 48-inch and 50-inch high speed circulation fans are very frequently installed. Therefore, 48inch and 50-inch high speed sized fans are used as the baselines for the 20-foot and 24-foot fans, respectively. To determine the baseline for 22-foot fans, we used the average value of BESS labs testing data of all 48-inch and 50-inch high speed circulation fans.

While HVLS fans are most likely to be used in dairy barn applications based on AgSG program experience, the savings for this measure are also based on the assumption that HVLS fans have wider applications than dairy barns alone, and savings will be similar in other livestock barns, such as those for poultry or swine.

According to the professional judgement of experienced program subject matter expert Terry Laube, farmers in Wisconsin typically turn their circulation fans on when it is 50°F or warmer to improve cow comfort. The HOUs shown above hold most true for dairy barn applications, and is deemed reasonable to hold true for other uses as well for controlling animal comfort.

The coincidence factor equals 1.0, as all hours during the peak window are assumed to be above 65°F.

Sources

1. Average of values from Cadmus Database March 2013, and PA Consulting Group Inc. Public *Service Commission of Wisconsin Focus on Energy Evaluation: Business Programs: Measure Life Study.* Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf.
2. RSMeans Mechanical Cost Data, 2012, Box Fan [Equipment].
3. Kammel, D.W., M.E. Raabe, and J.J. Kappelman, University of Wisconsin-Madison. "Design of High Volume Low Speed Fan Supplemental Cooling System in Dairy Free Stall Barns." Accessed September 29, 2015. http://www.uwex.edu/energy/pubs/HVLSFreestallDesign.pdf
4. Wisconsin Energy Efficiency and Renewable Energy Resource. “Dairy > Ventilation.” Accessed September 29, 2015. http://www.uwex.edu/energy/dairy_V.html
5. Bio-Environmental and Structural System Lab, University of Illinois. “BESS Labs High Speed Fan Performance Criteria.” Circ Fans Tab, 48”-50” fan section. All data originally from BESS labs fan test reports.
6. State of Pennsylvania. Pennsylvania Public Utility Commission. *Technical Reference Manual*. Page 492. June 2015. Accessed December 8, 2015. http://www.puc.state.pa.us/filing_resources/issues_laws_regulations/act_129_information/technical_reference_manual.aspx
7. *Wisconsin Focus on Energy Technical Reference Manual.* Outside Air Temperature Bin Analysis. Sum of Wisconsin average hours-of-use ≥ 50°F. October 2015.

Revision History

Version Number	Date	Description of Change
01	10/01/2015	New measure

Gas Furnaces

	Measure Details
Measure Master ID	LP or Oil Furnace with ECM: 90%+ AFUE (Existing), 3679 Tier 2, 90%+ AFUE (Existing), 3781 Natural Gas Furnace, Tier 2, 95% AFUE, 3783 Natural Gas Furnace with ECM: 95%+ AFUE (Existing), 1981 Tier 2, 95%+ AFUE (Existing), 3782 96%+ AFUE, 3868 Tier 2, 96%+ AFUE, 3870 97%+ AFUE, 3440 Tier 2, 97%+ AFUE, 3871 98%+ AFUE, 3869 Tier 2, 98%+ AFUE, 3872
Measure Unit	Per furnace
Measure Type	Prescriptive
Measure Group	HVAC
Measure Category	Furnace
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	416 (excluding non-ECM)
Peak Demand Reduction (kW)	0.0759 (excluding non-ECM)
Annual Therm Savings (Therms)	Varies by AFUE and fuel type
Lifecycle Energy Savings (kWh)	9,545 (excluding non-ECM)
Lifecycle Therm Savings (Therms)	Varies by AFUE and fuel type
Water Savings (gal/yr)	0
Effective Useful Life (years)	23[1]
Incremental Cost ($/unit)	Varies by measure, see Appendix D

Measure Description

Conventional gas furnaces produce by-products, such as water vapor and carbon dioxide, which are usually vented out through a chimney along with a considerable amount of heat. This occurs not only when the furnace is in use, but also when it is turned off. Newer designs increase energy efficiency by reducing the amount of heat that escapes and by extracting heat from the flue gas before it is vented. These furnaces use much less energy than conventional furnaces.

Description of Baseline Condition

The current federal furnace standard is a 78% AFUE without an electronically commutated motor (ECM). However, data on furnace sales in Wisconsin indicate a higher market baseline for natural gas furnaces. Non-income eligible measures (Tier 1) use a 92.8% AFUE furnace without an ECM as the baseline, based on sales and audit data indicating that this was the average AFUE of units sold in Wisconsin in 2015.[2] Income eligible measures (Tier 2) maintain an 80% AFUE baseline, the lowest AFUE for which sales were present in the sales data, due to income restraints for participating consumers. The measure characteristics were previously based on a 90% AFUE furnace without an ECM for Tier 1 and a 78% AFUE furnace without an ECM for Tier 2 from 2011 through 2014.

Description of Efficient Condition

The efficient furnace condition varies by measure-specific requirements; the measure master name largely explains the efficient condition for each measure. For all measures, the efficient condition pertains to a furnace installed in a residential application.

Annual Energy-Savings Algorithm

$$\text{Therms}_{\text{SAVED}} = \text{CAP} * \text{hours}_{\text{HEATING}} * (1/\text{AFUE}_{\text{BASE}} - 1/\text{AFUE}_{\text{EE}}) * (1/100)$$

$$\text{kWh}_{\text{SAVED}} = \text{kWh}_{\text{SAVED COOLING}} + \text{kWh}_{\text{SAVED HEATING}} + \text{kWh}_{\text{SAVED CIRC}}$$

$$\text{kWh}_{\text{SAVED COOLING}} = \text{tons} * \text{EFLH}_{\text{COOLING}} * 12 \text{ kBtu/ton} * (1/\text{SEER}_{\text{BASE}} - 1/\text{SEER}_{\text{ECM}}) * \text{AC\%}$$

$$\text{kWh}_{\text{SAVED HEATING}} = \text{hours}_{\text{HEATING}} * \Delta\text{kW}_{\text{HEAT}}$$

$$\text{kWh}_{\text{SAVED CIRC}} = \text{hours}_{\text{CIRC}} * \Delta\text{kW}_{\text{CIRC}}$$

Where:

CAP = Heating capacity (= 72 MBtu/hour)[3]

$\text{AFUE}_{\text{BASE}}$ = Baseline AFUE (= 80% for Tier 2 and 92.8% for Tier 1)

AFUE_{EE} = Efficient AFUE (= 95%, 96%, 97%, or 98%)

tons = Cooling capacity in tons (= 2.425)[4]

$\text{EFLH}_{\text{COOLING}}$ = Effective full-load cooling hours (= 410 average; varies by location; see table below)

Effective Full-Load Cooling Hours by Location

Location	$EFLH_{COOLING}$	Weighting by Participant
Green Bay	344	22%
Lacrosse	323	3%
Madison	395	18%
Milwaukee	457	48%
Wisconsin Average	380	9%
Overall	**410**	

$SEER_{BASE}$ = Baseline SEER (= 12)[4]

$SEER_{ECM}$ = SEER of unit with ECM (= 13)[4]

AC% = % of non-A/C furnace measures that also had an A/C installed (= 92.5%)[4]

$hours_{HEATING}$ = Hours of heating operation (= 1,158 hours)[4]

ΔkW_{HEAT} = Heating demand (= 0.116 kW)[4]

$hours_{CIRC}$ = Annual hours on circulate setting (= 1,020 hours)[4]

ΔkW_{CIRC} = Demand on circulate setting (= 0.207 kW)[4]

Summer Coincident Peak Savings Algorithm

Peak electrical energy savings for the ECM changed based on the Focus on Energy ECM Study[4] and is deemed as 0.0759 kW/unit.

$$kW_{SAVED} = tons * 12\ kBtu/ton * (1/EER_{BASE} - 1/EER_{ECM}) * CF * AC\%$$

Where:

EER_{BASE} = Baseline SEER (= 10.5)[4]

EER_{ECM} = EER of unit with ECM (= 11)[4]

CF = Coincidence factor (= 68%)[4]

Lifecycle Energy-Savings Algorithm

$$Therm_{LIFECYCLE} = Therms_{SAVED} * EUL$$

$$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$$

Where:

EUL = Effective useful life (= 18 years)[1]

Assumptions

The incremental costs for 95% and 97% AFUE furnaces was established in previous workpapers, based on a combination of installation data and surveys with participating trade allies regarding cost differences between 95% and 97% AFUE furnaces and 92% AFUE furnaces. Incremental cost for 96% AFUE furnaces was calculated as the average between the 95% and 97% AGUE costs. Incremental cost for 98% AFUE furnaces was derived by adding the same cost increment to the 97% cost as was between 95%, 96%, and 97% AFUE furnaces.

Deemed Savings

Deemed Savings for Tier 1 and Tier 2 Measures

Measure	MMID	kW	Annual kWh	Lifecycle kWh	Annual therms	Lifecycle therms	Inc. Cost[5]
Tier 1							
LP or Oil Furnace w/ECM, 90%+ AFUE (Existing)	3679	0.0792	416	7,492	0	0	$432.00
Natural Gas Furnace w/ECM, 95%+ AFUE (Existing)	1981	0.0792	416	7,492	21	483	$345.93
Natural Gas Furnace w/ECM, 96%+ AFUE	3868	0.0792	416	7,492	30	690	$1,071.47
Natural Gas Furnace w/ECM, 97%+ AFUE	3440	0.0792	416	7,492	39	897	$1,797.00
Natural Gas Furnace w/ECM, 98%+ AFUE	3869	0.0792	416	7,492	48	1,104	$2,522.54
Tier 2							
LP or Oil Furnace w/ECM, Tier 2, 90%+ AFUE (Existing)	3781	0.0792	416	7,492	0	0	$432.00
Natural Gas Furnace, Tier 2, 95% AFUE	3783	0	0	0	165	3,795	$1,194.00
Natural Gas Furnace w/ECM, Tier 2, 95%+ AFUE (Existing)	3782	0.0792	416	7,492	165	3,795	$1,565.00
Natural Gas Furnace w/ECM, Tier 2, 96%+ AFUE	3870	0.0792	416	7,492	174	4,002	$2,007.50
Natural Gas Furnace w/ECM, Tier 2, 97%+ AFUE	3871	0.0792	416	7,492	183	4,209	$2,450.00
Natural Gas Furnace w/ECM, Tier 2, 98%+ AFUE	3872	0.0792	416	7,492	191	4,393	$2,892.50

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. Cadmus. *Focus on Energy Calendar Year 2013 Baseline Market Study.* May 14, 2014. Available online: https://focusonenergy.com/sites/default/files/Appendix%20B%20-%20FOC_XC_Deemed_WriteUp_12122013%20(2).pdf
3. Focus on Energy. *SPECTRUM Focus Prescriptive Database.* Average furnace size of 13,000 furnaces. 2012.
4. Focus on Energy. *Deemed Savings Report.* October 27, 2014. Available online: https://focusonenergy.com/sites/default/files/FoE_Deemed_WriteUp%20CY14%20Final.pdf
5. Wisconsin Public Service Commission. *Incremental Cost Database*. December 2014.

Revision History

Version Number	Date	Description of Change
01	03/05/2012	Original
02	11/05/2012	Updated memo
03	02/20/2013	Review and updates for new formatting
04	08/15/2014	New format, changes from 2014 Baseline Study and ECM Study
05	09/29/2014	Final results from the 2014 ECM study
06	10/29/2014	Final edits/additions from 2014 Cadmus ECM study and Deemed Savings Report
07	04/28/2016	Addition of 96%, 97%, 98% AFUE measures

Variable Frequency Drive HVAC Applications

	Measure Details
Measure Master ID	VFD, HVAC Fan, 2643 VFD, HVAC Heating Pump, 2644 VFD, High Speed Ventilation/Circulation Fan, Ag, 3777
Measure Unit	Per horsepower
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Motors and Drives
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential-multifamily
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	$130.00/hp[2]

Measure Description

This measure addresses the installation of a VFD on a newly constructed or existing HVAC fan or pump.

Description of Baseline Condition

The baseline condition is a pump or fan that operates at a constant speed.

Description of Efficient Condition

VFDs physically slow motors' driving pumps and fans in order to achieve reduced flow rates at considerable energy savings. Traditionally, flow rates have been reduced by increasing the head pressure drop in a system and riding the pump or fan curve back to a new flow rate (throttling control). Alternately, some systems have bypasses that divert a portion of the flow back to the pump or fan inlet to reduce system flow (bypass control).

This measure addresses VFDs installed on new construction or existing HVAC related fans and pumps that previously were not VFD controlled. This measure also includes implementing VFD's on agricultural high-speed axial fans to be automatically controlled through a temperature/air quality sensor signal. Recent market data has shown that some farms and trade allies are starting to implement VFDs or purchase fans with VFDs already installed for livestock housing ventilation/circulation axial style fans to help achieve greater energy savings.

The installation of a VFD must accompany the permanent removal or disabling of any throttling devices such as inlet vanes, bypass dampers, and throttling valves. Unit must operate a minimum of 2,000 hours annually. Redundant back-up units and replacing existing VFDs do not qualify.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{BASE} – kWh_{VFD}$

$kWh_{BASE} = (Watts_{BASE} * HOURS) / 1,000$

$kWh_{VSD} = \Sigma(Watts_{VSD,i} * CAP_i \times * HOURS) / 1,000$

Where:

$Watts_{BASE}$ = Power draw of baseline motor at constant baseline speed (= user defined value)

HOURS = Annual operating hours (= user defined value)

1,000 = Kilowatt conversion factor

$Watts_{VSD,I}$ = Power draw of motor with VFD at capacity *i* (= user defined value)

CAP_i = Percentage of time motor runs at capacity *i* (should add to 100%; = user defined value)

Summer Peak Savings Algorithm

$kW_{SAVED} = kW_{BASE} – kW_{VSD}$

$kW_{BASE} = Watts_{BASE} /1,000$

$kW_{VSD} = \Sigma(Watts_{VSD,i} * CAP_{i,PEAK}) / 1,000$

Where:

$CAP_{i,PEAK}$ = Percentage of time motor runs at capacity *i* during the peak period (should add to 100%)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[1]

Sources

1. PA Consulting Group Inc. *State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study.* Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf; For 2643, also supported by California Energy Commission and California Public Utilities Commission. Database for Energy Efficient Resources (DEER) 2008. Available online: http://www.energy.ca.gov/deer.
2. Evaluator and Implementer Consensus on setting cost on a per hp basis, instead of per motor. Cost set at $130.00 per hp, determined as survey value across full size range of motors eligible for this measure. NEEP 2013 Incremental Cost Study used to develop value (Incremental Cost Study Phase Two Final Report, Navigant Consulting, 2013). Available online: http://www.neep.org/Assets/uploads/files/emv/emv-products/NEEP%20ICS2%20FINAL%20REPORT%202013Feb11-Website.pdf.

Revision History

Version Number	Date	Description of Change
01	10/25/2012	Initial draft
02	03/08/2013	Update based on evaluation comments
03	10/06/2015	Added agriculture high speed fans

RTU Optimization - Programmable Thermostat

	Measure Details
Measure Master ID	Programmable Thermostat: RTU Optimization Advanced, 3120 RTU Optimization Standard, 3121
Measure Unit	Per 1,000 square feet (kSF)
Measure Type	Hybrid
Measure Group	HVAC
Measure Cateogry	Other
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by inputs
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by inputs
Lifecycle Energy Savings (kWh)	Varies by inputs
Lifecycle Therm Savings (Therms)	Varies by inputs
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Incremental Cost ($/unit)	$150.00 (standard);[2] $292.00 (advanced)[3]

Measure Description

A majority of commercial spaces are heated and cooled by packaged rooftop units. This measure allows for installing and programming a programmable thermostat to reset space temperatures during unoccupied periods and save energy. The advanced measure involves installing a more advanced programmable thermostat that can operate two modes of ventilation for occupied and unoccupied periods, thus reducing or eliminating ventilation when not needed. The advanced thermostat option requires an economizer with multiple ventilation set points, a more advanced thermostat, and additional wiring.

Description of Baseline Condition

The baseline equipment is a non-programmable thermostat controlling a packaged rooftop unit.

Description of Efficient Condition

The efficient equipment includes a programmed programmable thermostat controlling a packaged rooftop unit. System must reset by 5 degrees or more for at least 6 hours per day.

Annual Energy-Savings Algorithm

Savings are calculated using the Honeywell Savings Estimator[5] tool for Rooftop Units, with inputs given in the table below.

Honeywell Savings Estimator Inputs

Data Input	Programmable Thermostat	Advanced Programmable Thermostat
Outdoor CO_2 Level	390 ppm	390 ppm
Building Type	Space Type[4]	Space Type[4]
Area	Tons[4] * 400 CFM/ton * 1 sq.ft./CFM	Tons[4] * 400 CFM/ton * 1 sq.ft./CFM
Construction	Frame Construction	Frame Construction
Thermal Envelope	ASHRAE Standard 90.1 - 2007	ASHRAE Standard 90.1 - 2007
City	Nearest to Site Address[4] of Eau Claire, Green Bay, La Crosse, Madison, Milwaukee	Nearest to Site Address[4] of Eau Claire, Green Bay, La Crosse, Madison, Milwaukee
Equipment Type	Unitary AC and Heating Type[4]	Unitary AC and Heating Type[4]
Efficiency	Cooling EER 10.0 Heating Natural Gas – 0.8 Heating Electric – 1.0	Cooling EER 10.0 Heating Natural Gas – 0.8 Heating Electric – 1.0
Damper Leakage	0%	0%
Base Case	Unoccupied Fan Cycling	Unoccupied Fan Cycling
Set Points Heating	Occupied 70°F Unoccupied (70°F – Heating Set Back)	Occupied 70°F Unoccupied (70°F – Heating Set Back)
Set Points Cooling	Occupied 75°F Unoccupied (75°F + Cooling Set Up)	Occupied 75°F Unoccupied (75°F + Cooling Set Up)
CO_2 Setpoint	1,100 ppm	1,100 ppm
Occupancy	Default Occupancy	Default Occupancy
Utility Rates	$0.70/therm, $0.10/kWh	$0.70/therm, $0.10/kWh

Annual Therm Savings (Natural Gas Heat)

Standard Programmable Thermostat = Natural Gas Energy (Base) – Natural Gas Energy (Setback)

Advanced Programmable Thermostat = Natural Gas Energy (Base) – Natural Gas Energy (Dry Bulb)

Annual Energy Savings (Natural Gas Heat)

Standard Programmable Thermostat = Electric Energy (Base) – Electric Energy (Setback)

Advanced Programmable Thermostat = Electric Energy (Base) – Electric Energy (Setback)

Annual Energy Savings (Electric Heat)

Standard Programmable Thermostat = Electric Energy (Base) – Electric Energy (Setback)

Advanced Programmable Thermostat = Electric Energy (Base) – Electric Energy (Setback) + Night Ventilation Savings

To determine Night Ventilation Savings, change heating type to natural gas and use the following formula: (Natural Gas Energy (Setback) – Natural Gas Energy (Dry Bulb)) * 29.3 kWh/therm * 0.8 (Electric Efficiency/Natural Gas Efficiency)

The following example provides savings for the retail sector in Milwaukee, using natural gas heating and inputs from the table above:

Inputs Calculated:

Area = 50 Tons (from application) * 400 CFM/ton * sq. ft./CFM

Where:

29.3 = Conversion from therms to kWh
CFM = Outside air flow in cubic feet per minute
EER = Energy efficiency ratio for cooling
Electric Energy = Model output from Honeywell savings estimator in kWh
Natural Gas Energy = Model output from Honeywell savings estimator in therms

Example Output Results

	Base	Setback	Dry Bulb	Enthalpy	Diff Enth	DCV	DCV+DB	DCV+Enth	DCV+DiffE
Natural Gas Energy (therms)	2,231	2,042	1,952	1,952	1,952	1,325	1,325	1,325	1,325
Electric Energy (kWh)	22,193	21,406	21,129	21,140	19,332	21,547	20,986	21,033	19,018
Electric Demand (kW)	18	18	18	18	18	16	16	16	16
Electricity Cost ($)	1,775	1,713	1,690	1,691	1,547	1,724	1,679	1,683	1,521
Natural Gas Cost ($)	1,562	1.430	1,367	1,367	1,367	928	928	928	928
Total Utility Cost ($)	3,337	3,142	3,057	3,058	2,913	2,652	2,607	2,610	2,449
Comp Run Time (hrs)	526	520	511	511	413	540	514	515	399
CO2 Emissions (mTons)	25	24	23	23	22	20	20	20	19
Equip Cost ($)	0	0	0	0	0	0	0	0	0

	Base	Setback	Dry Bulb	Enthalpy	Diff Enth	DCV	DCV+DB	DCV+Enth	DCV+DiffE
Cost Savings (%)	0	5,844	8,391	8,361	12,706	20,527	21,876	21,786	26,611
Cost Savings ($)	0	195	280	279	424	685	730	727	888
Payback (yrs)	0	0	0	0	0	0	0	0	0

Summer Coincident Peak Savings Algorithm

There are no peak savings for this measure.

Lifecycle Energy-Savings Algorithm

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 5 years)[1]

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. DEER Measure Cost Summary. Revised June 2, 2008.
3. Median material cost for preapproved list is $180.00; additional labor is required for programming and running wire from output to economizer, estimated at 2 hours per thermostat at labor rate of $56.48.
4. Inputs from program application.
5. Honeywell. https://customer.honeywell.com/Documents/setupFullSE4_2_0_1.zip

Revision History

Version Number	Date	Description of Change
01	03/11/2013	New measure
02	05/07/2013	Revised

A/C Split or Packaged System, High Efficiency

	Measure Details
Measure Master ID	A/C Split or Packaged System, High Efficiency: Business, All Sizes, 3022 Multifamily, > 5.4 tons, 3761
Measure Unit	Per ton
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Rooftop Unit / Split System AC
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by capacity
Peak Demand Reduction (kW)	Varies by capacity
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by capacity
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	MMID 3022 = $82.34[2]; MMID 3761 = $100.00[8]

Measure Description

This measure is installing high-efficiency, unitary packaged, and split air conditioning equipment. This measure also applies to replacing an existing unit at the end of its useful life or installing a new unit in a new or existing building. For businesses, this measure includes all sizes of cooling equipment to provide one consistent incentive structure (per ton) for commercial trade allies. For multifamily properties, this measure only includes cooling equipment > 5.4 tons, which would normally be used in a fitness area, meeting rooms, pool, or other common area spaces. Multifamily equipment ≤ 5.4 tons is covered by MMIDs 2192, 2193, and 2194, and incentives are paid per AC unit for 14, 15, and 16 SEER equipment to match the residential incentive structure, as this equipment would typically be installed by a residential trade ally.

Description of Baseline Condition

The baseline equipment for new construction or where new equipment is required by code is a standard efficiency packaged or split air conditioner that meets the 2009 IECC energy efficiency requirements. The rating conditions for the baseline and efficient equipment efficiencies must be equivalent.

Baseline Equipment for New Construction

Equipment Type	Minimum Efficiency[3]
Standard AC Unit < 65 kBtu/hour (5.42 tons or less)	13.0 SEER
Standard AC Unit ≥ 65 and < 135 kBtu/hour (5.42 to 11.25 tons)	11.2 EER
Standard AC Unit ≥ 135 and < 240 kBtu/hour (11.25 to 20 tons)	11.0 EER
Standard AC Unit ≥ 240 and < 760 kBtu/hour (20 to 63.33 tons)	10.0 EER
Standard AC Unit ≥ 760 kBtu/hour (63.33 tons or more)	9.7 EER

The baseline equipment for existing buildings is a standard efficiency packaged or split air conditioner that meets the 2006 IECC energy efficiency requirements. The rating conditions for the baseline and efficient equipment efficiencies must be equivalent.

Baseline Equipment for Existing Building

Equipment Type	Minimum Efficiency[4]
Standard AC Unit < 65 kBtu/hour (5.42 tons or less)	10.0 SEER
Standard AC Unit ≥ 65 and < 135 kBtu/hour (5.42 to 11.25 tons)	10.3 EER
Standard AC Unit ≥ 135 and < 240 kBtu/hour (11.25 to 20 tons)	9.7 EER
Standard AC Unit ≥ 240 and < 760 kBtu/hour (20 to 63.33 tons)	9.5 EER
Standard AC Unit ≥ 760 kBtu/hour (63.33 tons or more)	9.2 EER

Description of Efficient Condition

The efficient equipment is a high-efficiency packaged air conditioner that exceeds the CEE Tier 2 energy efficiency requirements listed in the table below.

Efficient Equipment Requirements

Equipment Type	Minimum to Qualify[5]
High Efficiency AC Unit < 65 kBtu/hour (5.42 tons or less)	15.0 SEER / 12.0 EER
High Efficiency AC Unit ≥ 65 and < 135 kBtu/hour (5.42 to 11.25 tons)	12.0 EER / 13.8 IEER
High Efficiency AC Unit ≥ 135 and < 240 kBtu/hour (11.25 to 20 tons)	12.0 EER / 13.0 IEER
High Efficiency AC Unit ≥ 240 and < 760 kBtu/hour (20 to 63.33 tons)	10.6 EER / 12.1 IEER
High Efficiency AC Unit ≥ 760 kBtu/hour (63.33 tons or more)	10.2 EER / 11.4 IEER

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{BASE} – kWh_{EE}$

$kWh_{BASE} = Capacity * RLF * EFLH_{COOL} * (1/EER_{BASE}) * (1\ kW/1{,}000)$

$kWh_{EE} = Capacity * RLF * EFLH_{COOL} * (1/EER_{EE}) * (1\ kW/1{,}000)$

Where:

Capacity = Capacity (size) of the unit in Btu/hour

RLF = Rated load factor; the peak cooling load/nameplate capacity. This factor compensates for oversizing the air conditioning unit (= 0.90)

$EFLH_{COOL}$ = Equivalent full-load cooling hours (= 410 for multifamily; =599 for commercial, industrial, agriculture, and schools and government; see tables below)

EER_{BASE} = Energy efficiency ratio of standard efficiency code baseline unit in Btu/watt-hour

1,000 = Kilowatt conversion factor

EER_{EE} = Energy efficiency ratio of efficient unit in Btu/watt-hour

Multifamily Equivalent Full-Load Cooling Hours by Location[6]

Location	$EFLH_{COOL}$	Weighting by Participant
Green Bay	344	22%
La Crosse	323	3%
Madison	395	18%
Milwaukee	457	48%
Wisconsin Average	380	9%
Overall	**410**	

Commercial, Industrial, Agriculture, Schools & Government Cooling Equivalent Full-Load Cooling Hours by Building Type[7]

Building Type	$EFLH_{COOL}$
College	877
Food Sales	749
Food Service	578
Healthcare	803
Hotel/Motel	663
Industrial	519
Office	578
Other	589
Public Assembly	535
Public Services (non-food)	535
Retail	567
School	439
Warehouse	358
Average	**599**

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kW_{BASE} - kW_{EE}$

$kW_{BASE} = Capacity * (1kW/1{,}000) * CF * (1/EER_{BASE})$

$kW_{EE} = Capacity * (1 kW/1{,}000) * CF * (1/EER_{EE})$

Where:

CF = Coincidence factor (= 68%)[6]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (=15 years)[1]

Deemed Savings

Deemed Savings Values by Capacity: Multifamily New Construction

Capacity (Btu/hour)	SEER/ EER_{BASE}	SEER/ EER_{EE}	MMID	kWh_{BASE}	kWh_{EE}	kWh_{SAVED}	kW_{BASE}	kW_{EE}	kW_{SAVED}	$kWh_{LIFECYCLE}$
100,000	11.2	12.0	3761	3,295	3,075	220	6.07	5.67	0.40	3,295
187,000	11.0	12.0		6,290	5,766	524	11.59	10.63	0.97	7,862
500,000	10.0	10.6		18,450	17,406	1,044	34.00	32.08	1.92	15,665
800,000	9.7	10.2		30,433	28,941	1,492	56.08	53.33	2.75	22,377

Deemed Savings Values by Capacity: Multifamily Retrofit

Capacity (Btu/hour)	SEER/ EER_{BASE}	SEER/ EER_{EE}	MMID	kWh_{BASE}	kWh_{EE}	kWh_{SAVED}	kW_{BASE}	kW_{EE}	kW_{SAVED}	$kWh_{LIFECYCLE}$
100,000	10.3	12.0	3761	3,583	3,075	508	6.60	5.67	0.94	7,613
187,000	9.7	12.0		7,133	5,766	1,367	13.14	10.63	2.52	20,507
500,000	9.5	10.6		19,421	17,406	2,015	35.79	32.08	3.71	30,231
800,000	9.2	10.2		32,087	28,941	3,146	59.13	53.33	5.80	47,187

Deemed Savings Values by Capacity:
Commercial, Industrial, Agriculture, Schools & Government New Construction

Capacity (Btu/hour)	SEER/ EER_{BASE}	SEER/ EER_{EE}	MMID	kWh_{BASE}	kWh_{EE}	kWh_{SAVED}	kW_{BASE}	kW_{EE}	kW_{SAVED}	$kWh_{LIFECYCLE}$
50,000	13.0	15.0	3022	2,073	1,797	276	3.08	2.67	0.41	4,147
100,000	11.2	12.0		4,813	4,493	321	7.14	6.67	0.48	4,813
187,000	11.0	12.0		9,189	8,423	766	13.64	12.50	1.14	11,487
500,000	10.0	10.6		26,955	25,429	1,526	40.00	37.74	2.26	22,886
800,000	9.7	10.2		44,462	42,282	2,180	65.98	62.75	3.23	32,693

Deemed Savings Values by Capacity:
Commercial, Industrial, Agriculture, Schools & Government Retrofit

Capacity (Btu/hour)	SEER/ EER_{BASE}	SEER/ EER_{EE}	MMID	kWh_{BASE}	kWh_{EE}	kWh_{SAVED}	kW_{BASE}	kW_{EE}	kW_{SAVED}	$kWh_{LIFECYCLE}$
50,000	10.0	15.0	3022	2,696	1,797	899	4.00	2.67	1.33	13,478
100,000	10.3	12.0		5,234	4,493	742	7.77	6.67	1.10	11,122
187,000	9.7	12.0		10,421	8,423	1,627	15.42	12.47	2.96	29,880
500,000	9.5	10.6		28,374	25,429	3,048	43.58	39.06	4.52	45,712
800,000	9.2	10.2		46,878	42,282	3,315	69.57	62.75	6.82	68,939

Assumptions

A default value of 0.90 was assumed for the rated load factor.

The deemed savings values were calculated for hypothetical units with capacities equal to the midpoint of each interval found in the IECC 2009 standard, with the exception of units < 65 kBtu/hour (which used 50 kBtu/hr) and units ≥ 760 kBtu/hour (which used 800 kBtu/hour).

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf Similar A/C measures (MMIDs 123-124, 821-879, 2192-2194).
2. NEEP. Incremental Cost Study Phase Three Final Report. Average of CEE Tier 2 values ($126.84 and $37.83) from Table 10. Available online: http://www.neep.org/incremental-cost-study-phase-3
3. International Energy Conservation Code. Table 503.2.3(1). 2009.
4. International Energy Conservation Code. Table 503.2.3(1). 2006.
5. Consortium for Energy Efficiency. *High Efficiency Commercial Air Conditioning and Heat Pump Initiative*. Page 30-31, values for “Heating Section Type” = “All Other.” January 2012. Available online: http://library.cee1.org/sites/default/files/library/5347/CEE_CommHVAC_HECAC__InitDescip.pdf
6. Cadmus. *Focus on Energy Evaluated Deemed Savings Changes*. November 14, 2014.
7. DEER model runs that were weather normalized for statewide use by population density.
8. Based on a review of TRM incremental cost assumptions from Vermont (Vermont Technical Reference Manual. August 2013. and California Municipal Utilities (CMUA Savings Estimation Technical Reference Manual). 2014. Available online: http://www.greenmountainpower.com/upload/photos/371TRM_User_Manual_No_2013-82-5-protected.pdf; http://cmua.org/energy-efficiency-technical-reference-manual

Revision History

Version Number	Date	Description of Change
01	10/07/2015	New measure
02	12/15/2015	Revised per evaluator comments

Demand Control Ventilation, RTU Optimization

	Measure Details
Measure Master ID	Demand Control Ventilation, RTU Optimization, 3266
Measure Unit	Per RTU
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Rooftop Unit / Split System AC
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by area of conditioned space and number of occupants
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by area of conditioned space and number of occupants
Lifecycle Energy Savings (kWh)	Varies by area of conditioned space and number of occupants
Lifecycle Therm Savings (Therms)	Varies by area of conditioned space and number of occupants
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	$2,796.00/AHU[2]

Measure Desription

Commercial spaces are required to provide ventilation based on a minimum flow rate of outside air, calculated using the area of conditioned space and number of occupants. Standard systems are unable to measure the number of occupants and must default to a maximum occupancy based ventilation rate. Demand control ventilation controls measure the carbon dioxide in the space as a proxy for the number of occupants and allow the occupant-based portion of ventilation to be reduced below the maximum, resulting in heating and cooling savings.

Description of Baseline Condition

The baseline equipment is a packaged RTU with an air side economizer and a fixed minimum ventilation rate.

Description of Efficient Condition

The efficient equipment includes a sensor that measures the carbon dioxide level of the space and an economizer that can adjust the ventilation rate to maintain carbon dioxide levels within the space according to code.

Annual Energy-Savings Algorithm

Savings are calculated using the Honeywell Savings Estimator[4] tool for RTUs, with inputs given in the following table.

Honeywell Savings Estimator Inputs

Data Input	Demand Controlled Ventilation
Outdoor CO_2 Level	390 ppm
Building Type [3]	Space type
Area [3]	Tons * 400 cfm/ton * 1 sq.ft./cfm
Construction	Frame
Thermal Envelope	ASHRAE Standard 90.1 - 2007
City	Nearest to site address[3] in Eau Claire, Green Bay, La Crosse, or Madison, Milwaukee
Equipment Type	Unitary AC and heating[3]
Efficiency	Cooling EER = 10 Heating Natural Gas EER = 0.8 Heating Electric EER = 1.0
Damper Leakage	0%
Base Case	Unoccupied fan cycling
Set Points Heating	Occupied 70°F Unoccupied (70°F heating set back)
Set Points Cooling	Occupied 75°F Unoccupied (75°F cooling set up)
CO_2 Setpoint	1,100 ppm
Occupancy	Default occupancy
Utility Rates	$0.70/therm; $0.10/kWh

Savings from Honeywell Estimator:

$\text{Therm}_{\text{SAVED}}$ = Natural Gas Energy (DCV + DB) – Natural Gas Energy (Dry Bulb)

$\text{kWh}_{\text{SAVED}}$ = Electric Energy (DCV + DB) – Electric Energy (Dry Bulb)

Where:

Natural Gas Energy = Model output from Honeywell Savings Estimator in therms[4]

DCV = Demand control ventilation

DB = Decibels

Dry Blub = The ambient air temperature

Electric Energy = Model output from Honeywell Savings Estimator in kWh[4]

Summer Coincident Peak Savings Algorithm

There are no peak savings for this measure.

Lifecycle Energy-Savings Algorithm

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (15 years)[1]

Assumptions

The minimum ventilation is based on ASHRAE 62.1-2007, which is representative or conservative for building stock addressed by measure.

Sources

1. 2013 Minnesota TRM: http://mn.gov/commerce-stat/pdfs/trm-version-1.3.pdf. 2013 Illinois TRM: http://www.ilsag.info/technical-reference-manual.html. The Minnesota TRM uses 15 year measure life. The Minnesota TRM EUL is sourced in the US Department of Energy Efficiency and Renewable Energy document: “Demand Control Ventilation Using CO2 Sensors”.
2. Historical data (1/1/14-8/10/16 paid proj) for MMID3266 = $2,796.00 per AHU. This excludes 1 project with $20.00 per AHU and 3 projects > $19,000.00 per AHU.
3. Inputs collected from customer in Focus on Energy application.
4. Honeywell Savings Estimator Model located at: https://customer.honeywell.com/Documents/setupFullSE4_2_0_1.zip

Revision History

Version Number	Date	Description of Change
01	03/11/2013	Intial measure entry

Air Conditioning Unit Tune Up - Coil Cleaning

	Measure Details
Measure Master ID	A/C Coil Cleaning: < 10 Tons, 3059 10-20 Tons, 3061 > 20 Tons, 3060
Measure Unit	Per ton of refrigeration capacity
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by sector and cooling capacity
Peak Demand Reduction (kW)	Varies by sector and cooling capacity
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector and cooling capacity
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	3[1]
Incremental Cost ($/unit)	$35.00/ton[4]

Measure Description

This measure is coil cleaning of packaged AC units operating in commercial applications, applicable for commercial and industrial customers, and applies savings from documented tune-ups for packaged or split system AC equipment.

Description of Baseline Condition

The baseline condition is an AC system with fouled condenser coils.

Description of Efficient Condition

The efficient equipment is a unitary or split system AC with condenser coil cleaning as part of a tune up.

Annual Energy-Savings Algorithm

For AC units < 65,000 Btu/hour, use SEER instead of EER to calculate:

$$kWh_{SAVED} = (EFLH_{COOL} * CAPY_{C} / 1{,}000) * (1/[EER * CCF] -1 / EER)$$

$$kWh_{SAVED} = (EFLH_{COOL} *CAPY_{C} / 1{,}000) * (1/[SEER * CCF] -1 / SEER)$$

Where:

$EFLH_{COOL}$ = Equivalent full-load hours for mechanical cooling (= varies by building type; see table below)[2]

$CAPY_C$ = Unit capacity for cooling in Btu/hour

1,000 = Kilowatt conversion factor

EER = Energy efficiency ratio (for AC and heat pump units < 65,000 Btu/hour, SEER should be used for cooling savings; = based on actual participant information)

CCF = Condenser coil fouling COP degradation factor for cooling (= 93.2%)[4]

SEER = Seasonal energy efficiency ratio (for AC and heat pump units > 65,000 Btu/hour, EER should be used for cooling savings; = based on actual participant information)

Equivalent Full-Load Cooling Hours by Building Type

Building Type	$EFLH_{COOL}$
College	877
Food Sales	749
Food Service	578
Healthcare	803
Hotel/Motel	663
Industrial	519
Office	578
Other	589
Public Assembly	535
Public Services (non-food)	535
Retail	567
School	439
Warehouse	358
Average	**599**

Summer Coincident Peak Savings Algorithm

For AC units < 65,000 Btu/hour, convert SEER to EER to calculate, using 11.3/13 as the conversion factor:

$kW_{SAVED} = (CF * CAPY_C / 1{,}000) * (1 / [EER * CCF] - 1 / EER)$

Where:

CF = Coincidence factor (= 0.90)[5]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 3 years)[1]

Assumptions

Calculation Variable Assumptions

Component	Type	Value	Source
$CAPY_C$	Variable	Nameplate	Data Gathering
EER	Variable	Nameplate	Data Gathering
$EFLH_{COOL}$	Variable	See Equivalent Full-Load Hours by Building Type table (above)	2
CCF	Fixed	93.2%	4
CF	Fixed	90%	5

Sources

1. California Energy Commission and California Public Utilities Commission. Database for Energy Efficient Resources (DEER) 2008. http://www.energy.ca.gov/deer/.DEER model runs weather normalized for statewide use by population density.
2. Weighted value for bin charges based on Southern California Edison program results for commerical and industrial buildings with 3,154 participating units. The weighting assumptions are calibrated annually to reflect Wisconsin findings.
3. Energy Center of Wisconsin (Scott Pigg). *Central Air Conditioning in Wisconsin*. ECW Report Number 241-1. 2008.
4. Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Air Conditioning Unit Tune Up - Refrigerant Charge Correction

	Measure Details
Measure Master ID	A/C Refrigerant Charge Correction: < 10 Tons, 3062 10-20 Tons, 3064 > 20 Tons, 3063
Measure Unit	Per ton of refrigeration capacity
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by sector and cooling capacity
Peak Demand Reduction (kW)	Varies by sector and cooling capacity
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector and cooling capacity
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	10[2]
Incremental Cost ($/unit)	$35.00/ton[4]

Description

This measure is refrigerant charging on packaged AC units operating in commercial applications, applicable for commercial and industrial customers, and applies savings from documented tune-ups for packaged or split system AC equipment.

Description of Baseline Condition

The baseline condition is an AC system with incorrect refrigerant charge.

Description of Efficient Condition

The efficient equipment is a unitary or split system AC that had refrigerant charge correction as part of a tune up.

Annual Energy-Savings Algorithm

For AC units < 65,000 Btu/hour, use SEER instead of EER to calculate:

$kWh_{SAVED} = (EFLH_{COOL} * CAPY_C / 1,000) * (1 / [EER * RCF] - 1 / EER)$

$kWh_{SAVED} = (EFLH_{COOL} * CAPY_C / 1,000) * (1 / [SEER * RCF] - 1 / SEER)$

Where:

$EFLH_{COOL}$ = Equivalent full-load hours for mechanical cooling (= varies by building type; see table below)

$CAPY_C$ = Unit capacity for cooling in Btu/hour

1,000 = Kilwatt conversion factor

EER = Energy efficiency ratio (for AC and heat pump units < 65,000 Btu/hour, SEER should be used for cooling savings; = use actual participant information)

RCF = Refrigerant charge COP degradation factor for cooling (= 98.3%)[5]

SEER = Seasonal energy efficiency ratio (for AC and heat pump units > 65,000 Btu/hour, EER should be used for cooling savings; = use actual participant information)

Equivalent Full-Load Cooling Hours by Building Type

Building Type	$EFLH_{COOL}$[3]
College	877
Food Sales	749
Food Service	578
Healthcare	803
Hotel/Motel	663
Industrial	519
Office	578
Other	589
Public Assembly	535
Public Services (non-food)	535
Retail	567
School	439
Warehouse	358
Average	**599**

Summer Coincident Peak Savings Algorithm

For AC units < 65,000 Btu/hour, convert SEER to EER to calculate, using 11.3/13 as the conversion factor:

$kW_{SAVED} = (CF * CAPY_C / 1{,}000) * (1 / [EER * RCF] - 1 / EER)$

Where:

CF = Coincidence factor (= 0.90)[4]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 10 years)[1]

Assumptions

Calculation Variable Assumptions

Component	Type	Value	Source
$CAPY_C$	Variable	Nameplate	Data Gathering
EER	Variable	Nameplate	Data Gathering
$EFLH_{COOL}$	Variable	See Equivalent Full-Load Hours by Building Type table (above)	3
RCF	Variable	98.3%	3, 5
CF	Fixed	90%	4

Charge Correction Factor Weighting

Correction Needed	Bin Charge	Weighting	RCF
≥-20%	-20%	5%	92%
-5% to -20%	-13%	27%	97%
-5% to 5%	0%	46%	100%
5% to 20%	13%	20%	97%
≥ 20%	20%	2%	92%

Sources

1. California Energy Commission and California Public Utilities Commission. Database for Energy Efficient Resources (DEER) 2008. http://www.energy.ca.gov/deer/ . DEER model runs weather normalized for statewide use by population density.
2. Energy Center of Wisconsin (Scott Pigg). *Central Air Conditioning in Wisconsin*. ECW Report Number 241-1. 2008.
3. U.S. Department of Energy, Weatherization Center. *Energy OutWest – Weatherization Field Guide.* "3.8 Evaluating Refrigerant Charge." Available online: http://www.waptac.org/data/files/website_docs/training/standardized_curricula/curricula_resources/us%20doe_evaluating%20refrigerant%20charge.pdf.
4. Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Chiller Plant Setpoint Adjustment

	Measure Details
Measure Master ID	EBTU Chiller Plant: Chilled Water Setpoint Adjustment, 3659 Condenser Water Setpoint Adjustment, 3660
Measure Unit	Per ton
Measure Type	Custom
Measure Group	HVAC
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Commercial, Industrial, Schools & Government
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	Varies by measure
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Incremental Cost ($/unit)	$108.00[2]

Measure Description

The intent of this measure is to capture savings associated with adjusting the chilled water setpoint to a higher temperature that is determined to still meet the building cooling load requirement. This involves re-programming the chiller plant controls to optimize chilled water setpoint temperatures for the building based on usage. This measure includes condenser water temperature setpoint adjustments as well.

This measure is not applicable to DX cooling systems. This measure is not applicable to buildings that already use a chilled water reset control strategy or that normally change their chilled water setpoint temperature on a regular basis for control.

The measure can be applied only once per building during the EUL. This measure is meant to be a part of the Express Building Tune-Up Program to help optimize building HVAC systems to operate more efficiently at existing building load conditions. It does not apply to newly constructed facilities that have not been commissioned.

Description of Baseline Condition

The baseline measure is a chiller plant with an opportunity for energy savings from adjusting either the chilled and/or condenser water supply setpoint temperature values of a chiller system up or down a few degrees, respectively. The existing chiller cannot already use a chiller control that varies the chiller and condenser temperatures on a regular basis.

Description of Efficient Condition

This efficient measure is a chiller plant that has undergone a setpoint increase in the chilled water and/or a setpoint decrease in the condenser water loop supply temperatures. The HVAC professional implementing these changes must also verify that any change in setpoint temperature values must still be determined to adequately meet building cooling loads to avoid undoing the setpoint changes at a later date.

Annual Energy-Savings Algorithm

Savings are determined by summing the baseline and proposed energy consumption formulas below across the bin data temperature ranges and corresponding bin temperature hours found in the EBTU workbook.[3,4]

$kWh_{SAVED} = kWh_{BASELINE} – kWh_{PROPOSED}$

$$kWh_{BASELINE} = \Sigma\ [(\Delta T_{EXISTING\ CHILLED\ H2O} * 500 * Chiller\ GPM * bin\ hrs * Chiller\_Eff * Area\ Load / 12{,}000) - (\Delta T_{BASELINE\ LMTD} * 500 * Condenser\ GPM * bin\ hrs * Chiller\_Eff * Area\ Load / 12{,}000)]$$

$$kWh_{PROPOSED} = \Sigma\ [(\Delta T_{PROPOSED\ CHILLED\ H2O} * 500 * Chiller\ GPM * bin\ hrs * Chiller\_Eff * Area\ Load / 12{,}000) - (\Delta T_{PROPOSED\ LMTD} * 500 * Condenser\ GPM * bin\ hrs * Chiller\_Eff * Area\ Load / 12{,}000)]$$

Where:

$\Delta T_{EXISTING\ CHILLED\ H2O}$ = Estimated chilled water return temperature - existing chilled water supply temperature

$\Delta T_{PROPOSED\ CHILLED\ H2O}$ = Estimated chilled water return temperature - proposed chilled water supply temperature

500 = Water sensible heat equation constant

Chiller GPM = (= 2 GPM/ton)[5]

bin hours = Bin hours used in workbook for each respective city[4]

Chiller_Eff = kW/ton partial load rating (= based on chiller type; see table below)

Area Load = Percentage based on linear interpolation of a 60°F dry bulb OAT balance point, bin data dry bulb OAT, and 2.5% dry bulb design summer/winter conditions for different Wisconsin cities[6] (see

Assumptions for more explanation of 2.5% dry bulb design conditions)

12,000 = Btu to ton conversion factor

$\Delta T_{BASLINE\ LMTD}$ = Logarithmic mean (see equation below)

$LMTD = (\Delta T_A – \Delta T_B) / [\ln (\Delta T_A / \Delta T_B)] = (\Delta T_A – \Delta T_B) / [\ln \Delta T_A – \ln \Delta T_B)]$

Where:

ΔT_A = Existing condenser water supply temperature (= 95°F)[7]

ΔT_B = Existing chilled water return temperature – existing chilled water supply temperature

Condenser GPM = (= 3 GPM/ton for electric chillers)[5]

$\Delta T_{PROPOSED\ LMTD}$ = Logarithmic mean (see equation below)

$LMTD = (\Delta T_A – \Delta T_B) / [\ln (\Delta T_A / \Delta T_B)] = (\Delta T_A – \Delta T_B) / [\ln \Delta T_A – \ln \Delta T_B)]$

Where:

ΔT_A = Proposed condenser water supply temperature (=95°F)[7]

ΔT_B = Proposed chilled water return temperature – proposed chilled water supply temperature

Cooling Efficiency Factor by System Type[8]

Cooling System Type	Cooling System Efficiency Factor at Partial Load (kW/ton)
Air-Cooled Chiller	0.95
Water-Cooled Chiller	0.64

The workbook calculator requires the following measure-specific inputs to be provided from the trained professional performing the tune-up/optimization measure:

- Chiller capacity (tons) = AHRI rated capacity (if possible), otherwise = general rated capacity
- Existing and proposed chilled water setpoints
- Existing and proposed condenser water setpoints
- Cooling system type (air-cooled chiller or water-cooled chiller)

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} / Hours_{COOL} * CF$

Where:

$Hours_{COOL}$ = Annual cooling hours of operation (= varies by city; see table below)

Annual Cooling Hours by City

City	BIN Annual Cooling Hours (Outside Air Temperature > 60°F)[9]
Green Bay	2,748
La Crosse	2,971
Madison	2,876
Milwaukee	2,830

CF = Coincidence factor (= 1)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 5 years)[1]

Assumptions

- Chilled and condenser water flow rates are assumed to be 2 GPM and 3 GPM per ton, respectively, of cooling system refrigeration capacity.[5]
- 2.5% dry bulb design conditions means that for cooling/heating seasons, the HVAC system is designed to adequately handle the cooling/heating of a given building for all outdoor air temperatures that do not exceed the hottest/coldest 2.5% of hours in the respective season. Explained another way, this is the point where the cooling/heating system can adequately handle the cooling/heating load of a given building for 97.5% of the total anticipated peak cooling/heating hours for the year.

Sources

1. Cadmus. EUL Response Memo. April 26, 2013. (Used RCx Program EUL standard and direction from CB&I to keep 5 year EUL standard).
2. RSMeans 2013 Facilities Construction Cost Data, 29th Edition
3. Wisconsin Focus on Energy. EBTU Measures Workbook Calculator.

4. National Renewable Energy Laboratory. Bin temperature data from respective Wisconsin city TMY3 weather data. Available online: http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html#W
5. Edison Electric Institute. Technical Information Handbook. Pg. 23. 2000.
6. ASHRAE Handbook, Fundamentals Volume for Wisconsin Cities. 1985. Available online: http://publicecodes.cyberregs.com/icod/ipc/2012/icod_ipc_2012_appd.htm
7. Edison Electric Institute. Technical Information Handbook. Pg. 12. 2000.
8. ASHRAE 90.1-2007. Table 6.8.1C. Simple average of minimum efficiency for chillers with capacity between 0 tons and 300 tons.

Revision History

Version Number	Date	Description of Change
01	09/2013	Initial TRM entry

Cooling System Tune-Up

	Measure Details
Measure Master ID	Chiller System Tune Up: Air Cooled, ≤ 500 Tons, 2666 Air Cooled, > 500 Tons, 2667 Water Cooled, ≤ 500 Tons, 2668 Water Cooled, > 500 Tons, 2669
Measure Unit	Per ton
Measure Type	Prescriptive
Measure Group	HVAC
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by cooling mechanism
Peak Demand Reduction (kW)	Varies by cooling mechanism
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by cooling mechanism
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Incremental Cost ($/unit)	$35.00/ton[4]

Measure Description

This measure is a chiller system tune-up for air and water cooled chillers completed in accordance with the chiller system tune-up checklist.

Tune-up requirements:

- Clean condenser coil/tubes
- Check cooling tower for scale or buildup
- Check contactors condition
- Check evaporator condition
- Check low-pressure controls
- Check high-pressure controls
- Check filter, replace as needed
- Check belt, replace as needed
- Check crankcase heater operation
- Check economizer operation

Measurement requirements:

- Record system pressure psig
- Record compressor amp draw
- Record liquid line temperature in °F
- Record subcooling and superheat temperatures in °F
- Record suction pressure psig and temperature in °F
- Record condenser fan amp draw
- Record supply motor amp draw

Description of Baseline Condition

The baseline is air-cooled and water-cooled chillers that operate at a diminished efficiency from design specifications.

Description of Efficient Condition

The efficient condition is a chiller system tune-up conducted to ensure that equipment is operating at its best and as preventative maintenance to extend the life of the equipment. Tune-ups improve the chiller's efficiency and performance and are useful system checks, as regular maintenance keeps the equipment operating as specified.

Annual Energy-Savings Algorithm

Because the existing chiller efficiency cannot be determined without extensive testing, the ASHRAE 90.1-2007[3] minimum efficiency for chillers is used for the baseline efficiency.

Minimum Efficiencies from ASHRAE 90.1-2007

Equipment Type	Size Category	Minimum Efficiency
Air Cooled, with Condenser	All capacities	2.80 COP; 3.05 IPLV
Air Cooled, without Condenser	All capacities	3.10 COP; 3.45 IPLV
Water Cooled, Electrically Operated, Positive Displacement (Reciprocating)	All capacities	4.2 COP; 5.05 IPLV
Water Cooled, Electrically Operated, Positive Displacement (Rotary Screw and Scroll)	< 150 tons	4.45 COP; 5.20 IPLV
	≥ 150 tons and < 300 tons	4.90 COP; 5.60 IPLV
Water Cooled, Electrically Operated, Positive Displacement (Rotary Screw and Scroll)	≥ 300 tons	5.50 COP; 6.15 IPLV
Water Cooled, Electrically Operated, Centrifugal	< 150 tons	5.00 COP; 5.25 IPLV
	≥ 150 tons and < 300 tons	5.55 COP; 5.90 IPLV
	≥ 300 tons	6.10 COP; 6.40 IPLV

The annual energy savings and demand reduction are calculated by applying a percentage savings to the baseline consumption. Parametric runs were applied to estimate deemed savings for this measure.

Existing Equipment as a Baseline:

$kWh_{SAVED} = (IPLV_{BASLINE\ EXISTING})$ * ton * HOURS * % savings

Where:

$IPLV_{BASLINE\ EXISTING}$ = Integrated part load value of baseline chiller (= 3.05 for air cooled; = 5.85 for water cooled)[3]

ton = Equipment size (= 50, 100, 150 for air cooled; = 100, 200, 300 for water cooled)

HOURS = Determined from weather bin hours and building design cooling load (~ 1,440)

% savings = Percentage savings associated with a chiller tune-up (= 5%)[2]

Summer Coincident Peak Savings Algorithm

Existing Equipment as a Baseline:

kW_{SAVED} = (Full Load $kW/Ton_{BASELINE\ EXISTING}$ * % savings) * CF * Tons

Where:

Full Load $kW/ton_{BASELINE\ EXISTING}$ = Full load power draw of baseline chiller[3]

CF = Coincidence factor (= 0.80)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED}$ * EUL

Where:

EUL = Effective useful life (= 5 years)[1]

Deemed Savings

Deemed Savings by Measure Type

	Measure	
	Air Cooled (MMID 2666 if ≤ 500 Tons; MMID 2667 if > 500 Tons)	Water Cooled (MMID 2668 if ≤ 500 Tons; MMID 2669 if > 500 Tons)
Average Annual Deemed Savings (kWh/yr/ton)	83	44
Peak Demand Reduction (kW/ton)	0.0461	0.0242
Average Lifecycle Deemed Savings (kWh/yr/ton)	415	218

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. United States Department of Energy. *Building Technologies Program: Hospitals Benefit by Improving Inefficient Chiller Systems.* White paper. August 2011. The paper found that coil cleaning, the primary savings associated with this cooling tune-up measure, reduces annual cooling energy consumption by 5% to 7%.
3. ASHRAE 90.1-2007 air cooled and water cooled chiller efficiencies. Simple averages were taken from the following sizes (in tons): air cooled 50, 100, 150; water cooled 100, 200, 300. The respective IPLVs were applied: air cooled 3.05, 3.05, 3.05; water cooled 5.25, 5.9, 6.4.
4. Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Economizer Optimization

	Measure Details
Measure Master ID	Economizer Optimization, 3661
Measure Unit	Per ton of refrigeration
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Incremental Cost ($/unit)	$108.00[2]

Measure Description

The intent of this measure is to determine economizer health and capture savings associated with correcting improper operation or damage of outside air economizer units. This measure can be applied only once per building address during the EUL lifecycle, and is meant to be a part of the Express Building Tune-Up Program to help optimizebuilding HVAC systems to operate more efficiently at existing building load conditions. It does not apply to newly constructed facilities that have not already been commissioned.

Description of Baseline Condition

The baseline condition is an air handling unit with an economizer that is either not in operation at all or that is in operation but has a limited OAT range of operation and has the potential to expand.

Description of Efficient Condition

The efficient condition is bringing a nonoperational economizer back to at least a baseline value, or increasing the economizer OAT operating range above baseline. The efficient condition OAT economizer range should not exceed 55°F to 75°F.

Annual Energy-Savings Algorithm

The following algorithms are based off measure workpaper3066 (Economizer, RTU Optimization) as found in the 2015 Focus on Energy TRM.[3] The algorithms was iterated for and summed over bin data of every hour of the year with an outside air dry-bulb temperature greater than or equal to 55°F (April 1 to

September 30), or the estimated average balance point of the buildings addressed. Bin data is found in the EBTU workbook.[4,5]

$kWh_{SAVED} = kWh/year_{BASELINE} – kWh/year_{PROPOSED}$

$kWh/year_{BASELINE} = kW_{hour\text{-}interval\text{-}BASELINE}$ * 1 hour)

$kW_{HOUR\text{-}INTERVAL\text{-}BASELINE} = CAP * R_{CAP} * (12 / EER) * Econ_{BASE}$

$kWh/year_{PROPOSED} = kW_{hour\text{-}interval\text{-}PROPOSED}$ * 1 hour)

$kW_{HOUR\text{-}INTERVALPROPOSED} = CAP * R_{CAP} * (12 / EER) * Econ_{PROP}$

Where:

CAP = Cooling capacity of equipment in tons (= varies by equipment; actual equipment values should be used)

R_{CAP} = Cooling load at which the air conditioning compressor is operating, as a percentage of the full load capacity CAP; interpolated for every hour between (55°F, 0%) and (95°F, 90%)

12 = Conversion factor from EER to kW/ton

EER = Energy efficiency ratio of the rooftop air handling unit, in Btu/(W*hr) (= varies by equipment; see table below)

Energy Efficiency Ratio by System Type

Cooling System Type	Cooling System Efficiency Factors (EER)
Direct Expansion	10.43[6]
Air-Cooled Chiller	12.63[7]
Water-Cooled Chiller	18.75[7]

$Econ_{BASE}$ = Binary variable (0 or 1) that indicates whether the economizer is in operation; baseline economizer operation occurs when the OAT range (dry-bulb) is operating between of 55°F and 65°F

1 hour = Duration of each hour-long interval

$Econ_{PROP}$ = Binary variable (0 or 1) that indicates whether the economizer is in operation; proposed economizer operation when the OAT range (dry-bulb) is greater than baseline of 55°F to 65°F

The following information is required to be supplied by the customer or trade ally applying for this measure:

- Type of facility chiller unit and capacity (tons)
- Efficiency of facility chiller unit (EER) when possible, otherwise a default value based on chiller unit type will be used
- Existing economizer OAT range (°F); when different than 55°F to 65°F, 'none' is also a possibility
- Proposed economizer OAT range (°F)

Summer Coincident Peak Savings Algorithm

There is no peak demand reduction from economizers because they are not expected to operate during peak demand hours based on typical economizer temperature ranges.

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (=5 years)[1]

Assumptions

Economizer modulation (mixing of outside air and inside air to match the set point temperature) is not taken into account for the savings analysis.

The fraction of full capacity of air conditioning compressor operation is assumed to be a linear function of outside air dry-bulb temperature (0% at 55°F and 90% at 95°F). This assumes correct sizing of the air conditioning unit installation, including some extra capacity for cooling beyond 95°F.

The savings are based on facility sizes within the EBTU scope requiring less than 300 tons of cooling.

The economizer operating time period is assumed to be between the months of April and September. This time period includes the peak summer months and some of the shoulder months when facility cooling needs are most expected. Temperature data for these months was pulled from the general TMY3 bin temperature data used for all EBTU measures.[5]

Sources

1. Cadmus. *EUL Response Memo*. April 26, 2013. (used the RCx program EUL standard and direction from CB&I to keep 5 year EUL standard).
2. RSMeans Facilities Construction Cost Data, 29th Edition. 2013. (54.00 per hour labor rate for work performed on air cooling equipment). Estimated two hours for completion of this measure

based on historical project experience. Estimate will be re-evaluated after first year of EBTU program and trade ally pricing feedback.

3. *Focus on Energy Technical Reference Manual.* 2015. Pgs. 69-71, measure 3066.
4. Focus on Energy EBTU Measures Workbook Calculator. Internal Implementer Spreadsheet. 2015.
5. Natural Renewable Energy Laboratory. Bin temperature data comes from respective Wisconsin cities TMY3 weather data. Available online: http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html#W
6. IECC 2009. Table 503.2.3(1). (direct expansion cooling efficiency values determined from simple minimum efficiencies averages for system capacities of ≥ 5.5 tons).
7. ASHRAE 90.1-2007. Table 6.8.1C. (chiller unit part load efficiency values determined from simple minimum efficiencies averages for chiller capacities of 0 tons to 300 tons).

Revision History

Version Number	Date	Description of Change
01	01/2016	New measure

Hot Water Supply Reset

	Measure Details
Measure Master ID	Hot Water Supply Reset, 3662
Measure Unit	Per MBh
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Commercial, Industrial, Schools & Government
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by temperature setpoint
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	Varies by temperature setpoint
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Incremental Cost ($/unit)	$108.00[2]

Measure Description

The intent of this measure is to capture savings by lowering the boiler hot water supply setpoint temperature for the primary heating loop based on actual building load and outdoor air temperature. This measure applies to non-condensing natural gas boilers only. This measure is meant to help optimize HVAC systems to operate more efficiently at existing building load conditions. It does not apply to newly constructed facilities that have not been commissioned.

Description of Baseline Condition

The baseline measure is an eligible building with a boiler hot water heating system that has working controls in place but does not use a hot water reset supply strategy, or has a reset strategy that an HVAC service professional determines can be optimized further.

Description of Efficient Condition

The efficient measure is a trained HVAC service professional determining if a new/change in the hot water supply reset strategy is possible to implement while still safely meeting buildings heating load requirements. The reset strategy should incorporate maximum and minimum water temperatures to correspond with the minimum and maximum outdoor air temperature range, respectively. Savings are calculated based on the particular existing and proposed reset strategy, accounting for boiler capacity. Hot water supply reset control incentives are for existing space heating boilers only. The controls should be set so that the boiler return water is not more than 10°F above the manufacturer's recommended minimum return temperature. The system must have an outdoor air temperature sensor in a shaded location, preferably on the north side of the building.

Annual Energy-Savings Algorithm

Savings are determined by summing the baseline and proposed energy consumption formulas below across the bin data temperature ranges and corresponding bin temperature hours found in the EBTU workbook.[3,4]

$\text{Therms}_{\text{SAVED}} = \text{Therms}_{\text{BASELINE}} - \text{Therms}_{\text{PROPOSED}}$

$\text{Therms}_{\text{BASELINE}} = \Sigma\ [500 * \text{GPM} * (\text{HW Supply Temp}_{\text{BASE}} - \text{HW Return Temp}) * \text{Area Load} / 100{,}000 / \text{boiler eff} * \text{Bin Hours}]$

$\text{Therms}_{\text{PROPOSED}} = \Sigma\ [500 * \text{GPM} * (\text{HW Supply Temp}_{\text{PROP}} - \text{HW Return Temp}) * \text{Area Load} / 100{,}000 / \text{boiler eff} * \text{Bin Hours}]$

Where:

500 = Water sensible heat formula constant[5]

GPM = Average gallons per minute of heating water during heating season (= user defined)

HW Supply Temp$_{\text{BASE}}$ = Existing hot water maximum supply temperature in °F (= user defined)

HW Supply Temp$_{\text{PROP}}$ = Proposed hot water reset curve temperature in °F (= user defined)

HW Return Temp = Hot water return temperature (= estimated based on OAT and hottest water supply temperature in the system; return temperature schedule is a constant between baseline and proposed used to model heat loss reduction

Area Load = Percentage of area load based on linear interpolation of a 60°F dry bulb OAT balance point, bin data dry bulb OAT, and 2.5% dry bulb design summer/winter conditions for different Wisconsin cities;[6] see Assumptions for more explanation of 2.5% dry bulb design conditions

100,000 = Conversion from Btu to therm

boiler eff = Efficiency of natural gas to heat conversion for heating purposes (= 80%)

Bin Hours = Dry-bulb temperature and time of day (also known as temperature bin data) (= based on statewide BIN weather data)[4]

The workbook calculator requires the following measure-specific inputs provided from the trained professional performing the tune-up/optimization measure:

- Actual average heating water supply loop flow rate (GPM) if known, or at ΔT=20°F conditions (can be listed or calculated based on boiler output rating)
- Boiler input MBh and efficiency rating (used for incentive calculation purposes)
- Existing constant hot water setpoint temperature
- Existing OAT hot water reset range along with corresponding maximum and minimum setpoints (°F; if prior reset strategy was in place)
- New OAT hot water reset range along with corresponding maximum and minimum setpoints (°F)

Summer Coincident Peak Savings Algorithm

There is no peak demand reduction for this measure.

Lifecycle Energy-Savings Algorithm

$\text{Therm}_{\text{LIFECYCLE}} = \text{Therm}_{\text{SAVED}} * \text{EUL}$

Where:

EUL = Effective useful life (=5 years)[1]

Assumptions

- Return water temperature schedule is assumed to be at ΔT=30°F for the coldest OAT and at ΔT=10°F for the warmest OAT compared to the existing hot water heating setpoint.[5]
- Assumed that the return water temperature schedule across the OAT range will stay the same between existing and hot water reset schedule to model the reduction of heat losses and subsequent energy savings.
- Assumed a constant GPM flow rate (should be based on the heating season average GPM if possible, or the rated boiler flow rate when boiler is at ΔT=20°F operation).
- Assumed that the hot water setpoint at minimum OAT range will be greater than or equal to the existing hot water setpoint constant.

- If hot water reset temperatures at higher OAT dip below the constant estimated for return water scheduled temperatures, then the hot water reset supply temperature will equal the calculated return temperature (since it effectively shuts off the boiler).
- Assumed that boiler operation occurs only during periods when OAT < 60°F.
- Assumed that the HVAC service professional making adjustment ensures that boiler return water will stay above the boiler minimum.
- 2.5% dry bulb design conditions means that for cooling/heating seasons, the HVAC system is designed to adequately handle the building cooling/heating for all outdoor air temperatures that do not exceed the hottest/coldest 2.5% of hours of the respective season. Explained another way, this means that the cooling/heating system can adequately handle the cooling/heating load of a given building for 97.5% of the total anticipated peak cooling/heating hours for the year.

Sources

1. Cadmus. *EUL Response Memo.* April 26, 2013. Used the RCx Program EUL standard and direction from CB&I to keep 5 year EUL standard).
2. RSMeans 2013 Facilities Construction Cost Data, 29th Edition
3. Wisconsin Focus on Energy. EBTU Measures Workbook Calculator.
4. Natural Renewable Energy Laboratory. Bin temperature data comes from respective Wisconsin cities TMY3 weather data. Available online: http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html#W
5. Edison Electric Institute. *Technical Information Handbook*. Pg. 24. 2000.
6. ASHRAE. *Handbook, Fundamentals Volume for Wisconsin Cities*. 1985. Available online: http://publicecodes.cyberregs.com/icod/ipc/2012/icod_ipc_2012_appd.htm

Revision History

Version Number	Date	Description of Change
01	08/10/2015	Initial TRM entry

Outside Air Intake Control Optimization

	Measure Details
Measure Master ID	Outside Air Intake Control Optimization, 3663
Measure Unit	Per CFM reduced
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Commercial, Industrial, Schools & Government
Annual Energy Savings (kWh)	Varies by baseline and proposed energy consumption
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by baseline and proposed energy consumption
Lifecycle Energy Savings (kWh)	Varies by baseline and proposed energy consumption
Lifecycle Therm Savings (Therms)	Varies by baseline and proposed energy consumption
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Incremental Cost ($/unit)	$212.00[2]

Measure Description

The intent of this measure is to capture savings associated with reducing outside air (OA) supply CFM to a minimum. The outside air intake levels should always conform to local codes and ASHRAE 62.1 standards. This measure applies to buildings that currently do not use a variable outside air intake control strategy. Measure can be applied only once per building during the EUL. This measure is meant to be a part of the Express Building Tune-Up Program to help optimize building HVAC systems to operate more efficiently at existing building load conditions. It does not apply to newly constructed facilities that have not been commissioned.

Description of Baseline Condition

The baseline measure is an eligible building that a qualified HVAC control professional has verified can save energy by reducing the outside air intake CFM compared to existing levels. The building must currently exceed the minimum outside air intake levels for standard occupancy as defined by local or state requirements.

Description of Efficient Condition

The efficient measure is having a trained HVAC professional determine an appropriate adjustment to the outside air intake levels that conforms to all applicable building codes but is reduced and will still meet the buildings requirements for proper ventilation. Measure rebates do not apply if the outside air CFM needs to increase.

Annual Energy-Savings Algorithm

Savings are determined by summing the baseline and proposed energy consumption formulas below across the bin data temperature ranges and corresponding bin temperature hours found in the EBTU workbook.[3,4]

$kWh_{SAVED} = (Btu_{BASELINE} – Btu_{PROPOSED}) / 12,000 * Chiller\_Eff + (Fan\ Energy_{BASE} - Fan\ Energy_{PROP})$

$Therm_{SAVED} = (Btu_{BASELINE} – Btu_{PROPOSED}) / 100,000 / Gas\ Eff$

$Btu_{BASELINE} = \Sigma\ (1.08 * OA\ existing\ supply\ CFM * |ST - OAT| * Bin\ Hours)$

$Btu_{PROPOSED} = \Sigma\ (1.08 * OA\ proposed\ supply\ CFM * |ST - OAT| * Bin\ Hours)$

$Fan\ Energy_{BASE} = Supply\ Fan\ HP * 0.7465 * Load\ Factor / Fan\ motor\ Efficiency * annual\ hours\ of\ fan\ operation$

$Fan\ Energy_{PROP} = Supply\ Fan\ HP * (OA\ proposed\ supply\ CFM / OA\ existing\ supply\ CFM) \wedge 2.5 * 0.7465 * Load\ Factor / Fan\ motor\ Efficiency * annual\ hours\ of\ fan\ operation$

Where:

1.08 = Constant for air sensible heat equation[5]

OA existing supply CFM = Actual outside air supply airflow (= based on user input)

ST = Building setpoint temperature (= 70°F for OAT > 60°F = 75°F for OAT < 60°F)

OAT = Outside air temperature (= determined by Wisconsin BIN data in EBTU workbook)[4]

Bin Hours = Dry-bulb temperature and time of day (also known as temperature bin data)

OA proposed supply CFM = Proposed air supply airflow (= based on user input) (= based on user input)

12,000 = Conversion factor from Btu to tons

Chiller_Eff = Kilowatts per ton (= varies by chiller type based on 80% of full load rating, see table below)

Cooling Efficiency by System Type

Cooling System Type	Cooling System Efficiency Factor at Partial Load (kW/ton)
Direct Expansion	1.15[6]
Air-Cooled Chiller	0.95[7]
Water-Cooled Chiller	0.64[7]

Supply Fan HP = Horsepower of supply fan (= based on user input)

0.7465 = Conversion from horsepower to kW

Load Factor = Ratio of average demand to maximum demand (= 80%)

Fan motor efficiency = Ratio between power transferred to the airflow and the power used by the fan (= actual motor nameplate rating)

Annual hours of fan operation = Hours in use (= based on user input)

2.5 = Fan affinity law

100,000 = Conversion from Btu to therm

Gas Eff = Efficency of gas unit (= 80%)

The workbook calculator requires the following measure-specific inputs to be provided from the trained professional performing the tune-up/optimization measure:

- Existing outside air intake volume in CFM
- Modified outside air intake volume in CFM (must still meet code minimum for carbon dioxide level control)
- Air supply fan size (hp)
- Number of hours outside air supply fan runs annually

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} / Hours_{COOL} * CF$

Where:

$Hours_{COOL}$ = Annual cooling hours of operation (= varies by city; see table below)

Annual Cooling Hours by City[8]

City	BIN Annual Cooling Hours (OAT > 60°F)
Green Bay	2,748
La Crosse	2,971
Madison	2,876
Milwaukee	2,830

CF = Coincidence factor (= 1 assuming that the reduction of outside air intake CFM will be constant over entire summer peak period)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (=5 years)[1]

Assumptions

- Partial load kW/ton rating for DX, air cooled, and water cooled chillers is the average of the IEER and IPLV minimum efficiency values.[6,7]
- Assumed use of 1 CFM of total supply air per square foot of conditioned building space.
- Assumed heating and cooling balance temperature of 60°F

Sources

1. Cadmus. EUL Response Memo. April 26, 2013. Used the RCx Program EUL standard and direction from CB&I to keep 5 year EUL standard.
2. RSMeans 2013 Facilities Construction Cost Data, 29th Edition
3. Wisconsin Focus on Energy. EBTU Measures Workbook Calculator.
4. Natural Renewable Energy Laboratory. Bin temperature data comes from respective Wisconsin cities TMY3 weather data. Available online: http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html#W
5. Edison Electric Institute. Technical Information Handbook. Pg. 24. 2000.
6. International Energy Conservation Code. Table 503.2.3(1). 2009. DX cooling efficiency values determined from simple average of minimum efficiencies for systems with ≥ 5.5 ton capacity.
7. ASHRAE 90.1-2007, Table 6.8.1C. Chiller unit part load efficiency values determined from simple average of minimum efficiencies for chillers with capacity 0 tons to 300 tons.
8. Wisconsin Focus on Energy. Technical Reference Manual. Pg. 389, Outside Air Temperature Bin Analysis. January 2015.

Revision History

Version Number	Date	Description of Change
01	11/2014	Initial TRM entry

Retrocommissioning, Express Building Tune-Up

	Measure Details
Measure Master ID	Retrocommissioning, Express Building Tune-Up, 3224
Measure Unit	Per project
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by project
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by project
Lifecycle Energy Savings (kWh)	Varies by project
Lifecycle Therm Savings (Therms)	Varies by project
Water Savings (gal/yr)	0
Effective Useful Life (years)	5 [1]
Incremental Cost ($/unit)	Actual Project Cost[2]

Measure Description

The Retrocommissioning Lite Program is an expansion to the Retrocommissioning Program, making retrocommissioning services available to customers without complex systems or large buildings that operate at a high cost per square foot. In addition, the program is focused on addressing deficiencies in mechanical and electrical systems to reduce energy consumption and operating costs while minimizing the out-of-pocket cost to the customer.

Mechanical issues that cause energy waste are frequently found in the targeted market segment. For example, motors are put in hand mode, broken damper actuators go unnoticed, and schedules set for the holiday shopping season are not set back to the current time of year. In most cases, targeted customers do not have a qualified facility manager onsite to identify the reason for increased energy consumption, and often lack awareness of the benefits associated with retrocommissioning services. In addition, they often have neither the resources nor the sufficient complexity to warrant a comprehensive audit. Because customers in the target demographic often cannot afford advanced energy efficiency services, these services are not invest marketed to them. This program raises awareness and offers package incentives for targeted customers to implement a highly focused set of low-cost measures.

Typical Details of Retrocommissioning Project

Measure Description	Peak Electric Demand Reduction (kW/Unit)	Electric Savings (kWh/Unit)	Natural Gas Savings (therms)	Incremental Measure Cost ($/unit)	Effective Useful Life (years)
Retrocommissioning Express Building Tune-Up: Typical Project Summary	0	37,500	1,875	$4,000.00	5

Description of Baseline Condition

The baseline condition is maintaining the current operations of the facility. This condition is documented during the comprehensive facility audit as a required pre-requisite to program participation.

Description of Efficient Condition

The efficient condition is implementing all, or part, of the recommended measures identified through the comprehensive facility audit mechanism. The savings for the efficiency improvements will be determined for each individual measure (e.g., setpoint adjustments, sensor calibrations) within the given facilities. Then, upon final implementation of the measures, the total energy savings through the efficiency improvements will be provided at the project level.

Annual Energy-Savings Algorithm

Annual energy savings methodologies will be used within the individual measure workbooks (or end use workbooks) to calculate the potential savings within a given facility. These savings will be provided at the project level upon implementation of the prescribed efficiency improvements.

Summer Coincident Peak Savings Algorithm

No peak demand reduction has been identified for this offering.

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 5 years)

Assumptions

The energy savings associated with the Retrocommissioning Lite Program will be determined through engineered workbooks that account for specific facility inputs, along with industry accepted standards and methodologies. The project savings will predominantly be achieved through optimizing four different measure end-use categories within the facility: Air-Side, Water-Side, Chiller Plant, and Lighting.

Annual energy savings are determined through engineering workbooks for both electric (gross kWh) and natural gas savings (gross therms).

The measure workbooks use assumptions based on accepted engineering methodologies, industry codes, and standards.

Sources

1. RCx Lite End Measure and End Use Engineering Summary. April 24, 2013.
2. Actual Project Cost

Revision History

Version Number	Date	Description of Change
01	04/26/2013	Initial TRM entry

Schedule Optimization

	Measure Details
Measure Master ID	Schedule Optimization: Weekday: Heating, 0-50,000 square feet, 3664 Cooling, 0-50,000 square feet, 3665 Heating, 50,000-100,000 square feet, 3668 Cooling, 50,000-100,000 square feet, 3669 Weekend: Heating, 0-50,000 square feet, 3666 Cooling, 0-50,000 square feet, 3667 Heating, 50,000-100,000 square feet, 3670 Cooling, 50,000-100,000 square feet, 3671
Measure Unit	Per hour reduction
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Commercial, Industrial, Schools & Government
Annual Energy Savings (kWh)	Varies by type of schedule optimization
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by type of schedule optimization
Lifecycle Energy Savings (kWh)	Varies by type of schedule optimization
Lifecycle Therm Savings (Therms)	Varies by type of schedule optimization
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Incremental Cost ($/unit)	$168.00[2]

Measure Description

This measure captures savings associated with resetting the scheduled weekly building nighttime (or unoccupied) supply air setpoint temperatures via programmable thermostats or direct digital control (DDC) systems. This is a simple temperature setback measure and not a temperature reset control strategy.

For this measures' savings to apply, the heating supply fuel must be natural gas, and cooling must be supplied by an electrically powered system. The measure can be applied only once per building during the EUL. This measure is meant to be a part of the Express Building Tune-Up Program to help optimize buildings HVAC systems to operate more efficiently at existing building load conditions. It does not apply to newly constructed facilities that have not been commissioned.

Description of Baseline Condition

The baseline measure is a building that already has an HVAC system not using its hourly setback scheduling or a building that can increase its scheduled setback hours. Building must have a consistent weekly operation schedule throughout the year. A buildings standard heating and cooling schedule are both eligible for adjustment.

Description of Efficient Condition

This efficient measure is an increased number of scheduled setback hours controlled through a building programmable HVAC system. A buildings' standard daily scheduled setback time must be increased by at least 1 hour during the weekdays or weekends to be eligible for an incentive.

Annual Energy-Savings Algorithm

Savings are the sum of the baseline and proposed energy consumption formulas below across the bin data temperature ranges and corresponding bin temperature hours.[3,4]

Energy savings are effectively summed over every hour of the year, effectively assuming that the same hour of the day (e.g., 1:00 a.m. to 2:00 a.m.) for each day in a given month will yield the same Btu/hour of energy use.

$kWh_{SAVED} = kWh_{BASELINE} - kWh_{PROPOSED}$

$Therm_{SAVED} = Therm_{BASELINE} - Therm_{PROPOSED}$

$kWh_{BASELINE} = \Sigma_{EXISTING}$ (1.08 * Hourly CFM * |SAT – MAT| * # of days per month / 12,000 * chiller_eff)

$Therm_{BASELINE} = \Sigma_{EXISTING}$ (1.08 * Hourly CFM * |SAT - MAT| * # of days per month / 100,000 / boiler_eff)

Baseline data is based on user-defined existing building schedule.

$kWh_{PROPOSED} = \Sigma_{PROPOSED}$ (1.08 * Hourly CFM * |SAT - MAT| * # of days per month / 12,000 * chiller_eff)

$Therm_{PROPOSED} = \Sigma_{PROPOSED}$ (1.08 * Hourly CFM * |SAT - MAT| * # of days per month / 100,000 / boiler_eff)

Proposed data is based on user-defined proposed building schedule, and should reflect a reduction of HVAC/occupied hours compared to baseline.

Where:

1.08 = Constant for air sensible heat equation[5]

Hourly CFM = Total building airflow in CFM * hourly area load (where the area load is a percentage value based on a linear interpolation of a 60°F dry bulb OAT balance point, bin data dry bulb OAT, and 2.5% dry bulb design summer/winter conditions for different Wisconsin cities.[6] See the Assumptions section for more explanation about the 2.5% dry bulb design conditions)

SAT = Supply air temperature for occupied hours (= 60°F for OAT > 60°F, 75°F for OAT ≤ 60°F); for scheduled unoccupied temperature setback hours, SAT = standard occupied hour temperature setting ± user-defined setback temperature for cooling and heating periods, respectively

MAT = (RAT * Return Air CFM + Weighted Average Hourly Temperature * Outside Air CFM) / Total Airflow CFM

Where:

RAT = Return air temperature (75°F for OAT > 60°F, 68°F for OAT ≤ 60°F)

Return Air CFM = Total airflow CFM - Outside Air CFM

Weighted Average Hourly Temperature = Calculated based on the maximum and minimum temperatures over every given hour of the day and number of occurrences per month based on bin data[3]

Outside Air CFM = Amount of outside air expected based on facility type and square footage as determined through CBECS statistical data inserted in the EBTU workbook[7,3]

Total Airflow CFM = 1 CFM per square foot of facility space

# of days per month = Variable by month (= 31 in January; = 28 in February; etc.)

12,000 = Btu to ton conversion factor

chiller_eff = Cooling efficiency of chiller (= varies by chiller type; see table below)

Cooling Efficiency by System Type

Cooling System Type	Cooling System Efficiency Factor at Partial Load Rating (kW/ton)
Direct Expansion	1.15[8]
Air-Cooled Chiller	0.95[9]
Water-Cooled Chiller	0.64[9]

100,000 = Btu to therm conversion factor

boiler_eff = Efficiency of natural gas to heat conversion for heating purposes (= 80%)

The workbook calculator requires the following inputs to be provided from the trained professional performing the tune-up/optimization measure:

- Majority facility space type (e.g., offices, classroom, lobby, health club)
- Square footage of facility’s conditioned space affected by schedule change
- Baseline (pre) and efficient (post) heating and cooling schedule hours, indicating when the system turns on and off during a typical weekday and weekend in 24 hour time format
- Amount of planned temperature setback degrees during scheduled unoccupied times
- Type of facility cooling system (direct expansion, air cooled, or water cooled)

Summer Coincident Peak Savings Algorithm

There are no peak savings for this measure, as the temperature setback scheduling is not expected to occur during Wisconsin Focus on Energy peak demand hours of 1:00 p.m. to 4:00 p.m. from June through August.

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (=5 years)[1]

Assumptions

- RAT fixed values of (75°F for OAT > 60°F, 68°F for OAT < 60°F) for calculation purposes
- SAT setpoints are increased or decreased by 5°F during weekly scheduled unoccupied hours during cooling and heating periods, respectively
- Heating and cooling balance temperature of 60°F

- Therm savings are calculated when daily weighted hourly temperatures are less than 60°F
- kWh savings are calculated when daily weighted hourly temperatures are greater than 60°F
- Same average weekly hours schedule is repeated throughout the year
- Total supply is 1 CFM per building square foot
- 2.5% dry bulb design conditions for cooling/heating seasons means that the HVAC system is designed to adequately handle the cooling/heating of a given building for all outdoor air temperatures that do not exceed the hottest/coldest 2.5% of hours of the respective season. Explained put another way, it means the cooling/heating system can adequately handle the cooling/heating load of a given building for 97.5% of the total anticipated peak cooling/heating hours for the year.

Sources

1. Cadmus. EUL Response Memo. April 26, 2013. (Used RCx Program EUL standard and direction from CB&I to keep five year EUL standard)
2. RSMeans 2013 Facilities Construction Cost Data, 29th Edition
3. Wisconsin Focus on Energy. EBTU Measures Workbook Calculator.
4. Natural Renewable Energy Laboratory. Bin temperature data comes from respective Wisconsin cities TMY3 weather data. Available online: http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html#W
5. Edison Electric Institute. Technical Information Handbook. Pg. 24. 2000.
6. ASHRAE Handbook, Fundamentals Volume for Wisconsin Cities. 1985. Available online: http://publicecodes.cyberregs.com/icod/ipc/2012/icod_ipc_2012_appd.htm
7. U.S. Energy Information Administration. "2003 CBECS Survey Data." http://www.eia.gov/consumption/commercial/data/2003/
8. International Energy Conservation Code. Table 503.2.3(1). 2009. (Direct expansion cooling efficiency values determined as simple averages of minimum efficiencies for system capacities of ≥ 5.5 tons).
9. ASHRAE 90.1-2007, Table 6.8.1C. (Chiller unit part load efficiency values determined as simple averages of minimum efficiencies, for chillers with capacity of 0 tons to 300 tons).

Revision History

Version Number	Date	Description of Change
01	11/2014	Initial TRM entry

Supply Air Temperature Reset

	Measure Details
Measure Master ID	Supply Air Temperature Reset, Heating, 3672 Supply Air Temperature Reset, Cooling, 3673
Measure Unit	Per degree Fahrenheit
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Commercial, Industrial, Schools & Government
Annual Energy Savings (kWh)	Varies by type of reset
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by type of reset
Lifecycle Energy Savings (kWh)	Varies by type of reset
Lifecycle Therm Savings (Therms)	Varies by type of reset
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Incremental Cost ($/unit)	$96.00[2]

Measure Description

This measure captures savings associated with implementing a new supply air temperature (SAT), cooling or heating, reset strategy or optimizing a programmed SAT reset strategy based on OAT ranges. To claim the measure savings, the heating must be supplied by a natural gas boiler, and the cooling system must be electrically powered. The savings apply specifically to constant air volume (CAV) systems.

This measure is meant to be a part of the Express Building Tune-Up Program to help optimize building HVAC systems to operate more efficiently at existing building load conditions. It does not apply to newly constructed facilities that have not been commissioned.

Description of Baseline Condition

This baseline measure is an HVAC system with preset SAT setpoints that are not based on OAT.

Description of Efficient Condition

This efficient measure is implementing or optimizing an SAT reset strategy based on OAT. The reset strategy should incorporate a maximum and minimum supply air temperature for both heating and cooling modes to correspond with a minimum and maximum outdoor air temperature range, respectively.

Annual Energy-Savings Algorithm

Savings are the sum of the baseline and proposed energy consumption formulas below across the bin data temperature ranges and corresponding bin temperature hours.[3,4]

$\text{kWh}_{\text{SAVED}}$ = Σ (SAT Btu Baseline – SAT Btu Proposed) / 12,000 * chiller_eff * % building affected

$\text{Therm}_{\text{SAVED}}$ = Σ (SAT Btu Baseline – SAT Btu Proposed) / 100,000 / boiler_eff * % building affected

SAT Btu Baseline = [(1.08 * Area_Load * $|\text{SAT}_{\text{BASE}}$ - OAT$|$ * Outside Air CFM + 1.08 * Area_Load * $|\text{SAT}_{\text{BASE}}$ - RAT$|$ * Return Air CFM] * bin hours

SAT Btu Proposed = [(1.08 * Area_Load * $|\text{SAT}_{\text{RESET}}$ - OAT$|$ * Outside Air CFM + 1.08 * Area_Load * $|\text{SAT}_{\text{RESET}}$ - RAT$|$ * Return Air CFM] * bin hours

Where:

1.08 = Constant for air sensible heat equation[5]

Area Load = Percentage value based on linear interpolation of a 60°F dry bulb OAT balance point, bin data dry bulb OAT, and 2.5% dry bulb design summer/winter conditions for different Wisconsin cities[6] (see Assumptions for more explanation about the 2.5% dry bulb design conditions)

SAT_{BASE} = Supply air temperature baseline (= user defined input; constant)

OAT = Outside Air Temperature (= determined from workbook bin data)

Outside Air CFM = Amount of outside air expected based on facility type and square footage as determined through CBECS statistical data inserted in the EBTU workbook[7,3]

RAT = Return air temperature (= 75°F for OAT > 60°F; = 68°F for OAT < 60°F)

Return Air CFM = Total building airflow – Outside Air CFM

bin hours = Heating and cooling hours for each city based on OAT[4]

$\text{SAT}_{\text{RESET}}$ = OAT reset range (= user input)

12,000 = Btu to ton conversion factor

chiller_eff = Cooling efficiency of chiller (= varies by chiller type; see table below)

Cooling Efficiency by System Type

Cooling System Type	Cooling System Efficiency Factor at Partial Load (kW/ton)
Direct Expansion	1.15[8]
Air-Cooled Chiller	0.95[9]
Water-Cooled Chiller	0.64[9]

% building affected = Amount of total building conditioned square footage affected by implementing the SAT reset control (= user defined input)

100,000 = Btu to therm conversion factor

boiler_eff = Efficiency of natural gas to heat conversion for heating purposes (= 80%)

The workbook calculator requires the following measure-specific inputs to be provided from the trained professional performing the tune-up/optimization measure:

- OAT Reset Range – Heating and Cooling (°F)
- Existing Facility Supply Air Heating and Cooling Temperature Setpoints (°F)
- SA Reset Temperature Range – Heating and Cooling (°F)
- Facility Type (e.g., office, library, retail)
- Useable Facility Square Footage
- Percentage of Total Facility Area Cooled
- Percentage of Total Facility Area Heated
- Number of Building Zones Affected
- Type of Chiller System
- Percentage of Building Square Footage Affected

Summer Coincident Peak Savings Algorithm

There is no peak demand reduction associated with this measure because during peak demand times, the cooling system will be operating above the bounds of the SAT reset curve.

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 5 years)[1]

Assumptions

- Partial load kW/ton rating for air cooled and water cooled chillers is average IPLV minimum efficiency value found in Focus on Energy HVAC catalog[9]
- Total supply of 1 CFM per building conditioned square foot

- Heating and cooling balance temperature = 60°F
- 2.5% dry bulb design conditions means that for cooling/heating seasons, the HVAC system is designed to adequately handle the cooling/heating of a given building for all outdoor air temperatures that do not exceed the hottest/coldest 2.5% of hours of the respective season. Explained another way, this means the cooling/heating system can adequately handle the cooling/heating load of a given building for 97.5% of the total anticipated peak cooling/heating hours for the year.

Sources

1. Cadmus. EUL Response Memo. April 26, 2013.(Used RCx Program EUL standard and direction from CB&I to keep 5 year EUL standard)
2. RSMeans 2013 Facilities Construction Cost Data, 29th Edition
3. Wisconsin Focus on Energy. EBTU Measures Workbook Calculator.
4. Natural Renewable Energy Laboratory. Bin temperature data comes from respective Wisconsin cities TMY3 weather data. Available online: http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html#W
5. Edison Electric Institute. Technical Information Handbook. Pg. 24. 2000.
6. ASHRAE. Handbook, Fundamentals Volume for Wisconsin Cities. 1985. Available online: http://publicecodes.cyberregs.com/icod/ipc/2012/icod_ipc_2012_appd.htm
7. U.S. Energy Information Administration. National CBECS Statistical Data. 2003. Available online: http://www.eia.gov/consumption/commercial/data/2003/
8. International Energy Conservation Code. Table 503.2.3(1). 2009. DX cooling efficiency values determined as simple average minimum efficiencies for systems with capacity ≥ 5.5 tons.
9. ASHRAE 90.1-2007. Table 6.8.1C. Chiller unit part load efficiency values are simple average minimum efficiencies for chillers with capacity of 0 tons to 300 tons.

Revision History

Version Number	Date	Description of Change
01	11/2014	Initial TRM entry

Temperature Sensor Calibration

	Measure Details
Measure Master ID	Temperature Sensor Calibration, 3674
Measure Unit	Per degree of calibration
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Commercial, Industrial, Schools & Government
Annual Energy Savings (kWh)	Varies by temperature ranges and hours
Peak Demand Reduction (kW)	Varies by temperature ranges and hours
Annual Therm Savings (Therms)	Varies by temperature ranges and hours
Lifecycle Energy Savings (kWh)	Varies by temperature ranges and hours
Lifecycle Therm Savings (Therms)	Varies by temperature ranges and hours
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Incremental Cost ($/unit)	$108.00[2]

Measure Description

This measure captures savings by calibrating temperature sensors in an air handling unit feeding a particular building zone. The measure savings are specific to air distribution systems, but are otherwise flexible. This measure does not include the cost to replace sensors that have completely failed.

To apply measure savings, the heating supply must be produced by a natural gas boiler, while the cooling system must be electrically powered. The measure can be applied only once per building during the EUL. This measure is meant to be a part of the Express Building Tune-Up Program to help optimize building HVAC systems to operate more efficiently at existing building load conditions. It does not apply to newly constructed facilities that have not been commissioned.

This measure is applicable for supply air temperature (SAT) and indoor air room temperature (IAT) sensors that are measuring and providing control feedback to the building HVAC systems.

Description of Baseline Condition

The baseline measure is a facility’s SAT and IAT sensors not having been calibrated and no Wisconsin Focus on Energy rebate applied for at least five years.

Description of Efficient Condition

The efficient measure is to re-calibrate SAT and IAT sensors by averaging three separate temperature readings with a secondary calibrated temperature device within close proximity of the sensor to be calibrated. This will determine the amount the facility temperature sensors are off from actual in order to make the necessary calibrations. The recalibrated sensors will help ensure that excess energy is not being wasted to heat or cool a space. Broken sensors that need total replacement are not eligible. Calibrated sensors should be adjusted to within two decimal places.

Annual Energy-Savings Algorithm

Savings are the sum of the baseline and proposed energy consumption formulas below across the bin data temperature ranges and corresponding bin temperature hours found in the EBTU workbook.[3,4]

kWh_{SAVED} = Σ (Temp Sensor cooling Btu Baseline – Temp Sensor cooling Btu Proposed) / 12,000 * chiller_eff * % building affected * bin hours

$Therm_{SAVED}$ = Σ (Temp Sensor heating Btu Baseline – Temp Sensor heating Btu Proposed) / 80% / 100,000 * % building affected * bin hours

Temp Sensor cooling/heating Btu Baseline = 1.08 * $Area\_Load_{BASE}$ * |SAT - OAT| * Outside Air CFM + 1.08 * $Area\_Load_{BASE}$ * Δ(SAT - RAT) * Return Air CFM

Temp Sensor cooling/heating Btu Proposed = 1.08 * $Area\_Load_{PROP}$ * |SAT - OAT| * Outside Air CFM + 1.08 * $Area\_Load_{PROP}$ * Δ(SAT - RAT) * Return Air CFM

Where:

1.08 = Constant for air sensible heat equation[5]

$Area\_Load_{BASE}$ = Percentage value based on linear interpolation of a 60°F dry bulb OAT balance point, bin data dry bulb OAT, and 2.5% dry bulb design summer/winter conditions for different Wisconsin cities[6] (see Assumptions for more explanation about the 2.5% dry bulb design conditions)

SAT = Supply air temperature (= 60°F for OAT > 60°F; = 75°F for OAT < 60°F)

OAT = Outside air temperature

Outside Air CFM = Amount of outside air expected based on facility type and square footage as determined through CBECS statistical data inserted in the EBTU workbook[7,3]

RAT = Return air temperature (= 75°F for OAT > 60°F; = 68°F for OAT < 60°F)

Return Air CFM = Total building airflow – Outside Air CFM (per zone)

$Area\_Load_{PROP}$ = Percentage value based on linear interpolation of a 60°F dry bulb OAT balance point, bin data dry bulb OAT ± calibrated values, and 2.5%

dry bulb design maximum/minimum temperatures for different Wisconsin cities[6]

12,000 = Btu to ton conversion factor

chiller_eff = kW/ton based on 80% of full load rating of chiller units (= based on type of chiller; see table below)

Cooling Efficiency by System Type

Cooling System Type	Cooling System Efficiency Factor at Partial Load (kW/ton)
Direct Expansion	1.15[8]
Air-Cooled Chiller	0.95[9]
Water-Cooled Chiller	0.64[9]

% building affected = Amount of total building square footage affected by sensor calibration (= user defined)

bin hours = Heating and cooling hours for each city based on OAT[4]

80% = Efficiency of natural gas to heat conversion for heating purposes

100,000 = Btu to therm conversion factor

The workbook calculator requires the following measure-specific inputs to be provided from the trained professional performing the tune-up/optimization measure:

- An average of three separate measurement reading of the un-calibrated air handling unit temperature sensor to determine the current baseline reading (measurements should be out two decimal places)
- An average of three separate temperature readings of the calibrated air flowing near the un-calibrated temperature sensor, used to read and calibrate the un-calibrated sensor (measurements should be out two decimal places)
- Majority facility space type (e.g., offices, classroom, lobby, health club)
- Percentage of facility being heated
- Percentage of facility being cooled
- Square footage of usable facility space
- Chiller system type (direct expansion, air cooled, or water cooled)

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} / Hours_{COOL} * CF$

Where:

$Hours_{COOL}$ = Annual cooling hours of operation (= based on city; see table below)

Annual Cooling Hours by City

City	BIN Annual Cooling Hours (OAT > 60°F)[10]
Green Bay	2,745
La Crosse	2,971
Madison	2,874
Milwaukee	2,830

CF = Coincidence factor (= 1)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (=5 years)[1]

Assumptions

- Therm savings are calculated only when the calibrated reading is greater than the original sensors reading
- kWh savings are calculated only when the calibrated reading is less than the original sensor reading
- Heating and cooling balance temperature = 60°F
- Total supply of 1 CFM per building square foot
- 2.5% dry bulb design conditions means that for cooling/heating seasons, the HVAC system is designed to adequately handle the cooling/heating of a given building for all outdoor air temperatures that do not exceed the hottest/coldest 2.5% of hours of the respective season. Explained another way, this means the cooling/heating system can adequately handle the cooling/heating load of a given building for 97.5% of the total anticipated peak cooling/heating hours for the year.

Sources

1. Cadmus. EUL Response Memo. April 26, 2013.(Used RCx Program EUL standard and direction from CB&I to keep 5 year EUL standard)
2. RSMeans 2013 Facilities Construction Cost Data, 29th Edition
3. Wisconsin Focus on Energy. EBTU Measures Workbook Calculator.
4. Natural Renewable Energy Laboratory. Bin temperature data comes from respective Wisconsin cities TMY3 weather data. Available online: http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html#W
5. Edison Electric Institute. Technical Information Handbook. Pg. 24. 2000.
6. ASHRAE. Handbook, Fundamentals Volume for Wisconsin Cities. 1985. Available online: http://publicecodes.cyberregs.com/icod/ipc/2012/icod_ipc_2012_appd.htm
7. U.S. Energy Information Administration. National CBECS Statistical Data. 2003. Available online: http://www.eia.gov/consumption/commercial/data/2003/
8. International Energy Conservation Code. Table 503.2.3(1). 2009. DX cooling efficiency values determined as simple average minimum efficiencies for systems with capacity ≥ 5.5 tons.
9. ASHRAE 90.1-2007. Table 6.8.1C. Chiller unit part load efficiency values are simple average minimum efficiencies for chillers with capacity of 0 tons to 300 tons.
10. Wisconsin Focus on Energy Technical Reference Manual. Outside Air Temperature Bin Analysis, pg. 389. January 2015.

Revision History

Version Number	Date	Description of Change
01	11/2014	Initial TRM entry

Valve Repair

	Measure Details
Measure Master ID	Valve Repair, Chilled Water, 3675 Valve Repair, Hot Water, 3676
Measure Unit	Per MBh
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by type of repair
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by type of repair
Lifecycle Energy Savings (kWh)	Varies by type of repair
Lifecycle Therm Savings (Therms)	Varies by type of repair
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Incremental Cost ($/unit)	$112.00[2]

Measure Description

This measure captures savings associated with repairing a chilled or hot water valve serving a cooling/heating coil in a central air handling unit. This measure is for addressing a valve that has a 70% failure rate at open or higher.

The incremental cost does not account for the potential replacement of unrepairable/broken valves. The heating supply must be produced by a natural gas boiler, and the cooling system must be electrically powered. The measure can be applied only once per building during the EUL. This measure is meant to be a part of the Express Building Tune-Up Program to help optimize building HVAC systems to operate more efficiently at existing building load conditions. It does not apply to newly constructed facilities that have not been commissioned.

Description of Baseline Condition

The baseline measure is a chilled or hot water valve in need of repair due to being stuck open at 70% or greater. If the valve is stuck at some point less than 70% open, this measure does not apply.

Description of Efficient Condition

The efficient measure is replacing or repairing a failed valve back to its optimal working state.

Annual Energy-Savings Algorithm

Savings are the sum of the baseline and proposed energy consumption formulas below across the bin data temperature ranges and corresponding bin temperature hours found in the EBTU workbook.[3,4]

kWh_{SAVED} = Σ [(Valve cooling Btu Baseline – Valve cooling Btu Proposed) / 12,000 * chiller_eff * Adjusted Hours]

$Therm_{SAVED}$ = Σ [(Valve heating Btu Baseline – Valve heating Btu Proposed) / 80% / 100,000 * Adjusted Hours]

Valve heating/cooling Btu Baseline = Capacity of heat_cool coil being served * 1,000 * stuck valve position % * Area Load

Valve heating/cooling Btu Proposed = Capacity of heat_cool coil being served * 1,000 * working valve position % * Area Load

Where:

Capacity of heat_cool coil being served = Expressed in MBh or Tons (= user defined; MBh for chilled water = # tons * 12)

1,000 = Kilowatt conversion factor

Stuck valve position % = Percentage open (= user defined)

Area Load = Percentage value based on linear interpolation of a 60°F dry bulb OAT balance point, bin data dry bulb OAT, and 2.5% dry bulb design summer/winter conditions for different Wisconsin cities[5] (see Assumptions for more explanation about the 2.5% dry bulb design conditions)

Working valve position % = Workbook-calculated value based on bin data OAT

12,000 = Btu to ton conversion factor

chiller_eff = Efficiency of cooling system in kilowatts per ton (= based on type of chiller; see table below)

Cooling Efficiency by System Type

Chiller Type	Cooling System Efficiency Factor at Partial Load (kW/ton)
Air-Cooled	0.95[6]
Water-Cooled	0.64[6]

Adjusted Hours = Bin hours * EFLH (see table below) / 8,760 total annual hours[4]

EFLH = Equivalent Full Load Hours

8,760 = Total hours in a year

Bin Hours = The number of average hours of occurrence during a month or year of a particular range of weather condition

Equivalent Full-Load Heating and Cooling Hours by City

City	$EFLH_{COOL}$[7]	$EFLH_{HEAT}$[7]
Green Bay	344	1,852
La Crosse	323	1,966
Madison	395	1,934
Milwaukee	457	1,883

80% = Efficiency of natural gas to heat conversion for heating purposes

100,000 = Btu to therm conversion factor

Summer Coincident Peak Savings Algorithm

There are no peak savings for this measure.

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (=5 years)[1]

Assumptions

- Heating and cooling balance temperature = 60°F
- 2.5% dry bulb design conditions means that for cooling/heating seasons, the HVAC system is designed to adequately handle the cooling/heating of a given building for all outdoor air temperatures that do not exceed the hottest/coldest 2.5% of hours of the respective season. Explained another way, this means the cooling/heating system can adequately handle the cooling/heating load of a given building for 97.5% of the total anticipated peak cooling/heating hours for the year.

Sources

1. Cadmus. EUL Response Memo. April 26, 2013.(Used RCx Program EUL standard and direction from CB&I to keep 5 year EUL standard)
2. RSMeans 2013 Facilities Construction Cost Data, 29th Edition
3. Wisconsin Focus on Energy. EBTU Measures Workbook Calculator.
4. Natural Renewable Energy Laboratory. Bin temperature data comes from respective Wisconsin cities TMY3 weather data. Available online: http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html#W
5. ASHRAE. Handbook, Fundamentals Volume for Wisconsin Cities. 1985. Available online: http://publicecodes.cyberregs.com/icod/ipc/2012/icod_ipc_2012_appd.htm
6. ASHRAE 90.1-2007. Table 6.8.1C. Chiller unit part load efficiency values are simple average minimum efficiencies for chillers with capacity of 0 tons to 300 tons.
7. Several Cadmus metering studies reveal that the ENERGY STAR calculator EFLH are over-estimated by 25%. The EFLHHEAT were adjusted by population-weighted HDD and TMY-3 values.

Revision History

Version Number	Date	Description of Change
01	11/2014	Initial TRM entry

VFD Fan Motor Control Restoration

	Measure Details
Measure Master ID	VFD Fan Motor Control Restoration, 3677
Measure Unit	Per horsepower
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by temperature ranges and hours
Peak Demand Reduction (kW)	Varies by temperature ranges and hours
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by temperature ranges and hours
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Incremental Cost ($/unit)	$56.00[2]

Measure Description

This measure captures savings associated with correcting the operating setting on a variable frequency drive (VFD) controlling an HVAC system-related fan motor that is stuck in ‘hand’ mode or is in bypass mode. Measure rebate does not apply if the original VFD was incented by Wisconsin Focus on Energy. Measure rebate applies to all other VFDs only once per building during the EUL. This measure is meant to be a part of the Express Building Tune-Up Program to help optimize building HVAC systems to operate more efficiently at existing building load conditions. It does not apply to newly constructed facilities that have not been commissioned.

Description of Baseline Condition

The baseline measure is a fan motor in a facility using a VFD for motor control, but not using the ‘automatic’ VFD control features.

Description of Efficient Condition

The efficient measure is restoring the automatic control features of a VFD controlling a fan motor load. The VFD should not be manually altered in its control operation after being set to automatic mode.

Annual Energy-Savings Algorithm

Savings are the sum of the baseline and proposed energy consumption formulas below across the bin data temperature ranges and corresponding bin temperature hours found in the EBTU workbook.[3,4]

kWh_{SAVED} = VFD Motor Baseline - VFD Motor Proposed

VFD Motor Baseline = Σ [Motor hp * 0.7465 / Motor eff * (Motor loading $\%_{BASE}$)^2.5 * Adjusted Run Hours]

VFD Motor Proposed = Σ [Motor hp * 0.7465 / Motor eff * (Motor loading $\%_{PROP}$)^2.5 * Adjusted Run Hours]

Where:

Motor hp = VFD controlled motor nameplate horsepower rating

0.7465 = Horsepower to kW conversion factor

Motor eff = Specific VFD controlled motor nameplate efficiency; otherwise use default of 90%

Motor Loading $\%_{BASE}$ = Percent capacity (Load Factor) of motor at baseline (= user defined)

Adjusted Run Hours = Bin hours * (annual VFD operational hours / 8,760 annual hours)

Motor Loading $\%_{PROP}$ = Percent capacity (Load Factor) of motor proposed; assumes the VFD is set back to 'automatic' control based on user-defined loading minimum and maximum percentages and on area load (area load is a percentage based on a linear interpolation of a 60°F dry bulb OAT balance point, bin data dry bulb OAT, and 2.5% dry bulb design summer/winter conditions for different Wisconsin cities;[5] see Assumptions for more explanation about the 2.5% dry bulb design conditions)

The workbook calculator requires the following measure-specific inputs to be provided from the trained professional performing the tune-up/optimization measure:

- Annual hours of VFD/fan operation
- Fan VFD application (cooling tower fan, chiller system fan, boiler/heating fan)
- Existing VFD control state (auto, manual, bypassed/off)
- Fan motor nameplate capacity controlled by VFD (horsepower)
- Fan motor nameplate efficiency percentage
- Measured speed at set point if VFD is stuck in 'hand' mode (Hz)
- VFD fan control loading minimum and maximum percentages

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} / Hours_{FAN} * CF$

Where:

$Hours_{FAN}$ = Annual hours of operation for the fan controlled by the VFD

CF = Coincidence factor (= based on VFD fan use; see table below)

Coincidence Factor by VFD Fan Use[6]

VFD Use	CF	Details
Cooling Tower Fan	0.9	DEER model runs are weather-normalized for statewide use by population density
Boiler Draft/Heating Fan	0.0	Assumed that heating fan not operating at peak summer period

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (=5 years)[1]

Assumptions

- Assumes 100% load factor for all motors running in a VFD bypassed state.
- 2.5% dry bulb design conditions means that for cooling/heating seasons, the HVAC system is designed to adequately handle the cooling/heating of a given building for all outdoor air temperatures that do not exceed the hottest/coldest 2.5% of hours of the respective season. Explained another way, this means the cooling/heating system can adequately handle the cooling/heating load of a given building for 97.5% of the total anticipated peak cooling/heating hours for the year.

Sources

1. Cadmus. EUL Response Memo. April 26, 2013. Used the RCx Program EUL standard and direction from CB&I to keep 5 year EUL standard.
2. RSMeans 2013 Facilities Construction Cost Data, 29th Edition
3. Wisconsin Focus on Energy. EBTU Measures Workbook Calculator.
4. Natural Renewable Energy Laboratory. Bin temperature data comes from respective Wisconsin cities TMY3 weather data. Available online: http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html#W

5. ASHRAE. Handbook, Fundamentals Volume for Wisconsin Cities. 1985. Available online: http://publicecodes.cyberregs.com/icod/ipc/2012/icod_ipc_2012_appd.htm
6. Wisconsin Focus on Energy Technical Reference Manual. Pg. 225, Variable Frequency Drive, summer coincident peak savings algorithm VFD coincidence factor chart. 2015.

Revision History

Version Number	Date	Description of Change
01	10/2014	Initial TRM entry

VFD Pump Control Restoration

	Measure Details
Measure Master ID	VFD Pump Control Restoration, 3678
Measure Unit	Per horsepower
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by temperature ranges and hours
Peak Demand Reduction (kW)	Varies by temperature ranges and hours
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by temperature ranges and hours
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Incremental Cost ($/unit)	$56.00[2]

Measure Description

This measure captures savings associated with correcting the operating setting on a variable frequency drive (VFD) controlling an HVAC system-related pump motor that is stuck in ‘hand’ mode or is in bypass mode. Measure rebate does not apply if the original VFD was incented by Wisconsin Focus on Energy. Measure rebate applies to all other VFDs only once per building during the EUL. This measure is meant to be a part of the Express Building Tune-Up Program to help optimize building HVAC systems to operate more efficiently at existing building load conditions. It does not apply to newly constructed facilities that have not been commissioned.

Description of Baseline Condition

The baseline measure is a pump motor in a facility using a VFD for pump control, but not using the ‘automatic’ VFD control features.

Description of Efficient Condition

The efficient measure is restoring the automatic control features of a VFD controlling a pump load. The VFD should not be manually altered in its control operation after being set to automatic mode.

Annual Energy-Savings Algorithm

Savings are the sum of the baseline and proposed energy consumption formulas below across the bin data temperature ranges and corresponding bin temperature hours found in the EBTU workbook.[3,4]

kWh_{SAVED} = VFD Pump Baseline - VFD Pump Proposed

VFD Pump Baseline = Σ [Motor hp * 0.7465 / Motor eff * (Motor loading $\%_{BASE}$)^2.5 * Adjusted Run Hours]

VFD Pump Proposed = Σ [Motor hp * 0.7465 / Motor eff * (Motor loading $\%_{PROP}$)^2.5 * Adjusted Run Hours]

Where:

Motor hp = VFD controlled motor nameplate horsepower rating

0.7465 = Horsepower to kW conversion factor

Motor eff = Specific VFD controlled pump motor nameplate efficiency; otherwise use default of 90%

Motor Loading $\%_{BASE}$ = Percent capacity (Load Factor) of motor at baseline (= user defined)

Adjusted Run Hours = Bin hours * (annual VFD operational hours / 8,760 annual hours)

Motor Loading $\%_{PROP}$ = Percent capacity (Load Factor) of motor proposed; assumes the VFD is set back to 'automatic' control based on user-defined loading minimum and maximum percentages and on area load (area load is a percentage based on a linear interpolation of a 60°F dry bulb OAT balance point, bin data dry bulb OAT, and 2.5% dry bulb design summer/winter conditions for different Wisconsin cities;5 see Assumptions for more explanation about the 2.5% dry bulb design conditions)

The workbook calculator requires the following measure-specific inputs to be provided from the trained professional performing the tune-up/optimization measure:

- Annual hours of VFD/fan operation
- Fan VFD application (cooling tower fan, chiller system fan, boiler/heating fan)
- Existing VFD control state (auto, manual, bypassed/off)
- Fan motor nameplate capacity controlled by VFD (horsepower)
- Fan motor nameplate efficiency percentage
- Measured speed at set point if VFD is stuck in 'hand' mode (Hz)
- VFD fan control loading minimum and maximum percentages

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} / Hours_{PUMP} * CF$

Where:

$Hours_{PUMP}$ = Annual hours of operation for the pump controlled by the VFD

CF = Coincidence factor (= based on VFD pump use; see table below)

Coincidence Factor by VFD Pump Use[6]

VFD Use	CF	Source
Chilled Water Pump	0.9	DEER model runs are weather-normalized for statewide use by population density
Hot Water Pump	0.0	Assumed that heating/hot water pump not operating at peak times

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (=5 years)[1]

Assumptions

- Assumes 100% load factor for all motors running in a VFD bypassed state.
- 2.5% dry bulb design conditions means that for cooling/heating seasons, the HVAC system is designed to adequately handle the cooling/heating of a given building for all outdoor air temperatures that do not exceed the hottest/coldest 2.5% of hours of the respective season. Explained another way, this means the cooling/heating system can adequately handle the cooling/heating load of a given building for 97.5% of the total anticipated peak cooling/heating hours for the year.

Sources

1. Cadmus. EUL Response Memo. April 26, 2013. Used the RCx Program EUL standard and direction from CB&I to keep 5 year EUL standard.
2. RSMeans 2013 Facilities Construction Cost Data, 29th Edition
3. Wisconsin Focus on Energy. *EBTU Measures Workbook Calculator.* January 2015.
4. Natural Renewable Energy Laboratory. Bin temperature data from respective Wisconsin City TMY3 weather data. Available online: http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html#W

5. ASHRAE. *Handbook, Fundamentals Volume for Wisconsin Cities*. 1985. Available online: http://publicecodes.cyberregs.com/icod/ipc/2012/icod_ipc_2012_appd.htm
6. *Wisconsin Focus on Energy Technical Reference Manual.* Pg. 225., Variable Frequency Drive, summer coincident peak savings algorithm VFD coincidence factor chart. 2015.

Revision History

Version Number	Date	Description of Change
01	10/2014	Initial TRM entry

Variable Speed ECM Pump, Domestic Hot Water Recirculation, Heating Water Circulation, and Cooling Water Circulation

	Measure Details
Measure Master ID	Variable Speed ECM Pump: Domestic Hot Water Recirculation: < 100 Watts Max Input, 3494 100 - 500 Watts Max Input, 3495 > 500 Watts Max Input, 3496 Heating Water Circulation: < 100 Watts Max Input, 3497 100 - 500 Watts Max Input, 3498 > 500 Watts Max Input, 3499 Cooling Water Circulation: < 100 Watts Max Input, 3500 100 - 500 Watts Max Input, 3501 > 500 Watts Max Input, 3502 Water Loop Heat Pump Circulation: < 100 Watts Max Input, 3503 100 - 500 Watts Max Input, 3504 > 500 Watts Max Input, 3505
Measure Unit	Per pump
Measure Type	Prescriptive
Measure Group	HVAC
Measure Category	Variable Speed Drive
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by wattage
Peak Demand Reduction (kW)	Varies by wattage
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by wattage
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	Varies by measure and wattage, see Appendix D

Measure Description

ECMs are high-efficiency brushless DC motors. They are typically fractional horsepower motors that have several benefits over the more common PSC fractional horsepower motor. One of these advantages is higher overall efficiency. PSC motors are generally 20% to 60% efficient, depending on their loading, while ECM motor efficiencies range from 70% to 80%. Other advantages include a reduction in the pump motor size, the variable speed capability of the pump, the ability to provide constant flow with varying pressures, a wider range of rpm, and the ability to be controlled by direct digital controls.

DHW recirculating pumps are commonly used in multifamily and commercial buildings to shorten the amount of time it would otherwise take for hot water to reach the occupants on upper floors and that have long piping runs. These recirculation pumps can be operated continuously or be controlled by a timer or an aquastat. An aquastat turns on the pump only when the temperature of the return line falls below a certain set point. Many of the ECM recirculating pumps currently on the market have integrated aquastat controls and the ability to be controlled and monitored wirelessly.

Heating and cooling water circulation pumps are commonly used in baseboard and radiant floor heating systems, as well as in coils in forced air systems in multifamily and commercial buildings. Cooling loops are often part of heat pump circulation systems. Often the primary and secondary loops run constantly throughout the heating or cooling season. ECM circulator pumps can modulate their speed to match the load.

Description of Baseline Condition

The baseline condition is a standard efficiency, constant volume PSC pump for domestic heating or cooling circulation without variable speed capabilities.

Description of Efficient Condition

The efficient condition is a properly sized, high-efficiency ECM pump for domestic heating or cooling circulation with variable speed capabilities to match demand.

Savings for this measure are from the reduction in the pump motor size, the variable speed capability of the pump, and the increased efficiency of the ECMs versus the fraction horsepower PSC motors.

Annual Energy-Savings Algorithm

Heating and Cooling Circulation Pumps:

$kWh_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1{,}000 * HOURS$

$Watts_{BASE} = Watts_{EE} * R$

$HOURS_{HEATING} = HDD * 24 * \Delta T$

$HOURS_{COOLING} = CDD * 24 * \Delta T$

Water Loop Heat Pump Circulation Pumps:

$kWh_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1{,}000 * (HOURS_{HEATING} + HOURS_{COOLING})$

$Watts_{BASE} = Watts_{EE} * R$

$HOURS_{HEATING} = HDD * 24 * \Delta T$

$HOURS_{COOLING} = CDD * 24 * \Delta T$

DHW Recirculation Pumps:

$kWh_{SAVED} = (Watts_{BASE} / 1{,}000 * HOURS_{DHW\text{-}BASE}) – (Watts_{EE} / 1{,}000 * HOURS_{DHW\text{-}EE})$

$HOURS_{DHW\text{-}BASE} = HOURS_{UNCONTROLLED} * 44.5\% + HOURS_{CONTROLLED} * 55.5\%$

$HOURS_{DHW\text{-}EE} = HOURS_{CONTROLLED}$

Where:

$Watts_{BASE}$ = Power consumption of constant speed PSC pump (= 278 watts for < 100 watt VSD ECM pumps; = 1,389 watts for 100 watt to 500 watt VSD ECM pumps; = 5,556 watts for > 500 watt VSD ECM pumps)

$Watts_{EE}$ = Power consumption of variable speed ECM pump (= 50 watts for < 100 watt VSD ECM pumps; = 250 watts for 100 watt to 500 watt VSD ECM pumps; = 1,000 watts for > 500 watt VSD ECM pumps)

1,000 = Kilowatt conversion factor

HOURS = Average annual pump run hours

R = Ratio of ECM watts to baseline watts based on measured data of comparable efficient and nonefficient pumps (18%)[2]

$HOURS_{HEATING}$= Average annual pump run hours for heating (= 2,285)[3]

HDD = Heating degree days (= 7,616; see table below)[5]

24 = Conversion factor, hours per day

ΔT = Design temperature difference (= 80°F for heating; = 20°F for cooling as 95°F outdoor design - 75°F indoor design)[6]

$HOURS_{COOLING}$= Average annual pump run hours for cooling (= 678)[3]

CDD = Cooling degree days (= 565; see table below)[5]

Heating and Cooling Degree Days by Location

Location	HDD[5]	CDD[5]
Milwaukee	7,276	548
Green Bay	7,725	516
Wausau	7,805	654
Madison	7,599	630
La Cross	7,397	729
Minocqua	8,616	423
Rice Lake	8,552	438
Statewide Weighted	**7,616**	**565**

$HOURS_{DHW\text{-}BASE}$= Average annual pump run hours for DHW recirculating (= 5,114)[3]

$HOURS_{DHW\text{-}EE}$= Average annual pump run hours for DHW recirculating (= 2,190)[3]

$HOURS_{UNCONTROLLED}$= Average annual pump run hours for DHW recirculating continuously running (= 8,760)

44.5% = Constant[4]

$HOURS_{CONTROLLED}$ = Average annual pump run hours for DHW recirculating controlled by a timer or aquastat (= 2,190)[3]

55.5% = Constant[4]

Summer Coincident Peak Savings Algorithm

The summer coincident peak savings algorithm only applies to cooling circulation pumps and DHW recirculation pumps.

$kW_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1,000 * CF$

Where:

CF = Coincidence factor (= 0.299 for chilled water pumps,[5] = 1.0 for DHW pumps)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[1]

Deemed Savings

Energy Savings for DHW Recirculation

Savings	< 100 Watt VSD ECM Pump MMID 3494	100 - 500 Watt VSD ECM Pump MMID 3495	> 500 Watt VSD ECM Pump MMID 3496
Energy Savings (kWh)	1,311	6,555	26,221
Lifecycle Savings (kWh)	19,666	98,329	393,317
Demand Reduction (kW)	0.228	1.139	4.556

Energy Savings for Heating Circulation

Savings	< 100 Watt VSD ECM Pump MMID 3497	100 - 500 Watt VSD ECM Pump MMID 3498	> 500 Watt VSD ECM Pump MMID 3499
Energy Savings (kWh)	520	2,602	10,409
Lifecycle Savings (kWh)	7,807	39,035	156,142
Demand Reduction (kW)	0.000	0.000	0.000

Energy Savings for Cooling Circulation

Savings	< 100 Watt VSD ECM Pump MMID 3500	100 - 500 Watt VSD ECM Pump MMID 3501	> 500 Watt VSD ECM Pump MMID 3502
Energy Savings (kWh)	154	772	3,089
Lifecycle Savings (kWh)	2,317	11,583	46,330
Demand Reduction (kW)	0.068	0.341	1.362

Energy Savings for Water Loop Heat Pump Circulation

Savings	< 100 Watt VSD ECM Pump MMID 3503	100 - 500 Watt VSD ECM Pump MMID 3504	> 500 Watt VSD ECM Pump MMID 3505
Energy Savings (kWh)	675	3,375	13,498
Lifecycle Savings (kWh)	10,124	50,618	202,472
Demand Reduction (kW)	0.068	0.341	1.362

Assumptions

Variable Speed ECM Pump, < 100 Watts Max Input

- Wattage inputs for qualifying pumps under 100 watts range from 3 watts to 93 watts. 50 watts was used as a conservative midpoint.

Variable Speed ECM Pump, 100 - 500 Watts Max Input

- Wattage inputs for qualifying pumps between 100 watts and 500 watts range from 130 watts to 500 watts. 250 watts was used as a conservative midpoint.

Variable Speed ECM Pump, > 500 Watts Max Input

- Wattage inputs for qualifying pumps greater than 500 watts range from 587 watts to 2,500 watts. 1,000 watts was used as a conservative midpoint.

Sources

1. U.S. Department of Energy. Pump Life Cycle Costs: A Guide to LCC Analysis for Pumping Systems. January 2001. Page 4. January 2001. Available online: https://www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/pumplcc_1001.pdf.
2. Cadmus. Impact Evaluation of the 2011–2012 ECM Circulator Pump Pilot Program. Table 2. Pump Spot Measurements. October 18, 2012.
3. DHW Recirculation System Control Strategies. Final Report 99-1. Pg. 3-30. January 1999. Hours-of-use for pumps with an aquastat control in multifamily applications.
4. Lawrence Berkeley National Laboratory. Water Heaters and Hot Water Distribution Systems. Prepared for California Energy Commission Public Interest Energy Research Program. Pg. 16, Figure 10: Control Types Installed or Maintained by Contractors. May 2008.
5. Illinois Statewide Technical Reference Manual for Energy Efficiency, Version 2.0. Pg. 235. June 7, 2013.
6. Used to match other measures: example: Natural Gas Furnace with ECM, 95%+ AFUE (Existing), 1981.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

Lighting

Lighting Fixture, Agricultural Daylighting

	Measure Details
Measure Master ID	Lighting Fixture, Agricultural Daylighting: ≤ 155 Watts, 3019 156 - 250 Watts, 3020 251 - 365 Watts, 3021
Measure Unit	Per luminaire or complete retrofit kit
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Controls
Sector(s)	Agriculture
Annual Energy Savings (kWh)	Varies by wattage
Peak Demand Reduction (kW)	Varies by wattage
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by wattage
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	MMID 3019,3020=$325.87;[2]MMID 3021=$535.04[5]

Measure Description

Various lighting technologies—such as LED, induction, ceramic metal halide, pulse start metal halide, and linear fluorescent high bay products—are energy-efficient alternatives to 320-watt pulse start metal halide fixtures. These options have become a popular for dairy facilities upgrades to long day lighting, a process used to help increase cows' milk production by simulating longer days and therefore increasing the animal food intake and thus milk production. Long day lighting requires a minimum of 15 footcandles of photopic light being present at cow eye level for 16 hours to18 hours each day.

Energy savings are achieved when installing energy-efficient LED, induction, ceramic metal halide, pulse start metal halide, and/or linear fluorescent options instead of 250-watt and 320-watt pulse start metal halide fixtures. When the design is optimized to the technology, a considerable amount of energy can be saved.

Description of Baseline Condition

The baseline condition is 250-watt and 320-watt pulse start metal halide options in new construction buildings and upon retrofit upgrades to long day lighting.

Description of Efficient Condition

The efficient condition is qualifying LED, induction, ceramic metal halide, pulse start metal halide, and/or linear fluorescent high bay options. Pulse start metal halides are not acceptable for new construction applications.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{320\ WATT\ PSMH} – kWh_{EE\ HIGH\ BAY} * Hours$

Where:

$kWh_{320\ WATT\ PSMH}$ = Annual electricity consumption of pulse start metal halide

$KWh_{EE\ HIGH\ BAY}$ = Annual electricity consumption of an eligible high/low bay option using LED, induction, ceramic metal halide, pulse start metal halide, or linear fluorescent technology

Hours = 6,205 hours; full details in Assumptions section below

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = Qty * (kWh_{SAVED})/1,000 * CF$

Where:

Qty = Quantity

1,000 = Kilowatt conversion factor

CF = Demand coincidence factor (= 1.0)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[1]

Deemed Savings

Annual Deemed Savings for Agricultural Long Day Lighting

Measure	MMID	Existing Building	New Construction
Long Daylighting High Bay Fixtures, ≤ 155 Watts	3019	834 kWh, 0.1344 kW	874 kWh, 0.1409 kW
Long Daylighting High Bay Fixtures, 156 - 250 Watts	3020	908 kWh, 0.1463 kW	956 kWh, 0.1541 kW
Long Daylighting High Bay Fixtures, 251 - 365 Watts	3021	847 kWh, 0.1365 kW	892 kWh, 0.1438 kW

Lifecycle Deemed Savings for Agricultural Long Day Lighting

Measure	MMID	Existing Building	New Construction
Long Daylighting High Bay Fixtures, ≤ 155 Watts	3019	12510 kWh	13110 kWh
Long Daylighting High Bay Fixtures, 156 - 250 Watts	3020	13620 kWh	14340 kWh
Long Daylighting High Bay Fixtures, 251 - 365 Watts	3021	12705 kWh	13380 kWh

Assumptions

A 320-watt pulse start metal halide was used as the baseline (it is the industry standard for lighting in several high bay applications including agricultural facilities), but 250-watt pulse start metal halides are also used in lower wattage applications.

The design of the long day lighting system should be based on the energy-efficient technology used.

Hours was based on long day lighting studies, which reveal that in order for long day lighting to work, the lights must deliver a minimum of 15 footcandles at cow eye level for 16 hours to 18 hours a day (17 * 365 = 6,205 hours).

The coincidence factor of 1 was based on the system being on for 16 hours to 18 hours each day.[3,4]

The energy-efficient high bay option is based on the following:

- An average of the following replacements was used to generate the deemed savings values in place of 320-watt PSMH:
    - Eligible Replacements = 5.8% 200-watt induction, 5.8% 225-watt induction, 5.8% 165-watt induction, 5.8% 200-watt PSMH or CMH, 5.8% 210-watt PSMH or CMH, 5.8% 220-watt PSMH or CMH, 5.8% 4-foot 6-lamp T8, 5.8% 4-foot 4-lamp T5HO, 5.8% LED < 250 watts, 5.8% 250-watt induction, 5.8% 300-watt induction, 5.8% 250-watt PSMH or CMH, 5.8% 270-watt PSMH or CMH, 5.8% 315-watt PSMH or CMH, 5.8% 4-foot 8-lamp T8, 5.8% 4-foot 6-lamp T5HO, and 5.8% LED < 365 watts
- An average of the following replacements was used to generate the deemed savings values in place of 250-watt metal halide:
    - Eligible Replacements = 10% 120-watt to 125-watt induction,10% 150-watt induction,10% 165-watt induction,10% 125-watt PSMH or CMH, 10% 140-watt PSMH or CMH, 10% 150-watt PSMH or CMH, 10% 4-foot 4-lampT8, 10% 4-foot 3-lamp T5HO, 10% 4-foot 2-lamp T5HO, and 10% LED < 155 watts

Sources

1. Focus on Energy Evaluation Business Programs: Measure Life Study Final Report. August 25, 2009.
2. Focus on Energy Evaluation Business Programs: Incremental Cost Study Final Report. October 28, 2009.
3. Photoperiod Manipulation of Lactation in Dairy Cattle. (2001-2004). Retrieved April 30, 2012. http://www.livestocktrail.illinois.edu/photoperiod
4. University of Wisconsin Madison. Long Day Lighting in Dairy Barns (August 2000). Healthy Farmers, Healthy Profits Project. Second Edition.
5. WESCO Distribution Pricing, 2013 + Labor * 10% add for barn install location = $535.04

Revision History

Version Number	Date	Description of Change
01	01/01/2013	Initial TRM entry
02	04/23/2013	Updated proposed fixture wattage for new construction, removed PSMH as option for new construction, and updated savings values

Daylighting Control

	Measure Details
Measure Master ID	Daylighting Control, 3406
Measure Unit	Per watt controlled
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Controls
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	8[1]
Incremental Cost ($/unit)	$0.73[2]

Measure Description

Daylighting controls save energy by reducing the total wattage input of the connected lighting load by matching the light output of the connected electric lighting system to the amount of natural light supplied by the sun that enters the space being lit. This is accomplished using dimming light sources or a system that steps the light of the connected fixtures based on controlling the lamps inside each connected fixture to produce different levels of illumination. This measure will provide reinforcement that integrating daylighting controls is an effective method to further reduce energy consumption.

Description of Baseline Condition

The baseline condition is any lighting equipment that is not connected to a daylighting controls system.

Description of Efficient Condition

The efficient condition is any lighting equipment that is connected to a daylighting controls system.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{UNCONTROLLED} * \text{Savings Factor}$

$kWh_{UNCONTROLLED} = Wattage_{UNCONTROLLED} / 1{,}000 * CF * HOURS$

Where:

$KWh_{UNCONTROLLED}$ = Annual electricity consumption per watt of lighting load that is not controlled by daylighting controls

Savings Factor = Savings percentage achieved per watt of lighting load that is controlled by daylighting controls[7]

$Wattage_{UNCONTROLLED}$ = Instantaneous electric consumption of lamp or fixture

1,000 = Kilowatt conversion factor

CF = Demand coincidence factor (= varies by sector; see table below)

Demand Coincidence Factor by Sector

Sector	CF[4,6]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64
Multifamily	0.77

HOURS = Average annual run hours (= varies by sector; see table below)

Average Annual Run Hours by Sector

Sector	HOURS[3,5]
Commercial	3,730
Industrial	3,299
Agriculture	4,745
Schools & Government	4,698
Multifamily	5,950

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = Wattage_{UNCONTROLLED} / 1{,}000 * CF$

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (8 years)[1]

Deemed Savings

Annual Savings per Watt of Lighting Load Controlled by Daylighting Controls

Measure	Commercial 3,730 (0.77)		Industrial 4,745 (0.77)		Agriculture 4,698 (0.67)		Schools & Gov 3,239 (0.64)		Multifamily 5,950 (0.77)	
	kWh	kW	kWh	kWh	kW	kW	kWh	kW	kWh	kW
Daylighting Control	1.12	0.0	1.43	0.97	0.0	0.0	1.41	0.0	1.78	0.0

Lifecycle Savings per Watt of Lighting Load Controlled by Daylighting Controls

Measure	Commercial 3,730 (0.77)	Industrial 4,745 (0.77)	Agriculture 4,698 (0.67)	Schools & Gov 3,239 (0.64)	Multifamily 5,950 (0.77)
	kWh	kWh	kWh	kWh	kWh
Daylighting Control	8.96	11.44	11.28	7.76	14.24

Sources

1. California Energy Commission and California Public Utilities Commission. Database for Energy Efficient Resources (DEER) 2008. http://www.energy.ca.gov/deer/ .
2. Actual cost from 2015-16 program data, 21 applications
3. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
4. Focus on Energy Business Programs Deemed Savings Manual V1.0. Lighting in Commercial Applications. March 22, 2010.
5. ACES. Deemed Savings Desk Review. November 3, 2010.
6. ACES. Default Deemed Savings Review Final Report. June 24, 2008. Available online: http://www.coned.com/documents/Con%20Edison%20Callable%20Load%20Study_Final%20Report_5-15-08.pdf. CF is within range of similar programs; see Table 4-1 showing multifamily housing (in unit) CF of 65% to 83%.
7. Williams, Allison, B. Atkinson P.E., K. Garbesi Ph.D., E. Page P.E., and F. Rubenstein, FIES. “Lighting Controls in Commercial Buildings.” Luekos Vol. 8, No. 3 (January 2012).

Revision History

Version Number	Date	Description of Change
01	04/2014	Initial TRM entry

Bi Level Controls, High Bay Fixtures

	Measure Details
Measure Master ID	Bi Level Controls, High Bay Fixtures: Gymnasium, 3260 Industrial, 3261 Retail, 3262 Warehouse, 3263 Public Assembly, 3264 Other, 3265
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Controls
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	8[1]
Incremental Cost ($/unit)	$95.00[2]

Measure Description

This measure is bi-level controls for high bay fixtures. Numerous new and existing installations use LED, induction, linear fluorescent, ceramic metal halide, and pulse start metal halide fixtures to light their high bay interiors, commonly in full light output 24 hours a day. Bi level controls and replacement products use ultrasonic and passive infrared sensors to adjust the light output to a safe but energy conserving low level when these spaces become unoccupied. These products save energy by more efficiently lighting the spaces based on occupancy.

Description of Baseline Condition

The baseline condition is LED, induction, fluorescent, ceramic metal halide, and/or pulse start metal halide fixture input wattages with no lighting controls at building interior.

Description of Efficient Condition

The efficient condition is individually controlled light fixtures that may include dimming, stepped dimming, and hi-lo ballast controls. The control must include a passive infrared and/or ultrasonic occupancy sensor with a feature to fail in "on" position in case of failure.

Fixtures must operate in a low-standby light level during vacancy and switch to full light output upon occupancy. The fixture cannot exceed 50% of full wattage during unoccupied periods.

Annual Energy-Savings Algorithm

All algorithms and methodology from: *Focus on Energy Business Programs Deemed Savings Manual V1.0*. March 22, 2010.[2]

The kW savings for this measure are deemed by space type, while kWh savings are deemed by sector and space type. Savings due to occupancy sensor installation are described by the following equations:

kWh_{SAVED} = LtgWatts / 1,000 * % Off * Hours * 50%

Where:

Ltg. Watts = Lighting wattage controlled, deemed (= 237 watts; updated per new wattage table to 310 watts)

1,000 = Kilowatt conversion factor

% Off = Percentage of time lights are controlled (= varies by space type; see table below)

Hours = Baseline hours per year (= varies by sector; see table below)

50% = Bi level factor for fixtures that include dimming, stepped dimming, or hi-lo ballast controls (at least 50% of light source or lamps must be reduced to qualify for incentive)

Percentage of Values by Space Type (Various Sources)[2]

Space Type	Cal. SPC	RLW Schools	LRC	Maine	Average
Gymnasiums	35%	48%	-	35%	**39%**
Industrial	45%	-	-	-	**45%**
Retail	15%	-	-	-	**15%**
Warehouses	45%	-	65%	50%	**53%**
Public Assembly	35%	59%	-	-	**47%**
Other	-	-	-	-	**40%**

Hours-of-Use by Sector[2]

Sector	Hours
Commercial	3,730
Schools & Government	3,239
Industrial	4,745
Agriculture	4,698

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = LtgWatts / 1,000 * CF

Where:

CF = Coincidence factor (= varies by space type; see table below)

Coincidence Factors by Space Type)[2]

Space Type	Cal. SPC	RLW Schools	Average
Gymnasiums	14%	15%	**15%**
Industrial	18%	-	**18%**
Retail	6%	-	**6%**
Warehouses	18%	-	**18%**
Public	14%	10%	**12%**
Other	-	-	**14%**

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE}$ = kWh_{SAVED} * EUL

Where:

EUL = Effective useful life (= 8 years)[1]

Deemed Savings

Annual and Lifecycle Deemed Savings in Agriculture and Commercial Sectors

Measure Name	MMID	Agriculture			Commercial		
		kW	kWh	Lifecycle	kW	kWh	Lifecycle
Bi Level Controls, High Bay Fixtures, Gymnasium	3260	0.0465	284	2,274	0.0465	226	1,806
Bi Level Controls, High Bay Fixtures, Industrial	3261	0.0559	328	2,624	0.0559	260	2,083
Bi Level Controls, High Bay Fixtures, Retail	3262	0.0186	109	875	0.0186	87	694
Bi Level Controls, High Bay Fixtures, Warehouse	3263	0.0559	386	3,090	0.0559	307	2,454
Bi Level Controls, High Bay Fixtures, Public Assembly	3264	0.0372	343	2,741	0.0372	272	2,176
Bi Level Controls, High Bay Fixtures, Other	3265	0.0434	292	2,332	0.0434	231	1,852

Annual and Lifecycle Deemed Savings in Industrial and Schools & Government Sectors

Measure Name	MMID	Industrial			Schools & Government		
		kW	kWh	Lifecycle	kW	kWh	Lifecycle
Bi Level Controls, High Bay Fixtures, Gymnasium	3260	0.0465	287	2,297	0.0465	196	1,568
Bi Level Controls, High Bay Fixtures, Industrial	3261	0.0559	331	2,650	0.0559	226	1,809
Bi Level Controls, High Bay Fixtures, Retail	3262	0.0186	110	883	0.0186	75	603
Bi Level Controls, High Bay Fixtures, Warehouse	3263	0.0559	390	3,121	0.0559	266	2,131
Bi Level Controls, High Bay Fixtures, Public Assembly	3264	0.0372	346	2,768	0.0372	236	1,889
Bi Level Controls, High Bay Fixtures, Other	3265	0.0434	294	2,356	0.0434	201	1,608

Assumptions

The annual hours of operation for interior high bay applications is based on sector.

Bi level controls are able to and must achieve at least a 50% reduction in power requirements. Many systems can reduce the light output below 50%.

Product weightings were based on historical project information (gathered October 3, 2013) with a projected increase and prevalence of LED fixtures based on market knowledge. The higher weighting of LED fixtures leads to a more conservative wattage estimate (see table below).

Weighted Average High Bay Lighting Replacement Wattage[2]

Measure	Watts	Agriculture	Commercial	Industrial	Schools & Government	Total
250-399 Watt Replacements	185	13.90%	5.10%	9.70%	18.50%	9.00%
400-699 Watt Replacements	316	73.50%	61.40%	74.90%	70.40%	70.70%
400-999 Watt Replacements	335	12.60%	30.40%	10.30%	9.20%	16.00%
≤ 500 Watts, Replacing ≥ 1,000 Watts	355	0.00%	2.50%	4.40%	1.10%	3.60%
≤ 800 Watts, Replacing ≥ 1,000 Watts	591	0.00%	0.60%	0.70%	0.70%	0.70%
Total		**100%**	**100%**	**100%**	**100%**	**100%**
Average Watts		**300**	**318**	**309**	**295**	**310**

Wattages for LED, induction, fluorescent, ceramic metal halide, and pulse start metal halide fixtures were grouped into five replacement categories based on the existing high bay fluorescent replacement option groups from the deemed savings manual (Table4-204). A weighted average of the wattages per lighting technology was then taken for the four groups based on historical project information (gathered October 3, 2013), with a projected increase and prevalence of LED fixture. Refer to the following table for the technology weightings.

Lighting Technology Weightings

Technology	Weighting
Linear Fluorescent	65%
LED	20%
PSMH/CMH	10%
Induction	5%

Wattage by Fixture Type

Replacing 250-399 Watt HID		Replacing 400 HID < 365 Watt		Replacing 1,000 HID < 800 Watt	
Measure Name	**Wattage**	**Measure Name**	**Wattage**	**Measure Name**	**Wattage**
Induction 120 watt	132	Induction 250 watt	275	Induction 750 watt	825
Induction 125 watt	138	Induction 300 watt	330	PSMH or CMH 575 watt	640
Induction 150 watt	161	PSMH or CMH 250 watt	281	LED	690
Induction 165 watt	174	PSMH or CMH 270 watt	290	T8 or T5HO ≤ 800 watt	535
PSMH or CMH 125 watts	146	PSMH or CMH 315 watt	343		
PSMH or CMH 140 watts	154	PSMH or CMH 320 watt	640		
PSMH or CMH 150 watts	185	LED	296		
LED	119	T8 6 lamp or T5HO 4 lamp	212		
T8 4 lamp or T5HO 2 lamp	144	T8 8 lamp or T5HO 6 lamp	359		
T8 6 lamp or T5HO 4 lamp	212	T8 or T5HO ≤ 500 watt	363		

Replacing 400 HID < 250 Watt		Replacing 1,000 HID < 500 Watt	
Measure Name	**Wattage**	**Measure Name**	**Wattage**
Induction 200 watt	220	LED	338
PSMH or CMH 200 watt	225	T8 8 lamp or T5HO 6 lamp	359
PSMH or CMH 210 watt	229	T8 or T5HO ≤ 500 watt	363
PSMH or CMH 220 watt	242		
LED	169		
T8 6 lamp or T5HO 4 lamp	212		

Sources

1. Focus on Energy Evaluation Business Programs: Measure Life Study Final Report. August 25, 2009.
2. Materials: WESCO Distribution Pricing, 2013 ($70.00) + Labor: RSMEANS, 2013 ($25.00) = $95.00
3. Focus on Energy Business Programs Deemed Savings Manual V1.0. March 22, 2010.

Revision History

Version Number	Date	Description of Change
01	12/2012	Initial TRM entry
02	10/2013	Changed entry from hybrid to prescriptive (MMID 3115)

Occupancy Sensors for High Bay Fixtures

	Measure Details
Measure Master ID	Occupancy Sensor, High Bay Fixtures: Gymnasium, 3254 Industrial, 3255 Retail, 3256 Warehouse, 3257 Public Assembly, 3258 Other, 3259
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Controls
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by fixture
Peak Demand Reduction (kW)	Varies by fixture
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by fixture
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	8[1]
Incremental Cost ($/unit)	$95.00[3]

Measure Description

This measure is occupancy sensors for high bay fixtures. Numerous new and existing installations use LED, induction, fluorescent, ceramic metal halide, and pulse start metal halide fixtures to light their high bay interiors, commonly in full light output for 24 hours a day. Occupancy controls and replacement products use ultrasonic and passive infrared sensors to turn the fixture off when these spaces become unoccupied. These products save energy by more efficiently lighting the spaces based on occupancy.

Description of Baseline Condition

The baseline condition is LED, induction, fluorescent, ceramic metal halide, and/or pulse start metal halide fixture input wattages with no lighting controls at the building interior.

Description of Efficient Condition

The efficient condition is an indoor wall, ceiling, or fixture mounted occupancy sensor being used to control a high bay fixture. The control must include a passive infrared and/or ultrasonic occupancy sensor with a feature to fail in “on” position in case of failure.

Annual Energy-Savings Algorithm

All algorithms and methodology are from: *Focus on Energy Business Programs Deemed Savings Manual V1.0*. March 22, 2010.[2]

The kW savings for this measure are deemed by space type, while kWh savings are deemed by sector and space type. Savings due to occupancy sensor installation are described by the following equations:

kWh_{SAVED} = LtgWatts / 1,000 * % Off * Hours

Where:

Ltg. Watts = Lighting wattage controlled, deemed (= 237 watts; updated per new wattage table to 310 watts)

1,000 = Kilowatt conversion factor

% Off = Percentage of time lights are controlled (= varies by space type; see table below)

Hours = Baseline hours per year (= varies by sector; see table below)

Percentage of Values by Space Type (Various Sources)[2]

Space Type	Cal. SPC	RLW Schools	LRC	Maine	Average
Gymnasiums	35%	48%	-	35%	**39%**
Industrial	45%	-	-	-	**45%**
Retail	15%	-	-	-	**15%**
Warehouses	45%	-	65%	50%	**53%**
Public Assembly	35%	59%	-	-	**47%**
Other	-	-	-	-	**40%**

Hours-of-Use by Sector[2]

Sector	Hours
Commercial	3,730
Schools & Gov	3,239
Industrial	4,745
Agriculture	4,698

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = LtgWatts / 1,000 * CF

Where:

CF = Coincidence factor (= varies by space type; see table below)

Coincidence Factors by Space Type [2]

Space Type	Cal. SPC	RLW Schools	Average
Gymnasiums	14%	15%	**15%**
Industrial	18%	-	**18%**
Retail	6%	-	**6%**
Warehouses	18%	-	**18%**
Public	14%	10%	**12%**
Other	-	-	**14%**

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 8 years)[1]

Deemed Savings

Annual and Lifecycle Deemed Savings in Agriculture and Commercial Sectors

Measure Name	MMID	Agriculture			Commercial		
		kW	kWh	Lifecycle	kW	kWh	Lifecycle
Occupancy Sensor, High Bay Fixtures, Gymnasium	3254	0.0465	569	4,548	0.0465	451	3,611
Occupancy Sensor, High Bay Fixtures, Industrial	3255	0.0559	656	5,248	0.0559	521	4,167
Occupancy Sensor, High Bay Fixtures, Retail	3256	0.0186	219	1,749	0.0186	174	1,389
Occupancy Sensor, High Bay Fixtures, Warehouse	3257	0.0559	773	6,181	0.0559	613	4,907
Occupancy Sensor, High Bay Fixtures, Public Assembly	3258	0.0372	685	5,481	0.0372	544	4,352
Occupancy Sensor, High Bay Fixtures, Other	3259	0.0434	583	4,665	0.0434	463	3,704

Annual and Lifecycle Deemed Savings in Industrial and Schools & Government Sectors

Measure Name	MMID	Industrial			Schools & Government		
		kW	kWh	Lifecycle	kW	kWh	Lifecycle
Occupancy Sensor, High Bay Fixtures, Gymnasium	3254	0.0465	574	4,594	0.0465	392	3,136
Occupancy Sensor, High Bay Fixtures, Industrial	3255	0.0559	663	5,300	0.0559	452	3,618
Occupancy Sensor, High Bay Fixtures, Retail	3256	0.0186	221	1,767	0.0186	151	1,206
Occupancy Sensor, High Bay Fixtures, Warehouse	3257	0.0559	780	6,243	0.0559	533	4,261
Occupancy Sensor, High Bay Fixtures, Public Assembly	3258	0.0372	692	5,536	0.0372	472	3,779
Occupancy Sensor, High Bay Fixtures, Other	3259	0.0434	589	4,711	0.0434	402	3,216

Assumptions

Product weightings were based on historical project information (gathered October 3, 2013) with a projected increase and prevalence of LED fixtures based on market knowledge. The higher weighting of LED fixtures leads to a more conservative wattage estimate (see table below).

Weighted Average High Bay Lighting Replacement Wattage[2]

Measure	Watts	Agriculture	Commercial	Industrial	Schools & Government	Total
250-399 Watt Replacements	185	13.90%	5.10%	9.70%	18.50%	9.00%
400-699 Watt Replacements	316	73.50%	61.40%	74.90%	70.40%	70.70%
400-999 Watt Replacements	335	12.60%	30.40%	10.30%	9.20%	16.00%
≤ 500 Watts, Replacing ≥ 1,000 Watts	355	0.00%	2.50%	4.40%	1.10%	3.60%
≤ 800 Watts, Replacing ≥ 1,000 Watts	591	0.00%	0.60%	0.70%	0.70%	0.70%
Total		**100%**	**100%**	**100%**	**100%**	**100%**
Average Watts		**300**	**318**	**309**	**295**	**310**

Wattages for LED, induction, fluorescent, ceramic metal halide, and pulse start metal halide fixtures were grouped into five replacement categories based on the existing high bay fluorescent replacement option groups from the deemed savings manual (Table4-204). A weighted average of the wattages per lighting technology was then taken for the four groups based on historical project information (gathered October 3, 2013), with a projected increase and prevalence of LED fixture. Refer to the following table for the technology weightings.

Lighting Technology Weightings

Technology	Weighting
Linear Fluorescent	65%
LED	20%
PSMH/CMH	10%
Induction	5%

Wattage by Fixture Type

Replacing 250-399 Watt HID		Replacing 400 HID < 365 Watt		Replacing 1,000 HID < 800 Watt	
Measure Name	**Wattage**	**Measure Name**	**Wattage**	**Measure Name**	**Wattage**
Induction 120 watt	132	Induction 250 watt	275	Induction 750 watt	825
Induction 125 watt	138	Induction 300 watt	330	PSMH or CMH 575 watt	640
Induction 150 watt	161	PSMH or CMH 250 watt	281	LED	690
Induction 165 watt	174	PSMH or CMH 270 watt	290	T8 or T5HO ≤ 800 watt	535
PSMH or CMH 125 watts	146	PSMH or CMH 315 watt	343		
PSMH or CMH 140 watts	154	PSMH or CMH 320 watt	640		
PSMH or CMH 150 watts	185	LED	296		
LED	119	T8 6 lamp or T5HO 4 lamp	212		
T8 4 lamp or T5HO 2 lamp	144	T8 8 lamp or T5HO 6 lamp	359		
T8 6 lamp or T5HO 4 lamp	212	T8 or T5HO ≤ 500 watt	363		

Replacing 400 HID < 250 Watt		Replacing 1,000 HID < 500 Watt	
Measure Name	**Wattage**	**Measure Name**	**Wattage**
Induction 200 watt	220	LED	338
PSMH or CMH 200 watt	225	T8 8 lamp or T5HO 6 lamp	359
PSMH or CMH 210 watt	229	T8 or T5HO ≤ 500 watt	363
PSMH or CMH 220 watt	242		
LED	169		
T8 6 lamp or T5HO 4 lamp	212		

Sources

1. Focus on Energy Evaluation Business Programs: Measure Life Study Final Report. August 25, 2009.
2. Focus on Energy Business Programs Deemed Savings Manual V1.0. March 22, 2010.
3. WESCO Distribution Pricing, 2013 ($70.00) + Labor ($25.00) = $95.00

Revision History

Version Number	Date	Description of Change
01	10/07/2013	Updated deemed savings and all fixture options and wattages
02	10/2016	Removed MMIDs 3292, 3296

Occupancy Sensors – Prescriptive

	Measure Details
Measure Master ID	Occupancy Sensor, Ceiling Mount: ≤ 500 Watts, 2471 ≥ 1,001 Watts, 2472 501-Watts to 1,000 Watts, 2473 Occupancy Sensor, ≤ 200 Watts: Wall Mount, 2483, 3361 Fixture Mount, 2474 Wall or Ceiling Mount, CALP, 3201 Fixture Mount, CALP, 3605 Occupancy Sensor > 200 Watts: Wall Mount, 2484, 3357 Fixture Mount, 2475 Wall or Ceiling Mount, CALP, 3202 Fixture Mount, CALP, 3606 Occupancy Sensor, Fixture Mount: ≤ 60 Watts, 3561 > 60 Watts, 3560
Measure Unit	Per sensor
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Controls
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by connected wattage
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by connected wattage
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	8[1]
Incremental Cost ($/unit)	Varies by measure, see Appendix D

Measure Description

Occupancy sensors reduce energy consumption by reducing the operating hours for lighting equipment in low occupancy areas, such as hallways, storage rooms, and restrooms. Occupancy sensors automatically turn lights off a preset time after people leave a space, and turn lights on automatically when movement is detected. Occupancy sensors feature a delay adjustment that determines the time that lights are on after no occupancy is detected, as well as a sensitivity adjustment that determines the magnitude of the signal required to trigger the occupied status.

The two primary technologies used for occupancy sensors are passive infrared (PIR) and ultrasonic. PIR sensors determine occupancy by detecting the difference in heat between a body and the background. Ultrasonic sensors detect people using volumetric detectors and broadcast sounds above the range of human hearing, then measure the time it takes the waves to return.

Description of Baseline Condition

The baseline condition is no occupancy sensor, with lighting fixtures being controlled by manual wall switches.

Description of Efficient Condition

The efficient condition is a hard-wired, fixture-, wall-, or ceiling-mounted occupancy sensor, where lighting fixtures are controlled by the sensors based on detected occupancy.

Annual Energy-Savings Algorithm

kWh_{SAVED} = Watts / 1,000 * SF* HOU

Where:

Watts = Controlled lighting wattage (= varies by measure; see table below)

Controlled Lighting Wattage for Occupancy Sensors by Measure

Measure Name	MMID	Average Connected Wattage
Ceiling Mount, ≤ 500 Watts	2471	350[2]
Ceiling Mount, ≥ 1,001 Watts	2472	1,200[2]
Ceiling Mount, 501-1,000 Watts	2473	750[2]
Wall Mount, ≤ 200 Watts	2483; 2474; 3201; 3361; 3605	150[2]
Wall Mount, > 200 Watts	2484; 2475; 3202; 3357; 3606	350[2]
Fixture Mount, ≤ 60 Watts	3561	35[3]
Fixture Mount, > 60 Watts	3560	89[3]

1,000 = Kilowatt conversion factor

SF = Savings factor, deemed (= 41%)[3]

HOU = Annual operating hours (= varies by sector; see table below)

Annual Operating Hours by Sector [3]

Sector	HOU
Multifamily	5,950
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239

Summer Coincident Peak Savings Algorithm

There are no deemed summer peak savings for this measure. Although occupancy sensors may reduce load during the peak period, most savings will occur during non-peak hours.

$kW_{SAVED} = Watts / 1,000 * CF$

Where:

CF = Coincidence factor (= 0 kW)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 8 years)[1]

Deemed Savings

Deemed Annual Electricity Savings (kWh) for Occupancy Sensors

Measure Name	MMID	Multifamily	Commercial	Industrial	Agriculture	Schools & Government
Ceiling Mount, ≤ 500 Watts	2471	854	535	681	674	465
Ceiling Mount, ≥ 1,001 Watts	2472	2,927	1,835	2,335	2,311	1,594
Ceiling Mount, 501-1,000 Watts	2473	1,830	1,147	1,459	1,445	996
Wall Mount, ≤ 200 Watts	2483; 2474; 3201; 3361; 3605	366	229	292	289	199
Wall Mount, > 200 Watts	2484; 2475; 3202; 3357; 3606	854	535	681	674	465
Fixture Mount, ≤ 60 Watts	3561	86	52	67	66	46
Fixture Mount, > 60 Watts	3560	217	133	169	167	115

Deemed Lifecycle Electricity Savings (kWh) for Occupancy Sensors

Measure Name	MMID	Multifamily	Commercial	Industrial	Agriculture	Schools & Government
Ceiling Mount, ≤ 500 Watts	2471	6,831	4,282	5,447	5,393	3,718
Ceiling Mount, ≥ 1,001 Watts	2472	23,419	14,681	18,676	18,491	12,749
Ceiling Mount, 501-1,000 Watts	2473	14,637	9,176	11,673	11,557	7,968
Wall Mount, ≤ 200 Watts	2483; 2474; 3201; 3361; 3605	2,927	1,835	2,335	2,311	1,594
Wall Mount, > 200 Watts	2484; 2475; 3202; 3357; 3606	6,831	4,282	5,447	5,393	3,718
Fixture Mount, ≤ 60 Watts	3561	686	419	534	528	364
Fixture Mount, > 60 Watts	3560	1,737	1,062	1,351	1,338	922

Assumptions

Occupancy controls at small commercial facilities can be expected achieve a 41% savings[3], based on an average derived from sources that specify the different savings factors in different spaces such as offices, corridors, restrooms, and storage areas.

The deemed summer peak savings is set to zero. Although occupancy sensors may reduce load during the peak period, no savings are assumed because uses are widely variable and most savings will occur during non-peak hours.

Occupancy controls at small commercial facilities can be expected achieve a 50% reduction in power requirements, so a 40% reduction is used as a conservative estimate. No kilowatt savings are estimated because of the variable nature of the uses.

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. Average wattage taken from common pin-based CFL fixtures and 4-foot linear fluorescent fixtures ≤ 60 watts and > 60 watts.
3. PA Consulting Group Inc. and Public Service Commission of Wisconsin. Focus on Energy. Evaluation, Business Programs: Deemed Savings Manual V1.0. March 22, 2010. Hours of Use can

be found in Table 3.2. Average connected wattages can be found on Final Report, Page 4-194 and Table 4-163.

4. WESCO Distribution Pricing, 2013 ($95.00)+ Labor ($25.00) = $120.00
5. WESCO Distribution Pricing ($70.00) + Labor ($25.00) = $95.00
6. WESCO Distribution Pricing, 2013 ($18.75) + Labor ($16.25) = $35.00

Revision History

Version Number	Date	Description of Change
01	04/06/2015	Initial TRM entry
02	04/12/2015	Combined workpapers, added comments

CFL, Reduced Wattage, Pin Based, Replacing CFL

	Measure Details
Measure Master ID	CFL, Reduced Wattage, Pin Based: 18 Watt, Replacing CFL, 3031 26 Watt, Replacing CFL, 3032 32 Watt, Replacing CFL, 3033 42 Watt, Replacing CFL, 3034
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Compact (CFL)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by wattage and sector
Peak Demand Reduction (kW)	Varies by wattage and sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by wattage and sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	3[1]
Incremental Cost ($/unit)	Varies by measure, see Appendix D

Measure Description

RW CFL lamps save energy by reducing the total input wattage of the luminaire as compared to the same luminaire operating with standard wattage lamps. This measure can be applied to common area spaces where there is more than sufficient light available for the tasks in that space using standard wattage CFL lamps, as these are areas where RW CFL lamps can be considered.

Description of Baseline Condition

The baseline equipment is standard wattage, pin-based CFL lamps.

Description of Efficient Condition

The efficient equipment is a RW CFL lamp being used to replace a standard wattage CFL lamp.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1{,}000 * HOU$

Where:

$Watts_{BASE}$ = Power consumption of baseline measure (= varies by measure; see table below)

$Watts_{EE}$ = Power consumption of efficient measure (= varies by measure; see table below)

Baseline and Efficient Wattage by Type of Measures

	Type 1	Type 2	Type 3	Type 4
Baseline Measure	18-Watt Pin-Based CFL Lamp	26-Watt Pin-Based CFL Lamp	32-Watt Pin-Based CFL Lamp	42-Watt Pin-Based CFL Lamp
Efficient Measure	14-Watt, 15-Watt, or 16-Watt Pin-Based CFL Lamp	21-Watt or 23-Watt Pin-Based CFL Lamp	27-Watt or 28-Watt Pin-Based CFL Lamp	33-Watt or 38-Watt Pin-Based CFL Lamp
$Watts_{BASE}$	18	26	32	42
$Watts_{EE}$	14, 15, 16	21, 23	27, 28	33, 38

1,000 = Kilowatt conversion factor

HOU = Annual operating hours (= varies by sector; see table below)

Annual Operating Hours by Sector

Sector	HOU[2]
Multifamily	5,950
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1{,}000 * CF$

Where:

CF = Coincidence factor (= 0.77)[3]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 3 years)[1]

Deemed Savings

Average Annual Deemed Savings for Pin-Based, Reduced-Wattage CFL Lamps

Measure	MMID	Existing Building
CFL, Reduced Wattage, Pin Based, 18 Watt, Replacing CFL	3031	18 kWh / 0.002 kW
CFL, Reduced Wattage, Pin Based, 26 Watt, Replacing CFL	3032	24 kWh / 0.003 kW
CFL, Reduced Wattage, Pin Based, 32 Watt, Replacing CFL	3033	27 kWh / 0.003 kW
CFL, Reduced Wattage, Pin Based, 42 Watt, Replacing CFL	3034	39 kWh / 0.005 kW

Average Lifecycle Deemed Savings for Pin-Based, Reduced-Wattage CFL Lamps

Measure	MMID	Existing Building
CFL, Reduced Wattage, Pin Based, 18 Watt, Replacing CFL	3031	54 kWh
CFL, Reduced Wattage, Pin Based, 26 Watt, Replacing CFL	3032	72 kWh
CFL, Reduced Wattage, Pin Based, 32 Watt, Replacing CFL	3033	81 kWh
CFL, Reduced Wattage, Pin Based, 42 Watt, Replacing CFL	3034	117 kWh

Assumptions

An average of 33% each of 14-watt, 15-watt, and 16-watt pin-based CFL lamps were used to generate the new measure average energy use for 18-watt lamp replacements.

An average of 50% each of 21-watt and 23-watt pin-based CFL lamps were used to generate the new measure average energy use for 26-watt lamp replacements.

An average of 50% each of 27-watt and 28-watt pin-based CFL lamps were used to generate the new measure average energy use for 32-watt lamp replacements.

An average of 50% each of 33-watt and 38-watt pin-based CFL lamps were used to generate the new measure average energy use for 42-watt lamp replacements.

Sources

1. Manufacturer rated life.
2. PA Consulting Group Inc. and Public Service Commission of Wisconsin. Focus on Energy. Evaluation, Business Programs: Deemed Savings Manual V1.0. March 22, 2010. Hours of Use can be found in Table 3.2. Average connected wattages can be found on Final Report, Page 4-194 and Table 4-163.
3. State of Wisconsin Public Service Commission. *Business Programs Deemed Savings Manual V1.0*. Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

ENERGY STAR Fluorescent Porch Fixture, < 30 Watts

	Measure Details
Measure Master ID	ENERGY STAR Fluorescent Commercial Threshold Fixture, < 30 Watts, SBP After A La Carte, 3763
Measure Unit	Per Luminaire
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Compact (CFL)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	162
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	486
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	3[1]
Incremental Cost ($/unit)	$20.00[3]

Measure Description

ENERGY STAR-qualified fluorescent commercial threshold fixtures are identical to residential porch and post mount luminaires. The fixtures are verified to meet both a performance and efficiency criteria, ensuring that a product's performance is similar to other time-tested technologies used for the same applications and that is meets ENERGY STAR efficiency criteria.

Description of Baseline Condition

The baseline condition is standard, screw-based incandescent or halogen lamps/luminaires. An average of 33% 60 watt (43 watt), 33% 75 watt (53 watt), and 33% 100 watt (72 watt) A-19 halogen and incandescent lamps that meet EISA 2007 as of January 1, 2013 were used to generate the baseline usage of 56 watts (this is consistent with MMID 3157 in the Wisconsin TRM).[6]

Description of Efficient Condition

The efficient condition is an ENERGY STAR-rated fluorescent in the following categories: Porch (wall mounted), Outdoor Porch Wall Mount, or Outdoor Post- Mount for commercial use.[4]

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{INC} - Watts_{CFL}) / 1{,}000 * HOU$

Where:

$Watts_{INC}$ = Wattage of standard incandescent fixture (= 56)
$Watts_{CFL}$ = Wattage of CFL product (= 19)[5]
1,000 = Kilowatt conversion factor
HOU = Hours-of-use (= 4,380)[2]

Summer Coincident Peak Savings Algorithm

There are no peak savings for this measure.

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 3 years)[1]

Assumptions

The 4,380 hours run time of fixtures is based on an annual average of 12 hours per day from NOAA.[2] This includes times when photocells turn on prior to exact sunset and turn off after exact sunrise, accounting for diminished outdoor lighting as well as time clock scheduled lighting.

ENERGY STAR approved CFLs have a minimum bulb life rating of 10,000 hours.[4]

Sources

1. Database of Energy Efficient Resources. 2014. Per EUL Table, an outdoor commercial CFL has an EUL of 2.44 years; in agreement with the Administrator, Evaluator, and Commission this was rounded up to 3 years.
2. U.S. Department of Commerce | National Oceanic & Atmospheric Administration | NOAA Research. NOAA Solar Calculator. http://www.esrl.noaa.gov/gmd/grad/solcalc/
3. Pricing. Incandescent and fluorescent pricing from www.lightingdirect.com and www.homedepot.com was averaged,then an installation cost of $10.00 ($30 per hr at 20 minutes) was added to both the baseline and efficient conditions. The incremental cost is the difference between baseline and proposed total cost. Detailed information contained in Implemeter sheet “EnergyStarPorch Certified-2015-03-20”.
4. ENERGY STAR. Light Bulb Key Product Criteria. Available online: http://www.energystar.gov/index.cfm?c=lamps.pr_crit_lamps

5. Wattage equates to the weighted average of luminaires listed in the 12-watt to 27-watt categories. Detailed information contained in Implemeter sheet “EnergyStarPorch Certified-2015-03-20”.
6. Wisconsin Focus on Energy Technical Reference Manual. October 22, 2015. MMID 3157.

Revision History

Version Number	Date	Description of Change
01	01/2016	New measure

HPT8, 1-Foot by 4-Foot, Replacing T12 or T8, 2 Lamp

	Measure Details
Measure Master ID	HPT8, 1-Foot by 4-Foot, Replacing T12 or T8, 2 Lamp: SBP A La Carte, 3391 SBP Package, 3392
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Linear
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	13[1]
Incremental Cost ($/unit)	$21.49[4]

Measure Description

High performance fixture replacements save energy over standard wattage fluorescent fixtures by increasing the number of lumens per watt and reducing the number of lamps needed to produce appropriate lighting levels. The one-lamp HP 1-foot by 4-foot fixture will replace a 2-lamp or greater T12 or T8 fixture.

Description of Baseline Condition

The baseline measure is EISA-compliant T8 linear fluorescent fixtures with 58 watts and two lamps; or T12 linear fluorescent fixtures with 82 watts and two lamps.

Description of Efficient Condition

The efficient condition is using one 32-watt T8 lamp in a 1-foot by 4-foot fixture combined with a ballast that has a normal ballast factor.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (W_{EX} - W_{HP}) / 1{,}000 * HOURS$

Where:

W_{EX} = Wattage of existing T8 or T12 lamps and ballasts

W_{HP} = Wattage of the of HP 2-lamp 1-foot by 4-foot luminaire

1,000 = Kilowatt conversion factor

HOURS = Average annual run hours (= varies by sector; see table below)

Hours-of-Use by Sector

Sector	Hours[2]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,299

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (W_{Ex} - W_{HP}) / 1{,}000 * CF$

Where:

CF = Demand coincidence factor (= varies by sector; see table below)

Demand Coincidence Factor by Sector

Sector	CF[3]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = (kWh_{EX} – kWh_{HP}) * N + (kWh_{EISA} – kWh_{HP}) * (EUL - N)$

$kWh_{EX} = W_{EX} / 1{,}000 * HOURS$

$kWh_{HP} = W_{HP} / 1{,}000 * HOURS$

$kWh_{EISA} = W_{EISA} / 1{,}000 * HOURS$

Where:

kWh_{EX} = Annual electricity consumption of existing T8 and T12 lamps and ballasts

kWh_{HP} = Annual electricity consumption of HP one-lamp, 1-foot by 4-foot luminaire

N = Number of years until 2016 (2014 = 2, 2015=1)

kWh_{EISA} = Annual electricity consumption of EISA compliant lamps and ballasts

W_{EISA} = Existing wattage of EISA compliant lamps and ballasts

EUL = Effective useful life (= 13 years)[1]

This calculation is used to account for the federal legislation stemming from EISA, which dictates the fluorescent fixture efficiency in lumens per watt. As of July 14, 2012, federal standards require that practically all linear fluorescents meet strict performance requirements, such that all consumers will need to upgrade to high performance T8 and T5 lamps and electronic ballasts when purchasing new bulbs. The effect is that first-year savings for T12 to T8 replacements can be assumed only for the remaining useful life of T12 equipment, at which point customers have no choice but to install equipment meeting the new standard.

The calculation above is based on the Illinois TRM, for which the standard is expected to become fully effective 2016. Therefore, the N is set as the number of years until 2016; after that, the remainder of the new fixture EUL will accumulate lifecycle savings with the baseline assuming that the EISA regulations are in full effect. As the years between the installed measures and 2016 decreases, the lifecycle savings decrease.

Deemed Savings

Average Annual Deemed Savings for HP 1-Lamp, 1-Foot by 4-Foot Fixture Replacement of 2-Lamp 1-Foot by 4-Foot T8 and T12 Fixtures

Measure	Commercial 3,730 (0.77)		Industrial 4,745 (0.77)		Agriculture 4,698 (0.67)		Schools & Gov 3,239 (0.64)	
	kWh	kW	kWh	kW	kWh	kW	kWh	kW
HPT8 1-Foot by 4-Foot Replacement, 2014-2015	156	0.0322	199	0.0322	197	0.0280	136	0.0268
HPT8 1-Foot by 4-Foot Replacement, 2016 and Beyond	111	0.0230	142	0.0230	140	0.0200	97	0.0191

Average Lifecycle Deemed Savings for HP 1-Lamp, 1-Foot by 4-Foot Fixture Replacement of 2-Lamp 1-Foot by 4-Foot T8 and T12 Fixtures

Sector	2014	2015	2016 and Beyond
Commercial	1,536	1,492	1,447
Industrial	1,955	1,898	1,841
Agriculture	1,935	1,879	1,822
Schools & Government	1,334	1,295	1,256

Assumptions

The following table is based on a July 2013 contractor pricing quote from Wesco Distribution for a reflector, lamp, and ballast. The quote is for materials only, and labor was estimated at approximately $25 for this product. The installed cost was rounded to $75.00 total ($50.00 for materials and $25.00 for labor).

Measure Cost Quotes

Item	Price	Brand
TRK14S-T8 with mirror reflector for 2-lamp T12 to 1-lamp T8 conversion	$34.10	Louv
F32T8ADV850/EW/ALTO (28 watt T8 lamp) wesco #28105	$3.15	PHL
IOPA2P32N35I 2-lamp T8 ballast - normal version	$10.40	ADV

The 1-foot by 4-foot HP fixture uses one 32-watt T8 and a ballast with a 0.88 ballast factor. Replaced fixtures are assumed to be 50% T8s and 50% T12s in 2014 and 2015.

The Illinois TRM assumes that this standard will become fully effective in 2016. Their recommendation is due to a realistic expectation that if a customer relamps an existing T12 fixture the day the standard takes effect, they would likely need to upgrade to T8s in less than five years. The Illinois TRM therefore recommends that for T12 systems, the baseline becomes a standard T8 in 2016, regardless of the equipment on the site. In addition, retrofits to T12 systems installed before 2016 have a baseline adjustment applied in 2016 for the remainder of the measure life.

Sources

1. Similar measure MMID 2561 (existing HPT8 one-lamp measure). PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Lighting Hours of Use and Coincidence Factors by Sector. March 22, 2010.

3. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Lighting Hours of Use and Coincidence Factors by Sector. March 22, 2010.
4. Online research, March 2016. Average price of "T12 Utube" lamp from: 1000bulbs.com.

Revision History

Version Number	Date	Description of Change
01	02/2014	Initial TRM entry
02	10/2016	Removed MMID 3390

8-Foot Linear Fluorescent T8 Replacement System

	Measure Details
Measure Master ID	T8, 2-Lamp, 4-Foot, HPT8 or RWT8: Replacing T12, 1-Lamp, 8-Foot, 0.78 < BF < 1.00, SBP A La Carte, 3307 Replacing T12, 1-Lamp, 8-Foot, 0.78 < BF < 1.00, 3122 Replacing T12, 1-Lamp, 8-Foot, BF ≤ 0.78, 3123 Replacing T12HO, 1-Lamp, 8-Foot, 0.78 < BF < 1.00, SBP A La Carte, 3312 Replacing T12HO, 1-Lamp, 8-Foot, 0.78 < BF < 1.00, 3124, 3801 Replacing T12HO, 1-Lamp, 8-Foot, BF ≤ 0.78, 3125 Replacing T12HO, 1-Lamp, 8-Foot, BF > 1.00, 3126, 3802 T8, 4-Lamp, 4-Foot, HPT8 or RWT8: Replacing T12, 2-Lamp, 8-Foot, 0.78 < BF < 1.00, SBP A La Carte, 3309 Replacing T12, 2-Lamp, 8-Foot, 0.78 < BF < 1.00, 3127, 3803 Replacing T12, 2-Lamp, 8-Foot, BF ≤ 0.78, 3128 Replacing T12HO 1L 8', 0.78 < BF < 1.00, SBP A La Carte, 3312 Replacing T12HO, 2-Lamp, 8-Foot, 0.78 < BF < 1.00, 3129, 3804 Replacing T12HO, 2-Lamp, 8-Foot, BF ≤ 0.78, 3130 Replacing T12HO, 2-Lamp, 8-Foot, BF > 1.00, 3131, 3805 Replacing T12VHO, 2-Lamp, 8-Foot, 0.78 < BF < 1.00, 3132 Replacing T12VHO, 2-Lamp, 8-Foot, BF ≤ 0.78, 3133 Replacing T12VHO, 2-Lamp, 8-Foot, BF > 1.00, 3134
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Linear
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	Varies by measure
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	Varies by measure, see Appendix D[2]

Measure Description

High performance (HP) and reduced wattage (RW) 4-foot linear fluorescent lighting fixtures that use low ballast factors, high wattage lamps, or reduced wattage lamps are an energy-efficient alternative to 8-foot, standard wattage T12, T12HO, and T12VHO linear fluorescent fixtures. These products can be installed on a two-to-one basis to replace 1-lamp or 2-lamp T12 luminaires without sacrificing lighting quality.

Description of Baseline Condition

For existing buildings, the baseline measure is 8-foot, 1-lamp or 2-lamp standard T12, T12HO, and T12VHO linear fluorescent fixtures. High output (HO) 8-foot T12 baseline lamps range from 95 watts to 110 watts, while for very high output (VHO) lamps the range is 185 watts to 215 watts.

Description of Efficient Condition

The efficient measure is 2-lamp or 4-lamp, 4-foot, high performance T8 fixtures with normal and low ballast factor, and reduced wattage, 25-watt and 28-watt T8s with high, normal, and low ballast factors.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{8' T12} - kWh_{HP/RW}$

Where:

$kWh_{8' T12}$ = Annual electricity consumption of an 8-foot T12, T12HO, or T12VHO linear fluorescent lamp fixture

$kWh_{HP/RW}$ = Annual electricity consumption of a 4-foot, linear fluorescent, high performance or reduced wattage fixture

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = Wattage/1,000 * CF$

Where:

Wattage = Wattage of installed fixture

1,000 = Kilwatt conversion factor

CF = Demand coincidence factor (= varies by sector; see table below)

Demand Coincidence Factor by Sector

Sector	CF[5]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[1]

Deemed Savings

Annual Deemed Savings for 8-FootLinear Fluorescent T8 Replacement System

Measure	MMID	Commercial 3,730 (0.77)		Schools & Gov 3,239 (0.64)		Industrial 4,745 (0.77)		Agriculture 4,698 (0.67)	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW
T8, 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12, 1-Lamp, 8-Foot, 0.78 < BF < 1.00	3122 SBP A La Carte, 3307	112	0.0231	97	0.0192	142	0.0231	141	0.0201
T8, 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12, 1-Lamp, 8-Foot, BF ≤ 0.78	3123	137	0.0283	119	0.0235	174	0.0283	173	0.0246
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12, 2-Lamp, 8-Foot, 0.78 < BF < 1.00	3127, 3803 SBP A La Carte, 3309	129	0.0266	112	0.0221	164	0.0266	162	0.0231
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12, 2-Lamp, 8-Foot, BF ≤ 0.78	3128	175	0.0362	152	0.0301	223	0.0362	220	0.0315
T8, 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 1-Lamp, 8-Foot, BF > 1.00	3126, 3802	202	0.0416	175	0.0346	257	0.0416	254	0.0362

Measure	MMID	Commercial 3,730 (0.77)		Schools & Gov 3,239 (0.64)		Industrial 4,745 (0.77)		Agriculture 4,698 (0.67)	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW
T8, 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 1-Lamp, 8-Foot, 0.78 < BF < 1.00	3124, 3801 SBP A La Carte, 3312	269	0.0555	234	0.0461	342	0.0555	339	0.0483
T8, 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 1-Lamp, 8-Foot, BF ≤ 0.78	3125	294	0.0606	255	0.0504	374	0.0606	370	0.0527
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 2-Lamp, 8-Foot, BF > 1.00	3131, 3805	322	0.0665	280	0.0553	410	0.0665	406	0.0579
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 2-Lamp, 8-Foot, BF ≤ 0.78	3130	507	0.1047	440	0.0870	645	0.1047	639	0.0911
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO, 2-Lamp, 8-Foot, BF > 1.00	3134	967	0.1997	840	0.1660	1,230	0.1997	1,218	0.1738
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO, 2-Lamp, 8-Foot, 0.78 < BF < 1.00	3132	1,106	0.2284	960	0.1898	1,407	0.2284	1,393	0.1987
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO, 2-Lamp, 8-Foot, BF ≤ 0.78	3133	1,153	0.2379	1,001	0.1977	1,467	0.2379	1,452	0.2070

Lifecycle Deemed Savings for 8-Foot Linear Fluorescent T8 Replacement System

Measure	MMID	Commercial 3,730 (0.77)	Schools & Gov 3,239 (0.64)	Industrial 4,745 (0.77)	Agriculture 4,698 (0.67)
		kWh	kWh	kWh	kWh
T8, 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12, 1-Lamp, 8-Foot, 0.78 < BF < 1.00	3122 SBP A La Carte, 3307	1,680	1,455	2,130	2,115
T8, 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12, 1-Lamp, 8-Foot, BF ≤ 0.78	3123	2,055	1,785	2,610	2,595
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12, 2-Lamp, 8-Foot, 0.78 < BF < 1.00	3127, 3803 SBP A La Carte, 3309	1,935	1,680	2,460	2,430
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12, 2-Lamp, 8-Foot, BF ≤ 0.78	3128	2,625	2,280	3,345	3,300
T8, 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 1-Lamp, 8-Foot, BF > 1.00	3126, 3802	3,030	2,625	3,855	3,810
T8, 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 1-Lamp, 8-Foot, 0.78 < BF < 1.00	3124, 3801 SBP A La Carte, 3312	4,035	3,510	5,130	5,085
T8, 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 1-Lamp, 8-Foot, BF ≤ 0.78	3125	4,410	3,825	5,610	5,550
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 2-Lamp, 8-Foot, BF > 1.00	3131, 3805	4,830	4,200	6,150	6,090
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 2-Lamp, 8-Foot, BF ≤ 0.78	3130	7,605	6,600	9,675	9,585
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing	3134	14,505	12,600	18,450	18,270

Measure	MMID	Commercial 3,730 (0.77)	Schools & Gov 3,239 (0.64)	Industrial 4,745 (0.77)	Agriculture 4,698 (0.67)
		kWh	kWh	kWh	kWh
T12VHO, 2-Lamp, 8-Foot, BF > 1.00					
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO, 2-Lamp, 8-Foot, 0.78 < BF < 1.00	3132	16,590	14,400	21,105	20,895
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO, 2-Lamp, 8-Foot, BF ≤ 0.78	3133	17,295	15,015	22,005	21,780

Measure Costs for 8-Foot Linear Fluorescent T8 Replacement System[2]

Measure	MMID	Cost ($)
T8, 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12, 1-Lamp, 8-Foot, 0.78 < BF < 1.00	3122; SBP A La Carte, 3307	$41.00
T8, 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12, 1-Lamp, 8-Foot, BF ≤ 0.78	3123	$41.00
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12, 2-Lamp, 8-Foot, 0.78 < BF < 1.00	3127, 3803; SBP A La Carte, 3309	$66.00
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12, 2-Lamp, 8-Foot, BF ≤ 0.78	3128	$66.00
T8, 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 1-Lamp, 8-Foot, BF > 1.00	3126, 3802	$41.00
T8, 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 1-Lamp, 8-Foot, 0.78 < BF < 1.00	3124, 3801; SBP A La Carte, 3312	$41.00
T8, 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 1-Lamp, 8-Foot, BF ≤ 0.78	3125	$41.00
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 2-Lamp, 8-Foot, BF > 1.00	3131	$66.00
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 2-Lamp, 8-Foot, BF ≤ 0.78	3130	$66.00
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO, 2-Lamp, 8-Foot, BF > 1.00	3134	$66.00
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO, 2-Lamp, 8-Foot, 0.78 < BF < 1.00	3132	$66.00
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO, 2-Lamp, 8-Foot, BF ≤ 0.78	3133	$66.00

Sources

1. Focus on Energy Evaluation Business Programs: Measure Life Study Final Report. August 25, 2009. And DEER 2014 EUL Table. http://www.deeresources.com/. Rated ballast life of 70,000 hours, not rated on bulb life. As such the value is capped at 15 years.
2. 2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.
3. Michigan Master Measure Database. 2011 baselines. Updated May 26, 2011.
4. Focus on Energy Business Programs Deemed Savings Manual V1.0. Commercial Applications. March 22, 2010.
5. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
6. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.

Revision History

Version Number	Date	Description of Change
01	12/2012	Initial TRM entry
02	10/2016	Removed MMID 3314

Reduced Wattage T5 and T5HO Lamps Replacing Standard T5 Lamps

	Measure Details
Measure Master ID	Reduced Wattage Lamps: Replacing Standard T5, 3023 Replacing Standard T5HO, 3024
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Linear
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	T5 = 6; T5HO = 8[1]
Incremental Cost ($/unit)	T5 = $3.27[4]; T5HO = $3.27[4]

Measure Description

Reduced wattage T5 and T5HO lamps save energy by reducing the total input wattage of the luminaires where they are installed. Reduced wattage T5 and T5HO lamps can be installed in place of existing standard wattage T5 and T5HO lamps where the tasks that take place in the space do not require the light level provided by the existing T5 and T5HO lamps.

Description of Baseline Condition

The baseline equipment is 4-foot, T5 28-watt lamps and 4-foot, 54-watt T5HO lamps.

Description of Efficient Condition

The efficient equipment is 4-foot, 26-watt T5 lamps and 4-foot, 44-watt, 47-watt, 49-watt, or 51-watt T5HO lamps.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{28wattT5\ or\ 54wattT5HO} - kWh_{RWLamp}$

Where:

$kWh_{28wattT5\ or\ 54wattT5HO}$ = Annual electricity consumption of standard 28-watt, 4-foot, T5 lamp or 4-foot, 54-watt T5HO lamp

kWh_{RWLamp} = Annual electricity consumption of reduced wattage 4-foot, 26-watt T5 lamp or 44-watt, 47-watt, 49-watt, or 51-watt T5HO lamp

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = Wattage / 1{,}000 * CF$

Where:

Wattage = Wattage of installed fixture (= ballast factor * lamp wattage)

1,000 = Kilowatt conversion factor

CF = Demand coincidence factor (= varies by sector; see table below)

Demand Coincidence Factor by Sector

Sector	CF[3]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = (kWh_{28wattT5\ or\ 54wattT5HO} - kWh_{RWLamp}) * EUL$

Where:

EUL = Effective useful life (= 6 years for T5; = 8 years for T5HO)[1]

Deemed Savings

Average Annual Deemed Savings for Reduced Wattage T5 and T5HO Lamps Replacing Standard

Measure	MMID	Commercial		Schools & Gov		Industrial		Agriculture	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW
RW T5 Lamp	3023	7	0.0015	6	0.0012	9	0.0015	9	0.0013
RW T5HO Lamp	3024	23	0.0048	20	0.0040	29	0.0048	29	0.0042

Average Lifecycle Deemed Savings for Reduced Wattage T5 and T5HO Lamps Replacing Standard T5

Measure	MMID	Commercial	Schools & Gov	Industrial	Agriculture
		kWh	kWh	kWh	kWh
RW T5 Lamp	3023	42	36	54	54
RW T5HO Lamp	3024	184	160	232	232

Assumptions

An average of 25% each of 44-watt, 47-watt, 49-watt, and 51-watt 4-foot T5HO lamps was used to generate the new measure wattage and savings for the T5HO lamp replacement measure.

A 26-watt T5 lamps was used to generate the new measure wattage and savings for the T5 lamp replacement measure.

Sources

1. Multiple manufacturers' product life rating (≈ 25,000 hours for T5 and ≈ 30,000 hours for T5HO lamps.
2. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
3. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.
4. Online research, March 2016. Average cost of T5 - High Efficiency - Fluorescent lamps. Available online: https://www.1000bulbs.com/category/f28t5-fluorescent-tubes/

Revision History

Version Number	Date	Description of Change
01	12/2012	Initial TRM entry

T8, Low-Watt Relamp

	Measure Details
Measure Master ID	T8, Low-Watt Relamp: 54 Watts, 8-Foot, 2707 8-Foot, 3135
Measure Unit	Per unit
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Linear
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	18
Peak Demand Reduction (kW)	0.0034
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	90
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Incremental Cost ($/unit)	$2.26[2]

Measure Description

Replacing standard T8 lamps with reduced wattage T8 lamps can result in energy savings while still maintaining adequate light levels. This measure is replacing standard replacing standard 59-watt, 8-foot T8 lamps with 54-watt T8 lamps. This measure is for the replacement of lamps only.

Light levels after relamping should meet current Illuminating Engineering Society of North America standards. Reduced-wattage lamps should be CEE listed, and should be used with compatible and existing T8 electronic ballasts. The nominal wattages of the new lamps must be 54 watt.

Description of Baseline Condition

Baseline lamp is 59-watt T8 lamps.

Description of Efficient Condition

54-watt T8 efficient lamps should be used with compatible T8 electronic ballasts:

Annual Energy-Savings Algorithm

$kWh_{SAVED} = [(P_E – P_P) / 1{,}000) * HOURS$

Where:

P_E = Existing lighting wattage
P_P = Proposed replacement lighting wattage
1,000 = Kilowatt conversion factor
HOURS = Annual operating hours

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = [(P_E – P_P) / 1{,}000) * CF$

Where:

CF = Demand coincident factor

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = [(P_E – P_P) / 1{,}000) * HOURS * EUL$

Where:

EUL = Effective useful life (= 5 years)[1]

Sources

1. PA Consulting Group Inc. *Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs: Measure Life Study, Final Report*. August 25, 2009.
2. Average of MMID 2590 and MMID 2591. 2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.

Revision History

Version Number	Date	Description of Change
01	10/25/2012	Initial draft
02	01/08/2013	Updated to new template
03	03/08/2013	Updated

T8, 2 Lamp, 4-Foot, Recessed Indirect Fixture, HPT8, Replacing 3 Lamp or 4 Lamp T8 or T12

	Measure Details
Measure Master ID	T8, 2 Lamp, 4-Foot, Recessed Indirect Fixture, HPT8, Replacing 3 Lamp or 4 Lamp T8 or T12, 2704
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Linear
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	179.0 kWh T5 fixture, 276.0 kWh T8 fixture
Peak Demand Reduction (kW)	0.0231 kW T5 fixture, 0.0355 kW T8 fixture
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	2,685.0 kWh T5 fixture, 4,140.0 kWh T8 fixture
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[3]
Incremental Cost ($/unit)	$167.17[4]

Measure Description

This measure is replacing 3 lamp or 4 lamp, 4-footstandard T8 and T12 fixtures with 2 lamp F28T5, HPT8, RWT8 2x4 high-efficiency recessed fixtures.

Description of Baseline Condition

The baseline measure is 3 lamp or 4 lamp, 4-foot standard T8 and T12 fixtures.

Description of Efficient Condition

The efficient measure is 2 lamp F28T5, HPT8, RWT8 2x4 high-efficiency recessed fixtures.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{DEEMED} * (HOURS_{MULTIFAMILY} / HOURS_{COMMERCIAL})$

Where:

kWh_{DEEMED} = Annual commercial deemed electricity savings

$HOURS_{MULTIFAMILY}$ = Annual multifamily deemed lighting hours (= 3,730)[2]

$HOURS_{COMMERCIAL}$ = Annual commercial deemed lighting hours (= 5,949.5; 16.3 hours/day * 365 days/year)[1]

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = Wattage / 1,000 * CF

Where:

CF = Coincidence factor (= 0.77)[1]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE}$ = kWh_{SAVED} * EUL

Where:

EUL = Effective useful life (= 15 years)[3]

Deemed Savings

Deemed Savings[2]

Measure	Annual Energy Savings (kWh)	Peak Demand Reduction (kW)	Lifecycle Energy Savings (kWh)
4-Foot, 2 Lamp, T5 Fixture	179.0	0.0231	2,685.0
4-Foot, 2 Lamp, T8 Fixture	276.0	0.0355	4,140.0

Sources

1. ACES. Deemed Savings Desk Review. Multifamily applications for common areas. November 3, 2010.
2. Focus on Energy Business Programs Deemed Savings Manual V1.0. Tables 4-185, 4-190, and 4-208, Commercial Applications. March 22, 2010.
3. CA DEER EUL IDs "ILtg-Lfluor-CommArea" and "Linear Fluorescents - MF Common Area."
4. 2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.

Revision History

Version Number	Date	Description of Change
01	01/02/2013	New measure

Ceramic Metal Halide Lamp, ≤ 25 Watts

	Measure Details
Measure Master ID	Ceramic Metal Halide Integral Ballast Lamps, ≤ 25 watts, 2238
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	High Intensity Discharge (HID)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	341
Peak Demand Reduction (kW)	0.0443[2]
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	3,751
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	11[1]
Incremental Cost ($/unit)	$61.84[3]

Measure Description

Integral ballast ceramic metal halide lamps are an energy-saving alternative to standard 70 watt to 100 watt incandescent lamps. These ceramic metal halide lamps can be applied in several common applications without sacrificing any needed performance.

Description of Baseline Condition

The baseline condition is 70 watt to 100 watt incandescent flood or spot lamps.

Description of Efficient Condition

The efficient condition is ceramic metal halide lamps with integrated ballasts.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{DEEMED} * (HOURS_{MULTIFAMILY} / HOURS_{COMMERCIAL})$

Where:

kWh_{DEEMED} = Annual commercial deemed electricity savings

$HOURS_{MULTIFAMILY}$ = Annual multifamily deemed lighting hours(=733.65)[2]

$HOURS_{CCOMMERCIAL}$= Annual commercial deemed lighting hours (=3,730)[2]

Summer Coincident Peak Savings

$kW_{DEMAND} = kW_{SAVED} / (HOURS * CF)$

Where:

CF = Coincidence factor (=1)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 11 years)[1]

Deemed Savings

Annual deemed savings per CMH integral ballast lamp is 341.0 kWh and 0.0443 kW.[2]

Lifecycle deemed savings per CMH integral ballast lamps is 682 kWh.

Sources

1. Averaged between Cadmus 2013 database, DEER 2008, 2009 Focus study, and Fannie Mae Estimated Useful Life Table: https://www.fanniemae.com/content/guide_form/4099f.pdf
2. Focus on Energy Business Programs Deemed Savings Manual V1.0. Tables 4-185 and 4-194 Commercial Applications. March 22, 2010.
3. Evaluator Online Research, May 2016. From: http://www.warehouse-lighting.com. Baseline cost is $8.27 for 120 watt incandescents. Average cost of 20-25 Watt metal halide flood is $70.14.

Revision History

Version Number	Date	Description of Change
01	01/2013	New measure
02	03/2013	Revised per comments
03	01/2016	Added parameter details

Exterior/Parking LED Fixtures

	Measure Details
Measure Master ID	LED Fixture, Replacing 150-175 Watt HID, Parking Garage: 24 Hour, 3100 Dusk to Dawn, 3101 LED Fixture, Replacing 250 Watt HID, Parking Garage: 24 Hour, 3103 Dusk to Dawn, 3104 LED Fixture, Replacing 70-100 Watt HID, Parking Garage: 24 Hour, 3109 Dusk to Dawn, 3110 LED Fixture, Replacing 320 Watt HID, Parking Garage, 3056
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	Varies by measure
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	Varies by measure
Incremental Cost ($/unit)	Varies by measure, see Appendix D

Measure Description

Parking garage and exterior LED fixtures are an energy-saving alternative to traditional standard wattage HID light sources used for the same applications. LED light sources can be applied in almost every common application type where HID light sources are currently found.

Description of Baseline Condition

The baseline is standard HID lamps between 70 watts and 400 watts.

Description of Efficient Condition

Replacements must be complete fixtures with a total power reduction of 40% or more. Lamp-only replacements are not eligible for incentive. LEDs must be on the DLC qualifying list.[2]

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) * HOU / 1{,}000$

Where:

$Watts_{BASE}$ = Annual electricity consumption of standard HID fixture (= see table below)

$Watts_{EE}$ = Annual electricity consumption of efficient LED fixture[2]

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 4,380 for dusk to dawn/exterior; = 8,760 for 24 hours)

Baseline Wattage by HID Lamp Type

Baseline HID Lamps	$Watts_{BASE}$
70-watt to 100-watt HID replacement	70-watt HID: 94 watts 100-watt HID: 129 watts
150-watt HID replacement	150-watt HID: 179 watts
175-watt HID replacement	175-watt HID: 210 watts
250-watt HID replacement	250-watt HID: 299 watts
320-watt HID replacement	320-watt HID: 368 watts

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1{,}000 * CF$

Where:

CF = Coincidence factor (= 0 for exterior lights; = 0 or 1 for garage lights)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (=16= 3101, 3104, 3110 and 8= 3100, 3103, 3109, 3506) [1]

Deemed Savings

Average Deemed Savings for Exterior LED Fixtures

Annual Savings Measure	MMID	Annual kWh Savings	Lifecycle kWh Savings
Exterior LED replacing 320-watt HID	3056	645	7,737

Average Annual Deemed Savings for Parking LED Fixtures

Measure (hours)	MMID	kWh	kW
Parking LED replacing 70-watt to 100-watt (8,760)	3109	391	0.045
Parking LED replacing 70-watt to 100-watt (4,380)	3110	195	0
Parking LED replacing 150-watt to 175-watt (8,760)	3100	682	0.078
Parking LED replacing 150-watt to 175-watt (4,380)	3101	341	0
Parking LED replacing 250-watt (8,760)	3103	1,048	0.120
Parking LED replacing 250-watt (4,380)	3104	524	0

Average Lifecycle Deemed Savings for Parking LED Fixtures

Measure (hours)	MMID	kWh
Parking LED replacing 70-watt to 100-watt (8,760)	3109	4,688
Parking LED replacing 70-watt to 100-watt (4,380)	3110	2,344
Parking LED replacing 150-watt to 175-watt (8,760)	3100	8,178
Parking LED replacing 150-watt to 175-watt (4,380)	3101	4,089
Parking LED replacing 250-watt (8,760)	3103	12,572
Parking LED replacing 250-watt (4,380)	3104	6,286

Assumptions

4,380 and 8,760 hours of annual operation were used for parking garage calculations

4,380 hours of annual operation were used for exterior lighting calculations, with dusk to dawn operation. A load factor of 1.0 was used for both parking garage and exterior lighting calculations.

It was assumed that LED lamps are capable of achieving a 40% reduction in power requirements.[2]

Sources

1. Cadmus review of manufacturers' measure life.
2. Design Lights Consortium. *Qualified Parts List*. Available online: http://www.designlights.org/.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

LED Downlights Replacing CFL Downlight

	Measure Details
Measure Master ID	LED Fixture, Downlights: ≤ 18 Watts, Replacing 1-Lamp Pin-Based CFL Downlight, 3394 > 18 Watts, Replacing 2-Lamp Pin-Based CFL Downlight, 3395
Measure Unit	Per luminaire
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	11[1]
Incremental Cost ($/unit)	$10.80 (MMID 3394);[2] $17.55 (MMID 3395)[2]

Measure Description

LED downlights can be used to replace existing 1- and 2-lamp pin-based CFL downlights used for the same application without sacrificing performance. LED downlights save energy because they consume less wattage than the 1- and 2-lamp pin-based CFL downlights products they replace.

Description of Baseline Condition

Low Wattage Downlights

The baseline condition is pin-based CFL downlights containing 1-lamp of 26 watts, 32 watts, or 42 watts in existing buildings and new construction or any 1-lamp pin-based CFL downlight between 26 watts and 45 watts. An average of 33.3% each for 1-lamp 26-watt pin-based CFL downlights, 1-lamp 32-watt pin-based CFL downlights, and 1-lamp 42-watt pin-based CFL downlights was used to generate the baseline usage. See the Assumptions section for additional information.

High Wattage Downlights

The baseline condition is pin-based CFL downlights containing 2-lamps of 26 watts, 32 watts, or 42 watts each in existing buildings and new construction or any 2-lamp pin-based CFL downlight with 26 watts to 45 watts. An average of 33.3% each for 2-lamp 26-watt pin-based CFL downlights, 2-lamp 32-watt pin-based CFL downlights, and 2-lamp 42-watt pin-based CFL downlights was used to generate the baseline usage. See the Assumptions section for additional information.

Description of Efficient Condition

Low Wattage Downlights

The efficient condition is low-wattage downlights that are ENERGY STAR-rated and/or Wisconsin Focus on Energy QPL-listed LED downlights that consume ≤ 18 watts.

High Wattage Downlights

The efficient condition is high-wattage downlights that are ENERGY STAR-rated and/or Wisconsin Focus on Energy QPL-listed LED downlights that consume > 18 watts.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{CFL} – Watts_{LEDEE}) / 1,000 * HOU$

Where:

$Watts_{CFL}$ = Wattage of 1-lamp or 2-lamp pin-based CFL downlights with 26 watt, 32 watt, or 42 watt lamps (= 37 as average for low wattage system; = 75 as average for high wattage systems)

$Watts_{LEDEE}$ = Average power consumption of ENERGY STAR-rated and/or Wisconsin Focus on Energy QPL-listed LED fixture (= 13 for systems ≤ 18 watts; = 32 for systems > 18 watts)[3]

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= varies by sector; see table below)

Hours-of-Use

Sector	HOU[4]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239
Multifamily	5,950[5]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{CFL} - Watts_{LEDEE}) / 1{,}000 * CF$

Where:

CF = Coincidence factor (= varies by sector; see table below)

Coincidence Factor

Sector	CF[6]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64
Multifamily	0.77

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 11 years)[1]

Deemed Savings

Average Annual Deemed Savings for LED Downlights Replacing 1 Lamp or 2 Lamp Pin-Based CFL

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Gov		Multifamily	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED downlights ≤ 18 watts replacing 1-lamp pin-based CFL downlight	3394	92	0.0190	117	0.0190	116	0.0166	80	0.0158	147	0.0190
LED downlights > 18 watts replacing 2-lamp pin-based CFL downlight	3395	160	0.0330	203	0.0330	201	0.0287	139	0.0274	255	0.0330

Average Lifecycle Deemed Savings for LED Downlights Replacing 1 Lamp or 2 Lamp Pin-Based CFL (kWh)

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Gov	Multifamily
LED downlights ≤ 18 watts replacing 1-lamp pin-based CFL downlight	3394	1,012	1,287	1,276	880	1,617
LED downlights > 18 watts replacing 2-lamp pin-based CFL downlight	3395	1,760	2,233	2,211	1,529	2,805

Assumptions

Fixture lamp weightings are based on a combination of energy audit experience and feedback from Lighting Certified individuals through the National Council on Qualifications for the Lighting Professions and individuals with lighting sales experience.

Sources

1. Cadmus. Review of manufacturers’ measure life.
2. Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.
3. ENERGY STAR® product list. August 28, 2015. (Average measured wattage taken from listed products in the Downlight Recessed, Downlight Solid State Retrofit, and Downlight Surface Mount fixture types, filtered by wattage limits).
4. *Focus on Energy Business Programs Deemed Savings Manual V1.0*. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
5. *Focus on Energy Deemed Savings Desk Review Multifamily Applications for Common Areas*. November 3, 2010. (5,949.5 annual operating hours based on 16.3 hours/day * 365 days/year).
6. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.

Revision History

Version Number	Date	Description of Change
01	04/01/2014	New measure
02	08/28/2015	Updated savings information

LED Downlight Fixtures ≤ 18 Watts

	Measure Details
Measure Master ID	LED Fixture, Downlight, ≤ 18 Watts, 3750, 3819
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	11[1]
Incremental Cost	$80.13[2]

Measure Description

LED downlight fixtures can replace existing incandescent fixtures without sacrificing performance, and save energy because they consume less wattage than the incandescent products they replace.

Description of Baseline Condition

The baseline condition is 50-watt to 99-watt incandescent fixtures using reflector lamps typically found in downlight retrofit applications. Reflector lamps are exempt from EISA lumen per watt standards.[7]

Description of Efficient Condition

The efficient equipment is an ENERGY STAR-rated downlight fixture that consumes ≤ 18 watts.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) * HOU / 1,000$

Where:

$Watts_{BASE}$ = Wattage of baseline incandescent fixtures; a weighted average of 10% for 50-watt, 40% for 65-watt, 25% for 75-watt and 25% for 90-watt sources was used (= 72.3 watts; see the Assumptions section)

$Watts_{EE}$ = Power consumption of efficient LED products (= 13 watts)[3]

HOU = Hours-of-use (= varies by sector; see table below)

1,000 = Kilowatt conversion factor

Hours-of-Use by Section

Sector	HOU[4]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239
Multifamily	5,950[5]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{LED}) / 1{,}000 * CF$

Where:

CF = Coincidence factor (= varies by sector; see table below)

Coincidence Factor by Sector

Sector	CF[6]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64
Multifamily	0.77

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 11 years)[1]

Assumptions

Lamp weightings are based on a combination of energy audit experience, direct install experience, and feedback from Lighting Certified individuals through the National Council on Qualifications for the Lighting Professions and individuals with lighting sales experience of fixtures categorized as downlights. Full incandescent baselines are used as customers are likely to replace failed equipment with the same technology as replacements are still available on the market with no changes to fixture performance.

Deemed Savings

Average Annual Deemed Savings for LED Downlights ≤ 18 Watts

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Gov		Multifamily	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED Downlights ≤ 18 Watts Replacing 60 Watt to 100 Watt Incandescent	3750, 3819	222	0.0458	282	0.0458	280	0.0399	193	0.0381	354	0.0458

Average Lifecycle Deemed Savings for LED Downlights ≤ 18 Watts

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Gov	Multifamily
LED Downlights ≤ 18 Watts Replacing 60 Watt to 100 Watt Incandescent	3750, 3819	2,442	3,102	3,080	2,123	3,894

Sources

1. Cadmus. Review of manufacturers' measure life.
2. Incremental cost taken from MMID 2984: Light Emitting Diode (LED) LED Fixture, Downlights, Accent Lights and Monopoint, ≤ 18 Watts, Common Area, derived from historical program data.
3. ENERGY STAR product list from October 13, 2015. Average measured wattage of Downlight Recessed, Downlight Solid State Retrofit, and Downlight Surface Mount fixture types, filtered by wattage limits.
4. *Focus on Energy Business Programs Deemed Savings Manual V1.0*. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
5. ACES. *Focus on Energy Deemed Savings Desk Review Multifamily Applications for Common Areas*. November 3, 2010. (5,949.5 annual operating hours based on 16.3 hours/day * 365 days/year).
6. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.
7. The Energy Independence and Securities Act (EISA) of 2007 Lighting Facts Summary: http://www.lightingfacts.com/Library/Content/EISA

Revision History

Version Number	Date	Description of Change
01	10/13/2015	New measure

LED Downlight Fixtures > 18 Watts

	Measure Details
Measure Master ID	LED Fixture, Downlight, > 18 Watts, 3749, 3820
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	11[1]
Incremental Cost	$12.46[2]

Measure Description

LED downlight fixtures can replace existing incandescent fixtures without sacrificing performance, and save energy because they consume less wattage than the incandescent products they replace.

Description of Baseline Condition

Several wattage baselines are averaged together to produce a single baseline. An incandescent baseline of 72 watts is used due to EISA legislation stating that 72 is the maximum replacement wattage for a 100-watt general service incandescent lamp.[7] Systems with 50 watts to 100 watt HID lamps are also used.

Description of Efficient Condition

The efficient equipment is an ENERGY STAR-rated downlight fixture that consumes > 18 watts.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) * HOU / 1{,}000$

Where:

$Watts_{BASE}$ = Wattage of baseline incandescent fixtures; a weighted average of 25% 72-watt incandescent and 50-watt, 70-watt, and 100-watt HIDs was used to generate the baseline wattage;see the Assumptions section (= 88.8 watts)[8]

$Watts_{EE}$ = Wattage of efficient LED products (= 32 watts)[3]

HOU = Hours-of-use (= varies by sector; see table below)

1,000 = Kilowatt conversion factor

Hours of Use

Sector	HOU[4]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239
Multifamily	5,950[5]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{LED}) / 1{,}000 * CF$

Where:

CF = Coincidence factor (= varies by sector; see table below)

Coincidence Factor

Sector	CF[6]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64
Multifamily	0.77

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 11 years)[1]

Deemed Savings

Average Annual Deemed Savings for LED Downlights > 18 Watts

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Gov		Multifamily	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED Downlights > 18 Watts Replacing 100 Watt Incandescent or 50 Watt o 100 Watt HID	3749, 3820	212	0.0438	270	0.0438	267	0.0381	184	0.0364	338	0.0438

Average Lifecycle Deemed Savings for LED Downlights > 18 Watts

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Gov	Multifamily
LED Downlights > 18 Watts Replacing 100 Watt Incandescent or 50 Watt o 100 Watt HID	3749, 3820	2,332	2,970	2,937	2,024	3,718

Assumptions

Fixture lamp weightings are based on a combination of energy audit experience and feedback from Lighting Certifiedindividuals through the National Council on Qualifications for the Lighting Professions and individuals with lighting sales experience. Incandescent and HID baselines are used because audit and market experience reveals that customers are likely to replace failed equipment with the same technology, as replacements are still available on the market with no changes to fixture performance.

Sources

1. Cadmus. Review of manufacturers' measure life.
2. Online Research, March 2016. Material cost is average sales price of "Led Downlight." Available online: https://www.1000bulbs.com/category/led-downlights/
3. ENERGY STAR product list from October 13, 2015. Average measured wattage of Downlight Recessed, Downlight Solid State Retrofit, and Downlight Surface Mount fixture types, filtered by wattage limits.

4. *Focus on Energy Business Programs Deemed Savings Manual V1.0*. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
5. ACES. *Focus on Energy Deemed Savings Desk Review Multifamily Applications for Common Areas*. November 3, 2010. (5,949.5 annual operating hours based on 16.3 hours/day * 365 days/year).
6. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.
7. The Energy Independence and Securities Act (EISA) of 2007 Lighting Facts Summary: http://www.lightingfacts.com/Library/Content/EISA
8. *Focus on Energy Default Wattage Guide.* HID wattages based on metal halide technologies.

Revision History

Version Number	Date	Description of Change
01	10/13/2015	New measure

ENERGY STAR LED Commercial Threshold Fixture, < 20 Watts

	Measure Details
Measure Master ID	ENERGY STAR LED Commercial Threshold Fixture, < 20 Watts, SBP after a la Carte, 3762
Measure Unit	Per luminaire
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	LED
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	202
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	1,414
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	7[1]
Incremental Cost ($/unit)	$50.00[3]

Measure Description

ENERGY STAR-qualified LED commercial threshold fixtures are identical to residential porch and post mount luminaires. The fixtures are verified to meet both a performance and efficiency criteria, ensuring that an LED product's performance is similar to other time-tested technologies used for the same applications and that it meets ENERGY STAR efficiency criteria.

Description of Baseline Condition

The baseline condition is standard, screw-based incandescent or halogen lamps/luminaires. An average of 33% 60 watt (43 watt), 33% 75 watt (53 watt), and 33% 100 watt (72 watt) A-19 halogen and incandescent lamps that meet EISA 2007 as of January 1, 2013 were used to generate the baseline usage of 56 watts (this is consistent with MMID 3157 in the Wisconsin TRM)[5].

Description of Efficient Condition

The efficient condition is an ENERGY STAR-rated LED in one of the following categories: Porch (wall mounted), Outdoor Porch Wall Mount, or Outdoor Post-Mount for or commercial use.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{INC} - Watts_{LED}) /1{,}000 * HOU$

Where:

$Watts_{INC}$ = Wattage of standard incandescent fixture (= 56)

$Watts_{LED}$ = Wattage of LED product (= 9.8)[4]

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 4,380)[2]

Summer Coincident Peak Savings Algorithm

There are no peak savings for this measure.

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 7 years)[1]

Deemed Savings

Average Annual Deemed Savings for LED Lamp Replacing Incandescent

Measure	MMID	kWh Saved
ENERGY STAR LED Commercial Threshold Fixture, < 20 Watts	3762	202

Average Lifecycle Deemed Savings for LED Lamp Replacing Incandescent

Measure	MMID	kWh Saved
ENERGY STAR LED Commercial Threshold Fixture, < 20 Watts	3762	1,414

Assumptions

The 4,380 hours run time of fixtures is based on an annual average of 12 hours per day from NOAA.[2] This includes times when photocells turn on prior to exact sunset and turn off after exact sunrise, accounting for diminished outdoor lighting as well as time clock scheduled lighting.

Sources

1. Cadmus review of manufacturers' measure life.
2. U.S. Department of Commerce | National Oceanic & Atmospheric Administration | NOAA Research. *NOAA Solar Calculator.* http://www.esrl.noaa.gov/gmd/grad/solcalc/

3. Pricing from web-based stores, June 16, 2015. Incandescent and LED pricing from www.lightingdirect.com and www.homedepot.com was averaged, then an installation cost of $10.00 ($30 per hr at 20 minutes) was added to both the baseline and efficient conditions. The incremental cost is the difference between baseline and proposed total cost.
4. Wattage equates to the weighted average of luminaires listed in the Ourdoor Porch Wall Mount, Outdoor Post-Mount, and Porch (wall mounted) categories. Detailed information contained in Implemeter sheet “EnergyStarPorch Certified-2015-03-20”.
5. *Wisconsin Focus on Energy Technical Resource Manual.* October 22, 2015. MMID 3157.

Revision History

Version Number	Date	Description of Change
01	01/2016	New measure

ENERGY STAR LED Lamp Replacing < 23 Watt CFL

	Measure Details
Measure Master ID	LED Lamp, ENERGY STAR: Replacing < 23 Watt CFL, 3745, 3838 Replacing < 23 Watt CFL, Common Area, 3746 Replacing < 23 Watt CFL, In Unit, 3747
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by hours-of-use
Peak Demand Reduction (kW)	Varies by hours-of-use
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by hours-of-use
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	Varies by sector
Incremental Cost ($/unit)	$3.00[4]

Measure Description

LED lamps save energy and increase rated life when replacing CFL products by providing a similar lumen output with lower input wattage.

Description of Baseline Condition

The baseline condition is the average wattage of ENERGY STAR-listed CFLs consuming < 23 watts.

Description of Efficient Condition

The efficient condition is the average wattage of ENERGY STAR-listed LEDs equivalent to ≤ 75 watt incandescent.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{LEDEE}) / 1,000 * HOU$

Where:

$Watts_{BASE}$ = Average wattage of ENERGY STAR-listed CFLs consuming < 23 watts (= 14 watts)[5]

$Watts_{LEDEE}$ = Energy efficient wattage; average wattage of ENERGY STAR-listed LEDs equivalent to ≤ 75 watt incandescent (= 8.9 watts)[6]

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= varies by sector; see table below)

Hours-of-Use by Sector

Sector	HOU[7]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239
Multifamily - Common Area[8]	5,950
Multifamily - In Unit[9]	840

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{LED}) / 1,000 * CF$

Where:

CF = Coincidence factor (= varies by sector; see table below)

Coincidence Factorby Sector

Sector	CF[7]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64
Multifamily - Common Area [9]	0.77
Multifamily - In Unit [9]	0.11

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= varies by sector; see table below)

Effective Useful Life by Sector

Sector	EUL
Commercial	7 years
Industrial	7 years
Agriculture	7 years
Schools & Government	7 years
Multifamily - Common Area	5 years
Multifamily - In Unit[8]	20 years

Deemed Savings

Annual Savings - ENERGY STAR LED Lamp Replacing < 23 Watt CFL

Commercial		Industrial		Agriculture		Schools & Gov		Multifamily- Common Area		Multifamily – In Unit	
kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
19	0.0039	24	0.0039	24	0.0034	16	0.0033	30	0.0039	4	0.0006

Lifecycle Savings (kWh) - ENERGY STAR LED Lamp Replacing < 23 Watt CFL

Commercial	Industrial	Agriculture	Schools & Gov	Multifamily- Common Area	Multifamily – In Unit
133	168	168	112	150	80

Sources

1. ENERGY STAR product list. October 20, 2015. Average rated life of LED products listed is approximately 26,399 hours (26,399/4,103 average sector hours = 6.4, rounded to 7 years).
2. ENERGY STAR product list. October 20, 2015. Average rated life of LED products listed is approximately 26,399 hours (26,399/5,950 average sector hours = 4.4, rounded to 5 years).
3. ENERGY STAR product list. October 20, 2015. Average rated life of LED products listed is approximately 26,399 hours (26,399/840 average sector hours = 31.4, rounded to 32 years; this

EUL is over 20 years, and under agreement with the PSC, Cadmus, the Administrator, and Implementers, LED EULs above 20 years are set at 20 years.

4. Cost data obtained through various online lighting retailers in October 2015, including 1000bulbs.com, warehouse-lighting.com, alconlighting.com, earthled.com, and toenic.com. Average prices of baseline equipment and qualifying efficient equipment used to obtain estimated incremental cost. Full data is available upon request.
5. ENERGY STAR product list. October 20, 2015.
6. *Focus on Energy Business Programs Deemed Savings Manual V1.0*. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
7. Focus on Energy Deemed Savings Desk Review Multifamily Applications for Common Areas. November 3, 2010. (5,949.5 annual operating hours based on 16.3 hours/day * 365 days/year).
8. Cadmus. Field Study Research of Residential Lighting. October 18, 2013. Results published in the 2014 Focus on Energy Deemed Savings Report: https://focusonenergy.com/sites/default/files/FoE_Deemed_WriteUp%20CY14%20Final.pdf
9. Cadmus. Field Study Research: Residential Lighting (CFL and incandescent bulbs). October 25, 2013. .

Revision History

Version Number	Date	Description of Change
01	10/20/2015	New measure

ENERGY STAR LED Lamp Replacing ≥ 23 Watt CFL

	Measure Details
Measure Master ID	LED Lamp, ENERGY STAR: Replacing ≥ 23 Watt CFL, 3742, 3837 Replacing ≥ 23 Watt CFL, Common Area, 3743 Replacing ≥ 23 Watt CFL, In Unit, 3744
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by hours-of-use
Peak Demand Reduction (kW)	Varies by hours-of-use
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by hours-of-use
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	Varies by sector
Incremental Cost ($/unit)	$11.00[4]

Measure Description

LED lamps save energy and increase rated life when replacing CFL products by providing a similar lumen output with lower input wattage.

Description of Baseline Condition

The baseline condition is the average wattage of ENERGY STAR-listed CFLs consuming ≥ 23 watts.

Description of Efficient Condition

The efficient condition is the average wattage of ENERGY STAR-listed LEDs equivalent to > 75 watt incandescent.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{LEDEE}) / 1,000 * HOU$

Where:

$Watts_{BASE}$ = Average wattage of ENERGY STAR-listed CFLs consuming ≥ 23 watts (= 26 watts)[5]

$Watts_{LEDEE}$ = Energy efficient wattage; average wattage of ENERGY STAR-listed LEDs equivalent to > 75 watt incandescent (= 16.7 watts)[5]

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= varies by sector; see table below)

Hours-of-Use by Sector

Sector	HOU[7]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239
Multifamily - Common Area	5,950
Multifamily - In Unit[8]	840

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{LEDEE}) / 1,000 * CF$

Where:

CF = Coincidence factor (= varies by sector; see table below)

Coincidence Factor by Sector

Sector	CF[6]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64
Multifamily - Common Area	0.77
Multifamily - In Unit[8]	0.11

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= varies by sector; see table below)

Effective Useful Life by Sector

Sector	EUL
Commercial	7 years
Industrial	7 years
Agriculture	7 years
Schools & Government	7 years
Multifamily - Common Area	5 years
Multifamily - In Unit[8]	20 years

Deemed Savings

Annual Savings - ENERGY STAR LED Lamp Replacing ≥ 23 Watt CFL

Commercial MMID 3742, 3837		Industrial MMID 3742, 3837		Agriculture MMID 3742, 3837		Schools & Gov MMID 3742, 3837		Multifamily – Common Area MMID 3743		Multifamily – In Unit MMID 3744	
kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
33	0.0069	42	0.0069	42	0.0060	29	0.0057	53	0.0069	7	0.0010

Lifecycle Savings (kWh) - ENERGY STAR LED Lamp Replacing ≥ 23 Watt CFL

Commercial MMID 3742, 3837	Industrial MMID 3742, 3837	Agriculture MMID 3742, 3837	Schools & Gov MMID 3742, 3837	Multifamily – Common Area MMID 3743	Multifamily – In Unit MMID 3744
231	294	294	203	265	140

Sources

1. ENERGY STAR product list. October 20, 2015. Average rated life of LED products listed is approximately 27,290 hours (27,290/4,103 average sector hours = 6.7, rounded to 7 years).
2. ENERGY STAR product list. October 20, 2015. Average rated life of LED products listed is approximately 27,290 hours (27,290/5,950 average sector hours = 4.6, rounded to 5 years).

3. ENERGY STAR product list. October 20, 2015. Average rated life of LED products listed is approximately 27,290 hours (27,290/840 average sector hours = 32.5, rounded to 33 years; this EUL is over 20 years, and under agreement with the PSC, Cadmus, the Administrator, and Implementers, LED EULs above 20 years are set at 20 years.
4. Cost data obtained through various online lighting retailers in October 2015, including 1000bulbs.com, warehouse-lighting.com, alconlighting.com, earthled.com, and toenic.com. Average prices of baseline equipment and qualifying efficient equipment used to obtain estimated incremental cost. Full data is available upon request.
5. ENERGY STAR product list. October 20, 2015.
6. *Focus on Energy Business Programs Deemed Savings Manual V1.0*. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
7. Cadmus. Field Study Research of Residential Lighting. October 18, 2013. Results published in the 2014 Focus on Energy Deemed Savings Report: https://focusonenergy.com/sites/default/files/FoE_Deemed_WriteUp%20CY14%20Final.pdf

Revision History

Version Number	Date	Description of Change
01	10/20/2015	New measure

LED Fixture or PSMH/CMH, Replacing 1,000 Watt HID, Exterior

	Measure Details
Measure Master ID	LED Fixture, Replacing 1,000 Watt HID, Exterior, 3407 PSMH/CMH, Replacing 1,000 Watt HID, Exterior, 3408
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	MMID 3407=20[1]; MMID 3408=15[1]
Incremental Cost ($/unit)	MMID 3407= $398.41;[2] MMID 3408= $53.00[4]

Measure Description

LED pole-mount, wall-mount, and flood light luminaires save energy when replacing 1,000-watt HID products by providing a similar lumen output with lower input wattage. These products can be installed on a one-for-one basis to replace 1,000-watt HID luminaires.

CMH and PSMH 575-watt pole-mount, wall-mount, and flood light luminaires save energy when replacing 1,000-watt HID products by providing a similar lumen output with lower input wattage. These products can be installed on a one-for-one basis to replace 1,000-watt HID luminaires.

Description of Baseline Condition

The baseline measure is 1,000-watt metal halide, high-pressure sodium HID luminaires for existing buildings and new construction buildings.

Description of Efficient Condition

The efficient measure is DLC-listed pole, wall, and flood luminaries and complete retrofit kits listed in one of the following DLC categories: 1, 2, 3, 25, 26, 27, or 28, which consumes ≤ 650 watts and has an initial lumen output of ≥ 35,000, 575 watt PSMH or CMH.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{1,000W\ HID} - kWh_{LED}$

$kWh_{SAVED} = kWh_{1,000W\ HID} - kWh_{575W\ PSMH\ or\ CMH}$

Where:

$kWh_{1,000W\ HID}$ = Average annual electricity consumption of 1,000-watt metal halide or high-pressure sodium luminaire

kWh_{LED} = Annual electricity consumption of a DLC listed pole, wall, and flood luminaries and complete retrofit kits listed in one of the following DLC categories: 1, 2, 3, 25, 26, 27, and 28, which consumes ≤ 650 watts and has an initial lumen output ≥ 35,000

$kWh_{575W\ PSMH\ or\ CMH}$ = Annual electricity consumption of a 575-watt PSMH or CMH lamp and ballast system or complete luminaire

Summer Coincident Peak Savings Algorithm

There are no peak savings for this measure.

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = (kWh_{1,000W\ HID} - kWh_{LED}) * EUL$

$kWh_{LIFECYCLE} = (kWh_{1,000W\ HID} - kWh_{575W\ PSMH\ or\ CMH}) * EUL$

Where:

EUL = Effective useful life (= 20 years for LED fixture;[1] = 15 years for PSMH/CMH fixture)[1]

Deemed Savings

Average Deemed Savings for DLC Listed LED

Savings	MMID	Exterior
Annual kWh	3407	1,841
Lifecycle kWh		20,252

Average Deemed Savings for PSMH or CMH

Savings	MMID	Exterior
Annual kWh	3408	1,364
Lifecycle kWh		20,466

Assumptions

An average of 50% metal halide 1,000-watt luminaires and 50% high-pressure sodium 1,000-watt luminaires was used to generate the baseline wattage.

4,380 hours run time of fixtures based on an annual average of 12 hours per day from NOAA data.[4] This also includes the times when photocells turn on prior to exact sunset and turn off after exact sunrise, accounting for diminished outdoor lighting as well as time clock scheduled lighting.

Applying a controls factor allows for a more conservative estimate of savings. Based on project experience with 1,000-watt HID baselines, less than 30% of the exterior 1,000-watt HID fixtures on the market have additional controls that may operate at conditions other than dusk to dawn.

Sources

1. Cadmus review of manufacturers' measure life.
2. Online research, March 2016. Average cost of "LED round high bay fixtures" over 400 Watt replacement. Available online: https://www.1000bulbs.com/category/round-high-bays/
3. U.S. Department of Commerce National Oceanic & Atmospheric Administration. "NOAA Solar Calculator." http://www.esrl.noaa.gov/gmd/grad/solcalc/
4. Evaluator Online Research, May 2016. From: Bestlights.com; venturelights.com; and warehouselighting.com and Focus on Energy Program information. Baseline cost is $322.00 for 1000 Watt HID Exterior lamps. Average cost of fixture types found in FoE Invoices from 2015-2016 is $375.00.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

LED Fixture Replacing T8/T12 U-Tube Lamps

	Measure Details
Measure Master ID	LED, 2x2, Replacing T12 2 Lamp U-Tube, SBP A La Carte, 3323 LED, 2x2, Replacing T12 2 Lamp U-Tube, SBP Package, 3366 LED, 2x2, Replacing T8 2 Lamp U-Tube, 3239
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	$108.75[5]

Measure Description

LED-based troffer replacements save energy over fluorescent fixtures due to the increased number of lumens per watt and increased light quality and distribution. There are varying wattage LED fixtures used to replace 2-foot by 2-foot troffers, which normally have single or dual T8 or T12 U-tube lamps installed. The LED fixture will replace fixtures with either dual (or greater) T12 U-tubes or dual (or greater) T8 U-tubes per 2-foot by 2-foot fixture.

Description of Baseline Condition

The baseline condition is a u-tube fixture, with wattages given in the following table.

U-Tube Fixture Wattages

Measure	MMID	Wattage
LED, 2x2, Replacing T12 2 Lamp U-Tube, SBP A La Carte	3323	82 watts
LED, 2x2, Replacing T12 2 Lamp U-Tube, SBP Package	3366	82 watts
LED, 2x2, Replacing T8 2 Lamp U-Tube	3239	70 watts

Description of Efficient Condition

The efficient condition is DLC-listed, 2x2 LED troffers of 44 watts, luminaires for ambient lighting of interior commercial spaces.[4]

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{EX} – kWh_{LED}$

Where:

kWh_{EX} = Annual electricity consumption of existing T8 or T12 lamps and ballasts

kWh_{LED} = Annual electricity consumption of LED 2x2 luminaire

Summer Coincident Peak Savings Algorithm

First Year Savings

$kW_{SAVED} = (W_{EX} - W_{LED}) / 1{,}000 * CF$

Where:

W_{EX} = Wattage of existing T8 or T12 lamps and ballasts

W_{LED} = Wattage of the existing LED 2x2 luminaire

1,000 = Kilowatt conversion factor

CF = Demand coincidence factor (= varies by sector; see table below)

Demand Coincidence Factor by Sector

Sector	CF[3]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64

Lifecycle Peak Savings

$kW_{LIFECYCLE} = \{(W_{EX} – W_{LED}) * (N) + (W_{EISA} – W_{LED}) * (EUL - N)\} / 1{,}000$

Where:

N = Number of years until 2016 (= 1 in 2015)

W_{EISA} = Wattage of EISA-compliant lamps and ballasts

EUL = Effective useful life (= 15 years)[1]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = (kWh_{SAVED} * N) + (kWh_{EISA} – kWh_{LED}) * (EUL - N)$

Where:

kWh_{EISA} = Annual electricity consumption of EISA compliant lamps and ballasts

Deemed Savings

Average Annual Deemed Savings

Measure	MMID	Commercial 3,730 (0.77)		Schools & Gov 3,239 (0.64)		Industrial 4,745 (0.77)		Agriculture 4,698 (0.67)	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED, 2x2, Replacing T12 2 Lamp U-Tube, SBP A La Carte	3323	96.8	0.0200	84.0	0.0166	123.1	0.0200	121.9	0.0174
LED, 2x2, Replacing T12 2 Lamp U-Tube, SBP Package	3366	96.8	0.0200	84.0	0.0166	123.1	0.0200	121.9	0.0174
LED, 2x2, Replacing T8 2 Lamp U-Tube	3239	140.0	0.0289	121.6	0.0240	178.1	0.0289	176.4	0.0252

Average Lifecycle Deemed Savings

Sector	Installation Year							
	2013		2014		2015		2016 and Beyond	
	kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED, 2x2, Replacing T12 2 Lamp U-Tube, SBP A La Carte, 3323								
Commercial	1,581.2	0.3264	1,537.9	0.3175	1,494.7	0.3085	1,451.4	0.2996
Schools & Govt.	1,373.0	0.2713	1,335.5	0.2639	1,297.9	0.2565	1,260.3	0.2490
Industrial	2,011.5	0.3264	1,956.4	0.3175	1,901.4	0.3085	1,846.3	0.2996
Agriculture	1,991.5	0.2840	1,937.0	0.2762	1,882.5	0.2685	1,828.0	0.2607
LED, 2x2, Replacing T12 2 Lamp U-Tube, SBP Package, 3366								
Commercial	1,581.2	0.3264	1,537.9	0.3175	1,494.7	0.3085	1,451.4	0.2996
Schools & Govt.	1,373.0	0.2713	1,335.5	0.2639	1,297.9	0.2565	1,260.3	0.2490
Industrial	2,011.5	0.3264	1,956.4	0.3175	1,901.4	0.3085	1,846.3	0.2996
Agriculture	1,991.5	0.2840	1,937.0	0.2762	1,882.5	0.2685	1,828.0	0.2607

Sector	Installation Year							
	2013		2014		2015		2016 and Beyond	
	kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED, 2x2, Replacing T8 2 Lamp U-Tube, 3239								
Commercial	1,451.4	0.2996	1,451.4	0.2996	1,451.4	0.2996	1,451.4	0.2996
Schools & Govt.	1,260.3	0.2490	1,260.3	0.2490	1,260.3	0.2490	1,260.3	0.2490
Industrial	1,846.3	0.2996	1,846.3	0.2996	1,846.3	0.2996	1,846.3	0.2996
Agriculture	1,828.0	0.2607	1,828.0	0.2607	1,828.0	0.2607	1,828.0	0.2607

Sources

1. Cadmus review of manufacturers’ measure life.
2. *Focus on Energy Business Programs Deemed Savings Manual V1.0*. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
3. *Focus on Energy Business Programs Deemed Savings Manual V1.0*. Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.T
4. *T*he new measure condition assumes an average of the DLC listing as of June 21, 2013.
5. Pricing Data obtained by Implementer through online retailers and contractors, August 2015.

Revision History

Version Number	Date	Description of Change
01	07/2013	Initial TRM entry

LED Fixture Replacing 2x4 Linear Fluorescent Fixture

	Measure Details
Measure Master ID	LED, 2x4, Replacing T8 2 Lamp, SBP After A La Carte, 3235
Measure Unit	Fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	$168.29

Measure Description

LED-based troffer replacements save energy over fluorescent fixtures due to the increased number of lumens per watt and increased light quality and distribution. There are varying wattage LED fixtures used to replace 2-foot by 4-foot troffers, which normally have two, three, or four T12 or T8 lamps with ballast installed. The LED fixture will replace fixtures with either T12 or T8 lamps.

Description of Baseline Condition

The baseline condition measure and wattages are shown in the following table.

Baseline Wattages[4]

Measure	Wattage
T8 Linear Fluorescent Fixtures (EISA compliant)	
2 Lamp T8	58 watts
3 Lamp T8	86 watts
4 Lamp T8	112 watts
T12 Linear Fluorescent Fixtures	
2 Lamp T12	82 watts
3 Lamp T12	130 watts
4 Lamp T12	144 watts

Description of Efficient Condition

The efficient condition is DLC-listed, retrofit kits of 2x4 LED troffers of 50 watts, luminaires for ambient lighting of interior commercial spaces.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{EX} – kWh_{LED}$

Where:

kWh_{EX} = Annual electricity consumption of existing T8 or T12 lamps and ballasts

kWh_{LED} = Annual electricity consumption of LED 2x4 luminaire

Summer Coincident Peak Savings Algorithm

First Year Savings

$kW_{SAVED} = (W_{EX} - W_{LED}) / 1,000 * CF$

Where:

W_{EX} = Wattage of existing T8 or T12 lamps and ballasts

W_{LED} = Wattage of LED 2x4 luminaire

1,000 = Kilowatt conversion factor

CF = Demand coincidence factor (= varies by sector; see table below)

Demand Coincidence Factor by Sector

Sector	CF[3]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64

Lifecycle Peak Savings

$kW_{LIFECYCLE} = \{kWh_{SAVED} * N + (W_{EISA} – W_{LED}) * (EUL - N)\} / 1,000$

Where:

N = Number of years until 2016 (= 1 in 2015)

W_{EISA} = Wattage of EISA compliant lamps and ballasts

EUL = Effective useful life (= 15 years)[1]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = (kWh_{SAVED} * N) + (kWh_{EISA} – kWh_{LED}) * (EUL - N)$

Where:

kWh_{EISA} = Annual electricity consumption of EISA compliant lamps and ballasts

Deemed Savings

Average Annual Deemed Savings for LED Troffer Fixture Replacement of 2-Foot by 4-Foot T8 and T12 Fixtures

Measure	MMID	Commercial 3,730 (0.77)		Schools & Gov 3,239 (0.64)		Industrial 4,745 (0.77)		Agriculture 4,698 (0.67)	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW
Replace 2 lamp T8	3235	29.1	0.0060	25.3	0.0050	37.0	0.0060	36.7	0.0052
Replace 3 lamp T8	3235	133.5	0.0276	116.0	0.0229	169.9	0.0276	168.2	0.0240
Replace 4 lamp T8	3235	230.5	0.0476	200.2	0.0396	293.3	0.0476	290.4	0.0414

Average Lifecycle Deemed Savings for LED Troffer Fixture Replacement of 2-Foot by 4-Foot T8 and T12 Fixtures

Sector	Installation Year							
	2013		2014		2015		2016 and Beyond	
	kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED 2x4 replacement of 2 lamp T8, 3235								
Commercial	436.6	0.0901	436.6	0.0901	436.6	0.0901	436.6	0.0901
Schools & Govt.	379.1	0.0749	379.1	0.0749	379.1	0.0749	379.1	0.0749
Industrial	555.4	0.0901	555.4	0.0901	555.4	0.0901	555.4	0.0901
Agriculture	549.9	0.0784	549.9	0.0784	549.9	0.0784	549.9	0.0784
LED 2x4 replacement of 3 lamp T8, 3225								
Commercial	2,003.2	0.4135	2,003.2	0.4135	2,003.2	0.4135	2,003.2	0.4135
Schools & Govt.	1,739.5	0.3437	1,739.5	0.3437	1,739.5	0.3437	1,739.5	0.3437
Industrial	2,548.3	0.4135	2,548.3	0.4135	2,548.3	0.4135	2,548.3	0.4135
Agriculture	2,523.1	0.3598	2,523.1	0.3598	2,523.1	0.3598	2,523.1	0.3598
LED 2x4 replacement of 4 lamp T8, 3235								
Commercial	3,457.9	0.7138	3,457.9	0.7138	3,457.9	0.7138	3,457.9	0.7138
Schools & Govt.	3,002.7	0.5933	3,002.7	0.5933	3,002.7	0.5933	3,002.7	0.5933
Industrial	4,398.9	0.7138	4,398.9	0.7138	4,398.9	0.7138	4,398.9	0.7138
Agriculture	4,355.3	0.6211	4,355.3	0.6211	4,355.3	0.6211	4,355.3	0.6211

Sources

1. Cadmus review of manufacturers' measure life.
2. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
3. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.
4. The new measure condition assumes an average of the DLC listing as of June 21, 2013.
5. Online Research, March 2016. Average price of "2x4 led troffer fixtures" on 1000bulbs.com; www.1000bulbs.com/category/2x4-led-troffer-fixtures/

Revision History

Version Number	Date	Description of Change
01	07/2013	Initial TRM entry
02	10/2016	Removed MMID 3232

LED Linear Ambient Fixture, Replacing T5 Lamp(s) in Cross Section

	Measure Details
Measure Master ID	LED Fixture, Linear Ambient: Replacing 1 or 2 T5 Lamp(s) in Cross Section, 3738 Replacing 3 or 4 T5 Lamps in Cross Section, 3739
Measure Unit	Per linear feet of fixture(s)
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by sector and measure
Peak Demand Reduction (kW)	Varies by sector and measure
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector and measure
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	16[1]
Incremental Cost ($/unit)	$27.50[2]

Measure Description

LED linear ambient luminaires save energy when replacing T5 products by providing a similar lumen output with lower input wattage. These products can be installed on a one-for-one basis to replace T5 luminaires.

Description of Baseline Condition

The baseline condition is one, two, three, or four lamp(s) in a cross-section T5 surface mount or suspended fixtures in existing and new construction buildings.

Description of Efficient Condition

The efficient condition is LED products that are DesignLights Consortium™ listed in the Linear Ambient General Application category.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{LED}) / 1,000 * HOU$

Where:

$Watts_{BASE}$ = For MMID 3738, this is the average per foot power consumption of 1 and 2-lamp T5 products, weighted 50% each (= 12 watts)[3]
For MMID 3739, this is the average per foot power consumption of 3 and 4-lamp T5 products, weighted 50% each (= 28 watts; see Assumptions section)[3]

$Watts_{LED}$ = Baseline per foot power consumption of DLC-listed LED fixture (= 4.4 watts)[4]

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= varies by sector; see table below)

Hours-of-Use by Sector

Sector	HOU[5]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239
Multifamily	5,950

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{LED}) / 1,000 * CF$

Where:

CF = Coincidence factor (= varies by sector; see table below)

Coincidence Factor by Sector

Sector	CF[5]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64
Multifamily	0.77

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 16 years)[1]

Deemed Savings

Annual Savings for LED Linear Ambient Fixtures

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Gov		Multifamily	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
Replacing 1 or 2 T5 Lamps in Cross Section	3738	28	0.0058	36	0.0058	35	0.0050	24	0.0048	45	0.0058
Replacing 3 or 4 T5 Lamps in Cross Section	3739	87	0.0179	110	0.0179	109	0.0156	75	0.0149	138	0.0179

Lifecycle Savings (kWh) for LED Linear Ambient Fixtures

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Gov	Multifamily
Replacing 1 or 2 T5 Lamps in Cross Section	3738	448	576	560	384	720
Replacing 3 or 4 T5 Lamps in Cross Section	3739	1,392	1,760	1,744	1,200	2,208

Assumptions

Fixture lamp weightings are based on feedback from a combination of energy audit experience, Lighting Certified individuals through the National Council on Qualifications for the Lighting Professions, and individuals with lighting sales experience.

Sources

1. Cadmus. Review of manufacturers' measure life for linear LED technologies (referenced similar technology under MMID 3111). 2015.
2. Implementer Retail Pricing Review October 2015.
3. *Wisconsin Focus on Energy Default Wattage Guide*. 2013.

4. DesignLights Consortium. Technical Requirements Table v3.0. Minimum Lumens per Foot (LPF) is 375 and minimum Lumens per Watt (LPW) is 85: (375 LPF / 85 LPW = 4.4 watts per foot) https://www.designlights.org/resources/file/TRT_V3_FULLTABLE_Final_9-1-15
5. Wisconsin Focus on Energy. *Business Programs Deemed Savings Manual V1.0.* Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.

Revision History

Version Number	Date	Description of Change
01	10/16/2015	New measure

LED Linear Ambient Fixture, Replacing T8/T12 Lamp(s) in Cross Section

	Measure Details
Measure Master ID	LED Fixture, Linear Ambient: Replacing 1 or 2 T8/T12 Lamp(s) in Cross Section, 3740 Replacing 3 or 4 T8/12 Lamps in Cross Section, 3741
Measure Unit	Per linear feet of fixture(s)
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by measure and sector
Peak Demand Reduction (kW)	Varies by measure and sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by measure and sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	16 years[1]
Measure Incremental Cost ($/unit)	$34.25[2]

Measure Description

LED linear ambient fixtures save energy when replacing one to four T8/T12 lamps in cross section by providing a similar lumen output with lower input wattage. These products can be installed on a one-for-one basis to replace one to four-lamp T8/T12 luminaires.

Description of Baseline Condition

The baseline condition is one to four lamp(s) in cross section T8/T12 surface mount or suspended fixtures in existing and new construction buildings.

Description of Efficient Condition

The efficient condition is LED products that are DesignLights Consortium™ listed in the Linear Ambient General Application category.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{LED}) / 1,000 * HOU$

Where:

$Watts_{BASE}$ = For MMID 3740, this is the average per foot power consumption of one- and two-lamp T8 products, weighted 50% each (= 11 watts)[3]
For MMID 3741, this is the average per foot power consumption of three- and four-lamp T8 products, weighted 50% each (= 4 watts; see Assumptions section)[3]

$Watts_{LED}$ = Baseline per foot power consumption of DLC-listed LED fixture (= 4.4 watts)[4]

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= varies by sector; see table below)

Hours-of-Use by Sector

Sector	HOU[5]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239
Multifamily	5,950

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{LED}) / 1,000 * CF$

Where:

CF = Coincidence factor (= varies by sector; see table below)

Coincidence Factor by Sector

Sector	CF[5]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64
Multifamily	0.77

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 16 years)[1]

Deemed Savings

Annual Savings for LED Linear Ambient Fixtures

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Gov		Multifamily	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
Replacing 1 or 2 T8/T12 Lamps in Cross Section	3740	24	0.0050	31	0.0050	30	0.0043	21	0.0041	39	0.0050
Replacing 3 or 4 T8/T12 Lamps in Cross Section	3741	74	0.0153	95	0.0153	94	0.0133	65	0.0128	119	0.0153

Lifecycle Savings (kWh) for LED Linear Ambient Fixtures

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Gov	Multifamily
Replacing 1 or 2 T8/T12 Lamps in Cross Section	3740	384	496	480	336	624
Replacing 3 or 4 T8/T12 Lamps in Cross Section	3741	1,184	1,520	1,504	1,040	1,904

Assumptions

Fixture lamp weightings are based on feedback from a combination of energy audit experience, Lighting Certified individuals through the National Council on Qualifications for the Lighting Professions, and individuals with lighting sales experience.

Sources

1. Cadmus. Review of manufacturers' measure life for linear LED technologies (referenced similar technology under MMID 3387).
2. Cost data obtained through various online lighting retailers in October 2015, including 1000bulbs.com, warehouse-lighting.com, alconlighting.com, earthled.com, and toenic.com.

Average prices of baseline equipment and qualifying efficient equipment used to obtain estimated incremental cost. Full data is available upon request.

3. Consortium for Energy Efficiency. *Legacy Ballast List, normal ballast factor*. 2015. Available online: http://library.cee1.org/content/commercial-lighting-qualifying-products-lists
4. DesignLights Consortium™. *Technical Requirements Table v3.0*. Minimum lumens per foot is 375 and minimum lumens per watt is 85 (375 / 85 = 4.4 watts per foot). Available online: https://www.designlights.org/resources/file/TRT_V3_FULLTABLE_Final_9-1-15
5. Wisconsin Focus on Energy. *Business Programs Deemed Savings Manual V1.0.* Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.

Revision History

Version Number	Date	Description of Change
01	10/16/2015	New measure

LED Replacement of 4-Foot T8 Lamps Direct Wire

	Measure Details
Measure Master ID	LED Replacement of 4-Foot T8 Lamps, Direct Wire, 3759, 3839
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	14[1]
Incremental Cost ($/unit)	$6.62[5]

Measure Description

Four-foot T8 LEDs are an energy-efficient alternative to standard 4-foot 32-watt, 28-watt, and 25-watt T8 fluorescent lamps found commonly throughout commercial, industrial, agriculture, school, government, and multifamily spaces. These products can replace 32-watt, 28-watt, and 25-watt T8 lamps one-for-one, and this measure incorporates those that replace the existing fluorescent lamp(s) and remove the ballast(s).

Description of Baseline Condition

The baseline condition is 4-foot standard 32-watt, 28-watt, and 25-watt T8 lamps on low (0.78), normal (0.88), and high (1.15) ballast factor ballasts. Lamps are weighted 60%, 30%, and 10%, respectively, in the savings calculations. The 32-watt lamp ballast factors are weighted 10%, 70%, and 20% with respect to low, normal, and high, while 28-watt and 25-watt lamp ballast factors are weighted 5%, 90%, and 5% in the savings calculations.[6]

Description of Efficient Condition

Equipment must be DLC listed with a measured wattage less than 24 and direct wires to line voltage, not operating off the existing fluorescent ballast(s) or external driver. This measure is not intended to be used in refrigerated case lighting applications. Products must carry a safety certification from a Nationally Recognized Testing Laboratory (such as UL or ETL), use non-shunted sockets for products that are single-end feed, sockets that are twist-lock and warrantied for line voltage, be installed by a licensed electrician, and have a re-lamp label applied to modified fixture.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{FLUORESCENT} - Watts_{LED}) /1,000 * HOU$

Where:

$Watts_{FLUORESCENT}$ = Weighted annual electricity consumption of standard 4-foot 32-watt, 28-watt, or 25-watt T8 fluorescent lamp operating on low/normal/high ballast factor ballasts (= 27.43 watts)

$Watts_{LED}$ = Weighted average annual electricity consumption of DLC-listed 4-foot linear LED < 24 watts, noted w/internal driver (= 17.78 watts)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= varies by sector; see table below)

Hours-of-Use by Sector

Sector	HOU[2]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239
Multifamily	5,950

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{FLUORESCENT} - Watts_{LED}) /1,000 * CF$

Where:

CF = Coincidence factor (= varies by sector; see table below)

Coincidence Factor by Sector

Sector	CF[2]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64
Multifamily	0.77

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 14 years)[1]

Deemed Savings

Annual Savings

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Gov		Multifamily	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED Replacement of 4-Foot T8 Lamps Direct Wire	3759, 3839	36	0.0074	46	0.0074	45	0.0065	31	0.0062	57	0.0074

Lifecycle Savings (kWh)

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Gov	Multifamily
LED Replacement of 4-Foot T8 Lamps Direct Wire	3759, 3839	504	644	630	434	798

Sources

1. DesignLights Consortium. Product list. March 20, 2015. Average Rated Life for Four-Foot Linear Replacement Lamps category under 24 measured watts came to ~49,983 hours (49,983 / 3,730 = 13.4, rounded to 14 years).
2. *Focus on Energy Business Programs Deemed Savings Manual V1.0.*. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
3. Deemed Savings Desk Review. November 3, 2010. Focus on Energy Deemed Savings Desk Review Multifamily Applications for Common Areas. November 3, 2010.
4. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.
5. Online research, Sept 2016. Available online: http://www.greenledzone.com/t8-led-tube-light-direct-wire-ballast-compatible-p/gl-lod-c08-m1218.htm?gclid=Cj0KEQjwxLC9BRDb1dP8o7Op68IBEiQAwWggQA7zZ34iQp1t8ivOd4GwDDOKE1flh40UVRP3kOWcoToaAh7p8P8HAQ;

http://greenlightdepot.com/collections/led-tube-lights/products/4ft-18w-led-linear-versa-tube-ul-dlc?variant=3706824772&gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFK5S0WZ_BBNcC7Y5DA7At4cO2rcAGaAl2RyJQZVbZE4MaAtJc8P8HAQ; https://www.1000bulbs.com/product/153506/PLT-10018.html?utm_source=SmartFeedGoogleBase&utm_medium=Shopping&utm_term=PLT-10018&utm_content=LED+Lighting+Specials&utm_campaign=SmartFeedGoogleBaseShopping&gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFKzDoix0ocMbl; https://www.1000bulbs.com/product/7028/TCP-31032841.html?utm_source=SmartFeedGoogleBase&utm_medium=Shopping&utm_term=TCP-31032841&utm_content=800+Series+Phosphors&utm_campaign=SmartFeedGoogleBaseShopping&gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFK3_139urG; https://www.1000bulbs.com/product/90200/USH-3000480.html?utm_source=SmartFeedGoogleBase&utm_medium=Shopping&utm_term=USH-3000480&utm_content=800+Series+Phosphors&utm_campaign=SmartFeedGoogleBaseShopping&gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFK2B1rtXuKJ; http://www.adlsupply.com/fluorescent-t8/sylvania-21781-fo32-841-eco/?gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFK7UbfdMKV6L5tIYN6DNgvVs1fr2zovtgAyLuo8_F6hEaAnRn8P8HAQ

6. Weights were estimated based on general market knowledge and historical application data. Lamp weightings were developed from a combination of 2013-2014 general application processing for HPT8 measures and custom T-LED proposals, lighting best practice, and engineering estimates on HPT8 Wisconsin Focus on Energy market influence. Low ballast factor ballasts are the least common in the marketplace, while thos with a normal ballast factor are the most common, and some have a high ballast factor. It is rare to use a low ballast factor for 28-watt and 25-watt lamps unless a space is drastically overlit. It is not best practice to use a high ballast factor for 25-watt and 28-watt lamps, as they will operate at their maximum ballast factor levels, whereas a 32-watt lamp on a normal ballast factor would provide better operation.

Revision History

Version Number	Date	Description of Change
01	03/24/2015	New measure

LED Track/Mono/Accent Fixtures ≤ 18 Watts

	Measure Details
Measure Master ID	LED Fixture, Track/Mono/Accent, ≤ 18 Watts, 3736
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	13[1]
Incremental Cost ($/unit)	$12.46[2]

Measure Description

LED track, mono-point, and accent fixtures can replace existing incandescent fixtures without sacrificing performance, and these products save energy because they consume less wattage than the incandescent products they replace.

Description of Baseline Condition

The baseline is a weighted average of incandescent fixtures between 35 watts and 100 watts.

Description of Efficient Condition

The efficient equipment is an ENERGY STAR- or DesignLights Consortium-rated fixture that consumes ≤ 18 watts.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{LEDEE}) * HOU / 1,000$

Where:

$Watts_{BASE}$ = Power consumption of baseline incandescent fixtures. A weighted average of 12.5% each for 35 watt, 50 watt, 53 watt, 60 watt, 65 watt, 70 watt, 72 watt, and 90 watt incandescent luminaires was used to generate the baseline wattage (see the Assumptions section)

$Watts_{LEDEE}$ = Power consumption of efficient LED products (= 12.6 watts)[3]

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= varies by sector; see table below)

Hours-of-Use by Sector

Sector	HOU[4]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239
Residential- multifamily[5]	5,950

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{LED}) / 1{,}000 * CF$

Where:

CF = Coincidence factor (= varies by sector; see table below)

Coincidence Factor by Sector

Sector	CF[6]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64
Multifamily	0.77

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 13 years)[1]

Deemed Savings

Average Annual Deemed Savings for LED Track/Mono/Accent ≤ 18 Watts

MMID	Commercial		Industrial		Agriculture		Schools & Gov		Multifamily	
	kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
3736	184	0.0379	234	0.0379	231	0.0330	160	0.0315	293	0.0379

Average Lifecycle Deemed Savings for LED Track/Mono/Accent ≤ 18 Watts

MMID	Commercial	Industrial	Agriculture	Schools & Gov	Multifamily
3736	2,392	3,042	3,003	2,080	3,809

Assumptions

Fixture lamp weightings are based on a combination of energy audit experience and feedback from Lighting Certified individuals through the National Council on Qualifications for the Lighting Professions and individuals with lighting sales experience.

Sources

1. Average rated life of ENERGY STAR- and DesignLights Consortium-listed products divided by commercial sector hours (47,051/3,730 = 12.61, rounded to 13 years). Qualifying equipment are complete luminaires and not replacement lamps.
2. Online Research, March 2016. Material cost is average sales price of "Led Downlight." Available online: https://www.1000bulbs.com/category/led-downlights/
3. Average wattage taken from ENERGY STAR product list (October 13, 2015) and DesignLights Consortium product list (October 7, 2015). Accent Light Line-voltage, Track or Mono-Point Directional Luminaires and Wall-Wash Luminaire product categories, filtered by wattage limits.
4. *Focus on Energy Business Programs Deemed Savings Manual V1.0*. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
5. Focus on Energy Deemed Savings Desk Review Multifamily Applications for Common Areas. November 3, 2010. (5,949.5 annual operating hours based on 16.3 hours/day * 365 days/year).
6. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.

Revision History

Version Number	Date	Description of Change
01	10/13/2015	New measure

LED Track/Mono/Accent Fixtures > 18 Watts

	Measure Details
Measure Master ID	LED Fixture, Track/Mono/Accent, > 18 Watts, 3737
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	13[1]
Incremental Cost ($/unit)	$12.46[2]

Measure Description

LED track, mono-point, and accent fixtures can replace existing incandescent fixtures without sacrificing performance, and these products save energy because they consume less wattage than the incandescent products they replace.

Description of Baseline Condition

The baseline condition is a weighted average of 25% each for 90-watt incandescent, 50-watt HID, 70-watt HID, and 100-watt HID (see additional information in the Assumptions section).

Description of Efficient Condition

The efficient equipment is an ENERGY STAR- or DesignLights Consortium-rated fixture that consumes > 18 watts.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) * HOU / 1,000$

Where:

$Watts_{BASE}$ = Power consumption of baseline incandescent fixtures (= 77.5 watts)

$Watts_{EE}$ = Power consumption of efficient LED products (= 32.2 watts)[3]

1,000 = Kilowatt conversion factor

HOU = Hours-of-use(= varies by sector; see table below)

Hours-of-Use by Sector

Sector	HOU[4]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239
Multifamily[5]	5,950

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{LED}) / 1{,}000 * CF$

Where:

CF = Coincidence factor (= varies by sector; see table below)

Coincidence Factor by Sector

Sector	CF[6]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64
Multifamily	0.77

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 13 years)[1]

Deemed Savings

Average Annual Deemed Savings for LED Track/Mono/Accent > 18 Watts

MMID	Commercial		Industrial		Agriculture		Schools & Gov		Multifamily	
	kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
3737	236	0.0487	300	0.0487	297	0.0424	205	0.0405	376	0.0487

Average Lifecycle Deemed Savings for LED Track/Mono/Accent > 18 Watts

MMID	Commercial	Industrial	Agriculture	Schools & Gov	Multifamily
3737	3,068	3,900	3,861	2,665	4,888

Assumptions

Fixture lamp weightings are based on a combination of energy audit experience and feedback from Lighting Certified individuals through the National Council on Qualifications for the Lighting Professions and individuals with lighting sales experience.

Sources

1. Average rated life of ENERGY STAR- and DesignLights Consortium-listed products divided by commercial sector hours (47,645/3,730 = 12.77, rounded to 13 years). Qualifying equipment are complete luminaires and not replacement lamps.
2. Online Research, March 2016. Material cost is average sales price of "Led Downlight." Available online: https://www.1000bulbs.com/category/led-downlights/
3. Average wattage taken from ENERGY STAR product list (October 13, 2015) and DesignLights Consortium product list (October 7, 2015). Accent Light Line-voltage, Track or Mono-Point Directional Luminaires and Wall-Wash Luminaire product categories, filtered by wattage limits.
4. *Focus on Energy Business Programs Deemed Savings Manual V1.0*. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
5. Focus on Energy Deemed Savings Desk Review Multifamily Applications for Common Areas. November 3, 2010. (5,949.5 annual operating hours based on 16.3 hours/day * 365 days/year).
6. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.

Revision History

Version Number	Date	Description of Change
01	10/13/2015	New measure

LED Tube Retrofit of 4-Foot T12 or T8 Fixtures

	Measure Details
Measure Master ID	T8 LED < 20 Watts, 1 Lamp, Replacing 2 Lamp or3 Lamp T12/T8 SBP Package, 3764 SBP A La Carte, 3765 SBP After A La Carte, 3766
Measure Unit	Per fixture
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Measure Type	Prescriptive
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	14[1]
Incremental Cost ($/unit)	$33.74[5]

Measure Description

Four-foot T8 LEDs are an energy-efficient alternative to standard 4-foot T12 or 32-watt, 28-watt, and 25-watt T8 fluorescent lamps found commonly throughout the commercial, industrial, agriculture, and schooland government sectors. This measure incorporates switching a fixture from two or three 4-foot fluorescent technology lamps to one LED tube in a 1-foot by 4-foot fixture.

Description of Baseline Condition

The baseline condition is a 1-foot by 4-foot fixture with two or three existing lamps, with savings weighted as 90% of the fixtures having 2 lamps. The lamps are 4-foot standard 32-watt, 28-watt, and 25-watt T8 lamps on low (0.78), normal (0.88), and high (1.15) ballast factor ballasts. Lamps are weighted 60%, 30%, and 10%, respectively, in the savings calculations. The 32-watt lamp ballast factors are weighted at 10%, 70%, and 20% with respect to low, normal, and high ballast factors, respectively. The 28-watt and 25-watt lamp ballast factors are weighted at 5%, 90%, and 5% in the savings calculations, respectively.[3]

Description of Efficient Condition

The efficient condition is a 1-foot by 4-foot fixture with one T8 LED < 20 watts. Equipment must be DesignLights Consortium (DLC)-listed and use a new external driver or operate on a new fluorescent ballast(s). The retrofit may or may not need a reflector, based on the situation. This measure is not intended for use in refrigerated case lighting applications and in those products that bring line voltage to existing sockets. Products must carry a safety certification from a NRTL, such as UL or ETL.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{FLUORESCENT} - Watts_{LED}) / 1{,}000 * HOU$

Where:

$Watts_{FLUORESCENT}$ = Weighted wattage of standard 4-foot 32-watt, 28-watt, or 25-watt T8 fluorescent lamp operating on low/normal/high ballast factor ballasts (= 30.1)[7]

$Watts_{LED}$ = Average wattage of one DLC-listed 4-foot linear LED < 20 watts with an external driver or operating on fluorescent ballast (= 17.2)[6]

1,000 = Kilowatt conversion factor

HOURS = Average annual run hours (= varies by sector; see table below)

Hours-of-Use by Sector

Sector	Hours-of-Use[2]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{FLUORESCENT} - Watts_{LED}) / 1{,}000 * CF$

Where:

CF = Coincidence factor (=varies by sector; see table below)

Coincidence Factor by Sector

Sector	CF[2]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (=14 years)[1]

Deemed Savings

Annual Energy Savings

Measure	Commercial 3,730 (0.77)		School & Gov 3,239 (0.64)		Industrial 4,745 (0.77)		Agriculture 4,698 (0.67)	
	kWh	kW	kWh	kW	kWh	kW	kWh	kW
T8 LED < 20 Watts, 1 Lamp, Replacing 2 Lamp or3 Lamp T12/T8	151	0.0311	131	0.0259	192	0.0311	190	0.0271

Lifecycle Energy-Savings

Measure	Commercial 3,730 (0.77)	School & Gov 3,239 (0.64)	Industrial 4,745 (0.77)	Agriculture 4,698 (0.67)
	kWh	kWh	kWh	kWh
T8 LED < 20 Watts, 1 Lamp, Replacing 2 Lamp or3 Lamp T12/T8	2,109	1,832	2,683	2,657

Sources

1. DesignLights Consortium. Product list. August 29, 2014. Average Rated Life for Four-Foot Linear Replacement Lamps category under 24 measured watts came to ~50,600 hours (50,600/3,730 = 13.57, rounded to 14 years).
2. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
3. Weights are estimated based on general market knowledge and historical application data.
4. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.

5. Fluorescent and LED pricing pulled from multiple online sources, then averaged for both baseline and efficient conditions. Incremental cost is the difference between baseline and proposed total cost. Internal Implementer Spreadsheet, 'Pricing' tab in Excel calculation Four-foot Linear LED replacing 4-foot T8 fluor 2to1 calculation_GDS_SBP_03_19_15.
6. DesignLights Consortium. Product list. August 29, 2014. Wattage equates to the weighted average of Four-Foot Linear Replacement Lamps with external drivers, and internal drivers compatible with existing ballasts.

Revision History

Version Number	Date	Description of Change
01	01/2016	New measure

Bi-Level Controls for Interior, Exterior, and Parking Garages

	Measure Details
Measure Master ID	LED Fixture, Bi-Level: Stairwell and Passageway, 3097 Stairwell and Passageway, SBP A La Carte, 3596 Stairwell and Passageway, SBP After A La Carte, 3597 Lighting Controls, Bi-Level: Exterior and Parking Garage Fixtures, Dusk to Dawn, 3251 Parking Garage Fixtures, 24 Hour, 3252
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	MMID 3097, 3596, 3597= Light Emitting Diode (LED) MMIDs 3251, 3252 = Controls
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	9[1]
Incremental Cost ($/unit)	Varies by measure, see Appendix D

Measure Description

Numerous existing installations use LED, induction, fluorescent, CMH, and PSMH fixtures to light their high-bay interiors, exteriors, and parking garages. These fixtures commonly operate in full light output 24 hours a day. Bi-level controls and replacement products use ultrasonic and PIR sensors to adjust the light output to a safe but energy-conserving low light level when these spaces become unoccupied. These products save energy by more efficiently lighting spaces based on occupancy.

Description of Baseline Condition

The baseline condition is LED, induction, fluorescent, CMH, and PSMH fixture input wattages with no lighting controls at building interiors, exteriors, and parking garages.

Description of Efficient Condition

The efficient condition is individually controlled light fixtures that may include dimming, stepped dimming, and/or hi-low ballast controls. Control must include a PIR and/or ultrasonic occupancy sensor with a fail-safe feature (fails in "on" position in case of sensor failure). Fixtures must operate in low-standby light level during vacancy and switch to full light output upon occupancy. The fixture cannot exceed 50% of full wattage during unoccupied periods.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{BASE} - kWh_{EE}$

$kWh_{BASE} = Watts_{FIXTURES} * HOU /1,000$

$kWh_{EE} = Watts_{FIXTURES} * HOU * 0.60/1,000$

Where:

kWh_{BASE} = Energy consumption of baseline equipment (standard non-controlled fixture)

kWh_{EE} = Energy consumption of efficient equipment (bi-level controlled fixture)

$Watts_{FIXTURES}$ = Input wattage of fixture(s) being controlled

HOU = Hours-of-use (= 8,760 for parking garages; = 4,380 for exterior; = varies by sector for interior, see table below)

1,000 = Kilowatt conversion factor

0.60 = 40% savings potential from bi-level controls

Interior Hours-of-Use by Sector

Sector	Hours-of-Use[2]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = Watts_{FIXTURES} / 1{,}000 * SF * CF$

Where:

SF = Savings factor (= 40%)[3]

CF = Coincidence factor (= 1 for parking; = 0 for exterior; = varies by sector for interior, see table below)

Interior Coincidence Factor by Sector

Sector	CF^2
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 9 years)[1]

Deemed Savings

Bi-Level Controls in Parking Garage

Savings per Fixture	MMID	All Sectors
kWh	3252	1,135
kW		0.1296
$kWh_{LIFECYCLE}$		9,082

Bi-Level Controls in Exterior

Savings per Fixture	MMIDs	All Sectors
kWh	3251 and 3343	568
kW		0
$kWh_{LIFECYCLE}$		4,541

Bi-Level Controls in Interior

Savings per Fixture	MMIDs	Commercial	Industrial	Agriculture	Schools & Government
kWh	3097, 3596, 3597 (LED) and 3117 (fluorescent)	483	615	609	420
kW		0.0998	0.0998	0.0868	0.0829
kWh$_{LIFECYCLE}$		3,867	4,920	4,871	3,358

Assumptions

It is assumed that an exterior lamp is on for a nighttime average of 4,380 hours. 8,760 hours are assumed for 24/7 parking garage. Savings for interior are based on the sector for interior high-bay applications.

While bi-level controls can achieve a 50% reduction in power requirements, a 40% reduction is used for Focus on Energy programs as a conservative estimate. No kilowatt savings are assigned to exterior lighting due to reduced hours-of-use for the same wattage.

Sources

1. Cadmus review of manufacturers' measure life.
2. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin. Focus on Energy Business Programs: Deemed Savings Manual V1.0. Table 3.2 Lighting Hours of Use in Commercial Applications. Updated March 22, 2010.
3. The program directs that wattagage must be reduced by a minimum of 50%, however 40% was is applied to account for any other power factors or unforseen power consumption.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Delamping, T12 to T8, T8 to T8

	Measure Details
Measure Master ID	Delamping: T12 to T8, 4-Foot, 2276 T8 to T8, 2277 T12 to T8, 8-Foot, 3184, 3320
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	MMIDs 2276 and 2277 = Delamping MMID 3184 and 3320 = Fluorescent, Linear
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	TBA[1]
Incremental Cost ($/unit)	Varies by measure, see Appendix D

Measure Description

This measure is the permanent removal of standard T12 and T8 lamps from two, three, and four lamp 4-foot and 8-foot fixtures. Although the savings are not accounted for here, the measure requires:

- Delamped fixtures must also include upgrading the remaining lamps to HPT8 or RWT8 lamps.
- If a qualifying combination of lamps and ballast are installed, delamped fixtures can also qualify for incentives for HPT8 or RWT8 systems based on the number of lamps in the delamped fixture.

If the existing fixture contains standard T8 ballasts, the ballast is not required to be replaced. Only the lamps must be upgraded. In this case, the project would only qualify for a reduced watt lamp incentive if reduced watt lamps are used. The project would not qualify for a system upgrade incentive.

Description of Baseline Condition

The baseline condition is a weighted average of two, three, and four lamp T12 and T8 fixtures; see the Assumptions section for weighting metrics.

Description of Efficient Condition

The efficient condition is a weighted average of one, two, and three lamp low, normal, and high ballast factor T8 fixtures with 32-watt lamps. See the Assumptions section for weighting metrics.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1,000 * HOU$

Where:

$Watts_{BASE}$ = Watts of baseline equipment (existing standard T12 and T8 fixture(s))

$Watts_{EE}$ = Power consumption of efficient measure (delamped T8 fixture(s))

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= varies by sector; see table below)

Hours-of-Use by Sector

Sector	HOU[2]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239
Multifamily	5,950

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1,000 * CF$

Where:

CF = Coincidence factor (= varies by sector; see table below)

Coincidence Factor by Sector

Sector	CF[2]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64
Multifamily	0.77

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 10 years)[1]

Deemed Savings

Average Annual Deemed Savings for Linear Fluorescent Delamping

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Gov		Multifamily	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
Delamping T12 to T8 (4-Foot)	2276	192	0.040	244	0.040	242	0.035	167	0.033	306	0.040
Delamping T8 to T8 (4-Foot)	2277	96	0.020	122	0.020	121	0.017	83	0.017	153	0.020
Delamping T12 to T8 (8-Foot)	3184, 3320	357	0.074	454	0.074	450	0.064	310	0.061	N/A	N/A

Average Lifecycle Deemed Savings for Linear Fluorescent Delamping

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Gov	Multifamily
		kWh	kWh	kWh	kWh	kWh
Delamping T12 to T8 (4-Foot)	2276	1,920	2,440	2,420	1,670	3,060
Delamping T8 to T8 (4-Foot)	2277	960	1,220	1,210	830	1,530
Delamping T12 to T8 (8-Foot)	3184, 3320	3,570	4,540	4,500	3,100	N/A

Assumptions

Weighting of delamping quantities is based on historical program data.

The baseline condition is a weighted average of two, three, and four lamp T12 and T8 fixtures:

- Delamping T12 to T8 (4-Foot)
  - 2 Lamp (10%)
  - 3 Lamp (30%)
  - T12 - 4 Lamp (60%)
- Delamping T8 to T8
  - 2 Lamp (10%)
  - 3 Lamp (30%)

    - T8 - 4 Lamp (60%)
- Delamping T12 to T8 (8-Foot)
    - T12 - 2 Lamp (80%)
    - HOT12 - 2 Lamp (20%)

Efficient Condition:

- Delamping T12 to T8 (4-Foot)
    - 2 to 1 Lamp (10%)
    - 3 to 1 Lamp (5%)
    - 3 to 2 Lamp (25%)
    - 4 to 2 Lamp (50%)
    - T8 - 4 to 3 Lamp (10%)
- Delamping T8 to T8
    - 2 to 1 Lamp (10%)
    - 3 to 1 Lamp (5%)
    - 3 to 2 Lamp (25%)
    - 4 to 2 Lamp (50%)
    - T8 - 4 to 3 Lamp (10%)
- Delamping T12 to T8 (8-Foot)
    - T8 – 2 Lamp (8-Foot) to 2 Lamp (4-Foot) (100%)

Sources

1. Early Replacement Calculator spreadsheet.
2. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
3. ACES. *Deemed Savings Desk Review*. November 3, 2010.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Delamping Light Fixtures

	Measure Details
Measure Master ID	Delamping: 200 - 399 Watt Fixture, 3001 ≥ 400 Watt Fixture, 3002
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Delamping
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by wattage and sector
Peak Demand Reduction (kW)	Varies by wattage and sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	TBA[1]
Incremental Cost ($/unit)	MMID 3001=$16.20;[5] MMID 3002 = $15.00[6]

Measure Description

This measure is to permanently remove existing high-wattage light fixtures from an existing ceiling. De-lamping savings do not include replacements. Customers are responsible for deciding whether de-lamping will maintain adequate light levels.

Description of Baseline Condition

The baseline equipment is 250-watt and 450-watt metal halide light fixtures.

Description of Efficient Condition

The efficient condition is permanent removal of unneeded light fixtures.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1{,}000 * HOU$

Where:

$Watts_{BASE}$ = Watts of high wattage baseline measure light fixture (= 299 for 200-watt or 399-watt light fixture; = 463 for ≥ 400-watt light fixture)[4]

$Watts_{EE}$ = Watts of efficient measure (= 0)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= varies by sector; see table below)

Hours-of-Use by Sector

Sector	HOU[2]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1,000 * CF$

Where:

CF = Coincidence factor (= varies by sector; see table below)

Coincidence Factor by Sector

Sector	CF[3]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 13 years)[1]

Deemed Savings

Deemed Savings for Delamping 200-Watt to 399-Watt Light Fixture

	MMID	Commercial	Industrial	Agriculture	Schools & Government
Annual Energy Savings (kWh)	3001	1,115	1,419	1,405	968
Peak Demand Reduction (kW)		0.2302	0.2302	0.2003	0.1914
Lifecycle Energy Savings (kWh)		14,499	18,444	18,261	12,590

Deemed Savings for Delamping ≥ 400-Watt Light Fixture

	MMID	Commercial	Industrial	Agriculture	Schools & Government
Annual Energy Savings (kWh)	3002	1,727	2,197	2,175	1,500
Peak Demand Reduction (kW)		0.3565	0.3565	0.3102	0.2963
Lifecycle Energy Savings (kWh)		22,451	28,560	28,277	19,496

Sources

1. Early Replacement Calculator spreadsheet.
2. State of Wisconsin Public Service Commission. *Business Programs Deemed Savings Manual V1.0.* Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
3. State of Wisconsin Public Service Commission. *Business Programs Deemed Savings Manual V1.0*. Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.
4. Vermont Energy Investment Corporation. *Ohio Technical Reference Manual*. August 2010.
5. Mid-Atlantic TRM Version 6.0. Page 323. Assumed labor for larger fixtures is 50% more than for fluorescent lamps. $10.80 * 1.5 = $16.20. Available online: http://www.neep.org/mid-atlantic-technical-reference-manual-v6
6. 2015 Implementer survey of Trade Ally's installation Cost.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry
02	10/2016	Removed MMIDs 3321 and 3322

T8 2-Foot Lamps Replacing T8 and T12 U-Tube Lamps

	Measure Details
Measure Master ID	T8 2-Foot Lamps: Replacing Single T12 U-Tube Lamp, 3325 Replacing Double T12 U-Tube Lamp, 3326
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Linear
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	Varies by measure
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	Varies by measure
Incremental Cost ($/unit)	$21.49 for single U-lamp;[4] $1.22 for double U-lamp[5]

Measure Description

Reduced wattage 2-foot T8 lamps save energy by reducing the total input wattage of the luminaires installed in a fixture. The 2-foot T8 lamps can be installed in varying amounts per fixture as necessary for lighting configurations, with the most common being three lamps in a 2-foot by 2-foot fixture. This measure replaces fixtures with either one or two U-tubes per 2-foot by 2-foot fixture.

Description of Baseline Condition

The wattage of the baseline equipment is shown in the table below.

U-Tube Fixture Wattages

Measure	MMID	Wattage
U-tube T12 1 Lamp	3325	48 watts
U-tube T12 2 Lamp	3326	82 watts

Description of Efficient Condition

The wattages for F17, 2-foot T8 lamps with a ballast factor of 0.82 are shown in the table below. The one exception is a single lamp F17T8, which has a ballast factor of 0.88.

Efficient Fixture Wattages

Measure	Wattage
2-Foot 1 Lamp F17T8	15 watts
2-Foot 2 Lamp F17T8	28 watts
2-Foot 3 Lamp F17T8	42 watts
2-Foot 4 Lamp F17T8	56 watts

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{U} – kWh_{F17T8}$

Where:

kWh_{U} = Annual electricity consumption of existing U-tube lamps and ballasts

kWh_{F17T8} = Annual electricity consumption of F17T8 lamps and ballasts

Summer Coincident Peak Savings Algorithm

First Year Savings

$kW_{SAVED} = (W_{U} - W_{F17T8}) / 1,000 * CF$

Where:

W_{U} = Wattage of existing U-tube lamps and ballasts

W_{F17T8} = Existing wattage of F17T8 lamps and ballasts

1,000 = Kilwatt conversion factor

CF = Demand coincidence factor (= varies by sector; see table below)

Demand Coincidence Factor by Sector

Sector	CF[3]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64

Subsequent Year Savings

$kW_{SAVED} = \{(W_U – W_{F17T8}) * N + (W_{UEISA} – W_{F17T8}) * (EUL - N)\} / 1,000$

Where:

N = Number of years until 2016 (=1 in 2015)

W_{UEISA} = Existing wattage of EISA-compliant U-tube lamps and ballasts

EUL = Effective useful life (3325, 3326 =15[2])

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = (kWh_U – kWh_{F17T8}) * N + (kWh_{UEISA} – kWh_{F17T8}) * (EUL - N)$

Where:

kWh_{UEISA} = Annual electricity consumption of EISA-compliant U-tube lamps and ballasts

Deemed Savings

Average Annual Deemed Savings

Measure	MMID	Commercial 3,730 (0.77)		Schools & Gov 3,239 (0.64)		Industrial 4,745 (0.77)		Agriculture 4,698 (0.67)	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW
F17T8, 2-Foot Lamps Replacing Single T12 U-Tube Lamps	3325	90.8	0.0187	78.8	0.0156	115.5	0.0187	114.3	0.0163
F17T8, 2-Foot Lamps Replacing Double T12 U-Tube Lamps	3326	149.2	0.0308	129.6	0.0256	189.8	0.0308	187.9	0.0268

Average Lifecycle Deemed kWh Savings

MMID	Commercial 3,730 (0.77)	Schools & Gov 3,239 (0.64)	Industrial 4,745 (0.77)	Agriculture 4,698 (0.67)
	kWh	kWh	kWh	kWh
3325	1362	1182	1732.5	1714.5
3326	2238	1944	2847	2818.5

Assumptions

The replacement of single U-tube fixtures uses an average of 1/3 single F17T8 replacements and 2/3 double F17T8 fixtures to generate the new measure wattage.

The replacement of double U-tube fixtures uses an average of 25% 4-Lamp F17T8, 50% 3-Lamp F17T8, and 25% 2-Lamp F17T8 fixture replacements to generate the new measure wattage.

Sources

1. Multiple Manufacturers Product Life Rating of ~ 24,000 hours.
2. DEER 2014 EUL Table. http://www.deeresources.com. Rated ballast life of 70,000 hours. Not rated on bulb life as such EUL is capped at 15 years.
3. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.
4. Online research, March 2016. Average price of "T12 Utube" lamp from: 1000bulbs.com.
5. 2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.

Revision History

Version Number	Date	Description of Change
01	07/2013	Initial TRM entry
02	10/2016	Removed MMIDs 3240, 3241, 3242, 3243

Exterior Lighting Optimization

	Measure Details
Measure Master ID	Exterior Lighting Optimization, LED: ≤ 60 Watts, Replacing 250 Watt HID, 3716 With Integrated Timer or Wireless Schedule, 3717 With Bi-Level Control, 3718 60-125 Watts, Replacing 250 Watt HID, 3719 With Integrated Timer or Wireless Schedule, 3720 With Bi-Level Control, 3721 125-200 Watts, Replacing 320 Watt HID, 3722 With Integrated Timer or Wireless Schedule, 3723 With Bi-Level Control, 3724 125-200 Watts, Replacing 400 Watt HID, 3725 With Integrated Timer or Wireless Schedule, 3726 With Bi-Level Control, 3727 200-650 Watts, Replacing 1000 Watt HID, 3728 With Integrated Timer or Wireless Schedule, 3729 With Bi-Level Control, 3730
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	High Intensity Discharge (HID)
Sector(s)	Commercial, Industrial, Agriculture, Schools and Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	=20 for fixtures;[2] = 8 for controls[5]
Incremental Cost ($/unit)	Varies by measure, see Appendix D[1]

Measure Description

Exterior lighting optimization (ELO) offers energy efficient LED upgrade choices for replacing or retrofitting qualifying exterior pole mount fixtures, wall mount fixtures, and fuel pump canopy luminaires. The ELO measures are structured to provide annual savings and set measure cost information for end users.

Description of Baseline Condition

The baseline condition is needing toreplace or retrofit 150-175 watt, 250 watt, 320 watt, 400 watt, and 1,000 watt HID systems that currently operate 4,380 hours per year. Fixtures must be exterior pole mount, wall mount, or fuel pump canopy mount where the head of the fixture is a minimum of 15 feet above finished grade.

Description of Efficient Condition

The efficient condition is one of the following situations:

- Facilities with existing 150-175 watt HIDs will have the option to upgrade to a new LED fixture or retrofit less than or equal to 60 input watts.
- Facilities with existing 250 watt HIDs will have the option to upgrade to a new LED fixture or retrofit between 61 and 125 input watts.
- Facilities with existing 320 watt or 400 watt HIDs will have the option to upgrade to a new LED fixture or retrofit between 126 and 200 input watts.
- Facilities with existing 1,000 watt HIDs will have the option to upgrade to a new LED fixture or retrofit between 201 and 650 input watts.

When applicable, twist-lock fixture mounted controls with integrated timers and/or wireless controls will also be an option of each ELO replacement/retrofit, enabling the capture of additional savings.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{HID} * HOU_{HID}) – (Watts_{ELO} * HOU_{ELO}) / 1,000$

Where:

$Watts_{HID}$ = Power consumption of baseline measure (= 1,079, 458, 368, 295, or 195 watts)[3]

HOU_{HID} = Average annual run hours (= 4,380)[5]

$Watts_{ELO}$ = Power consumption of efficient LED upgrade (= 288, 152, 89, or 40 watts)[4]

HOU_{ELO} = Average annual run hours (= 4,380 for fixtures without controls; = 2,920 for fixture upgrades w/integrated timer and/or wireless schedule; = 2,628 for fixture upgrade w/bi-level control. See Assumptions section)

1,000 = Kilowatt conversion factor

Summer Coincident Peak Savings Algorithm

There are no summer coincident peak savings for ELO measures.

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life for fixtures (=20 for fixtures;[2] = 8 for controls[5])

For systems with controls

$kWh_{LIFECYCLE} = (kWh_{SAVED} * EUL) + ((kWh_{SAVED\ W/CONTROLS} – kWh_{SAVED}) * (EUL_{CONTROLS}))$

Where:

$KWh_{SAVED\ W/CONTROLS}$ = Annual electricity consumption of chosen energy efficient ELO measure option with additional controls hours reduction

$EUL_{CONTROLS}$ = Effective useful life for lighting controls (= 8 years)[5]

Deemed Savings

Annual and Lifecycle Energy Savings for LED Fixture/Retrofit

Measure Description	MMID	Annual kWh Savings	Lifecycle kWh Savings
≤ 60 watt replacing 150-175 watt HID	3716	701	14,020
≤ 60 watt replacing 150-175 watt HID w/integrated timer or wireless schedule	3717	759	14,484
≤ 60 watt replacing 150-175 watt HID w/bi-level control	3718	771	14,580
> 60 watt, but ≤ 125 watt replacing 250 watt HID	3719	920	18,400
> 60 watt, but ≤ 125 watt replacing 250 watt HID w/integrated timer or wireless schedule	3720	1,051	19.448
> 60 watt, but ≤ 125 watt replacing 250 watt HID w/bi-level control	3721	1,077	19,656
> 125 watt, but ≤ 200 watt replacing 320 watt HID	3722	964	19,280
> 125 watt, but ≤ 200 watt replacing 320 watt HID w/integrated timer or wireless schedule	3723	1,183	21,032
> 125 watt, but ≤ 200 watt replacing 320 watt HID w/bi-level control	3724	1,227	21,384
> 125 watt, but ≤ 200 watt replacing 400 watt HID	3725	1,358	27,160
> 125 watt, but ≤ 200 watt replacing 400 watt HID w/integrated timer or wireless schedule	3726	1,577	28,912
> 125 watt, but ≤ 200 watt replacing 400 watt HID w/bi-level control	3727	1,621	29,264
> 200 watt, but ≤ 650 watt replacing 1,000 watt HID	3728	3,460	69,200

Measure Description	MMID	Annual kWh Savings	Lifecycle kWh Savings
> 200 watt, but ≤ 650 watt replacing 1,000 watt HID w/integrated timer or wireless schedule	3729	3,883	72,584
> 200 watt, but ≤ 650 watt replacing 1,000 watt HID w/bi-level control	3730	3,968	73,264

Installed Measure Cost Table[1]

Measure	Installed Cost
200 watt < LED ≤ 650 watt	$1,229.00
200 watt < LED ≤ 650 watt w/integrated timer	$1,470.00
200 watt < LED ≤ 650 watt w/bi-level	$1,470.00
125 watt < LED ≤ 200 watt	$1,225.00
125 watt < LED ≤ 200 watt w/integrated timer	$1,466.00
125 watt < LED ≤ 200 watt w/bi-level	$1,466.00
60 watt < LED ≤ 125 watt	$742.00
60 watt < LED ≤ 125 watt w/integrated timer	$983.00
60 watt < LED ≤ 125 watt w/bi-level	$983.00
LED ≤ 60 watt	$275.00
LED ≤ 60 watt w/integrated timer	$516.00
LED ≤ 60 watt w/bi-level	$516.00

Assumptions

It is a requirement that options that include integrated timer controls or wireless schedules be set to reduce the controlled fixture's hours of operation by a minimum of four hours per night. This results in a decrease from 4,380 to 2,920 annual run hours. Bi-level control options are able to achieve a 50% reduction in power requirements. A 60% reduction in burn hours is used to be conservative similar to MMIDs 3251 and 3252.

Sources

1. 2012-2013 data gathered from installation contractors from all four geographical quadrants of the Focus on Energy program territory. Of 40 installation parties contacted, 12 completed the questionnaire in time to be included in the dataset. Internet pricing data, accessed in August 2015 from a variety of sources, was used for LED materials, some HID ballasts, controls sockets, and photocell/timer controls. Products that were selected were randomly chosen based on them meeting the measure definitions.
2. Cadmus. Review of manufacturers' measure life. 2015.

3. Wisconsin Focus on Energy. *Default Wattage Guide.* Version 1.0. 2013.
4. Philips Advance. *Lighting Electronics Atlas.* 2012-2013.
5. DesignLights Consortium. 2013 Listed fixtures.
6. U.S. Department of Commerce, National Oceanic & Atmospheric Administration. *NOAA Solar Calculator*. Available online: http://www.esrl.noaa.gov/gmd/grad/solcalc/ (this includes times when photocells turn on prior to exact sunset and turn off after exact sunrise, accounting for diminished outdoor lighting as well as time clock scheduled lighting).
7. *Focus on Energy Evaluation Business Programs: Measure Life Study Final Report*. August 25, 2009.

Revision History

Version Number	Date	Description of Change
01	01/2016	New measure

HID, Reduced Wattage, Replacing HID, Interior, Exterior, Parking Garage

	Measure Details
Measure Master ID	HID, Reduced Wattage: Interior: Replacing 1,000 Watt HID, 3067 Replacing 175 Watt HID, 3068 Replacing 250 Watt HID, 3070 Replacing 320 Watt HID, 3072 Replacing 400 Watt HID, 3073 Exterior: Replacing 1,000 Watt HID, 3036 Replacing 400 Watt HID, 3037 Replacing 320 Watt HID, 3038 Replacing 250 Watt HID, 3039 Replacing 175 Watt HID, 3040 Parking Garage: Replacing 175 Watt HID, 3069 Replacing 250 Watt HID, 3071
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	High Intensity Discharge (HID)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily (exterior measures only)
Annual Energy Savings (kWh)	Varies by baseline and sector
Peak Demand Reduction (kW)	Varies by baseline and sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	4[1]
Incremental Cost ($/unit)	Varies by measure, see Appendix D

Measure Description

RW HID direct replacement lamps save energy by reducing the total input wattage of the luminaire as compared to the same luminaire operating with standard wattage HID lamps. This measure can be applied in spaces where standard wattage HID lamps are being used. These RW HID products have a similar or equivalent lumen output to the lamps that they replace, which allows them to be installed anywhere that standard wattage HID lamps are found.

Description of Baseline Condition

The baseline is standard 175-watt, 250-watt, 320-watt, 400-watt, and 1,000-watt HID lamps.

Description of Efficient Condition

The efficient condition is 145-watt, 150-watt, 205-watt, 220-watt, 260-watt, 330-watt, 360-watt, and 860-watt RW HID lamps.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} - Watts_{EE})/ 1,000 * HOU$

Where:

$Watts_{BASE}$ = Wattage of baseline standard HID lamp (= varies by measure; see table below)

$Watts_{EE}$ = Wattage of efficient RW direct replacement HID lamp (= varies by measure; see table below)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 4,380 for exterior; = 8,760 for parking garages; = varies by sector for interior; see table below)

Wattages for Deemed Savings Calculations

Measure	$Watts_{BASE}$	$Watts_{EE}$
Exterior RW HID Lamp 1,000-Watt Replacement	1,079	928.8
Interior HID Lamp 1,000-Watt Replacement	1,079	928.8
Exterior RW HID Lamp 400-Watt Replacement	455	396.75
Interior HID Lamp 400-Watt Replacement	455	396.75
Exterior RW HID Lamp 320-Watt Replacement	356	299
Interior HID Lamp 320-Watt Replacement	356	299
Exterior RW HID Lamp 250-Watt Replacement	293	250.75
PG HID Lamp 250-Watt Replacement	293	250.75
Interior HID Lamp 250-Watt Replacement	293	250.75
Exterior RW HID Lamp 175-Watt Replacement	210	177
PG HID Lamp 175-Watt Replacement	210	177
Interior HID Lamp 175-Watt Replacement	210	177

Interior Hours-of-Use by Sector

Sector	HOU[2]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1,000 * CF$

Where:

CF = Coincidence factor (= 0.00 for exterior; = 1.0 for parking garages; = varies by measure for interior, see table below)

Interior Coincidence Factor by Sector

Sector	CF[2]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 4 years)[1]

Deemed Savings

Average Annual Deemed Savings for Reduced Wattage HID Direct Replacement Lamps

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Gov		Res-Multifamily	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
HID, Reduced Wattage Replacing 1,000-Watt HID, Exterior	3036	658	0	658	0	658	0	658	0	658	0
HID, Reduced Wattage Replacing 1,000-Watt HID, Interior	3067	560	0.1157	713	0.1157	706	0.1006	486	0.0961	N/A	
HID, Reduced Wattage, Replacing 400-Watt HID, Exterior	3037	255	0	255	0	255	0	255	0	255	0
HID reduced Wattage, Replacing 400-Watt HID, Interior	3073	217	0.0449	276	0.0449	274	0.0390	189	0.0373	N/A	

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Gov		Res-Multifamily	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
HID, Reduced Wattage, Replacing Lamp 320-Watt HID, Exterior	3038	250	0	250	0	250	0	250	0	250	0
HID, Reduced Wattage, Replacing Lamp 320-Watt HID, Interior	3072	213	0.0439	270	0.0439	268	0.0382	185	0.0365	N/A	
HID, Reduced Wattage Replacing 250-Watt HID, Exterior	3039	185	0	185	0	185	0	185	0	185	0
HID, Reduced Wattage Replacing 250-Watt HID, Parking Garage	3071	370	0.0423	370	0.0423	370	0.0423	370	0.0423	N/A	
HID, Reduced Wattage Replacing 250-Watt HID, Interior	3070	158	0.0325	200	0.0325	198	0.0283	137	0.0270	N/A	
HID, Reduced Wattage Replacing175-Watt HID, Exterior	3040	145	0	145	0	145	0	145	0	145	0
HID, Reduced Wattage Replacing175-Watt HID, Parking Garage	3069	289	0.0330	289	0.0330	289	0.0330	289	0.0330	N/A	
HID, Reduced Wattage Replacing 175-Watt HID, Interior	3068	123	0.0254	157	0.0254	155	0.0221	107	0.0211	N/A	

Average Lifecycle Deemed Savings for Reduced Wattage HID Direct Replacement Lamps (kWh)

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Gov	Res-Multifamily
HID, Reduced Wattage Replacing 1,000-Watt HID, Exterior	3036	2,632	2,632	2,632	2,632	2,632
HID, Reduced Wattage Replacing 1,000-Watt HID, Interior	3067	2,241	2,851	2,823	1,946	N/A
HID, Reduced Wattage, Replacing 400-Watt HID, Exterior	3037	1,021	1,021	1,021	1,021	1,021
HID reduced Wattage, Replacing 400-Watt HID, Interior	3073	869	1,106	1,095	755	N/A
HID, Reduced Wattage, Replacing Lamp 320-Watt HID, Exterior	3038	999	999	999	999	999
HID, Reduced Wattage, Replacing Lamp 320-Watt HID, Interior	3072	850	1,082	1,071	738	N/A
HID, Reduced Wattage Replacing 250-Watt HID, Exterior	3039	740	740	740	740	740
HID, Reduced Wattage Replacing 250-Watt HID, Parking Garage	3071	1,480	1,480	1,480	1,480	N/A

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Gov	Res-Multifamily
HID, Reduced Wattage Replacing 250-Watt HID, Interior	3070	630	802	794	547	N/A
HID, Reduced Wattage Replacing175-Watt HID, Exterior	3040	578	578	578	578	578
HID, Reduced Wattage Replacing175-Watt HID, Parking Garage	3069	1,156	1,156	1,156	1,156	N/A
HID, Reduced Wattage Replacing 175-Watt HID, Interior	3068	492	626	620	428	N/A

Assumptions

Same ballast factors were assumed for each replacement watt product (e.g., a 1.18 ballast factor was used for 250-watt products and their replacements). The assumptions for exterior replacement lamps are:

- 400-watt metal halide replacement: An average of 50% each of 360-watt RW and 330-watt RW was used to generate the new measure wattage.
- 250-watt HID replacement: An average of 50% each of 220-watt RW and 205-watt RW was used to generate the new measure wattage.
- 175-watt HID replacement: An average of 50% each of 150-watt RW and 145-watt RW was used to generate the new measure wattage.

Sources

1. Cadmus review of manufacturers' measure life. Multiple manufacturers' product life rating (with a minimum of 20,000 hours / 4,380 hours = 4.5 years, rounded down to 4 years to be conservative).
2. State of Wisconsin Public Service Commission. Business Programs Deemed Savings Manual V1.0. March 22, 2010.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

LED Troffer, 1x4, Replacing 4-Foot 1-2 Lamp T8 Troffer

	Measure Details
Measure Master ID	LED, 1x4, Replacing T8, 1- Lamp or 2-Lamp, 3760
Measure Unit	Per luminaire or integrated 37etrofit kit
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential-multifamily
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	16[1]
Incremental Cost ($/unit)	$77.00[2]

Measure Description

LED 1x4 troffers save energy when replacing 1-lamp or 2-lamp T8 products by providing a similar lumen output with lower input wattage. These products can be installed on a one-for-one basis to replace 1-lamp or 2-lamp T8 luminaires.

Description of Baseline Condition

The baseline measure is 4-foot, 1-lamp and 2-lamp T8 troffers in existing buildings and new construction buildings.

Description of Efficient Condition

The efficient condition is LED products that are DesignLights Consortium™ (DLC) listed in the "1x4 Luminaires for Ambient Lighting of Interior Commercial Spaces" or "Integrated Retrofit Kits for 1x4 Luminaires" primary use categories, which consume ≤25 watts.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{LED}) / 1,000 * HOU$

Where:

$Watts_{BASE}$ = Baseline wattage, or the average power consumption of a 1-lamp 32-watt T8 and a 2-lamp 32-watt T8, weighted at 50% eacj (= 43.5 watts)[3]

$Watts_{LED}$ = Energy efficient wattage, or the average power consumption of DLC-listed LED fixtures (= 22 watts)[4]

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= varies by sector; see table below)

Hours-of-Use by Sector

Sector	HOU[5]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239
Multifamily (common area)	5,950

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{LED}) / 1,000 * CF$

Where:

CF = Coincidence factor (= varies by sector; see table below)

Coincidence Factor by Sector

Sector	CF[5]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64
Multifamily (common area)	0.77

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 16 years)[1]

Deemed Savings

Annual Savings

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Gov		Multifamily	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED Troffer, 1x4, Replacing 4-Foot 1-Lamp and 2-Lamp T8 Troffer	3760	81	0.0167	103	0.0167	102	0.0145	70	0.0139	129	0.0167

Lifecycle Savings (kWh)

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Gov	Multifamily
LED Troffer, 1x4, Replacing 4-Foot 1-Lamp and 2-Lamp T8 Troffer	3760	1,295	1,647	1,631	1,124	2,066

Sources

1. Cadmus review of manufacturers' measure life
2. Various online lighting retailers. August 2015.
3. Consortium for Energy Efficiency. *Legacy Ballast List*. 2015.
4. DesignLights Consortium. *Product List.* Average measured wattage from products listed in the 1x4 Luminaires for Ambient Lighting of Interior Commercial Spaces and Integrated Retrofit Kits for 1x4 Luminaires primary use categories consuming ≤25 watts. August 7, 2015.
5. Focus on Energy. *Business Programs Deemed Savings Manual V1.0*. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.

Revision History

Version Number	Date	Description of Change
01	01/01/2013	New measure
02	08/14/2015	Updated savings information

LED Troffer, 2x4, Replacing 4-Foot, 3-4 Lamp T8 Troffer

	Measure Details
Measure Master ID	LED Troffer, 2x4, Replacing 4-Foot, 3-4 Lamp T8 Troffer, 3111, 3291, 3348
Measure Unit	Per luminaire or integrated retrofit kit
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, –Residential-multifamily
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	16[1]
Incremental Cost ($/unit)	$168.29[2]

Measure Description

LED 2x4 troffers save energy when replacing 3-lamp or 4 lamp T8 products by providing a similar lumen output with lower input wattage. These products can be installed on a one-for-one basis to replace 3-lamp or 4-lamp T8 luminaires.

Description of Baseline Condition

The baseline measure is 4-foot, 3-lamp and 4-lamp T8 troffers for existing buildings and new construction buildings.

Description of Efficient Condition

The efficient measures are LED products that are DesignLights Consortium™ listed in the “2x4 Luminaires for Ambient Lighting of Interior Commercial Spaces” or “Integrated Retrofit Kits for 2x4 Luminaires” primary use categories, which consume ≤ 55 watts.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{LEDEE}) / 1,000 * HOU$

Where:

$Watts_{BASE}$ = Baseline wattage, or the average power consumption of a 3-lamp 32-watt T8 and a 4-lamp 32-watt T8, weighted 50% each (= 97 watts)[3]

$Watts_{LEDEE}$ = Energy efficient wattage, or the average power consumption of a DesignLights Consortium-listed LED fixture (= 45 watts)[4]

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= varies by sector, see table below)

Hours of Use by Sector

Sector	HOU[5]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239
Multifamily	5,950

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{LEDEE}) / 1{,}000 * CF$

Where:

CF = Coincidence factor (= varies by sector, see table below)

Coincidence Factor by Sector

Sector	CF[5]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64
Multifamily	0.77

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 16 years)[1]

Deemed Savings

Annual Savings

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Gov		Multifamily	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED Troffer, 2x4, Replacing 4-Foot 3-4 Lamp T8 Troffer	3111, 3291, 3348	195	0.0402	248	0.0402	245	0.0350	169	0.0334	311	0.0402

Lifecycle Savings (kWh)

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Gov	Multifamily
LED Troffer, 2x4, Replacing 4-Foot 3-4 Lamp T8 Troffer	3111, 3291, 3348	3,120	3,968	3,920	2,704	4,976

Sources

1. Cadmus review of manufacturers' measure life.
2. Online Research, March 2016. Average price of "2x4 led troffer fixtures." Actual cost. Available online: www.1000bulbs.com/category/2x4-led-troffer-fixtures/
3. Consortium for Energy Efficiency. Legacy Ballast List. 2015.
4. DesignLights Consortium. Product List. Average measured wattage from 2x4 Luminaires for Ambient Lighting of Interior Commercial Spaces and Integrated Retrofit Kits for 2x4 Luminaires primary use categories consuming ≤55 Watts. August 7, 2015.
5. *Focus on Energy Business Programs Deemed Savings Manual V1.0*. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.

Revision History

Version Number	Date	Description of Change
01	01/01/2013	New measure
02	08/14/2015	Updated savings information

LED Fixture, ≤ 180 Watts, Replacing 4 Lamp T5 or 6 Lamp T8, High Bay, DLC Listed

	Measure Details
Measure Master ID	LED Fixture, ≤ 180 Watts, Replacing 4 Lamp T5 or 6 Lamp T8, High Bay, DLC Listed, 3393, 3809
Measure Unit	Per luminaire
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	16[1]
Incremental Cost ($/unit)	$215.69[2]

Measure Description

LED high bay fixtures save energy when replacing 4 lamp T5 or 6 lamp T8 high bay products by providing a similar lumen output with lower input wattage. These products can be installed on a one-for-one basis to replace 4 lamp T5 or 6 lamp T8 high bay luminaires.

Description of Baseline Condition

The baseline condition is 4-foot 4 lamp T5HO, or 6 lamp T8 high/low bay fixtures for existing buildings and new construction buildings. An average of 50% 4-foot 4 lamp T5HO and 50% 6 lamp T8 high/low bay luminaires was used to generate the baseline wattage.

Description of Efficient Condition

The efficient condition is DLC-listed LED high bay “High-Bay Luminaires for Commercial and Industrial Buildings,” “High-Bay Aisle Luminaires,” or “Retrofit Kits for High-Bay Luminaires for Commercial and Industrial Buildings” that consume ≤ 180 watts.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{LF\ HIGHBAY} - Watts_{LED}) / 1{,}000 * HOU$

Where:

$Watts_{LF\ HIGHBAY}$ = Annual electricity consumption of 4-foot 4 lamp T5HO or 6 lamp T8 high/low bay luminaires (= 228 watts)[5]

$Watts_{LED}$ = Annual electricity consumption of DLC-listed high/low bay luminaire or retrofit kit

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= varies by sector; see table below)

Hours-of-Use by Sector

Sector	HOU[3]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239
Multifamily	5,950

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{LF\ HIGHBAY} - Watts_{LED}) / 1{,}000 * CF$

Where:

CF = Coincidence factor (= varies by sector; see table below)

Coincidence Factor by Sector

Sector	CF[4]
Commercial	0.77
Industrial	0.77
Schools & Government	0.64
Agriculture	0.67
Multifamily Common Area	0.77

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 18 years)[1]

Deemed Savings

Average Annual Deemed Savings for DLC-Listed LED Highbay ≤ 180 Watts

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Gov		Multifamily	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED Fixture, ≤ 180 Watts, Replacing 4 Lamp T5 or 6 Lamp T8, High Bay, DLC Listed	3393, 3809	334	0.0689	424	0.0689	420	0.0599	290	0.0572	532	0.0689

Average Lifecycle Deemed Savings for DLC-Listed LED Highbay ≤ 180 Watts (kWh)

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Gov	Multifamily
LED Fixture, ≤ 180 Watts, Replacing 4 Lamp T5 or 6 Lamp T8, High Bay, DLC Listed	3393, 3809	6,006	7,640	7,564	5,215	9,580

Sources

1. Cadmus review of manufacturers' measure life.
2. Cost data obtained through various online lighting retailers from July 2016.
3. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
4. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.
5. The wattage shown is an weighted average of 75% 6 lamp LF and 25% 4 lamp T5HO highbay fixtures.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

LED Fixture, Downlights, ≤ 18 Watts, Replacing Incandescent Downlight, Exterior

	Measure Details
Measure Master ID	LED Fixture, Downlights, ≤ 18 Watts, Replacing Incandescent Downlight, Exterior, 3405
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	193
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	1,932
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	11[1]
Incremental Cost ($/unit)	$17.55[3]

Measure Description

LED downlight luminaires can replace existing incandescent luminaires without sacrificing performance; they save energy because they consume less wattage than the incandescent luminaries they replace. There is no demand reduction since this measure is used during evening and night lighting hours.

Description of Baseline Condition

The baseline measure is 50 watt to 72 watt incandescent luminaires.

Description of Efficient Condition

The efficient measure is ENERGY STAR-rated LED downlights that consume ≤ 18 watts.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{INC} - Watts_{LED}) /1{,}000 * HOU * Con_{FACT}$

Where:

$Watts_{INC}$ = Wattage of standard incandescent fixture (= 62)

$Watts_{LED}$ = Wattage of LED product (= 13)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 4,380)

Con_{FACT} = Control factor (= 0.90)

Summer Coincident Peak Savings Algorithm

There are no peak savings for this measure.

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (10 years)[1]

Assumptions

A weighted average of 16.66% each for 50 watt, 53 watt, 60 watt, 65 watt, 70 watt, and 72 watt incandescent luminaires was used to generate the baseline wattage.

4,380 hours run time of fixtures based on an annual average of 12 hours per day from NOAA data.[2] This also includes the times when photocells turn on prior to exact sunset and turn off after exact sunrise, accounting for diminished outdoor lighting as well as time clock scheduled lighting.

Applying a controls factor allows for a more conservative estimate of savings. Based on project experience, less than 10% of the exterior fixtures on the market have additional controls that may operate at conditions other than dusk to dawn.

Sources

1. Cadmus review of manufacturers' measure life.
2. U.S. Department of Commerce National Oceanic & Atmospheric Administration.– "NOAA Solar Calculator." http://www.esrl.noaa.gov/gmd/grad/solcalc/.
3. Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

Exterior LED Downlights Luminaires > 18 Watts

	Measure Details
Measure Master ID	Exterior LED Downlights Luminaires > 18 Watts, 3404
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	226.3
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	2,263
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	11[1]
Incremental Cost ($/unit)	$12.46[3]

Measure Description

LED downlight luminaires can replace existing incandescent luminaires used for the same application without sacrificing performance. LED downlights save energy because they consume less wattage than the incandescent luminaries they replace.

Description of Baseline Condition

The baseline condition is 80-watt halogen and 50-watt to 100-watt HID luminaires.

Description of Efficient Condition

The efficient condition is ENERGY STAR-rated LED downlights that consume less than 18 watts.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{INC} - kWh_{LED}$

$kWh_{INC} = Wattage_{INC} / 1{,}000 * HOURS * CF$

$kWh_{LED} = Wattage_{LED} / 1{,}000 * HOURS * CF$

Where:

kWh_{INC} = Annual electricity consumption of standard wattage incandescent fixtures

kWh_{LED} = Annual electricity consumption of LED products

Wattage = Instantaneous electric consumption of lamp or fixture

1,000 = Kilowatt conversion factor

HOURS = Average annual run hours (= 4,380)[3]

CF = Controls factor that accounts for the small percentage of systems in the market with additional controls (= 0.9)

Summer Coincident Peak Savings Algorithm

There are no peak savings for this measure.

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 11 years)[1]

Deemed Savings

Average Annual Deemed Savings for LED Downlights > 18 Watts

Measure	Exterior 4380 (0.00)	
	Savings (kWh)	Savings (kW)
LED Downlights > 18 watts	226.3	0.0

Average Lifecycle Deemed Savings for LED Downlights > 18 Watts

Measure	Exterior 4380 (0.00)
	Savings (kWh)
LED Downlights > 18 watts	2,263

Assumptions

A weighted average of 25% each for 80-watt halogen, 50-watt HID, 70-watt HID, and 100-watt HID luminaires was used to generate the baseline wattage.

The 4,380 HOURS was based on an annual average of 12 hours per day from NOAA data.[2] This includes when photocells turn on prior to exact sunset and turn off after exact sunrise, accounting for diminished outdoor lighting as well as time clock scheduled lighting.

Applying a controls factor allows for a more conservative savings estimate. Based on project experience, less than 10% of the exterior fixtures on the market have additional controls that may operate at conditions other than dusk to dawn.

Sources

1. Cadmus review of manufacturers' measure life.
2. U.S. Department of Commerce, National Oceanic & Atmospheric Administration. NOAA Solar Calculator. Available online: http://www.esrl.noaa.gov/gmd/grad/solcalc/
3. Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.

Revision History

Version Number	Date	Description of Change
01	04/2014	Initial TRM entry

Exterior LED Fixtures Replacement

	Measure Details
Measure Master ID	LED Fixture, Exterior: Replacing 150-175 Watt HID, 3099, 3824, 3289 Replacing 250 Watt HID, 3102, 3825, 3301 Replacing 320 Watt HID, 3105 Replacing 320-400 Watt HID, 3106, 3826 Replacing 400 Watt HID, 3107, 3827, 3303 Replacing 70-100 Watt HID, 3108, 3828, 3304
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by wattage
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by wattage
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Incremental Cost ($/unit)	Varies by measure, see Appendix D

Measure Description

Exterior LED fixtures are an energy-saving alternative to traditional standard wattage HID light sources that have been used for the same applications. LED light sources can be applied in almost every common application type where HID light sources are currently found. This measure is only for replacing existing HID fixtures.

Description of Baseline Condition

The baseline condition is existing HID lamps between 70 watts and 400 watts.[2]

Description of Efficient Condition

The efficient condition is LED fixtures that meet program requirements. Replacements must be complete fixtures or a retrofit of interior components with a total power reduction of 40% or more. Lamp-only replacements are not eligible for an incentive. LEDs must be on the qualifying DLC list.[3]

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} - Watts_{EE}) /1{,}000 * HOU$

Where:

$Watts_{BASE}$ = Wattage of standard HID fixture

$Watts_{EE}$ = Wattage of LED fixture

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 4,380)

Wattages Used for Deemed Savings Calculations

Measure	$Watts_{BASE}$[5]	$Watts_{EE}$[4]
Exterior LED replacing 70-watt to 100-watt HID Average	111.5	31
Exterior LED replacing 150-watt to 175-watt HID Average	194.5	59
Exterior LED replacing 250-watt HID Average	299.0	94
Exterior LED replacing 320-watt HID	368.0	160
Exterior LED replacing 400-watt HID	463.0	178

Summer Coincident Peak Savings Algorithm

There are no peak savings for this measure.

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 12 years)[1]

Deemed Savings

Average Annual Deemed Savings for Exterior LED Fixtures

Measure	MMID	kWh	kW
Exterior LED replacing 70-watt to 100-watt HID Average	3108, 3828, 3304	344	0
Exterior LED replacing 150-watt to 175-watt HID Average	3099, 3824, 3289	594	0
Exterior LED replacing 250-watt HID Average	3102, 3825, 3301	870	0
Exterior LED replacing 320-watt HID	3105	859	0
Exterior LED replacing 400-watt HID	3106, 3826, 3107, 3827, 3290, 3303	1,215	0

Average Lifecycle Deemed Savings for Exterior LED Fixtures

Measure	MMID	kWh
Exterior LED replacing 70-watt to 100-watt HID Average	3108, 3828, 3304	4,131
Exterior LED replacing 150-watt to 175-watt HID Average	3099, 3824, 3289	7,127
Exterior LED replacing 250-watt HID Average	3102, 3825, 3301	10,438
Exterior LED replacing 320-watt HID	3105	10,312
Exterior LED replacing 400-watt HID	3106, 3826, 3107, 3827, 3290, 3303	14,575

Assumptions

Calculations are based on exterior lighting that operates 4,380 hours annually, 12 hours per day (dusk to dawn).

LED lamps can achieve a 40% reduction in power requirements.

Sources

1. Cadmus review of manufacturers’ measure life.
2. Based on market research.
3. Design Lights Consortium. *Qualified Products List*.
4. Focus on Energy Default Wattage Guide 2013, Version 1.0.
5. Focus on Energy Default Wattage Guide 2013, Version 1.0.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

LED Replacing Incandescent, Exterior

	Measure Details
Measure Master ID	LED Lamp, ENERGY STAR, Exterior: Replacing Incandescent Lamp ≤ 40 Watts, 3402 Replacing Incandescent Lamp > 40 Watts, 3403
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by baseline
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by baseline
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	7[1]
Incremental Cost ($/unit)	MMID 3402=$6.05;[2] MMID 3403= $9.40[4]

Measure Description

ENERGY STAR-rated LED replacement lamps save energy by reducing the total input wattage of the luminaire as compared to the same luminaire operating with standard wattage incandescent lamps. This measure provides an energy-efficient alternative to using incandescent lamps in several exterior applications.

Description of Baseline Condition

Less than or Equal to 40 Watts

One baseline condition is for standard incandescent lamps. The baseline wattage is generated using an average of 50% 25-watt incandescents and 50% 40-watt incandescents.

Greater than 40 Watts

Another baseline condition is for standard and EISA compliant incandescent lamps of 53 watts, 60 watts, 65 watts, 70 watts, 72 watts, and 80 watts. The baseline wattage is generated using an average of 16.66% each of 53-watt incandescent, 60-watt incandescent and halogen, 65-watt incandescent, 70-watt halogen, 72-watt halogen, and 80-watt halogen lamps.

Description of Efficient Condition

The efficient equipment must be an ENERGY STAR-rated LED lamp. The efficient wattage is generated using an average of 33% each of 11.68 watt, 16.70 watt, and 17.81 watt ENERGY STAR-rated LEDs.

Annual Energy-Savings Algorithm[3]

$kWh_{SAVED} = (Watts_{INCANDESCENT} - Watts_{EXT\ LED})\ /1{,}000 * HOU$

Where:

$Watts_{INCANDESCENT}$ = Wattage of standard incandescent lamps = 67 if > 40 watts; = 32.5 if ≤ 40 watts)

$Watts_{EXT\ LED}$ = Wattage of ENERGY STAR-rated LED lamp with a lumen output rating equivalent to the lumen output of incandescent being replaced (= 15.4)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 4,380)

Summer Coincident Peak Savings Algorithm

There are no peak savings for this measure.

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 7 years)[1]

Deemed Savings

Average Annual Deemed Savings for LED Lamp Replacing Incandescent

Measure	MMID	kWh Saved
LED Lamp, ENERGY STAR, Replacing Incandescent Lamp ≤ 40 Watts, Exterior	3402	106
LED Lamp, ENERGY STAR, Replacing Incandescent Lamp > 40 Watts, Exterior	3403	202

Average Lifecycle Deemed Savings for LED Lamp Replacing Incandescent

Measure	MMID	kWh Saved
LED Lamp, ENERGY STAR, Replacing Incandescent Lamp ≤ 40 Watts, Exterior	3402	742
LED Lamp, ENERGY STAR, Replacing Incandescent Lamp > 40 Watts, Exterior	3403	1,414

Assumptions

4,380 hours run time of fixtures based on an annual average of 12 hours per day from NOAA data.[3] This also includes the times when photocells turn on prior to exact sunset and turn off after exact sunrise, accounting for diminished outdoor lighting as well as time clock scheduled lighting.

Sources

1. Cadmus review of manufacturers' measure life.
2. Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.
3. U.S. Department of Commerce National Oceanic & Atmospheric Administration. "NOAA Solar Calculator." http://www.esrl.noaa.gov/gmd/grad/solcalc/.
4. Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®. Weighted Average 60,75, and 100 W LEDs.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

LED Fixtures, High Bay

	Measure Details
Measure Master ID	LED Fixture, High Bay < 155 Watts, Replacing 250 Watt HID, 3091, 3806 < 250 Watts, Replacing 320-400 Watt HID, 3092, 3810 < 250 Watts, Replacing 400 Watt HID, 3093, 3807 < 365 Watts, Replacing 400 Watt HID, 3094, 3808 < 500 Watts, Replacing 1,000 Watt HID, 3095 < 800 Watts, Replacing 1,000 Watt HID, 3096
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by wattage and sector
Peak Demand Reduction (kW)	Varies by wattage and sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by measure and sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Incremental Cost ($/unit)	Varies by measure, see Appendix D

Measure Description

High bay LED fixtures are an energy-saving alternative to traditional standard wattage HID light sources used for the same applications. LED light sources can be used in almost every common type of application where HID light sources are currently found.

Description of Baseline Condition

The baseline is standard HID lamps that range from 250 watts to 1,000 watts.

Description of Efficient Condition

To meet program requirements, the LED replacements must be complete fixtures that result in a total power reduction of 40% or more. The LEDs must also be on the qualifying DLC list. Lamp-only replacements are not eligible for incentive.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = [(Qty_{BASE} * Watts_{BASE}) – (Qty_{EE} * Watts_{EE})]/1{,}000 * HOU$

Where:

Qty_{BASE} = Quantity of standard HID fixture

$Watts_{BASE}$ = Baseline consumption of standard HID fixture (= varies by measure; see table below)

Qty_{EE} = Quantity of LED fixture

$Watts_{EE}$ = Efficient consumption of LED fixture (= varies by measure; see table below)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= varies by sector; see table below)

Hours-of-Use by Sector

Sector	HOU[2]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239

Baseline and Efficient Lamp Consumption

Measure	$Watts_{BASE}$	$Watts_{EE}$
LED Fixture, High Bay, < 155 Watts Replacing 250-Watt HID	293	119
LED Fixture, High Bay, < 250 Watts Replacing 400-Watt HID	455	169
LED Fixture, High Bay, < 250 Watts Replacing 320-Watt to 400-Watt HID	356	169
LED Fixture, High Bay, < 365 Watts Replacing 400-Watt HID	455	296
LED Fixture, High Bay, < 800 Watts Replacing 1,000-Watt HID	1,079	690
LED Fixture, High Bay, < 500 Watts Replacing 1,000-Watt HID	1,079	500

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = [(Qty_{BASE} * Watts_{BASE}) – (Qty_{EE} * Watts_{EE})]/1{,}000 * CF$

Where:

CF = Coincidence factor (= varies by sector; see table below)

Coincidence Factor by Sector

Sector	CF^2
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 18 years)[1]

Deemed Savings

Average Annual Deemed Savings for High Bay LED Fixtures

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Gov	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED Fixture, High Bay, < 155 Watts Replacing 250-Watt HID	3091, 3806	649	0.1340	826	0.1340	817	0.1166	564	0.1114
LED Fixture, High Bay, < 250 Watts Replacing 400-Watt HID	3093, 3807	1,067	0.2202	1,357	0.2202	1,344	0.1916	926	0.1830
LED Fixture, High Bay, < 250 Watts Replacing 320-Watt to 400-Watt HID	3092, 3810	698	0.1440	887	0.1440	879	0.1253	606	0.1197
Fixture, High Bay, < 365 Watts Replacing 400-Watt HID	3094, 3808	593	0.1224	754	0.1224	747	0.1065	515	0.1018
LED Fixture, High Bay, < 800 Watts Replacing 1,000-Watt HID	3096	1,451	0.2995	1,846	0.2995	1,828	0.2606	1,260	0.2490
LED Fixture, High Bay, < 500 Watts Replacing 1,000-Watt HID	3095	2,160	0.4458	2,747	0.4458	2,720	0.3879	1,875	0.3706

Average Lifecycle Deemed Savings for High Bay LED Fixtures (kWh)

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Gov
LED Fixture, High Bay, < 155 Watts Replacing 250-Watt HID	3091, 3806	11,682	14,861	14,714	10,145
LED Fixture, High Bay, < 250 Watts Replacing 400-Watt HID	3093, 3807	19,202	24,427	24,185	16,674
LED Fixture, High Bay, < 250 Watts Replacing 320-Watt to 400-Watt HID	3092, 3810	12,555	15,972	15,813	10,902
Fixture, High Bay, < 365 Watts Replacing 400-Watt HID	3094, 3808	10,675	13,580	13,446	9,270
LED Fixture, High Bay, < 800 Watts Replacing 1,000-Watt HID	3096	26,117	33,224	32,895	22,679
LED Fixture, High Bay, < 500 Watts Replacing 1,000-Watt HID	3095	38,874	49,452	48,963	33,757

Assumptions

LED lamps are capable of achieving a 40% reduction in power requirements.

Sources

1. Cadmus review of manufacturers’ measure life.
2. State of Wisconsin Public Service Commission of Wisconsin. *Focus on Energy Evaluation, Business Programs Deemed Savings Manual V1.0*. Table 3.2 Lighting Hours of Use and Coincidence Factors by Sector. March 22, 2010.
3. *Focus on Energy Default Wattage Guide*. 2013. All values are based on metal halide fixtures, except as otherwise noted.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry
02	10/2016	Removed MMIDs 3285, 3287, 3288

LED, Horizontal Case Lighting

	Measure Details
Measure Master ID	LED, Horizontal Case Lighting, 3114, 3335
Measure Unit	Per linear foot
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	55
Peak Demand Reduction (kW)	0.0063
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	1,100
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	Varies by measure
Incremental Cost ($/unit)	MMID 3114=$21.55/ft;[7] MMID 3335=$22.00[8]

Measure Description

This measure is horizontal LED case lighting replacing existing fluorescent case lighting in both freezers and cooler applications. The measure incentives are based on the feet of lamp replaced.

Description of Baseline Condition

The baseline is a mix of fluorescent T8 lamps, T12 lamps, and HOT12 lamps in a multideck refrigerated or freezer case. The deemed value of the existing fluorescent lamps is 10.93 watts per linear foot of lamp. This estimate represents the assumed base case technology of F32 T8 fluorescent lamps with electronic ballasts, F40 T12 fluorescent lamps with energy-saving magnetic ballasts, and F48 HOT12 fluorescent lamps with energy-saving magnetic ballasts. A weighting of 60% for F32 T8 fixtures, 20% for F40 T12 fixtures, and 20% for F48 HOT12 fixtures was used based on industry market research. The deemed wattage value was taken from specifications for a standard refrigeration multideck case.[3,4]

Description of Efficient Condition

The efficient equipment is LED fixtures in a multideck refrigerated or freezer case. The deemed value for the LED replacement lamp is 6.29 watts per linear foot of multideck case, based on DLC qualifying products. The deemed wattage value was taken from specifications for a standard refrigeration multideck case with LED lighting.[3,4]

Annual Energy-Savings Algorithm

$kWh_{SAVED} = [P_E – P_P + ((P_E * F_{FH} – P_P * F_{LH})/COP_{COOLING})] * HOU$

Where:

P_E = Existing fluorescent lighting wattage per linear foot (= 0.01093 kW)

P_P = Replacement LED lighting wattage per linear foot (= 0.00629 kW)

F_{FH} = Fluorescent lighting to heat factor (= 79%)[5]

F_{LH} = LED lighting to heat factor (= 80%)[5]

$COP_{COOLING}$ = Coefficient of performance of refrigeration system (= 2.22)[5]

HOU = Hours-of-use (= 8,760)[6]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = [P_E – P_P + ((P_E * F_{FH} – P_P * F_{LH})/COP_{COOLING})] * CF$

Where:

CF = Coincidence factor (= 1)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 20 years for MMID 3114;[1] =16 years for MMID 3335)[2]

Assumptions

The deemed value for the fluorescent lighting to heat factor is 79%, based on an analysis stating that 21% of the power to a fluorescent light is converted to light while the remainder (79%) is infrared radiation or direct heat.[5]

The deemed value for the LED lighting to heat factor is 80%, as the midpoint based on an analysis stating that 15-25% of the power to an LED light is converted to light, while the remainder (75-85%) is converted directly to heat.[6]

The deemed value of the COP for a refrigeration system is 2.5 for coolers and 1.3 for freezers. The COP was weighted 77% to coolers and 23% to freezers, for an overall value of 2.22.[6]

The deemed annual operating hours is 8,760, the number of hours in a year.[6]

Sources

1. Cadmus review of manufacturers' measure life, similar measures MMIDs 2456-2457.
2. DEER 2008 and Regional Technical Forum http://www.energy.ca.gov/deer/ and http://rtf.nwcouncil.org/
3. Arthur D. Little, Inc. *Energy Savings Potential for Commercial Refrigeration Equipment – Final Report.* 1996.
4. Navigant Consulting, Inc. *Energy Savings Potential and R&D Opportunities for Commercial Refrigeration*. 2009.
5. United States Department of Energy Office of Energy Efficiency & Renewable Energy. The calculation assumes that 100% of the thermal energy produced by the lights is removed by the refrigeration system.
6. PA Consulting Group Inc. *State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation Business Programs: Deemed Savings Manual v1.0*. Updated March 22, 2010.
7. Northeast Energy Efficiency Partnerships. Navigant Consulting, Inc. "Incremental Cost Study Phase Three Final Report." May 28, 2014. Available online: http://www.neep.org/file/1084/download?token=NVG0i03k&usg=AFQjCNGXS4vZFo7qPMCZWUIKoZDw2jMxsA&sig2=BeIyTynJm37D7OptXInZiQ&cad=rja
8. Regional Technical Forum, UES Measures. "Commercial: Grocery - Display Case LEDs (Reach-in Cases)." Measure Workbook 3.2; November 16, 2015. $22.00 for all "Commercial: Grocery - Display Case LEDs (Reach-in Cases)" measures. Available online: http://rtf.nwcouncil.org/measures/measure.asp?id=104

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

LED, Direct Install

	Measure Details
Measure Master ID	LED, Direct Install: 12 Watts, 3274, 3347 12 Watts, SBP A La Carte, 3631 > 12 Watts, 3577, 3578 > 12 Watts, SBP A La Carte, 3629 > 16 Watt, 3579, 3580 > 16 Watt, SBP A La Carte, 3630
Measure Unit	Per LED
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by wattage and sector
Peak Demand Reduction (kW)	Varies by wattage and sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by wattage and sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	7[1]
Incremental Cost ($/unit)	Varies by measure, see Appendix D

Measure Description

This measure is an ENERGY STAR-qualified LED screw-in bulb installed by a qualified Small Business Program trade ally to replace an incandescent screw-in bulb. Assumptions are based on a direct installation, not a time-of-sale purchase. Replacement involves a functioning bulb.

Description of Baseline Condition

The baseline equipment is assumed to be the EISA requirements (see table below).[2]

Baseline Wattage by Measure

Measure	Baseline Wattage
LED, > 16 Watt, DI	72
LED, > 12 Watt, DI	53
LED, 12 Watt, DI	43
LED, 8 Watt, DI	29

Description of Efficient Condition

The efficient measure is a standard screw-based LED lamp. Based on experiences for the 2014 Small Business Program, the following table shows the most common wattages installed.

Efficient Wattages by Measure

Measure	LED Wattage
LED, > 16 Watt, DI	18.0
LED, > 12 Watt, DI	12.5
LED, 12 Watt, DI	10.5
LED, 8 Watt, DI	8.0

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE})/1,000 * HOU$

Where:

$Watts_{BASE}$ = Baseline wattage (= varies by measure; see table above)

$Watts_{EE}$ = Efficient wattage (= varies by measure; see table above)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= varies by sector; see table below)

Hours-of-Use by Sector

Sector	HOU[3]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239

Summer Coincident Peak Savings Algorithm

$kW_{SAVED}= (Watts_{BASE} – Watts_{EE})/1,000 * CF$

Where:

CF = Coincidence factor (= varies by sector; see table below)

Coincidence Factor by Sector

Sector	CF[3]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (=7 years)[1]

Deemed Savings

Annual Savings

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Government	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED, > 16 Watt	3580, 3630	201	0.0416	256	0.0416	254	0.0362	175	0.0346
LED, > 12 Watt	3577, 3578, 3629	151	0.0312	192	0.0312	190	0.0271	131	0.0259
LED, 12 Watt	3274, 3347, 3631	121	0.0250	154	0.0250	153	0.0218	105	0.0208
LED, 8 Watt	3273	78	0.0162	100	0.0162	99	0.0141	68	0.0134

Lifecycle Savings

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Government
LED, > 16 Watt	3580, 3630	1,407	1,792	1,778	1,225
LED, > 12 Watt	3577, 3578, 3629	1,057	1,344	1,330	917
LED, 12 Watt	3274, 3347, 3631	847	1,078	1,071	735
LED, ≤ 8 Watt	3273	546	700	693	476

Sources

1. Cadmus review of manufacturers’ measure life.
2. Focus on Energy. Approach to Accounting for Changes in Lighting Baseline. May 2013.

3. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
4. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

LED Exit Signs

	Measure Details
Measure Master ID	LED Exit Sign, Retrofit, 2768
Measure Unit	Per sign
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by baseline
Peak Demand Reduction (kW)	Varies by baseline
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by baseline
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	8 MESP, 16 Small Business[4]
Incremental Cost ($/unit)	$98.43[5]

Measure Description

Exit signs that have earned the ENERGY STAR label use 5 watts or less, compared to standard signs that use up to 40 watts. Savings result from replacing incandescent or fluorescent exit signs with LED exit signs, which use significantly less electricity. The savings estimate assumes that both incandescent and fluorescent exit signs undergo early replacement rather than replacement at failure.

Description of Baseline Condition

The baseline condition is an incandescent (40 watt) or CFL (16 watt) exit sign with one or two bulbs.

Description of Efficient Condition

The efficient condition is an LED exit sign. The fixture must meet ENERGY STAR v2.0 specifications.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1{,}000 * HOU$

Where:

$Watts_{BASE}$ = Wattage of baseline measure (= 16 for CFL exit sign; = 40 for incandescent exit sign)[2]

$Watts_{EE}$ = Wattage of LED exit sign (= 2.9)[1]

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 8,760)[3]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} – Watts_{EE})/1{,}000 * CF$

Where:

CF = Coincidence factor (= 1)[3]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 8 years Multifamily; = 16 years Small Business)[4]

Deemed Savings

The default assumption is generated using 50% CFL replacements and 50% incandescent replacements.

Deemed Savings for LED Exit Signs

Type of Savings	MMID	Baseline Measure Type		
		CFL	Incandescent	Default
Annual Energy Savings (kWh)	2768	115	325	220
Peak Demand Reduction (kW)		0.013	0.037	0.025
Lifecycle Energy Savings (kWh) - MESP		918	2,600	1,759
Lifecycle Energy Savings (kWh) – Small Business		1,836	5,200	3,518

Sources

1. ENERGY STAR. “Exit Signs.” ENERGY STAR Savings Calculator. http://www.energystar.gov/index.cfm?c=exit_signs.pr_exit_signs.
2. ENERGY STAR. “Save Energy, Money and Prevent Pollution with Light-Emitting Diode Exit Signs.” http://www.energystar.gov/ia/business/small_business/led_exitsigns_techsheet.pdf.
3. *Mid-Atlantic Technical Reference Manual, Version 3*. March 2013.

4. *PA* Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
5. Online Research, March 2016. Average sales price of Led Exit Signs on 1000bulbs.com = $26.43; RSMeans, 2015 labor cost for install of Signs, interior electric exit sign, wall mounted , 6" = $72.00. $26.43 (material cost) + $72.00 (labor cost) = $98.43.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

LED Downlights ≥ 4,000 Lumens and ≤ 100 Watts

	Measure Details
Measure Master ID	LED Fixture, Downlights: ≤ 100 Watts, ≥ 4000 Lumens, Interior, 3396 ≤ 100 Watts, ≥ 4000 Lumens, Exterior, 3397 ≥ 6,000 Lumens, Interior, 3398 ≥ 6,000 Lumens, Exterior, 3399
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	Varies by measure
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	11[1]
Incremental Cost ($/unit)	Varies by Measure, see Appendix D

Measure Description

LED downlights can replace existing interior and exterior 150-watt to 250-watt HID fixtures used for the same application without sacrificing performance. LED downlights save energy because they consume less wattage than the HID products they replace.

Description of Baseline Condition

≥ 4,000 Lumen ≤ 100 Watt LED Downlights

An average of 50% each 150-watt and 175-watt HID fixtures was used to generate the baseline usage for existing buildings and new construction, as these wattages provide similar fixture outputs as the recommended LED replacement lumen package.

≥ 6,000 Lumen LED Downlights

One-hundred percent 250-watt HID fixtures were used to generate the baseline usage for existing buildings and new construction, as this wattage provides similar fixture outputs as the recommended LED replacement lumen package.

Description of Efficient Condition

Replacement of 150-175 Watt HID

The efficient measure is an ENERGY STAR listed and/or Wisconsin Focus on Energy QPL-listed LED downlight that produces ≥ 4,000 lumens and consumes ≤ 100 watts.

Replacement of 176-250 Watt HID

The efficient measure is an ENERGY STAR-listed and/or Wisconsin Focus on Energy QPL-listed LED downlight that produces ≥ 6,000 lumens.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{HID} - Watts_{LEDEE}) / 1{,}000 * HOU * Con_{FACT}$

Where:

$Watts_{HID}$ = System wattage of standard HID fixtures (= 196 watts for 150 watt and 175 watt fixtures; = 292 watts for 250-watt fixtures)[7]

$Watts_{LEDEE}$ = System wattage of energy-efficient LED products (= 80 watts for systems ≥ 4,000 lumens; = 123 watts for systems ≥ 6,000 lumens)[3]

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 4,380 for exterior; = varies by sector for interior, see table below). 4,380 hours run time of exterior fixtures based on an annual average of 12 hours per day from NOAA data.[6] This includes times when photocells turn on prior to exact sunset and turn off after exact sunrise, accounting for diminished outdoor lighting as well as time clock scheduled lighting.

Con_{FACT} = Control factor (= 0.90), exterior only. Applying a control factor allows for a more conservative estimate of savings. Based on Energy Advisor and qualified lighting professional project experience, less than 10% of the exterior fixtures on the market have additional controls that may operate at conditions other than dusk to dawn.

Interior Hours-of-Use by Sector[4]

Sector	HOU
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239
Multifamily	5,950

Summer Coincident Peak Savings Algorithm

$kW_{SAVED}= (Watts_{HID} - Watts_{LEDEE}) /1{,}000 * CF$

Where:

CF = Coincidence factor, interior fixtures only (= varies by sector; see table below)

Interior Coincidence Factor by Sector

Sector	CF[5]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64
Multifamily	0.77

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (=11 years)[1]

Deemed Savings

Average Annual Deemed Savings

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Gov		Multifamily	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED Fixture, Downlights ≤ 100 Watts, ≥ 4,000 Lumens, Interior	3396	432	0.0891	549	0.0891	544	0.0776	375	0.0741	689	0.0891
Exterior LED Downlights ≥ 4,000 Lumens and ≤ 100 Watts	3397	456	0	456	0	456	0	456	0	456	0
LED Fixture, Downlights ≥ 6,000 Lumens, Interior	3398	632	0.1304	804	0.1304	796	0.1135	549	0.1084	1,008	0.1304
LED Fixture, Downlights ≥ 6,000 Lumens, Exterior	3399	668	0	668	0	668	0	668	0	668	0

Average Lifecycle Deemed Savings

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Gov	Multifamily
LED Fixture, Downlights ≤ 100 Watts, ≥ 4,000 Lumens, Interior	3396	4,752	6,039	5,984	4,125	7,579
Exterior LED Downlights ≥ 4,000 Lumens and ≤ 100 Watts, Exterior	3397	5,016	5,016	5,016	5,016	5,016
LED Fixture, Downlights ≥ 6,000 Lumens, Interior	3398	6,952	8,844	8,756	6,039	11,088
LED Fixture, Downlights ≥ 6,000 Lumens, Exterior	3399	7,348	7,348	7,348	7,348	7,348

Sources

1. Cadmus. Review of manufacturers' measure life.
2. Cost information based on market knowledge of accredited lighting experts, trade allies, and cost information gathered from supplier listings on March 1, 2014.
3. Average wattages taken from ENERGY STAR qualified product list dated August 28, 2015, then filtered by lumen and wattage criteria.
4. *Focus on Energy Business Programs Deemed Savings Manual V1.0*. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
5. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.
6. U.S. Department of Commerce | National Oceanic & Atmospheric Administration | NOAA Research - NOAA Solar Calculator http://www.esrl.noaa.gov/gmd/grad/solcalc/
7. Wisconsin Focus on Energy. *Default Wattage Guide*. HID wattages averaged between mercury vapor, high pressure sodium, and metal halide technologies.

Revision History

Version Number	Date	Description of Change
01	04/01/2014	New measure
02	09/04/2015	Updated savings values

LED Fixture, Downlights, Accent Lights, and Monopoint ≤ 18 Watts

	Measure Details
Measure Master ID	LED Fixture, Downlights, Accent Lights, and Monopoint ≤ 18 Watts: Common Area, 2984 In Unit, 3158
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by location
Peak Demand Reduction (kW)	Varies by location
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by location
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	2984=11 and 3158=20[1]
Incremental Cost ($/unit)	MMID 2984 = $12.46[8]; MMID 3158 = $56.46[9]

Measure Description

LED downlights, accent lights, and monopoint fixtures can replace existing incandescent fixtures without sacrificing performance, and save energy because they consume less wattage than the incandescent products they replace.

Description of Baseline Condition

The baseline is a 60-watt to 100-watt incandescent fixture.

Description of Efficient Condition

The efficient equipment is a monopoint fixture that consumes ≤ 18 watts, an ENERGY STAR-rated LED downlight that consumes ≤ 18 watts, and an ENERGY STAR-rated LED accent lights that consumes ≤ 18 watts.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) * HOU / 1{,}000$

Where:

$Watts_{BASE}$ = Power consumption of baseline incandescent fixtures (= varies by location and lumen output; see table below)

$Watts_{EE}$ = Power consumption of efficient LED products (= varies by location and lumen output; see table below)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 5,950 in common area;[2] = 829 in unit)[6]

Wattage by Location and Lumen Output

Location	Lumen Output	Typical Wattage	$Watts_{BASE}$[3]	$Watts_{EFFICIENT}$[4]
In Unit	750-1,049	60	49	13
	1,050-1,489	75	58	16
Common Area	750-1,049	60	49	13
	1,050-1,489	75	58	16

Summer Coincident Peak Savings Algorithm

$kW_{SAVED}= (Watts_{BASE} – Watts_{EE}) / 1{,}000 * CF$

Where:

CF = Coincidence factor (= 0.77 in common area;[5] = 0.11 in unit)[7]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 11 year for MMID 2984; = 20 years for MMID 3158)[1]

Assumptions

The baseline for this measure is a combination of halogen and incandescent efficiencies for 2014. The weighted average is based on estimated sales percentages: 0-309 lumens = 20%; 310-749 lumens = 30%; 750-1,049 lumens = 40%; 1,050-1,489 lumens = 10%.

Sources

1. Cadmus review of manufacturers' measure life.
2. ACES. *Deemed Savings Desk Review*. November 3, 2010.
3. United States Environmental Protection Agency. "Next Generation Lighting Programs: Opportunities to Advance Efficient Lighting for a Cleaner Environment." EPA-430-R-11-115, pg. 27. October 2011. http://www.energystar.gov/lightingresources.
4. Predominant wattage in each category.
5. *Focus on Energy Business Programs Deemed Savings Manual V1.0*. Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.
6. Cadmus. Field Study Research: Residential Lighting. October 18, 2013. Conducted regarding CFL and incandescent bulbs.
7. Cadmus. Field Study Research: Residential Lighting. October 25, 2013. Conducted regarding CFL and incandescent bulbs.
8. Online Research, March 2016. Material cost is average sales price of "Led Downlight." Available online: https://www.1000bulbs.com/category/led-downlights/

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

LED 1-Foot by 4-Foot Replacing 2 Lamp Linear Fluorescent

Measure Master ID	LED, 1x4, Replacing T8 or T12, 2-Lamp, 3387
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	16[1]
Incremental Cost ($/unit)	$77.00[3]

Measure Description

LED-based fixture replacements or complete LED retrofits save energy over fluorescent fixtures by increasing the number of lumens per watt and increasing the light quality and distribution. There are varying wattage LED fixtures used to replace 1’x4’ dimension fixtures, which normally have two T12 or T8 lamps with ballast installed. While not in the savings calculations, this measure can be used for replacing specialty 1’x4’ fixtures that have three T12 or T8 lamps. The 1’x4’ LED fixture will replace a 2 lamp or greater T12 or T8 fixture.

LED fixtures are counted on a per-fixture basis. A partial retrofit of the fixture is not allowed, including linear LED tubes and LED luminaires that adhere to the interior of the existing fixture housing.

Description of Baseline Condition

T8 Linear Fluorescent Fixtures (EISA compliant)

2 Lamp T8	58 watts

T12 Linear Fluorescent Fixtures

2 Lamp T12	82 watts

The baseline is a 2 lamp T8 fixture. 3 Lamp replacements are allowed, although not included in the calculation because of the expected limited number applied in the field.

This measure does not include replacing 1 lamp T12 or T8 1-foot by 4-foot fixtures.

Description of Efficient Condition

The DLC provides a listing of qualified LED products. The efficient condition uses the listing for 1'x4' Luminaires for Ambient Lighting of Interior Commercial Spaces. The new measure condition assumes an average of the DLC listing on December 2, 2013.

Average of DLC Listing

1'x4' LED troffer	36 watts

DLC-listed equipment in the following categories are not acceptable as replacements.

- Four-Foot Linear Replacement Lamps
- Two-Foot Linear Replacement Lamps

Replacing T8 or T12 fixtures use the DLC listing of 1'x4' Luminaires for Ambient Lighting of Interior Commercial Spaces. The new measure condition assumes an average of the DLC listing on December 2, 2013. The efficient condition wattage and hours of operation are an average of the listing on this date.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{EX} – Watts_{LED}) /1{,}000 * HOU$

Where:

$Watts_{EX}$ = Wattage of existing T8 or T12 lamps and ballasts

$Watts_{LED}$ = Wattage of LED 1-foot by 4-foot luminaire

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= varies by sector; see table below)

Hours-of-Use by Sector

Sector	HOU[1]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239
Multifamily	5,950

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{Ex} - Watts_{LED}) / 1,000 * CF$

Where:

CF = Coincidence factor (= varies by sector; see table below)

Coincidence Factor by Sector

Sector	CF[2]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64
Multifamily	0.77

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 16 years)[1]

Deemed Savings

Average Annual Savings

Measure	kWh Savings	kW Savings
Commercial	81	0.0168
Industrial	104	0.0168
Agriculture	102	0.0146
Schools & Government	71	0.0140

Average Lifecycle Savings

Measure	kWh Savings
Commercial	1,296
Industrial	1,664
Agriculture	1,632
Schools & Government	1,136

Assumptions

This measure does not include the replacement of 1-lamp T12 or T8 1'x4' fixtures. This calculation is used to account for the federal legislation stemming from EISA, which dictates the fluorescent fixture efficiency in lumens per watt. Initiated on July 14, 2012, federal standards will require that practically all linear fluorescents meet strict performance requirements that will essentially require all T12 users to upgrade to high performance T8 and T5 lamps and electronic ballasts when purchasing new bulbs. The effect is that first-year savings for T12 to T8 replacements can be assumed only for the remaining useful life of T12 equipment, at which point customers have no choice but to install equipment meeting the new standard.

Cost Assumptions: Cost is expected to be $10 less for materials than the 2'x4' LED replacements based on preliminary quotes from suppliers. Labor costs are the same as for 2'x4' LED replacements. Labor is estimated at approximately $40 for the troffer replacement and $20 for the troffer retrofit. The installed cost was rounded to $150.00 ($110.00 materials + $40.00 labor or $130.00 material + $20.00 labor).This price is expected to drop over time.

Sources

1. Cadmus review of manufacturers' measure life.
2. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Lighting Hours of Use and Coincidence Factors by Sector. March 22, 2010.
3. Retailer Cost Data obtained by Implementer through online retailers, August 2015.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry
02	10/2016	Removed MMIDs 3388, 3389

LED 8-Foot, Replacing T12 or T8, 1 or 2 Lamp

	Measure Details
Measure Master ID	LED, 8-Foot, Replacing T12 or T8: 1 Lamp, 3425, 3426 2 Lamp, 3428, 3429 LED, 4-Foot, 2 Lamp, < 20 Watts, Replacing 8-Foot, 1 Lamp T12 or T8, SBP A La Carte, 3616 LED, 4-Foot, 4 Lamp, < 20 Watts, Replacing 8-Foot, 2 Lamp T12 or T8, SBP A La Carte, 3617
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	16[1]
Incremental Cost ($/unit)	Varies by measure, see Appendix D

Measure Description

This measure is replacing an 8-foot T12 or T8 linear fluorescent fixture with an 8-foot LED-based (or equivalent) fixture. Energy savings result from the decrease in fixture wattage, and the increased lumens per watt improves light quality and distribution. There are varying wattages LED fixtures used to replace 8-foot fixtures, and normally install one or two 8-foot T12 or T8 lamps with ballasts.

Four different measures will be used depending on the configuration of the existing fixture. These are for 1 and 2 lamp standard output 8-foot T8 or T12 fixtures and 1 and 2 lamp high output T8 or T12 fixtures. A partial retrofit of a fixture does not qualify, which include linear LED tubes and LED luminaires that adhere to the interior of the existing fixture housing. A retrofit that includes two fixtures combined to create the equivalent of an 8-foot fixture (such as two 4-foot fixtures) is acceptable.

Description of Baseline Condition

The baseline condition wattage is outlined in the following table.

T8 Linear 8-Foot Fluorescent Fixture Baseline Conditions (EISA compliant)

Measure	Wattage
8-foot 1 Lamp T8	65
8-foot 2 Lamp T8	110
4-Foot, 2 Lamp, < 20 Watts	N/A
4-Foot, 4 Lamp, < 20 Watts	N/A

Replaced standard output 1 and 2 lamp fixtures are assumed to be 80% T12 and 20% T8. Replaced high output 1 and 2 lamp fixtures are assumed to be 95% T12 and 5% T8. The Illinois TRM assumes that EISA standards will become fully effective in 2016.

Description of Efficient Condition

DLC provides a listing of qualified LED products. The efficient condition uses an average from a filtered listing of luminaires for Low-Bay Commercial and Industrial Building applications (V2.0) and similar products from other reputable manufacturers. The new measure condition assumes an average of five models on the DLC listing on December 10, 2013 and six models from two additional manufacturers that are intending to be DLC listed. These models were included because of the low number of DLC-qualified products at the time of this analysis.

Efficient Condition Wattage by Measure

Measure	Wattage
8-foot LED Fixture Standard Output	60
8-foot LED Fixture Standard Output	84
4-Foot, 2 Lamp, < 20 Watts	N/A
4-Foot, 4 Lamp, < 20 Watts	N/A

In order to guide the marketplace and ensure that future qualified products meet the intentions of this work paper, the following maximum wattages for the efficient condition are allowable.

Maximum Wattages Allowable for Efficient Condition

Existing Fixture	Maximum Efficient Specification
8-foot LED Fixture Standard Output	70 watts
8-foot LED Fixture Standard Output	95 watts
4-Foot, 2 Lamp, < 20 Watts	N/A
4-Foot, 4 Lamp, < 20 Watts	N/A

Replaced standard output 1 and 2 lamp fixtures are assumed to be 80% T12 and 20% T8. Replaced high output 1 and 2 lamp fixtures are assumed to be 95% T12 and 5% T8.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{EX} – Watts_{LED}) /1{,}000 * HOU$

Where:

$Watts_{EX}$ = Wattage of existing T8 and T12 lamps and ballasts

$Watts_{LED}$ = Wattage of LED 8-foot luminaire

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= varies by sector; see table below)

Hours-of-Use by Sector

Sector	HOU[1]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{EX}-Watts_{LED}) /1{,}000 * CF$

Where:

CF = Coincidence factor (= varies by sector; see table below)

Coincidence Factor by Sector

Sector	CF[2]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 16 years)[1]

Assumptions

For MMIDs 3428-3435: Labor to install the fixture is estimated at approximately $20.00. The installed cost is estimated as $480.00 ($460.00 materials + $20.00 labor), and is expected to drop over time.

The incremental cost was determined as the difference between the standard replacement of the fixture ($110.00) and the energy-efficient fixture replacement ($480.00), for a total of $370.00.

Sources

1. Cadmus review of manufacturers’ measure life.
2. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry
02	10/2016	Removed MMIDs 3427, 3430, 3432, 3433, 3435, 3436

LED Replacement of 4-Foot T8 Lamps Using Existing Ballast

	Measure Details
Measure Master ID	LED Replacement of 4-Foot T8 Lamps Using Existing Ballast, 3512, 3823
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	16[1]
Incremental Cost ($/unit)	$11.29[4]

Measure Description

Four-foot T8 LEDs are an energy-efficient alternative to standard 4-foot 32/28/25 watt T8 fluorescent lamps found commonly throughout commercial, industrial, agriculture, school, government, and multifamily spaces. These products can replace 32/28/25 watt T8 lamps one-for-one operating off the existing fluorescent ballast.

Description of Baseline Condition

The baseline condition is 4-foot standard 32/28/25 watt T8 lamps on low (0.78), normal (0.88), and high (1.15) ballast factor ballasts. Lamps are weighted 60%, 30%, and 10%, respectively, in the savings calculations. 32-watt lamps are weighted 10%, 70%, and 20% with respect to low, normal, and high ballast factors; while 28-watt and 25-watt lamps are weighted 5%, 90%, and 5% for the same ballast factors in the savings calculations.[5]

Description of Efficient Condition

Equipment must be DLC-listed with less than 24 watts based on a normal ballast factor (0.88) and operate off the existing fluorescent ballast. This measure is not intended to be used in refrigerated case lighting applications. Products must carry a safety certification from a NRTL, such as UL or ETL.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} - Watts_{LED}) / 1,000 * HOU$

Where:

$Watts_{BASE}$ = Weighted annual electricity consumption of standard 4-foot 32/28/25 watt T8 fluorescent lamp operating on low/normal/high ballast factor ballasts

$Watts_{LED}$ = Weighted average annual electricity consumption of DLC-listed 4-foot linear LED < 24 watts, operating off existing ballast

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= varies by sector; see table below)

Hours-of-Use by Sector

Sector	HOU[2]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239
Multifamily	5,950

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{LED}) /1,000 * CF$

Where:

CF = Coincidence factor (= varies by sector; see table below)

Coincidence Factor by Sector

Sector	CF[3]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64
Multifamily	0.77

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 16 years)[1]

Deemed Savings

Annual Savings

Measure	Commercial		Industrial		Agriculture		Schools & Gov		Multifamily	
	kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED Replacement of 4-Foot T8 Lamps Using Existing Ballast	24	0.0049	30	0.0049	30	0.0043	21	0.0041	37	0.0048

Lifecycle Savings (kWh)

Measure	Commercial	Industrial	Agriculture	Schools & Gov	Multifamily
LED Replacement of 4-Foot T8 Lamps Using Existing Ballast	384	480	480	336	592

Sources

1. Cadmus review of manufacturers’ measure life.
2. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
3. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.
4. "Online research, Sept 2016. Available online: http://www.greenledzone.com/t8-led-tube-light-direct-wire-ballast-compatible-p/gl-lod-c08-m1218.htm?gclid=Cj0KEQjwxLC9BRDb1dP8o7Op68IBEiQAwWggQA7zZ34iQp1t8ivOd4GwDDOKE1flh40UVRP3kOWcoToaAh7p8P8HAQ; http://www.shineretrofits.com/james-industry-bt816w4ft-16-watt-4-foot-led-plug-and-play-ballast-compatible-t8-linear-tube-lamp-frosted-aluminum-housing.html?gclid=Cj0KEQjwxLC9BRDb1dP8o7Op68IBEiQAwWggQAYs8tG6hrZ21H2cx1HyxyJIthWTf8X1LY6FTU_i9_AaApAp8P8HAQ; https://www.earthled.com/products/thinklux-led-fluorescent-replacement-tube-4-foot-18-watt-universal-t8-or-t12-ballast-compatible-dimmable?variant=20878204932; https://www.1000bulbs.com/product/7028/TCP-

31032841.html?utm_source=SmartFeedGoogleBase&utm_medium=Shopping&utm_term=TCP-31032841&utm_content=800+Series+Phosphors&utm_campaign=SmartFeedGoogleBaseShopping&gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFK3_139urG; https://www.1000bulbs.com/product/90200/USH-3000480.html?utm_source=SmartFeedGoogleBase&utm_medium=Shopping&utm_term=USH-3000480&utm_content=800+Series+Phosphors&utm_campaign=SmartFeedGoogleBaseShopping&gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFK2B1rtXuKJ; http://www.adlsupply.com/fluorescent-t8/sylvania-21781-fo32-841-eco/?gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFK7UbfdMKV6L5tIYN6DNgvVs1fr2zovtgAyLuo8_F6hEaAnRn8P8HAQ

5. Weights are estimated based on general market knowledge and historical application data.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

LED Replacement of 4-Foot T8 Lamps with Integral or External Driver

	Measure Details
Measure Master ID	LED Replacement of 4-Foot T8 Lamps with Integral or External Driver, 3511, 3822
Measure Unit	Per lamp
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Measure Type	Prescriptive
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	16[1]
Incremental Cost ($/unit)	$46.55[4]

Measure Description

Dual 4-foot T8 LEDs are an energy-efficient alternative to standard 8-foot fluorescent lamps found commonly throughout multifamily, commercial, industrial, agriculture, and schools and government facilities. These products can replace 96-watt T12 and 75-watt T8 lamps two-for-one when replacing the existing fluorescent lamp(s) and ballast(s).

Description of Baseline Condition

Because 8-foot standard 96-watt T12 lamps are required to be replaced by 8-foot T8 lamps, the baseline is an 8-foot T8 with 75 watts per lamp. These are generally operated on low (0.78), normal (0.88), and high (1.15) ballast factor ballasts within their fixtures. Lamps are weighted 10%, 70%, and 20%, respectively, in the savings calculations.[5]

Description of Efficient Condition

Efficient equipment must be DLC-listed, less than 20 watts, and use a new external driver not operate off the existing fluorescent ballast(s). This measure is not intended to be used in refrigerated case lighting applications or in products intended to bring line voltage to existing sockets. Products must carry a safety certification from a NTRL, such as UL or ETL.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{FLUORESCENT} - Watts_{LED}) / 1,000 * HOU$

Where:

$Watts_{FLUORESCENT}$ = Weighted annual electricity consumption of standard 8-foot 75-watt T8 fluorescent lamp operating on low/normal/high ballast factor ballasts

$Watts_{LED}$ = Weighted average annual electricity consumption of two DLC-listed 4-foot linear LEDs < 20 watts, noted w/external driver

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= varies by sector; see table below)

Hours-of-Use by Sector

Sector	HOU[2]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239
Multifamily	5,950

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{FLUORESCENT} - Watts_{LED}) / 1,000 * CF$

Where:

CF = Coincidence factor (= varies by sector; see table below)

Coincidence Factor by Sector

Sector	CF[3]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64
Multifamily	0.77

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 16 years)[1]

Deemed Savings

Annual Savings

Annual Savings	Commercial		Industrial		Agriculture		Schools & Gov		Multifamily	
	kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED Replacement of 4-Foot T8 Lamps w/External Driver	131	0.0270	166	0.0270	165	0.0235	113	0.0224	327	0.2510

Lifecycle Savings

Lifecycle Savings (kWh)	Commercial	Industrial	Agriculture	Schools & Gov	Multifamily
LED Replacement of 4-Foot T8 Lamps w/External Driver	2,096	2,656	2,640	1,808	5,232

Sources

1. Cadmus review of manufacturers' measure life.
2. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
3. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.
4. Online research, Sept 2016. Available online: https://www.energyavenue.com/Sylvania/73107?gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFK-uSa-sFtYYo2HoW5piw9OCxbjku5rFsAlCYHiszo2UaAvPJ8P8HAQ; https://a19led.com/products/cree-ur-series-retrofit-kit-ur2-48-45l-40k-10v-fd?utm_medium=cpc&utm_source=googlepla&variant=16950356097&gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFK6i-wzHiYiyYqQK-8Pkn5xth3-d_JRLhZy3vCUDWo1kaAugw8P8HAQ; http://www.adlsupply.com/ballasts/philips-advance-icn-2p32-n/?gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFK49fTcL_EluiJxnnAgMbLGQvMyjl_LjjXKPLUwd5TkoaAlPi8P8HAQ; http://www.lighting-spot.com/ge-232-mv-n.html?fee=24&fep=527&gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFKwQ8BslaEWkUNaQJiYJLq1E2EvCC8qV6AszId7rFH0waAjHg8P8HAQ; https://www.bulbamerica.com/products/osram-sylvania-32w-120v-t8-2-lamp-high-efficiency-electric-ballast?CAWELAID=120150920000389459&CAGPSPN=pla&CAAGID

=11213624286&CATCI=pla-129513636246&catargetid=120150920000808680&cadevice=c&gclid=Cj0KEQjw57W9BRDM9_a-2v"

5. Weights are estimated based on general market knowledge and historical application data.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

LED Lamp Replacing Incandescent Lamp ≤ 40 Watts

	Measure Details
Measure Master ID	LED, ≤ 40 Watt, ENERGY STAR, Replacing Incandescent, 3112
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	7[1]
Incremental Cost ($/unit)	$6.05[4]

Measure Description

ENERGY STAR-rated LED replacement lamps save energy by reducing the total input wattage of the luminaire as compared to the same luminaire operating with standard wattage incandescent lamps. This measure will provide an energy-efficient alternative to using incandescent lamps in several applications.

Description of Baseline Condition

The baseline condition is standard 25-watt and 40-watt incandescent lamps.

Description of Efficient Condition

Efficient equipment must be an ENERGY STAR-rated LED lamp.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1{,}000 * HOU$

Where:

$Watts_{BASE}$ = Average consumption of standard 25-watt or 40-watt incandescent lamp (= 32.5 watts)

$Watts_{EE}$ = Consumption of reduced ENERGY STAR-rated lamp of equivalent lumen output to ≤ 40-watt incandescent (= 6 watts)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= varies by sector; see table below)

Hours-of-Use by Sector

Sector	HOU[2]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1{,}000 * CF$

Where:

CF = Coincidence factor (= varies by sector; see table below)

Coincidence Factor by Sector

Sector	CF[3]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 7 years)[1]

Deemed Savings

Average Annual Deemed Savings for LED Lamp Replacing Incandescent Lamp ≤ 40 Watts

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Gov	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED Lamps ENERGY STAR ≤ 40 Watts	3112	100	0.0204	127	0.0204	126	0.0178	87	0.0169

Average Lifecycle Deemed Savings for LED Lamp Replacing Incandescent Lamp ≤ 40 Watts

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Gov
		kWh	kWh	kWh	kWh
LED Lamps ENERGY STAR ≤ 40 Watts	3112	700	889	882	609

Assumptions

Assumes an average of 25-watt and 40-watt incandescent lamps in calculation of baseline usage.

Assumes that average ENERGY STAR-rated LED of 5.64 watts for ≤ 40-watt replacement products.

Sources

1. Cadmus review of manufacturers’ measure life.
2. State of Wisconsin Public Service Commission. *Business Programs Deemed Savings Manual V1.0.* Table 3.2 Lighting Hours of Use and Coincidence Factors by Sector. March 22, 2010.
3. State of Wisconsin Public Service Commission. *Business Programs Deemed Savings Manual V1.0.* Table 3.2 Lighting Hours of Use and Coincidence Factors by Sector. March 22, 2010.
4. Evaluator Online Cost research from 1000bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

LED Lamp Replacing Incandescent Lamp > 40 Watts

	Measure Details
Measure Master ID	LED, > 40 Watt, ENERGY STAR, Replacing Incandescent, 3113, 3821
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	7[1]
Incremental Cost ($/unit)	$9.40[4]

Measure Description

ENERGY STAR-rated LED replacement lamps save energy by reducing the total input wattage of the luminaire as compared to the same luminaire operating with standard wattage incandescent lamps. This measure will provide an energy-efficient alternative to using incandescent lamps in several applications.

Description of Baseline Condition

The baseline condition is standard 53-watt, 60-watt, 65-watt, 70-watt, 72-watt, and 80-watt incandescent lamps.

Description of Efficient Condition

Efficient equipment must be an ENERGY STAR-rated LED lamp.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1,000 * HOU$

Where:

$Watts_{BASE}$ = Average power consumption of standard incandescent lamps (= 66.7 watts)

$Watts_{EE}$ = Power consumption of ENERGY STAR-rated LED lamp with a lumen output rating equivalent to a > 40-watt incandescent (= 14.2 watts)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= varies by sector; see table below)

Hours-of-Use by Sector

Sector	HOU[2]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1,000 * CF$

Where:

CF = Coincidence factor (= varies by sector; see table below)

Coincidence Factor by Sector

Sector	CF[3]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 7 years)[1]

Deemed Savings

Average Annual Deemed Savings for LED Lamp Replacing Incandescent Lamp > 40 Watts

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Gov	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED Lamps ENERGY STAR > 40 Watts	3113, 3821	196	0.0404	249	0.0404	247	0.0352	170	0.0336

Average Lifecycle Deemed Savings for LED Lamp Replacing Incandescent Lamp > 40 Watts

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Gov
		kWh	kWh	kWh	kWh
LED Lamps ENERGY STAR > 40 Watts	3113, 3821	1,372	1,743	1,729	1,190

Assumptions

An average of 16.67% each of 53-watt incandescent, 60-watt incandescent and halogens, 65-watt incandescent, 70-watt halogens, 80-watt halogens, and 100-watt halogen lamps was used to generate the baseline wattage.[3]

An average of 20% each of 9-watt, 11-watt, 13-watt, 18-watt, and 20-watt ENERGY STAR-rated LED lamps was used to generate the new wattage.[3]

Sources

1. Cadmus review of manufacturers' measure life.
2. State of Wisconsin Public Service Commission. *Business Programs Deemed Savings Manual V1.0.* March 22, 2010.
3. Based on market knowledge.
4. Evaluator Online Cost research from 1000bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

LED Tube Retrofit of 4-Foot T12 or T8 Fixtures

	Measure Details
Measure Master ID	T8 LED < 20 Watts, 2L, Replacing 3L or 4L T12/T8, SBP After A La Carte, 3582
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	16[1]
Incremental Cost ($/unit)	MMID 3582= $62.00[6]

Measure Description

Four-foot T8 LEDs are an energy-efficient alternative to standard 4-foot 32/28/25 watt T8 fluorescent lamps found commonly throughout small commercial facilities. These products can replace 32/28/25 watt T8 lamps one-for-one, incorporating replacing the existing fluorescent lamp(s) and ballast(s).

Description of Baseline Condition

The baseline condition is 4-foot standard 32/28/25 watt T8 lamps on low (0.78), normal (0.88), and high (1.15) ballast factor ballasts. Lamps are weighted 60%, 30%, and 10%, respectively, in the savings calculations. 32-watt lamps are weighted 10%, 70%, and 20% with respect to low, normal, and high ballast factors, while 28-watt and 25-watt lamp ballast factors are weighted 5%, 90%, and 5% for those same ballast factors in the savings calculations.[3]

Description of Efficient Condition

Efficient equipment must be DLC-listed, less than 20 watts, and use a new external driver or operate on a new fluorescent ballast(s). This measure is not intended to be used in refrigerated case lighting applications and those products which intend to bring line voltage to existing sockets. Products must carry a safety certification from a NRTL, such as UL or ETL.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1,000 * HOU$

Where:

$Watts_{BASE}$ = Power consumption of baseline measure based on ballast factor

$Watts_{EE}$ = Power consumption of efficient equipment based on ballast factor

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= varies by sector; see table below)

Hours-of-Use by Sector

Sector	HOU[2]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1,000 * CF$

Where:

CF = Coincidence factor (= varies by sector; see table below)

Coincidence Factor by Sector

Sector	CF[4]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (=16 years)[1]

Deemed Savings

Annual Savings

Measure	Commercial		Industrial		Agriculture		Schools & Gov	
	kWh	kW	kWh	kW	kWh	kW	kWh	kW
T8 LED < 20W, 3L, replace 3 or 4L T12/T8	166	0.0342	211	0.0342	209	0.0297	144	0.0284
T8 LED < 20W, 2L, replace 3 or 4L T12/T8	230	0.0474	292	0.0474	289	0.0413	199	0.0394

Lifecycle Savings

Measure	Commercial	Industrial	Agriculture	Schools & Gov
	kWh	kWh	kWh	kWh
T8 LED < 20W, 3L, replace 3 or 4L T12/T8	2,656	3,376	3,344	2,304
T8 LED < 20W, 2L, replace 3 or 4L T12/T8	3,680	4,672	4,624	3,184

Sources

1. Cadmus review of manufacturers’ measure life.
2. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
3. Weights estimated based on general market knowledge and historical application data.
4. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.
5. Market research documented in Excel spreadsheet Four-foot Linear LED replacing 4-foot T8 flour 4to3 calculation_GDS_SBP_12_26_14.
6. Program Implementer market research 2014.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

LED Lamp Replacing Neon Sign

	Measure Details
Measure Master ID	LED, Replacing Neon Sign, 3353
Measure Unit	Per fixture (or per sign)
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	$55.00[7]

Measure Description

This measure is installing a new LED open sign to replace an old neon sign with high voltage magnetic transformers. All new open signs must meet UL-84 requirements.

Traditionally, these signs consist of 5 or 6 millimeter (roughly 1/2 inch) diameter neon tubing with a 3,000 to 15,000 magnetic high-voltage transformer. The tubing length varies by the sign size, but averages 10 feet. Electrical drive levels vary by brightness, but neon tubing of this diameter typically operates at 6 watts to 8 watts per linear foot.

The high voltage neon transformers that drive the neon tubing are designed to provide a limited and reasonably constant current of 20 to 30 mill amperes. One of the consequences of this transformer design is an extremely poor normal power factor. Normal power factors range from 45% to 50%, while high power factors range from 85% to 90%.

Improvements in solid-state electronics over the last two decades have led to the availability of electronic neon transformers and LED alternatives to neon tube technology. Electronic neon transformers can supply the needed current limitation and regulation with roughly twice the efficiency of magnetic transformers, while providing a high power factor. LED technology can provide a neon-like appearance at the same or higher brightness levels, with six to eight times the efficiency of neon tubes that use magnetic transformers. LEDs also have the advantage of being powered by inherently safe low-voltage drivers in lieu of high voltage neon transformers.

LED drivers can be either electronic switching or linear magnetic, with the supplies for electronic switching being the most efficient. The on-off power switch may be on either the power line or load side of the driver, with the line side location providing significantly lower standby losses when the sign is turned off.

Description of Baseline Condition

The baseline condition is a neon open sign with a normal magnetic ballast neon sign power factor.

Description of Efficient Condition

The efficient equipment is the new LED open sign.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1,000 * HOU$

Where:

$Watts_{BASE}$ = Wattage of neon sign with magnetic high voltage transformer (= 189)

$Watts_{EE}$ = Wattage of LED sign with low voltage transformer (= 20)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use, estimated as 80% of that listed in the Deemed Savings Manual to account for when the facility is occupied but not open (= varies by sector; see table below)

Hours-of-Use by Sector

Sector	HOU[4]
Commercial	80% of 3,730 = 2,984
Industrial	80% of 4,745 = 3,796
Agriculture	80% of 4,698 = 3,758
Schools & Government	80% of 3,239 = 2,591

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1,000 * CF$

Where:

CF = Coincidence factor (= 1.0 for commercial, industrial, and agriculture sectors; = 0.59 for schools & government sector)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[1]

Deemed Savings

Deemed Savings by Sector

Savings	MMIDs	Commercial	Industrial	Agriculture	Schools & Government
kWh	3003 and 3353	504	642	635	438
kW		0.1690	0.1690	0.1690	0.0997
Lifecycle kWh		7,564	9,623	9,527	6,568

Assumptions

The peak demand coincidence factor varies from the typical weighted average factors because it is assumed that the open sign (if owned by the facility) will be on during peak times. Therefore, the demand coincidence factor is set to 1.0 or 0.59.

The baseline wattage of the fixtures has two components: the real power and the reactive power. Neon open signs have low-grade magnetic ballasts that create a very low power factor and increase the apparent power from the grid. The 2004 Core Program LED Open Sign Pilot findings (in California) revealed a power factor of 0.41. In order for the grid to supply the power, the wattage draw of the neon signs must be divided by the power factor. In other words, the wattage draw is only 41% of the power that needs to be supplied from the grid to operate the neon sign.

The baseline is 189 watts to account for varying real power requirements between 90 and 100 watts.

Sources

1. Cadmus review of manufacturers' measure life.
2. Itron. 2004-2005 DEER Update Study Final Report. Table 3-8, pg. 3-12. December 2005.
3. Pacific Gas & Electric. Lighting Rebate Catalog and Application. 2007. Retrieved February 2008.
4. State of Wisconsin Public Service Commission. *Business Programs Deemed Savings Manual V1.0.* Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.

5. U.S. Department of Energy. (n.d.). *Save Energy, Money, and Prevent Pollution with Light-Emitting Diode Exit Signs.* February 2008. Available online: http://www.energystar.gov/ia/business/small_business/led_exitsigns_techsheet.pdf.
6. GDS Associates. LED Open Signs. Work Paper PGEPLTG018. August 20, 2009.
7. 2015 Implementer survey of Trade Ally's installation Cost.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

DLC Listed 2x2 LED Fixtures

	Measure Details
Measure Master ID	LED Fixture, 2x2, DLC Listed: Low Output, 3400 High Output, 3401
Measure Unit	Per luminaire
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	16[1]
Incremental Cost ($/unit)	$108.75[2]

Measure Description

LED 2x2 troffers save energy when replacing 2-lamp to 4-lamp T8 products and 2-lamp to 4-lamp 2G11 base lamps by providing a similar lumen output with lower input wattage. These products can be installed on a one-for-one basis to replace 2x2 2-lamp to 4-lamp T8, T12, or 2G11 lamp base luminaires.

Description of Baseline Condition

The baseline condition is 2-foot 2-lamp, 3-lamp, and 4-lamp T8 or 2G11 lamp base troffers for existing buildings and new construction buildings.

Description of Efficient Condition

Low Output 2x2

The efficient condition for low output lamps is DesignLights Consortium™ (DLC) products listed in the “2x2 Luminaires for Ambient Lighting of Interior Commercial Spaces” and “Integrated Retrofit Kits for 2x2 Luminaires” primary use categories, which consume ≤ 36 watts.

High Output 2x2

The efficient condition for high output lamps is DLC products listed in the “2x2 Luminaires for Ambient Lighting of Interior Commercial Spaces” and “Integrated Retrofit Kits for 2x2 Luminaires” primary use categories, which consume ≤ 85 watts.

Annual Energy-Savings Algorithm

Low Output 2x2

$kWh_{SAVED} = (Watts_{BASE} – Watts_{LED}) / 1,000 * HOU$

Where:

$Watts_{BASE}$ = Baseline wattage, or the average power consumption of 2-lamp, 3-lamp, and 4-lamp 17-watt T8 or 2-lamp T8 U-bend fixtures, weighted at 2%, 38%, 20%, and 40%, respectively (= 56 watts, see the Assumptions section)

$Watts_{LED}$ = Energy efficient wattage, or the average power consumption of DLC-listed LED fixture ≤ 36 watts (= 30 watts)[3]

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= varies by sector, see table below)

Hours-of-Use by Sector

Sector	HOU[4]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239
Multifamily	5,950

High Output 2x2

$kWh_{SAVED} = (Watts_{BASE} – Watts_{LED}) / 1,000 * HOU$

Where:

$Watts_{BASE}$ = Baseline wattage, or the average power consumption of 2-lamp, 3-lamp, and 4-lamp 2G11 base fixtures, weighted between 40-watt, 50-watt, and 55-watt lamps (= 146 watts, see the Assumptions section)

$Watts_{LED}$ = Energy efficient wattage, or the average power consumption of DLC-listed LED fixtures ≤ 85 watts (= 39 watts)[3]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{LED}) / 1{,}000 * CF$

Where:

CF = Coincidence factor (= varies by sector, see table below)

Coincidence Factor

Sector	CF[4]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64
Multifamily	0.77

Lifecycle Energy-Savings Algorithm

$kWh_{LIFETIME} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 16 years)[1]

Deemed Savings

Annual Savings

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Gov		Multifamily	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
DLC Listed 2X2 LED, Low Output	3400	94	0.0195	120	0.0195	119	0.0170	82	0.0162	151	0.0195
DLC Listed 2X2 LED, High Output	3401	399	0.0824	508	0.0824	503	0.0717	347	0.0685	637	0.0824

Lifecycle Savings (kWh)

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Gov	Multifamily
DLC Listed 2X2 LED, Low Output	3400	1,504	1,920	1,904	1,312	2,416
DLC Listed 2X2 LED, High Output	3401	6,384	8,128	8,048	5,552	10,192

Assumptions

The table below provides fixture lamp weightings used in baseline calculation. The related assumptions are based on a combination of feedback from energy audit experience, Lighting Certified individuals through the National Council on Qualifications for the Lighting Professions, and individuals with lighting sales experience.

Fixture Lamp Weightings - Baseline

2-Lamp T8 Wattage and Weighting	2-Lamp T8 U Bend Wattage and Weighting	3-Lamp T8 Wattage and Weighting	4-Lamp T8 Wattage and Weighting
36	55	52	66
2%	40%	38%	20%

Fixture Lamp Weightings – Efficient Condition

2-Lamp 40-Watt 2G11 2x2	3-Lamp 40-Watt 2G11 2x2	4-Lamp 40-Watt 2G11 2x2
5%	25%	5%
2-Lamp 50-Watt 2G11 2x2	**3-Lamp 50-Watt 2G11 2x2**	**4-Lamp 50-Watt 2G11 2x2**
5%	25%	5%
2-Lamp 55-Watt 2G11 2x2	**3-Lamp 55-Watt 2G11 2x2**	**4-Lamp 55-Watt 2G11 2x2**
5%	20%	5%

Sources

1. Cadmus review of manufacturers' measure life.
2. Various online retailers (including homedepot.com, grainger.com, and shineretrofits.com). A full list can be made available upon request. October 2015.
3. DesignLights Consortium. Product List. Average Measured Wattage for products listed in the 2x2 Luminaires for Ambient Lighting of Interior Commercial Spaces and Integrated Retrofit Kits for 2x2 Luminaires primary use categories ≤ 36 watts and ≤ 85 watts. October 7, 2015.
4. Focus on Energy. *Business Programs Deemed Savings Manual V1.0*. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.

Revision History

Version Number	Date	Description of Change
01	04/01/2014	New measure
02	10/07/2015	Updated savings and definitions

2-Lamp F28T5, HPT8, RWT8 2x4 High-Efficiency Recessed Fixtures

	Measure Details
Measure Master ID	2 Lamp F28T5, HPT8, RWT8 2x4 High-Efficiency Recessed Fixtures, 2703
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Linear
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by type of fixture
Peak Demand Reduction (kW)	Varies by type of fixture
Annual Therm Savings (Therms)	None
Lifecycle Energy Savings (kWh)	Varies by type of fixture
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[3]
Incremental Cost ($/unit)	$185.50[4]

Measure Description

This measure is replacing 3-lamp or 4-lamp 4-footstandard T8 and T12 fixtures with 2-lamp F28T5, HPT8, RWT8 2x4 high-efficiency recessed fixtures.

Description of Baseline Condition

The baseline equipment is 3-lamp or 4-lamp 4-foot standard T8 and T12 fixtures.

Description of Efficient Condition

The efficient equipment is 2-lamp F28T5, HPT8, RWT8 2x4 high-efficiency recessed fixtures.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{DEEMED} * (HOURS_{MULTIFAMILY} / HOURS_{COMMERCIAL})$

Where:

kWh_{DEEMED} = Annual commercial deemed electricity savings

$HOURS_{MULTIFAMILY}$ = Annual multifamily deemed lighting hours

$HOURS_{COMMERCIAL}$ = Annual commercial deemed lighting hours

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = Wattage / 1{,}000 * CF$

Where:

CF = Coincidence factor (= 0.77)[1]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[3]

Deemed Savings

Annual Deemed Savings[2]

Measure	Annual Energy Savings (kWh)	Coincident Peak Demand Reduction (kW)
4-Foot 2-Lamp T5 Fixtures	179.0	0.0231
4-Foot 2-Lamp T8 Fixtures	276.0	0.0355

Lifecycle Deemed Savings[2]

Measure	Energy Savings (kWh)
4-Foot 2-Lamp T5 Fixtures	2,685.0
4-Foot 2-Lamp T8 Fixtures	4,140.0

Assumptions

3,730 annual operating hours used.[1]

Sources

1. ACES. *Deemed Savings Desk Review*. Multifamily applications for common areas. November 3, 2010.
2. *Focus on Energy Business Programs Deemed Savings Manual V1.0*. Tables 4-190 and 4-208 Commercial Applications. March 22, 2010.
3. CA DEER EUL ID "ILtg-Lfluor-CommArea" "Linear Fluorescents - MF Common Area."

4. 2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.
5. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 4-185 Commercial Applications. March 22, 2010.

Revision History

Version Number	Date	Description of Change
01	01/02/2013	New measure

High Bay Fluorescent Lighting

	Measure Details
Measure Master ID	High Bay Fluorescent Lighting: T8 4L Replacing 250-399 W HID, 2884, 3811, 3329 T8 6L Replacing 400-999 W HID, 3331, 3812 T8 8L Replacing 400-999 W HID, 2886 T8 8L ≤ 500 W, Replacing ≥ 1,000 W HID, 2887, 3333 T8 10L ≤ 500 W, Replacing ≥ 1,000 W HID, 2888 T8 (2) 6L ≤ 500 W, Replacing ≥ 1,000 W HID, 2889 T5HO 2L Replacing 250-399 W HID, 2890, 3330 T5HO 3L Replacing 250-399 W HID, 2891 T5HO 4L Replacing 400-999 W HID, 2892, 3813, 3332 T5HO 6L Replacing 400-999 W HID, 2893, 3814 T5HO 6L ≤ 500 W, Replacing ≥ 1,000 W HID, 2894, 3334 T5HO 8L ≤ 500 W, Replacing ≥ 1,000 W HID, 2895 T5HO (2) 4L ≤ 500 W, Replacing ≥ 1,000 W HID, 2896 T5HO (2) 6L ≤ 800 W, Replacing ≥ 1,000 W HID, 2897
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Linear
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	Varies by measure
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	Varies by measure
Incremental Cost ($/unit)	Varies by measure, see Appendix D

Measure Description

In high-bay lighting applications (ceiling heights generally over 15 feet), HID fixtures have typically been used due to their high lumen output. In recent years, however, improvements in fluorescent lamps and the emergence of new high-intensity fluorescent fixtures have made fluorescent lighting the most cost-effective choice for lighting high indoor spaces. These high-intensity fluorescent systems are more energy efficient than HID solutions and feature lower lumen depreciation rates, better dimming options, virtually instant start-up and re-strike, better color rendition, and reduced glare.

Similar high-intensity fluorescent lighting fixtures are also available for low bay applications, generally with equipment available in the same product family as the manufacturers' high bay products.

Description of Baseline Condition

The baseline condition is HID fixtures and lamps.

Description of Efficient Condition

The efficient condition varies by the wattage of the baseline lamp (see table below).

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1{,}000 * HOU$

Where:

$Watts_{BASE}$ = Wattage of a HID lamp (= varies by measure; see table below)

$Watts_{EE}$ = Wattage of HOT5 or HOT8 lamp (= varies by measure; see table below)

Wattages Used for Deemed Savings Calculations

Measure	$Watts_{BASE}$	$Watts_{EE}$
2L HOT5	293	117
3L HOT5	293	179
4L T8	293	151
4L HOT5	356	234
6L T8	356	224
4L HOT5	455	234
6L HOT5	455	355
6L T8	455	224
8L T8	455	291
6L HOT5	1,079	355
8L HOT5	1,079	585
(2) 4L HOT5	1,079	468
(2) 6L HOT5	1,079	709
8L T8	1,079	291
10L T8	1,079	366
(2) 6L T8	1,079	447

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= varies by sector; see table below)

Hours-of-Use by Sector

Sector	HOU[2]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1,000 * CF$

Where:

CF = Coincidence factor (= varies by sector; see table below)

Coincidence Factor by Sector

Sector	CF[2]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (2884, 3811, 2886, 2887, 2888, 2889, 2890, 2891, 2892, 3813, 2893, 3814, 2894, 2895, 2896, 2897 = 14 years[1] and 3329, 3330, 3331, 3812, 3332, 3333, 3334 = 15 years)[2]

Deemed Savings

Annual Electric Savings (kWh/year/lamp removed)

Existing Wattage	New Fixture Type	MMID	Commercial	Industrial	Agriculture	Schools & Government
250 watts - 399 watts	2L HOT5	2890, 3330	656	835	827	570
	3L HOT5	2891	425	541	536	369
	4L T8	2884, 3811, 3329	532	676	669	462
400 watts - 999 watts	4L HOT5	2892, 3813, 3332	824	1,049	1,038	716
	6L HOT5	2893, 3814	375	477	472	326
	6L T8	3331, 3812	863	1,098	1,088	750
	8L T8	2886	612	778	770	531
1,000 watts	6L HOT5	2894, 3334	2,701	3,435	3,401	2,345
	8L HOT5	2895	1,841	2,342	2,318	1,598
	(2) 4L HOT5	2896	2,277	2,897	2,868	1,977
	(2) 6L HOT5	2897	1,378	1,753	1,736	1,197
	8L T8	2887, 3333	2,937	3,737	3,700	2,551
	10L T8	2888	2,658	3,381	3,347	2,308
	(2) 6L T8	2889	2,355	2,996	2,967	2,045

Summer Peak Savings

Existing Wattage	New Fixture Type	MMID	Commercial	Industrial	Agriculture	Schools & Government
250 watts – 399 watts	2L HOT5	2890, 3330	0.136	0.136	0.118	0.113
	3L HOT5	2891	0.088	0.088	0.076	0.073
	4L T8	2884, 3811, 3329	0.11	0.11	0.095	0.091
400 watts - 999 watts	4L HOT5	2892, 3813, 3332	0.17	0.17	0.148	0.141
	6L HOT5	2893, 3814	0.077	0.077	0.067	0.064
	6L T8	3331, 3812	0.178	0.178	0.155	0.148
	8L T8	2886	0.126	0.126	0.11	0.105
1,000 watts	6L HOT5	2894, 3334	0.557	0.557	0.485	0.463
	8L HOT5	2895	0.38	0.38	0.331	0.316
	(2) 4L HOT5	2896	0.47	0.47	0.409	0.391
	(2) 6L HOT5	2897	0.285	0.285	0.248	0.236
	8L T8	2887, 3333	0.606	0.606	0.528	0.504
	10L T8	2888	0.549	0.549	0.477	0.456
	(2) 6L T8	2889	0.486	0.486	0.423	0.404

Lifecycle Savings (kWh)

Existing Wattage	New Fixture Type	MMID	Commercial	Industrial	Agriculture	Schools & Government
250 watts - 399 watts	2L HOT5	2890, 3330	9,191	11,692	11,576	7,981
	3L HOT5	2891	5,953	7,573	7,498	5,169
	4L T8	2884, 3811, 3329	7,441	9,466	9,373	6,462
400 watts - 999 watts	4L HOT5	2892, 3813, 3332	11,541	14,681	14,536	10,021
	6L HOT5	2893, 3814	5,248	6,676	6,610	4,557
	6L T8	3331, 3812	12,089	15,379	15,226	10,498
	8L T8	2886	8,564	10,895	10,787	7,437
1,000 watts	6L HOT5	2894, 3334	37,807	48,095	47,619	32,831
	8L HOT5	2895	25,771	32,783	32,458	22,378
	(2) 4L HOT5	2896	31,880	40,556	40,154	27,684
	(2) 6L HOT5	2897	19,295	24,546	24,303	16,755
	8L T8	2887, 3333	41,123	52,314	51,795	35,710
	10L T8	2888	37,207	47,331	46,863	32,309
	(2) 6L T8	2889	32,977	41,951	41,535	28,636

Sources

1. Average of: Cadmus 2013 database; 2007 GDS residential measure life report: http://www.iar.unicamp.br/lab/luz/ld/Arquitetural/interiores/ilumina%E7%E3o%20industrial/measure_life_GDS.pdf; California Energy Commission and California Public Utilities Commission. Database for Energy Efficient Resources (DEER) 2008. http://www.energy.ca.gov/deer/ ; and PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation Business Programs: Deemed Savings Manual v1.0. Updated March 22, 2010.
2. DEER 2014 EUL Table. http://www.deeresources.com/. Rated ballast life of 70,000 hours. Not rated on bulb life as such capped at 15 years.
3. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation Business Programs: Deemed Savings Manual v1.0. Updated March 22, 2010.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry
02	10/2016	Removed MMID 2885

Exterior – Induction, PSMH, CMH, Linear Florescent Fixtures

	Measure Details
Measure Master ID	Induction, PSMH/CMF or Linear Fluorescent, Exterior: Replacing 150-175 Watt HID, 3078, 3829 Replacing 250 Watt HID, 3081, 3830 Replacing 320 -Watt HID, 3084 Replacing 400 Watt HID, 3086, 3832 Replacing 70-100 Watt HID, 3087, 3833
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Other
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by fixture
Peak Demand Reduction (kW)	Varies by fixture
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by fixture
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	Varies by measure, see Appendix D

Measure Description

Induction, PSMH, CMH, and linear fluorescent lighting fixtures save energy by reducing the light fixture wattage compared to standard metal halide fixtures, without sacrificing illumination quality and safety. These lighting technologies are appropriate for exterior applications.

Description of Baseline Condition

The baseline measure is standard HID lamps between 70 watts and 400 watts, located on exterior poles or high canopies.

Description of Efficient Condition

The efficient measure is induction, PSMH, CMH, and linear fluorescent fixtures between 35 watts and 250 watts.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1,000 * HOU$

Where:

$Watts_{BASE}$ = Wattage of baseline HID fixture

$Watts_{EE}$ = Wattage of efficient induction fixture, PSMH fixture, CMH fixture, or linear fluorescent fixture

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 4,380)

Summer Coincident Peak Savings Algorithm

There are no peak savings for this measure.

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[1]

Deemed Savings

Deemed Savings by Measure

Measure	MMID	Annual Savings (kWh)	Peak Demand Reduction (kW)	Lifecycle Savings (kWh)
Induction, PSMH/CMH, or Linear Fluorescent, Replacing 70-Watt to 100-Watt HID, Exterior	3087, 3833	247	0	3,712
Induction, PSMH/CMH, or Linear Fluorescent, Replacing 150-Watt to 175-Watt HID, Exterior	3078, 3829	329	0	4,938
Induction, PSMH, CMH, or Linear Fluorescent Replacing 250-Watt HID, Exterior	3081, 3830	605	0	9,076
Induction, PSMH, CMH, or Linear Fluorescent Replacing 320-Watt HID, Exterior	3084	556	0	8,344
Induction, PSMH, CMH, or Linear Fluorescent Replacing 400-Watt HID, Exterior	3086, 3832	972	0	14,585

Assumptions

The induction wattages shown below include the ballast wattage, which was calculated as 10% of the lamp wattage based on the manufacturer specifications. All exterior replacement calculations use 4,380 hours of annual operation, half the total hours in a year.

70-watt to 100-watt HID exterior replacements are weighted as follows:

- Baseline = 50% 70-watt HID and 50% 100-watt HID (= 111.5 watts)
- Eligible Replacements = 50% linear fluorescent ≤ 60 watts, 25% 35-watt induction, and 25% 55-watt induction (= 55 watts)

150-watt to 175-watt HID exterior replacements are weighted as follows:

- Baseline = 50% 150-watt HID and 50% 175-watt HID (= 194.5 watts)
- Eligible Replacements = 33.33% 100-watt induction, 33.33% 100-watt PSMH or CMH, and 33.33% ≤ 120-watt linear fluorescent (= 119 watts)

250-watt HID exterior replacements are weighted as follows:

- Baseline = 100% 250-watt HID (= 299 watts)
- Eligible Replacements = 14.3% 120-watt to 125-watt induction, 14.3% 150-watt induction, 14.3% 165-watt induction, 14.3% 125-watt PSMH or CMH, 14.3% 140-watt PSMH or CMH, 14.3% 150-watt PSMH or CMH, and 14.3% ≤ 155-watts linear fluorescent (= 161 watts)

320-watt HID exterior replacements are weighted as follows:

- Baseline = 100% 320-watt HID (= 368 watts)
- Eligible Replacements = 16.6% 200-watt induction, 16.6% 225-watt induction, 16.6% 250-watt induction, 16.6% 200-watt PSMH or CMH, 16.6% 210-watt PSMH or CMH, and 16.6% 220-watt PSMH or CMH (= 241 watts)

400-watt HID exterior replacements are weighted as follows:

- Baseline = 100% 400-watt HID (= 463 watts)
- Eligible Replacements = 16.6% 200-watt induction, 16.6% 225-watt induction, 16.6% 250-watt induction, 16.6% 200-watt PSMH or CMH, 16.6% 210-watt PSMH or CMH, and 16.6% 220-watt PSMH or CMH (= 241 watts)

Source

1. Database for Energy Efficient Resources (DEER). 2014. http://www.deeresources.com/. Rated ballast life of 70,000 hours. Not rated on bulb life. Capped at 15 years.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Parking Garage Induction PSMH CMH LF Fixtures

	Measure Details
Measure Master ID	Induction, PSMH/CMH, or Linear Fluorescent, Parking Garage: Replacing 150-175 Watt HID, 24 Hour, 3079 Replacing 150-175 Watt HID, Dusk to Dawn, 3080 Replacing 250 Watt HID, 24 Hour, 3082 Replacing 250 Watt HID, Dusk to Dawn, 3083 Replacing 70-100 Watt HID, 24 Hour, 3088 Replacing 70-100 Watt HID, Dusk to Dawn, 3089
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Other
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by fixture
Peak Demand Reduction (kW)	Varies by fixture
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by fixture
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	Varies by measure, see Appendix D

Measure Description

Induction, PSMH, CMH, and linear fluorescent lighting fixtures save energy by reducing the light fixture wattage compared to standard metal halide fixtures, without sacrificing illumination quality and safety. These lighting technologies are appropriate for parking garage applications.

Description of Baseline Condition

The baseline is standard HID lamps between 70 watts and 400 watts located in parking garages.

Description of Efficient Condition

The efficient condition is induction, PSMH, CMH, and linear fluorescent fixtures between 35 watts and 250 watts.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1,000 * HOU$

Where:

$Watts_{BASE}$ = Wattage of baseline HID fixture

$Watts_{EE}$ = Wattage of efficient induction fixture, PSMH fixture, CMH fixture, or linear fluorescent fixture

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (varies by hours of operation; = 4,380 for night run only; = 8,760 if on continuously)

Summer Coincident Peak Savings Algorithm

There are no peak savings for this measure.

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[1]

Deemed Savings

Average Annual Deemed Savings

Measure	MMID	kWh	kW
Induction, PSMH/CMH, or Linear Fluorescent, Replacing 70 Watt to 100 Watt HID, Parking Garage, 24 Hour	3088	495	0.057
Induction, PSMH, CMH, or Linear Fluorescent, Replacing 70 Watt to 100 Watt, Parking Garage, Dusk to Dawn	3089	247	0
Induction PSMH, CMH, or Linear Fluorescent, 150 Watt to 175 Watt Parking Garage, 24 Hour	3079	658	0.075
Induction, PSMH/CMH, or Linear Fluorescent, Replacing 150 Watt to 175 Watt HID, Parking Garage, Dusk to Dawn	3080	329	0
Induction PSMH, CMH, or Linear Fluorescent, 250 Watt, Parking Garage, 24-hour	3082	1.210	0.141
Induction PSMH, CMH, or Linear Fluorescent, 250 Watt, Parking Garage, Dusk to Dawn	3083	605	0

Average Lifecycle Deemed Savings

Measure	MMID	kWh
Induction, PSMH/CMH, or Linear Fluorescent, Replacing 70 Watt to 100 Watt HID, Parking Garage, 24 Hour	3088	7,424
Induction, PSMH, CMH, or Linear Fluorescent, Replacing 70 Watt to 100 Watt, Parking Garage, Dusk to Dawn	3089	3,712
Induction PSMH, CMH, or Linear Fluorescent, 150 Watt to 175 Watt, Parking Garage, 24 Hour	3079	9,877
Induction, PSMH/CMH, or Linear Fluorescent, Replacing 150 Watt to 175 Watt HID, Parking Garage, Dusk to Dawn	3080	4,938
Induction PSMH, CMH, or Linear Fluorescent, 250 Watt, Parking Garage, 24-hour	3082	18,152
Induction PSMH, CMH, or Linear Fluorescent, 250 Watt, Parking Garage, Dusk to Dawn	3083	9,076

Assumptions

The induction wattages shown below include the ballast wattages, which was calculated as 10% of the lamp wattage based on the manufacturer specifications.

All garage replacement calculations use 8,760 or 4,380 hours of annual operation.

70-watt to 100-watt HID parking garage replacements are weighted as follows:

- Baseline = 50% 70-watt HID and 50% 100-watt HID (= 111.5 watts)
- Eligible Replacements = 25% 35-watt induction, 25% 55-watt induction, and 50% ≤ 60-watt linear fluorescent (= 55 watts)

150-watt to 175-watt HID parking garage replacements are weighted as follows:

- Baseline = 50% 150-watt HID and 50% 175-watt HID (= 194.5 watts)
- Eligible Replacements = 33.33% 100-watt induction, 33.33% 100-watt PSMH or CMH, and 33.33% ≤ 120-watt linear fluorescent (= 119 watts)

250-watt HID parking garage replacements are weighted as follows:

- Baseline = 100% 250-watt HID (= 299 watts)
- Eligible Replacements = 14.3% 120-watt to 125-watt induction, 14.3% 150-watt induction, 14.3% 165-watt induction, 14.3% 125-watt PSMH or CMH, 14.3% 140-watt PSMH or CMH, 14.3% 150-watt PSMH or CMH, and 14.3% ≤ 155-watt linear fluorescent (= 161 watts)

Source

2. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

High Bay – Induction, PSMH, CMH Fixtures

	Measure Details
Measure Master ID	High Bay – Induction, PSMH, CMH Fixtures: ≤ 250 Watt, Replacing 320-400 Watt HID, 3075, 3816 ≤ 250 Watt, Replacing 400 Watt HID, 3076, 3817 ≤ 365 Watt, Replacing 400 Watt HID, 3077, 3818 Replacing 250 Watt HID, 3090, 3815 Induction, 750 Watt, Replacing 1,000 Watt HID, High Bay, 3074
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Other
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	Varies by measure
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1] 27 (for 750-watt induction)[2]
Incremental Cost ($/unit)	Varies by measure, see Appendix D

Measure Description

Induction, pulse-start metal halide, and ceramic metal halide lighting fixtures save energy by reducing the light fixture wattage compared to standard metal halide fixtures, without sacrificing illumination quality and safety. These lighting technologies are appropriate for high bay applications.

Description of Baseline Condition

The baseline condition is standard HID lamps between 250 watts and 1,000 watts, located in a parking garage.

Description of Efficient Condition

The efficient condition is induction, pulse-start metal halide, and ceramic metal halide fixtures between 120 watts and 750 watts.

Annual Energy-Savings Algorithm

$kWh_{SAVED\ IND} = kWh_{HID} - kWh_{IND}$

$kWh_{SAVED\ PSMH} = kWh_{HID} - kWh_{PSMH}$

$kWh_{SAVED\ CMH} = kWh_{HID} - kWhc_{MH}$

Where:

kWh_{HID} = Annual electricity consumption of standard HID fixture
kWh_{IND} = Annual electricity consumption of induction lighting fixture
kWh_{PSMH} = Annual electricity consumption of pulse start metal halide fixture
kWh_{CMH} = Annual electricity consumption of ceramic metal halide fixture

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = Wattage / 1{,}000 * CF$

$kW_{IND} = kW_{PEAK\ HID} - kW_{PEAK\ IND}$

$kW_{PSMH} = kW_{PEAK\ HID} - kW_{PEAK\ PSMH}$

$kW_{CMH} = kW_{PEAK\ HID} - kW_{PEAK\ CMH}$

Where:

$kW_{PEAK\ HID}$ = Peak demand of existing HID system
$kW_{PEAK\ IND}$ = Peak demand of new induction lighting system
$kW_{PEAK\ PSMH}$ = Peak demand of new pulse start metal halide lighting system
$kW_{PEAK\ CMH}$ = Peak demand of new ceramic metal halide lighting system
HOURS = Hours-of-use (= varies by sector; see table below)

Hours-of-Use by Sector

Sector	HOU[2]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239

CF = Demand coincidence factor (= varies by sector; see table below)

Demand Coincidence Factor by Sector

Sector	CF[4]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE\ IND} = (kWh_{HID} - kWh_{IND}) * EUL$

$kWh_{LIFECYCLE\ PSMH} = (kWh_{HID} - kWh_{PSMH}) * EUL$

$kWh_{LIFECYCLE\ CMH} = (kWh_{HID} – kWh_{CMH}) * EUL$

Where:

EUL = Effective useful life (= 15 years;[1] = 27 years for 750-watt induction)[2]

Deemed Savings

Average Annual Deemed Savings for High Bay Induction PSMH/CMH Fixtures

Measure	MMID	Commercial 3,730 (0.77)		Schools & Gov 3,239 (0.64)		Industrial 4,745 (0.77)		Agriculture 4,698 (0.67)	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW
HB PSMH, CMH, IND Replacing 250 Watt HID	3090, 3815	510	0.1053	443	0.0875	649	0.1053	642	0.0916
HB PSMH, CMH, IND (250 Watt or Less) Replacing 400 Watt HID	3076, 3817	827	0.1706	718	0.1418	1,052	0.1706	1,042	0.1484
HB PSMH, CMH, IND (250 Watt or Less) Replacing 320-400 Watt HID NC (Based on 320 watt savings)	3075, 3816	499	0.1031	433	0.0857	635	0.1031	628	0.0897
HB PSMH, CMH, IND (365 Watt or Less) Replacing 400 Watt HID	3077, 3818	546	0.1128	474	0.0938	695	0.1128	688	0.0982
HB IND 750 Watt High Bay Replacing 1,000 Watt HID	3074	970	0.2002	842	0.1664	1,234	0.2002	1,222	0.1742

Average Lifecycle Deemed Savings for High Bay Induction PSMH/CMH Fixtures

Measure	MMID	Commercial 3,730 (0.77)	Schools & Gov 3,239 (0.64)	Industrial 4,745 (0.77)	Agriculture 4,698 (0.67)
		kWh	kWh	kWh	kWh
HB PSMH, CMH, IND Replacing 250 Watt HID	3090, 3815	7,650	6,645	9,735	9,630
HB PSMH, CMH, IND (250 Watt or Less) Replacing 400 Watt HID	3076, 3817	12,405	10,770	15,780	15,630
HB PSMH, CMH, IND (250 Watt or Less) Replacing 320-400 Watt HID NC (Based on 320 watt savings)	3075, 3816	7,485	6,495	9,525	9,420
HB PSMH, CMH, IND (365 Watt or Less) Replacing 400 Watt HID	3077, 3818	8,190	7,110	10,425	10,320
HB IND 750 Watt High Bay Replacing 1,000 Watt HID	3074	26,190	22,734	33,318	32,994

Measure Costs for High Bay Induction PSMH/CMH Fixtures

Measure	MMID	Cost ($)
HB PSMH, CMH, IND Replacing 250 Watt HID	3090, 3815	$100.00
HB PSMH, CMH, IND (250 Watt or Less) Replacing 400 Watt HID	3076, 3817	$240.00
HB PSMH, CMH, IND (250 Watt or Less) Replacing 320-400 Watt HID NC (Based on 320 watt savings)	3075, 3816	$290.00
HB PSMH, CMH, IND (365 Watt or Less) Replacing 400 Watt HID	3077, 3818	$240.00
HB IND 750 Watt High Bay Replacing 1,000 Watt HID	3074	$750.00

Assumptions

Hours of operation and coincidence factor based on sector. Induction wattage shown includes ballast wattage, which was calculated as 10% of lamp wattage based on the manufacturer specifications. 250-watt HID high bay replacements of ≤ 155 watts weighted as follows:

- Baseline = 100% 250-watt HID
- Eligible Replacements = 16.6% 120-watt to 125-watt induction, 16.6% 150-watt induction, 16.6% 165-watt induction,16.6% 125-watt PSMH or CMH, 16.6% 140-watt PSMH or CMH, and 16.6% 150-watt PSMH or CMH

320-watt HID high bay replacements of ≤ 250 watts weighted as follows:

- Baseline = 100% 320-watt HID
- Eligible Replacements = 16.6% 200-watt induction, 16.6% 225-watt induction, 16.6% 165-watt induction, 16.6% 200-watt PSMH or CMH, 16.6% 210-watt PSMH or CMH, and 16.6% 220-watt PSMH or CMH

400-watt HID high bay replacements of ≤ 365 watts weighted as follows:

- Baseline = 100% 400-watt HID
- Eligible Replacements = 16.6% 250-watt induction, 16.6% 300-watt induction, 16.6% 250-watt PSMH or CMH, 16.6% 270-watt PSMH or CMH, 16.6% 315-watt PSMH or CMH, and 16.6% 320-watt PSMH

1,000-watt HID high bay replacements of ≤ 800 watts weighted as follows:

- Baseline = 100% 1,000-watt HID
- Eligible Replacements = 50% 750-watt induction, and 50% 575-watt PSMH or CMH

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. Based on market research.
3. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
4. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.

Revision History

Version Number	Date	Description of Change
01	12/2012	Initial TRM entry
02	09/2015	Updates and revisions

Motors and Drives

Ag, VFD, Field Irrigation Pump

	Measure Details
Measure Master ID	VFD, Variable Torque, Irrigation Well Pump, 3776
Measure Unit	Per motor controlled hp
Measure Type	Hybrid
Measure Group	Motors & Drives
Measure Category	Variable Speed Drive
Sector(s)	Agriculture
Annual Energy Savings (kWh)	Varies by unit size
Peak Demand Reduction (kW)	Varies by unit size
Annual Therm Savings (Therms)	0
Life-cycle Energy Savings (kWh)	Varies by unit size
Life-cycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	$130.00[2]

Measure Description

Variable frequency drives installed on well pumps serving crop irrigation systems have the potential to save both summer peak kW and kWh by adjusting the pump motor speed to match the load. Pumps are often sized to provide water to multiple ‘pivots’ (irrigation heads) that do not all run simultaneously at all times. Irrigation pivots sometimes direct water further when an adjustable arm is used to reach a corner of the field, and are periodically used to push water up an incline. A VFD adjusts the pump motor speed to meet the conditions, saving both energy and demand.

Description of Baseline Condition

The baseline system is an irrigation pump motor operating with or without some sort of non-VFD-provided pressure control attached to irrigation heads.

Description of Efficient Condition

In the efficient condition there is a VFD installed, so the pump motor can be sped up and down as necessary to meet the appropriate demand for water depending on well water depth and number of pivots at any given time. A crop irrigation water pump must operate ≥ 1,000 hours per year. This measure is only eligible for pumps not currently using VFD control, not for end of life VFD replacement.

Annual Energy-Savings Algorithm

The energy-saving algorithm and corresponding curve tables used for this measure were calculated using a spreadsheet tool based on flow control curves operational values (as determined from an engineering bulletin[4] as well as savings calculators[5,6] from two different VFD manufacturers).

$kWh_{SAVED} = kWh_{BASE} - kWh_{VFD}$

$kWh_{BASE} = \Sigma(Watts_{BASE\_i} * CAP_i * hours) / 1{,}000$

$kWh_{VFD} = \Sigma(Watts_{VFD\_i} * CAP_i * hours) / 1{,}000$

Where:

$Watts_{BASE\_i}$ = Power draw of pump motor based on baseline flow control type full load percentage, with the baseline flow control type being user defined, and defaulting to ‘on/off’ if not known (= varies; see Pump Power Curve table below)

CAP_i = Percentage of time motor runs at capacity i, where CAP_i add to 100% (= varies; see Focus on Energy Default Loading Curve table below)[3]

hours = Average hours per year the irrigation pump operates (= user defined)

1,000 = Kilowatt conversion factor

$Watts_{VFD\_i}$ = Power draw of the pump motor controlled by VFD at capacity i (= varies; see Pump Power Curve table below)

Focus on Energy Default Loading Curve

Capacity (GPM)	Time at Capacity (CAP_i)
10%	0%
20%	0%
30%	0%
40%	0%
50%	20%
60%	0%
70%	60%
80%	0%
90%	20%
100%	0%

Pump Power Curves

Capacity (GPM)	Type of Flow Control (Percentage of Full Load Power at Different Flow Capacities)					
	$\text{Watts}_{\text{BASE\_i}}$					$\text{Watts}_{\text{VFD\_i}}$
	Outlet Control Valve	Bypass Valve	Eddy Current Clutch	Torque Converter	On/Off	VFD
10%	61.39%	102.00%	17.04%	18.16%	100.00%	19.12%
20%	67.19%	102.00%	19.98%	24.92%	100.00%	14.32%
30%	72.61%	102.00%	25.03%	33.38%	100.00%	13.05%
40%	77.65%	102.00%	32.01%	43.12%	100.00%	15.30%
50%	82.31%	102.00%	40.75%	53.72%	100.00%	21.07%
60%	86.59%	102.00%	51.06%	64.76%	100.00%	30.37%
70%	90.49%	102.00%	62.77%	75.81%	100.00%	43.19%
80%	94.01%	102.00%	75.69%	86.46%	100.00%	59.53%
90%	97.15%	102.00%	89.64%	96.29%	100.00%	79.40%
100%	99.91%	102.00%	104.45%	104.88%	100.00%	102.79%

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (kW_{BASE} - kW_{VFD}) * CF$

$kW_{BASE} = \Sigma(\text{Watts}_{BASE\_i} * CAP_i) / 1{,}000$

$kW_{VFD} = \Sigma(\text{Watts}_{VFD\_i} * CAP_i) / 1{,}000$

Where:

CF = Coincidence factor (= varies; appropriate kW demand reduction on hybrid calculation determined using table below)

Coincidence Factor Determination

"Do you regularly irrigate your field crops during 1:00 p.m. to 4:00 p.m. during June, July, and August?"	Proposed Coincidence Factor
(> 90% of the time)	1.00
(90% - 51% of the time)	0.66
(50% - 10% of the time)	0.33
(< 10% of the time)	0.00

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[1]

Assumptions

The VFD speed (for variable torque applications) must be automatically controlled by differential pressure, flow, or other variable signal. The irrigation system controlled must have significant load diversity that will result in savings through motor speed variation. Conditions requiring the motor to be loaded consistently above 90% or consistently loaded below 50% are not eligible for this incentive, as these operating conditions will not realize sufficient savings from proposed VFD savings calculation.

Sources

1. Efficiency Vermont. Technical Reference Users Manual: Measure Savings Algorithms and Cost *Assumptions.* pg. 20. August 9, 2013. Available online: http://www.greenmountainpower.com/upload/photos/371TRM_User_Manual_No_2013-82-5-protected.pdf
2. Navigant Consulting. *NEEP Incremental Cost Study Phase Two Final Report.* January 2013. Available online: http://www.neep.org/incremental-cost-study-phase-2
3. Baldor Electric Company. *The Energy Independence and Security Act of 2007: The law's requirement for 1 to 500 hoursepower AC motors Effective December 19,2010*. pg. 10. January 23, 2009. Available online: http://www.baldor.com/mvc/DownloadCenter/Files/MS501
4. Westinghouse. *Flow Control*. Bulletin B-851, F/86/Rev-CMS 8121.
5. ABB. "PumpSave." Last updated 2016. http://www.abb.com/product/seitp322/5fcd62536739a42bc12574b70043c53a.aspx
6. Toshiba Tool: (set filters to product family=drives and download type=software, look for "Cost Savings Estimator"): http://www.toshiba.com/ind/downloads_main.jsp

Revision History

Version Number	Date	Description of Change
01	10/08/2015	Initial release

VFD, Diary Milk Pump,Agriculture

	Measure Details
Measure Master ID	VFD, Dairy Milk Pump, Agriculture, 3797
Measure Unit	Per pound of milk cooled per day
Measure Type	Prescriptive
Measure Group	Motors & Drives
Measure Category	VFD
Sector(s)	Agriculture
Annual Energy Savings (kWh)	0.3304
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	4.9553
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	$3,004.00[2]

Measure Description

Milk pumps in dairy milking operations move the milk into a well-water plate cooler before it flows to the mechanical cooling system. The milk flow is usually not consistent as it comes from the cows. Since the load on the milk pump changes as the flow of milk varies during the milking process, quite often milk may either surge or trickle into the well water plate cooler throughout the milking cycles, reducing the effectiveness of heat transfer across the plate cooler heater exchanger fins. By slowing the milk pump flow rate, a greater water to milk flow ratio is achieved, increasing heat transfer between the milk and well water. A VFD or VSD provides the necessary control of the milk pump for a slower, more consistent and even flow of milk through the plate cooler. The well water being pumped through the plate cooler serves as the milk coolant, and is assumed to be reused for other farm needs, typically as water for animal consumption.

Description of Baseline Condition

The baseline condition is a milk pump motor operating at full speed to transfer milk from the receiver jar to the plate cooler without any variable speed milk pump flow control.

Description of Efficient Condition

The efficient condition is to install a VFD to control the milk pump and slow the milk flow through the plate cooler, increasing the effectiveness of heat transfer between the milk and well water. Slowing milk flow can cool milk coming out of the plate cooler by several additional degrees, up to a maximum of

15°F.[6] These extra degrees of essentially 'free' cooling equates to the refrigeration system compressor needing less energy to cool the milk down to its final storage temperature of approximatley 38°F. Under the right circumstances, the maximum milk temperature from the plate cooler, in conjunction with a VFD on the milk pump, can be within 4°F of well water temperature.[4]

Annual Energy-Savings Algorithm

The prescriptive deemed savings are based on an average per pound of milk per day cooled on a dairy farm as calculated using the hybrid calculations on file with past applications.[2]

kWh_{SAVED} = lbs of Milk * $C_{P,MILK}$ * ΔT_{MILK} * 365 / $EER_{COMPRESSOR}$ / 1,000

Where:

lbs of Milk = Estimated daily pounds of milk produced by the dairy farm that needs to be cooled through use of a milk pre-cooler (= 22,800)[3]

$C_{P,MILK}$ = Specific heat of milk (= 0.94 Btu/(lb-°F))[5]

ΔT_{MILK} = Temperature difference between the output of plate-cooler milk before and after the use of variable speed control on the milk pump. The average plate cooler milk temperature without VFD control is 66.41°F.[3] The use of VFD control on the milk pump can help decrease milk temperature in the plate cooler to within no more than an estimated 4°F of the well water temperature.[4,7] The lowest plate cooler theoretical milk temperature with VFD control is 52.3°F.[7] + 4°F = 56.3°F (Final ΔT_{MILK} value= 66.41°F - 56.3°F = 10.11°F)

365 = Number of milking days per year

$EER_{COMPRESSOR}$ = Energy efficiency ratio of compressor (~ 8.4 Btu/watt for a reciprocating compressor; ~ 10.5 Btu/watt) for a scroll compressor).[6] For purposes of this calculation, use the EER for a scroll compressor, as these are starting to become much more common and the standard for new dairy refrigeration equipment, and it provides a slightly more conservative savings values.

1,000 = Kilowatt conversion factor

Using the algorithm above and the stated values yields a total savings of approximately 7,532 kWh. (7,532 annual kWh / 22,800 daily lbs of milk = 0.3304 annual kWh/daily pound of milk).

Summer Coincident Peak Savings Algorithm

There are no summer coincident peak savings for dairy milk pump VFDs. Research of refrigeration compressor power demands reveals no substantial evidence that any notable demand reduction is possible in relation to using a VFD with a milk pre-cooler to pre-cool milk that would otherwise need to be chilled through mechanical refrigeration.

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[1]

Assumptions

The electric savings value does not account for the potential of electric savings on the milk pump itself due to the VFD usage; this is because milk pumps are typically ≤ 2 HP, and savings are minimal compared to savings from the refrigeration compressor. The purpose of installing variable speed control on a milk pump is not to achieve savings from the pump itself, and these savings are minor.

This measure refers to using a VFD to provide milk pump control; however, VSDs are also eligible if they adequately reduce the speed of the milk pump to achieve higher well water to milk flow ratios (e.g., from 1:1 to 2:1).

Deemed savings values listed include the mix of both single and double pass plate coolers used on Wisconsin farms in conjunction with VFD on milk pump installations. Single and double pass plate coolers are assumed to achieve around 25°F and 35°F, respectively, of milk cooling without a VFD controlling the milk pump.[6] (The average value of milk cooling from the plate cooler alone determined from the sample of actual project data is (98°F - 66.41°F = 31.59°F).

The measure savings are based on an assumed well water temperature of 52.3°F used as milk coolant.[7] It is assumed the lowest milk temperature that could be achieve is 56.3°F (or 4°F higher than well water coolant temp)[4] and that the maximum additional cooling for any style of plate cooler in conjunction with a variable speed controlled milk pump is 15°F of additional cooling.[8]

The savings calculation does not account for the pump energy needed to pump the cold well water through the plate cooler; since the plate cooler output of warmed well water is then used for animal watering, this water pumping would normally already occur for animal watering needs.

Sources

1. California Energy Commission and California Public Utilities Commission. *Database for Energy Efficient Resources.* 2008. http://www.energy.ca.gov/deer/
2. *Vermont Technical Reference Manual.* Page 24. August 2013. Available online: http://www.greenmountainpower.com/upload/photos/371TRM_User_Manual_No_2013-82-5-protected.pdf
3. Internal Implementer sheet: 'Ag VFD Milk Pump Analysis' showing a sample of 79 projects submitted to Wisconsin Focus on Energy for the old hybrid VFD milk pump measure from January 2013 through December 2015. Project reported values important for this workpaper were averaged for the 79 sample projects and used in the savings algorithms above to arrive at the stated prescriptive savings.
4. EnSave. "Milk Pump Variable Speed Drive." http://www.usdairy.com/~/media/usd/public/ensavemilkpumpvariablespeeddrive.pdf
5. Journal of Food Engineering. "Determination of specific heat of milk at different fat content between 1C and 59C using micro DSC." Jin Hu. (Table 1) *(Units converted from J/(g*K) to BTU/(lb*°F)).*
6. Sanford, Scott (Senior Outreach Specialist Biological Systems Engineering at University of Wisconsin-Madison). "Energy Efficiency for Dairy Enterprises." Presentation to AgSG program. December 2014. Supporting slides available online: http://farmenergymedia.extension.org/sites/default/files/Dairy%20Energy%20Conservation-2013.pdf (Compressor EER default estimate values as presented and based on Sanford's past project studies were used in this workpaper calculation to account for a generic cooling system efficiency with each respective compressor type).
7. U.S. Department of Energy. "Domestic Hot Water Scheduler." Average water main temperature of all locations measured in Wisconsin by scheduler, weighted by city populations.
8. Sanford, Scott. 2004c. "Energy Conservation in Agriculture: Variable Speed Milk Pumps." University of Wisconsin - Cooperative Extension Publication (A3784-7). Madison, Wisconsin: University of Wisconsin.

Revision History

Version Number	Date	Description of Change
01	09/30/2015	New measure

VFD, Vacuum Pump, Agriculture

	Measure Details
Measure Master ID	VFD, Dairy Vacuum Pump, Agriculture, 3798
Measure Unit	Per pound of milk pumped per day
Measure Type	Prescriptive
Measure Group	Motors & Drives
Measure Category	VFD
Sector(s)	Agriculture
Annual Energy Savings (kWh)	1.0465 kWh
Peak Demand Reduction (kW)	0.0001 kW
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	15.6975 kWh
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	$4,014.00[2]

Measure Description

Vacuum pumps in dairy milking operation create suction to extract milk from the cow and move the milk to the mechanical cooling system. The vacuum pump is also typically used to flush warm wash water through the milk pipeline to clean it between milkings in order to prevent bacteria growth. The load on the pump changes between attachments (moving milkers from one cow to the next), as one quarter is emptied and a teat cup drops off, and different amounts of milk is moving through the system at any given time.

An alternate way to control the motor systems is using VFDs to physically slow the pump motors. These reduced flow rates save a considerable amount of energy when the suction load drops in the system. If the total CFM demand of vacuum pump falls below 35% of rated pump speed, the pump motor will start to overheat. Therefore, the pump CFM produced for milking or washing needs to have ≥ 35% of the rated CFM of the pump.[3] The average amount of milk pumped per day based on sample project data comes out to around 17,868 pounds;[5]this value is used to determine the measure unit value for the average deemed savings.

Description of Baseline Condition

The baseline condition is a vacuum pump motor operating at full speed when used to handle the demand of the vacuum pump for milking operation, as well as for cleaning the milk pipeline. The only control for the vacuum pump in the baseline condition is a conventional type of vacuum pump regulator, which acts to throttle the flow of a vacuum pump in order to control the suction pressure.

Description of Efficient Condition

The efficient condition is to install a VFD or VSD on the motor to vary the electric frequency (Hertz) going into the motor that allows for varying the motor speed. The VSD will be automatically controlled by a vacuum or pressure sensor/transducer that measures the changes in pressure in the milking suction system during milking and washing cycles.

Customer can buy a variable speed vacuum pump from a manufacturer that includes a vacuum pump and all variable speed control components in one package, ready to install. Customer may also retrofit an existing baseline vacuum pump setup by installing an appropriate off-the-shelf VSD and additional sensor/transducer components, if not already present, to achieve variable speed control for the pump. Each variable speed vacuum pump setup is different. The VSD controlling the pump should have a control sequence (typically PID control) tuned to meet the appropriate suction needs of the milking operation as part of the equipment installation and commissioning process.

Annual Energy-Savings Algorithm

The prescriptive deemed savings are based on the average pounds of milk per day cooled on a dairy farm, as calculated using the hybrid calculations on file with past applications.[2]

$kWh_{SAVED} = kWh_{NO\_VFD} – kWh_{W/VFD}$

kWh_{NO_VFD} = Pump HP * 0.746 * Motor Load / Motor Eff * (Annual milking hours + Annual washing hours)

$kWh_{W/VFD}$ = ($kW_{Milking}$ * Annual milking hours + kW_{Wash} * Annual washing hours)

$kW_{MILKING}$ = (0.05 * (Larger of: (*2 CFM/milking unit * # of milking units)* **OR** *Minimum Pump Capacity*) + 1.7729[3,4]

$kW_{WASHING}$ = (0.05 * 5 CFM/milking unit) * (# of milking units + 1.7729)[3,4]

Where:

kWh_{NO_VFD} = Baseline condition

$kWh_{W/VFD}$ = Efficient condition

Pump Hp = Motor horsepower of the pump (~ 10 HP,[4] producing around 100 CFM of suction)[3]

0.746 = Horsepower to kilowatt conversion factor

Motor Load = Estimated percentage of full load for motor (~ 90%)

Motor Eff = Motor efficiency, based on motor HP and NEMA energy efficient full load motor efficiency ratings (~ 89.5%)[5]

Annual milking hours = 365 days * # of milkings per day (~ 2.45) * Hours per milking (~ 4.92)[5]

Annual washing hours = 365 days * # of milk pipeline washings per day (~ 2.45) * Vacuum pump washing run time (~ 0.75 hours)[5]

0.05 = Formula constant, Regression coefficient for average ASD speed and processed milk units [3,4]

2 CFM/milking unit = Formula constant for vacuum pump milking operation[3,4]

Minimum pump capacity = Minimum speed of 35% that the constant torque vacuum pump needs to keep to prevent from overheating the pump/motor (100 CFM * 35% = 35 CFM)[3]

1.7729 = Formula constant, Regression coefficient for average ASD speed and processed milk units [3,4]

5 CFM/milking unit = Formula constant for vacuum pump washing operation[3,4]

# of milking units = Number of milking units controlled by the vacuum pump, based on an average of Spectrum project data (~ 15.79)[5]

The formula above yields an average project savings of approximately 18,700 kWh. Converting that to the prescriptive base unit yields: (18,700 kWh / 17,868 lbs of milk per day ~ 1.0465 kWh/lb of milk per day).

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = [(Pump HP * 0.746 * Motor Load / Motor Eff) – $kWh_{W/VFD}$ / (Annual milking hours + Annual washing hours)] * CF

Where:

CF = Coincidence factor (~ 0.45)

The kW demand reduction is calculated as an average, and is only counted for dairy farms that milk at least three times per day, as it is assumed that a dairy farm will be running their vacuum pump during the demand period for one milking time every day in this scenario (1:00 p.m. to 4:00 p.m.). Based on project data used for this workpaper, approximately 45% of the sample milked more than twice a day and are eligible for claiming kW savings. Therefore, a CF of 0.45 is used in the savings algorithm above. The defined values stated above lead to an average savings of 1.6596 kW after the CF is applied. It is assumed that the same demand power requirements are needed during every milking operation of the day.

The formula and description above yields an average project savings of approximately 1.6596 kW. Converting that to the prescriptive base unit yields: (1.6596 kW / 17,868 lbs of milk per day ~ 0.0001 kW/lb of milk per day).

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[1]

Assumptions

The average milk production per cow in Wisconsin is around 75 pounds per producing cow, based on information submitted by customers and presented by Scott Sanford of UW-Madison.[3] Some reports stating a lower average production appear to be including the animals' 'dry' time prior to freshening into the equation. For the purpose of the savings calculation, we consider only the producing animals in the dairy.

This measure is based on the assumption that the vacuum pump is large enough to produce the total CFM suction required for all the milking and washing operational needs. It is assumed that each HP of vacuum pump size equates to ~ 10 CFM of suction.[3] The variable speed energy savings calculation is based on information performed and presented by Scott Sanford regarding the energy reduction achieved through VSD vacuum pumps on four farms.[3,4]

It is assumed that the correct sized VSD is installed to control the vacuum pump properly across its operating range.

Finally, 365 days per year of milking operations is assumed.

Sources

1. California Energy Commission and California Public Utilities Commission. *Database for Energy Efficient Resources.* 2014. Available online: http://www.energy.ca.gov/deer
2. Vermont Technical Reference Manual. Page 22. March 16, 2015. (VFD milk pump cost = $4,014.00 based on Vermont project data from 2003-2012). Available online: http://psb.vermont.gov/sites/psb/files/docketsandprojects/electric/majorpendingproceedings/TRM%20User%20Manual%20No.%202015-87C.pdf

3. Sanford, Scott (Senior Outreach Specialist Biological Systems Engineering at University of Wisconsin-Madison). "Energy Efficiency for Dairy Enterprises." Presentation to AgSG program. December 2014. Supporting slides available online: http://farmenergymedia.extension.org/sites/default/files/Dairy%20Energy%20Conservation-2013.pdf
4. Sanford, Scott. "Milking System Air Consumption When Using a Variable Speed Vacuum Pump." 2003. http://www.uwex.edu/uwmril/pdf/RuralEnergyIssues/Dairy/ASAE_033014_Sanford_MSAirConsumption.pdf
5. Internal Implementer 'Ag VFD Vacuum Pump Analysis' spreadsheet showing sample data of 78 hybrid vacuum pump projects entered in Spectrum from January 2013 through December 2015. The average input values for the savings algorithms were used from the project inputs of these 78 sample projects.

Revision History

Version Number	Date	Description of Change
01	09/30/2015	New measure

Other

DEET Behavioral Savings

	Measure Details
Measure Master ID	DEET, Savings Period 1, 3652 DEET, Savings Period 2, 3653 DEET, Savings Period 3, 3654 DEET, Savings Period 4, 3655 DEET, Savings Period 5, 3656 DEET, Savings Period 6, 3657 DEET, Savings Persistence, 3658
Measure Unit	Per building
Measure Type	Hybrid
Measure Group	Other
Measure Category	Whole Building
Sector(s)	Schools & Government
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	Varies by measure
Annual Therm Savings (Therms)	Varies by measure
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	Varies by measure
Water Savings (gal/yr)	0
Effective Useful Life (years)	3[1]
Incremental Cost ($/unit)	$12,000.00[2]

Measure Description

According to the U.S. Environmental Protection Agency, 30% of a district's total energy may be used inefficiently or unnecessarily.[3] Schools have a considerable opportunity to reduce energy consumption and district energy costs. Recommended behavior changes that will conserve energy include turning off unnecessary lights, shutting down computers, reducing phantom loads, and disseminating regular energy conservation reminders.

This measure is a series of behavioral incentives based on savings measured directly from utility bills in K-12 schools every six months for three years. The amount of kW, kWh, and therm savings incentives is determined by comparing reporting period utility bills to an established baseline (12 months prior to starting the initiative). Program/sector kW, kWh, and therms savings are determined by comparing reporting period consumption to previous year consumption using utility bills.

Description of Baseline Condition

The baseline condition is a school building that has not completed any measures incented by Focus on Energy within 12 months. In addition, participating buildings must not be planning for major renovations and/or energy upgrades within three years from the start of initiative.

Description of Efficient Condition

DEET participants will use less energy than their baseline by expanding management-driven savings to include occupant behavioral energy savings, sustaining energy reductions, increasing occupancy involvement in energy reduction initiatives, and increasing occupants' realization of the financial and environmental impact of individual and group energy consumption.

Annual Energy-Savings Algorithm

kWh and therms savings are calculated every six months for three years (for a total of six calculation/reporting periods). Measured savings will use the previous year consumption as a baseline.

$kWh_{SAVED} = kWh_{BP} - kWh_{RP}$

$Therms_{SAVED} = Therms_{BP} - Therms_{RP}$

$Therms_{BP} = (Therms_{BPACT}) * (HDD_{30YRAVG} / HDD_{BP})$

$Therms_{RP} = Therms_{NORM} = (Therms_{RPACT}) * (HDD_{30YRAVG} / HDD_{RP})$

Where:

kWh_{BP} = Electrical consumption during baseline period (= varies by building)

kWh_{RP} = Electrical consumption during reporting period (= varies by building)

$Therms_{BP}$ = Natural gas consumption during baseline period (= varies by building)

$Therms_{RP}$ = Natural gas consumption during reporting period (= varies by building)

$Therms_{BPACT}$ = Actual natural gas consumption during baseline period (= varies by building)

$HDD_{30YRAVG}$ = 30-year average heating degree days

HDD_{BP} = Heating degree days during baseline period (= varies by year)

$Therms_{NORM}$ = Natural gas consumption normalized for heating loads (= varies by building)

$Therms_{RPACT}$ = Actual natural gas consumption for reporting period (= directly from utility bill; varies by building)

HDD_{RP} = Heating degree days during reporting period (= varies by year)

Summer Coincident Peak Savings Algorithm

There will be no peak savings for Periods 1, 3, and 5. For Periods 2, 4, and 6, the monthly kW for June, July, and August of the reporting year is averaged and used as the kW_{RP}.

$kW_{SAVED} = kW_{BP} - kW_{RP}$

Where:

kW_{BP} = Average monthly kW usage for baseline year (= average of $kW_{JUNE} + kW_{JULY} + kW_{AUG}$; varies by building)

kW_{RP} = Average monthly kW usage for reporting year (= average of $kW_{JUNE} + kW_{JULY} + kW_{AUG}$; varies by building)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 3 years)[1]

Assumptions

The 30-year average HDDs per month by Wisconsin city are provided in the table below.

30-Year HDD[4] Values Per Month by Wisconsin City

Month	Milwaukee	Green Bay	Wausau	Madison	La Crosse	Minocqua	Rice Lake
January	1,443	1,591	1,440	1,561	1,623	1,632	1,623
February	1,211	1,238	1,313	1,272	1,200	1,293	1,455
March	934	1,019	1,278	844	911	1,222	1,125
April	595	630	550	607	514	574	531
May	358	265	460	217	242	321	414
June	126	87	39	105	80	124	84
July	29	38	33	18	10	73	45
August	36	74	54	45	40	97	64
September	116	182	143	233	186	294	185
October	471	560	568	568	522	528	571
November	817	932	844	916	861	969	1,007
December	1,262	1,288	1,261	1,404	1,373	1,665	1,624
Total	**7,398**	**7,903**	**7,982**	**7,791**	**7,561**	**8,793**	**8,726**

The incremental cost of $12,000 per building was based on the following assumptions:

- According to project experience, we assumed that staff will spend approximately 45 minutes per month on the DEET Initiative, doing activities such as reviewing DEET-related emails and reports, addressing energy topics in staff meetings, and discussing energy with students.
- We assumed an average staff wage of $30/hour based on working 1,500 hours for the median teacher salary of $45,227 in La Crosse, Wisconsin.[5] (Note: administrators have a higher salary and support staff will have a lower salary). The total, at $30/hour multiplied by 0.75 hour/month and 9 months/year, is $202.50 (rounded to $200).
- We assumed an average of 50 staff per building based on field experience ($200 multiplied by 50 staff/building = $10,000/building).
- Finally, based on rough estimates from general data available to the program, we assumed each building would spend an average of $2,000 in buildings and grounds discretionary funds on small energy projects (such as replacing incandescent/CFLs with LEDs, installing timers and/or power strips, and adding LED task lighting or vending misers). Since this is the first time an initiative like DEET has been proposed in Wisconsin, we concluded that an incremental cost of $10,000 for staff time and $2,000 for energy projects per building is reasonable and appropriate.

Sources

1. Skumatz, Lisa A. “Measuring the Impacts of Behavior Change Programs: Filling in the Blanks.” 2012 ACEEE Summer Study on Energy Efficiency in Buildings. Available online: http://beccconference.org/wp-content/uploads/2013/12/Hannah-Arnold_BECC-Presentation-FINAL-2013-11-20.pdf
2. Staff estimate- $2000.00 for energy projects + $10000.00 average staff time in average-sized building
3. United States Environmental Protection Agency. Schools: An Overview of Energy Use and Energy Efficiency Opportunities. 2006. Available online: http://www.energystar.gov/ia/partners/publications/pubdocs/Schools.pdf
4. Renewable Resource Data Center, National Renewable Resource Laboratory. National Solar Radiation Database (Base of 65°F) Typical Meteorological Year 3. Available online: http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html
5. Public School Teacher Salaries, La Crosse, WI. 2015. Available online: http://www1.salary.com/WI/La-Crosse/Public-School-Teacher-salary.html

Revision History

Version Number	Date	Description of Change
01	09/01/2015	New measure

Process

Process Exhaust Filtration

	Measure Details
Measure Master ID	Process Exhaust Filtration, 3244
Measure Unit	Per CFM
Measure Type	Hybrid
Measure Group	Process
Measure Category	Filtration
Sector(s)	Commercial, Industrial
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by project
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	Varies by project
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1,2,3]
Incremental Cost ($/unit)	$2.89/CFM[6]

Measure Description

Process exhaust air filtration systems save energy by reducing the heat load on a make-up air system by recirculating filtered process air instead of bringing in colder outdoor make-up air during the heating season. Energy savings result from the reduced temperature difference through the heat exchanger of the supply air system. The temperature difference between the filtered indoor air and the indoor supply air temperature is much lower than the difference between outdoor air and indoor supply air temperature. This reduction in heat load results in natural gas savings.

Exhaust filtration systems typically use cartridge filters and are frequently found in welding fume exhaust and paint booth exhaust applications. This measure is incented per CFM of make-up air eliminated and savings will be realized in industrial and service facilities. Systems must run a minimum of 2,000 hours annually in order to be eligible.

Description of Baseline Condition

The baseline condition is 100% of process exhaust fumes being evacuated from the space associated with the industrial process, with ventilation provided by 100% outside air with heating provided by a natural gas fired make-up air unit.

Description of Efficient Condition

The efficient condition is a filtration system that reduces or eliminates the need to discharge 100% of process exhaust by filtering and recirculating the air and thereby reducing or eliminating make-up air demand and associated heating energy.

Annual Energy-Savings Algorithm

$\text{Btu/°F} = \text{CFM} * \text{Specific Heat}$

$\text{Btu}_{\text{SAVED}} = \text{Btu/°F} * \Delta\text{T} * \text{HOURS}$

$\text{Therm}_{\text{SAVED}} = \text{BTU}_{\text{SAVED}} / (\text{System Efficiency} * 100{,}000)$

Note: Fan energy savings are neglected for this measure, as eliminating the makeup air fan is offset by the increased energy usage of the exhaust fan due to static pressure increases.

Where:

BTU/°F = Energy required to heat volume of make-up air for each additional degree Fahrenheit

CFM = Volumetric flow rate of eliminated make-up air unit (= actual)

Specific Heat = 1.08 Btu/hr/CFM-°F (dry air)

$\text{BTU}_{\text{SAVED}}$ = Total energy required to heat eliminated make-up air

ΔT = Difference between average indoor temperature and average outside winter temperature

HOURS = Annual hours requiring exhaust (= actual)

$\text{Therm}_{\text{SAVED}}$ = Natural gas energy required to heat make-up air before eliminated

System Efficiency = Heating efficiency of make-up air system (= actual)

100,000 = Conversion from Btu to therm

Summer Coincident Peak Savings Algorithm

There are no peak savings associated with this measure.

Lifecycle Energy-Savings Algorithm

$\text{Therm}_{\text{LIFECYCLE}} = \text{Therm}_{\text{SAVED}} * \text{EUL}$

Where:

EUL = Effective useful life (15 years)[1,2,3]

Assumptions

The average inside temperature, 65°F, assumed to equal design temperature. Average outdoor winter temperature of 30.8°F.[5] (Therefore ΔT = 65°F – 30.8°F = 34.2°F).

Sources

1. Using current EULs, rooftop units are very similar to the industrial ventilation system but without a heating or cooling coil. Focus on Energy currently uses a 15 year EUL for rooftop units.
2. Chartered Institution of Building Services Engineers. "Probabilistic Estimation Of Service Life." http://www.cibse.org/knowledge/cibse-technical-symposium-2011/probabilistic-estimation-of-service-life. The industrial ventilation system would consist of a fan and a set of filters; fan EUL is 15 to 20 years depending on type and filter EUL is 15 to 20 years depending on type.
3. Wisconsin DOA guideline document for lifecycle costing of state building projects. Page 36 lists 10 to 20 years for rooftop units and 15 to 30 years for fans depending on type.
4. SPECTRUM historical projects (custom projects that implemented comparable measures).
5. Focus on Energy Deemed Savings Manual.
6. Historical Focus on Energy project data, 2013. 8 projects, average total cost of process exhaust filtration is $2.89 per CFM.

Revision History

Version Number	Date	Description of Change
01	07/2015	Initial TRM entry

Pressure Screen Rotor

	Measure Details
Measure Master ID	Pressure Screen Rotor, 2496
Measure Unit	Per horsepower
Measure Type	Hybrid
Measure Group	Process
Measure Category	Specialty Pulp & Paper
Sector(s)	Industrial
Annual Energy Savings (kWh)	Varies by horsepower
Peak Demand Reduction (kW)	Varies by horsepower
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by horsepower
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[2]
Incremental Cost ($/unit)	$200.77/hp[3]

Measure Description

Paper mills use pressure screens to separate contaminants from the pulp produced from recycled products. A motor is used to spin the rotor at a high velocity, forcing the pulp through narrow slots or apertures that are a barrier to debris, stickies, contaminates, and uncooked or undeveloped bundles of wood fibers (shives). This makes contaminate-free pulp available for further processing.

Pressure screen rotors are an energy-efficient method of removing large contaminants from pulp stock. The new dual element foil design more efficiently removes the contaminants while using less power.

Description of Baseline Condition

The baseline technology for removing contaminants is with a narrow slotted screen.

Description of Efficient Condition

The efficient condition is a pressure screen rotor design.

Annual Energy-Savings Algorithm

There are two methods for estimating savings. The first method relies on pre-retrofit and post-retrofit amp measurements from the participant application; the second method determines deemed savings using an energy savings factor of 30% based on Focus on Energy project history.

Method #1: Custom Approach (Amps Known)

$kWh_{SAVED} = (Amps_{PRE} - Amps_{POST}) * 1.73 * V * PF * Hrs/wk * Weeks$

Method #2: Deemed Approach (Amps Unknown)

$kWh_{SAVED} = HP * LF / Eff * 0.746 * S * Hrs/wk * Weeks$

Where:

$Amps_{PRE}$ = Pre-retrofit pulper amps (= actual; requested in program application or measured)

$Amps_{POST}$ = Post-retrofit pulper amps (= actual; requested in program application or measured)

1.73 = Constant to calculate kWh

V = Voltage of pulper (= actual; requested in program application or reported by customer)

PF = Power factor (= actual reported by customer or deemed 0.75)

Hrs/wk = Hours per week (= actual; requested in program application or reported by customer)

Weeks = Weeks of operation per year (= actual; requested in program application or reported by customer)

HP = Motor horsepower (= actual; reported by customer)

LF = Motor load factor (= actual reported by customer or deemed 65%)

Eff = Estimated motor efficiency (= actual reported by customer or deemed 92%)

0.746 = Conversion HP to Watts

S = Deemed savings factor (= 30%)[1]

Summer Coincident Peak Savings Algorithm

Method #1: Custom Approach (Amps Known)

$kW = (Amps_{PRE} - Amps_{POST}) * 1.73 * V * PF$

Method #2: Deemed Approach (Amps Unknown)

$kW = HP * LF / Eff * 0.746 * S$

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[2]

Sources

1. Focus on Energy industrial sector project history. 2013.
2. Engineering judgement.
3. Historical Project Data, 2016. Large Energy User Program. 7 projects, 4/2011 to 7/2014. Average cost is $200.77 per hp

Revision History

Version Number	Date	Description of Change
01	05/2015	Initial TRM entry

Repulper Rotor

	Measure Details
Measure Master ID	Repulper Rotor, 2538
Measure Unit	Per horsepower
Measure Type	Hybrid
Measure Group	Process
Measure Category	Specialty Pulp & Paper
Sector(s)	Industrial
Annual Energy Savings (kWh)	Varies by amperage
Peak Demand Reduction (kW)	Varies by amperage
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by amperage
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[3]
Incremental Cost ($/unit)	$343.17/hp[4]

Measure Description

A repulper is a large tank with a mixer, or rotor, on the bottom. Pulping rotors are rebuilt or replaced periodically, providing facility managers with the opportunity to investigate new repulper rotors for their facility. Manufacturers of paper process equipment designed new energy-efficient repulper rotors to help offset rising energy costs, including energy-efficient repulper rotors (HM rotors, new energy efficient repulping blades) replacing conventional HOG-type rotors (bexisiting conventional repulping blades, baseline). HM rotors have a tall, swept-back blade design that provides effective turbulence of the fiber suspension product and maximizes rotor fiber contact while consuming less horsepower than conventional rotors.

Description of Baseline Equipment

The baseline technology is a HOG rotor.

Description of Efficient Equipment

The efficient condition is a HM rotor.

Annual Energy-Saving Algorithm

There are two methods for estimating savings. The first method relies on pre-retrofit and post-retrofit amp measurements as provided in the participant application or obtained; the second method uses deemed savings using an energy savings factor of 23%.[1]

Method #1: Custom Approach (Amps Known)

$kWh_{SAVED} = (Amps_{PRE} - Amps_{POST}) * 1.73 * V * PF * Bwk * t * Weeks$

Method #2: Deemed Approach (Amps Unknown)

$kWh_{SAVED} = HP * LF / Eff * 0.746 * S * Bwk * t * Weeks$

Where:

$Amps_{PRE}$ = Pre-retrofit pulper amps (= actual; from program application or measured)

$Amps_{POST}$ = Post-retrofit pulper amps (= actual; from program application or measured)

1.73 = Constant to calculate kWh

V = Voltage of pulper (= actual; from program application or reported by customer)

PF = Power factor (= actual reported by customer or deemed 0.75)

Bwk = Batches per week (= actual; from program application or reported by customer)

t = Time per pulp batch in minutes (= actual; from program application or reported by customer)

Weeks = Weeks of pulping per year (= actual; from program application or reported by customer)

HP = Motor horsepower (= actual; reported by customer)

LF = Motor load factor (= actual reported by customer or deemed 65%)

Eff = Estimated motor efficiency (=actual reported by customer or deemed 92%)

0.746 = Conversion HP to Watts

S = Savings factor (= deemed 23%)[2]

Summer Concident Peak Savings Algorithm

Method #1: Custom Approach (Amps Known)

$kW = (Amps_{PRE} - Amps_{POST}) * 1.73 * V * PF$

Method #2: Deemed Approach (Amps Unknown)

$kW = HP * LF / Eff * 0.746 * S$

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)

Sources

1. As determined from the pilot study performed in 2005 by Wisconsin Focus on Energy in partnership with an in-state towel, tissue, and paper manufacturing company based in Wisconsin. Voith High Efficiency HM Rotor Energy Data A Repulper Rotor Design Case Study. 2005. http://oaktrust.library.tamu.edu/bitstream/handle/1969.1/5580/ESL-IE-05-05-21.pdf?sequence=4&isAllowed=y. Accessed May 2015.
2. *Focus on Energy Business Programs - Industrial Sector*. December 16, 2005. Repulper rotor reduces energy costs by 23%.
3. Engineering judgement.
4. Historical Project Data, 2016. Large Energy User Program. 3 projects, 8/2012 to 7/2014. Average cost is $361.03 per hp.

Revision History

Version Number	Date	Description of Change
01	05/2015	Initial TRM entry

Variable Frequency Drive (Variable Torque and Constant Torque)

	Measure Details
Measure Master ID	Variable Frequency Drive, Process Fan, 2647 Variable Frequency Drive, Process Pump, 2648, 3835 Variable Frequency Drive, Constant Torque, 3280, 3836
Measure Unit	Per motor
Measure Type	Hybrid
Measure Group	Process
Measure Category	Variable Speed Drive
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by motor
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by motor
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	Varies by measure, see Appendix D

Measure Description

Fans, pumps, conveyors, and other motor-driven equipment require controls to vary their operation to produce the desired output (sufficient airflow to cool a building, deliver hot water for heating, or move product down a conveyor). Traditionally, flow rates have been reduced by increasing the head and riding the pump (or fan) curve back to a new flow rate (throttling control). Alternately, some systems have bypasses that divert a portion of the flow back to the pump or fan inlet to reduce system flow (bypass control). Other systems simply start and stop the motor to meet the given load (on/off control). An alternate way to provide control of motor systems is to use VFDs, which physically slow the motors driving pumps, fans, and other equipment in order to achieve reduced flow rates at considerable energy savings.

There are three categories of motor applications, but only two (variable torque and constant torque) have the potential for energy savings when adding VFDs. The categories of motor applications are as follows:[2]

1. ***Variable Torque Loads.*** This category consists of centrifugal pumps and fans. For these applications, the motors follow the fan or affinity laws, resulting in the input power varying with the pump or fan rotational speed. This means that small reductions in flow (20%, for example) can produce large input power savings (50%).

2. ***Constant Torque Loads.*** This category consists of equipment where the torque requirement is independent of speed. Examples include cranes, hoists, conveyors, extruders, mixers, and positive displacement pumps. The input power varies linearly with the rotational speed (e.g., a 20% reduction in speed equals a 20% reduction in input power).
3. ***Constant Horsepower Loads.***[3] For equipment in this category, the torque varies inversely with the speed of the motor. Therefore, the power requirement does not vary, regardless of speed. Examples include lathes, drilling, and milling equipment. This equipment category does not offer energy savings for installing VFDs, and is therefore ineligible for VFD incentives.

The following rules and requirements apply to the VFD application:

- VFD must be used in conjunction with a process (non HVAC) pumping application.
- Redundant or back-up units do not qualify.
- Routine replacement of existing VFDs does not qualify.
- VFD speed (for variable torque applications) must be automatically controlled by differential pressure, flow, temperature, or other variable signal.
- VFD speed (for constant torque applications) may be either automatically or manually controlled.
- The system controlled must have significant load diversity that will result in savings through motor speed variation. Conditions requiring the motor to be loaded consistently above 80% or consistently loaded below 30% are not eligible for this incentive, as these operating conditions may not realize sufficient savings from a VFD.
- Copies of invoices that clearly show the drive’s size are required.
- Incremental cost assumed to equal measure installed cost. HVAC and process systems either have equipment described under the Description of Baseline Condition section or have a VFD. Baseline condition equipment is required for operation, so VFD is a replacement technology, not an incremental improvement in efficiency (like for a chiller or boiler).

Description of Baseline Condition

The baseline condition is a motor for a variable torque or constant torque application operating at full speed and using throttling, bypass, or on/off control to handle variable outputs from the driven device (pump, fan, etc.).

Description of Efficient Condition

The efficient condition is adding a VFD to the motor to vary the electric frequency (i.e., Hertz) going to the motor, which will allow the speed of the motor to be varied. For variable torque (pump and fan) applications, the VFD must be automatically controlled by a variable input signal. Constant torque applications have the option to be manually controlled to vary the speed of equipment associated with production in a manufacturing environment.

Annual Energy-Savings Algorithm

Energy savings for this measure are custom calculated using a spreadsheet tool,[4] which is based on an engineering bulletin[5] and savings calculators[6] from two different VFD manufacturers. This spreadsheet tool uses power curves developed from data obtained by measuring the operating characteristics of various fans and pumps. The curves are representative of typical VFD operation.

- Equation used in the software tool:
- Power at Design GPM [CFM] = Nameplate Horsepower * Conversion Constant (kW/hp) * Motor Load at Design GPM [CFM] / Nameplate Efficiency

Computed for each capacity level:

- Percentage of Design kW = A1 + (A2 * Capacity) + (A3 * $(\text{Capacity})^2$) + (A4 * $(\text{Capacity})^3$)
- Percentage of Design kW for VSD = A1 + (A2 * Capacity) + (A3 * $(\text{Capacity})^2$) + (A4 * $(\text{Capacity})^3$)
    - Where A1, A2, A3, and A4 are variables unique to each “before VFD” control type, allowing a quadratic equation to be created to represent the load profile. The next table shows values for A1, A2, A3, and A4.

Equation Variables: Before VFD

Control	A1	A2	A3	A4	CF
Pumps					
Outlet Control Valve	55.21240	0.63700	0.00190	0.00000	0.9
Eddy Current Clutch	16.39683	-0.05647	0.01237	-0.00003	0.9
Torque Converter	13.51137	0.34467	0.01269	-0.00007	0.9
Bypass Valve	102.00000	0.00000	0.00000	0.00000	0.9
VFD_Pump	27.44751	-1.00853	0.01762	0.00000	0.9
On/Off	100.00000	0.00000	0.00000	0.00000	0.9
Fans					
Inlet Guide Vane, FC Fans	20.00000	0.06808	0.00128	0.00009	0.9
Inlet Guide Vanes	47.26190	0.67944	0.01554	0.00014	0.9
Inlet Damper Box	50.25833	0.71648	0.01452	0.00013	0.9
Outlet Damper, FC Fans	20.41905	0.10983	0.00745	0.00000	0.9
Discharge Damper	55.92857	-0.56905	0.02462	-0.00014	0.9
Eddy Current Drives	16.39683	-0.05647	0.01237	-0.00003	0.9
VFD_Fan	5.90000	-0.19567	0.00766	0.00004	0.9
Constant Torque VFD					
Constant_Torque_VFD	0.00000	1.00000	0.00000	0.00000	0.78

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} / HOURS * CF$

Where:

HOURS = Annual hours of operation for the system controlled by the VFD

CF = Coincidence factor (= varies by VFD use; see table below)

Coincidence Factor by VFD Use

VFD Use	CF	Source
Hot Water Pump	0.00	Heating pumps operate in winter (off peak)
Equipment type = Other Pump, Other Fan Baseline flow controls = Fan with Inlet Damper Box, Eddy Current Drives, Torque Converter	0.00	Assume no demand reduction
Chilled Water Pump	0.90	DEER model runs are weather normalized for statewide use by population density.
Constant Volume Fan (on/off control)	0.90	
Air foil / inlet guide vanes	0.90	
Forward curved fan with discharge damper	0.90	
Forward curved inlet guide vanes	0.90	
Inlet guide vanes, fan type unknown	0.90	
Cooling tower fan	0.90	
Process pump	0.78	Per Michigan Energy Measures Database[7]
Process fan	0.78	
Constant torque process applications	0.78	Assume same CF as other process equipment
Pool pump	0.78	Assume same CF as process equipment

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Expected useful life (= 15 years)[1]

Sources

1. 2013 Vermont TRM. http://www.greenmountainpower.com/upload/photos/371TRM_User_Manual_No_2013-82-5-protected.pdf
2. Office of Energy Efficiency and Renewable Energy Advanced Manufacturing Office. Motor Systems Tip Sheet #11, Adjustable Speed Drive Part Load Efficiency.

3. Smart Energy Design Assistance Center. *SEDAC Tech Note – Variable Frequency Drives*. November 2011.
4. Focus on Energy. *VFD calculation spreadsheet.* Modified to handle constant torque loads.
5. "Flow Control." Westinghouse publication, Bulletin B-851, F/86/Rev-CMS 8121.
6. ABB and Toshiba energy saving spreadsheet tools.
   ABB Pump Save (use version 4.4):
   http://www.abb.com/product/seitp322/5fcd62536739a42bc12574b70043c53a.aspx
   ABB Fan Save (use version 4.4):
   http://www.abb.com/product/seitp322/5b6810a0e20d157fc1256f2d00338395.aspx
   Toshiba (set filters to product family=drives and download type=software, look for "Cost Savings Estimator"): http://www.toshiba.com/ind/downloads_main.jsp.
7. "Michigan Energy Measures Database." 2013. Available online: http://www.michigan.gov/mpsc/0,4639,7-159-52495_55129---,00.html. Refer to "VFD 1.5 to 50 hp Process Pumping" and "VFD for Process Fans Under 50 hp" measures.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

Refrigeration

ECM Compressor Fan Motor

	Measure Details
Measure Master ID	ECM Compressor Fan Motor, 2306
Measure Unit	Per motor
Measure Type	Prescriptive
Measure Group	Refrigeration
Measure Category	Motor
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	396
Peak Demand Reduction (kW)	0.0792
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	5,940
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	$260.00[4]

Measure Description

Compressor and condenser packaged unit fans typically run 4,500 hours per year to blow air across the compressor and condenser to cool the equipment and refrigerant. The long-time standard in refrigeration equipment is SP fan motors, which are highly inefficient and generate excessive heat. Higher-efficiency ECMs use 75% less energy to run and generate less heat. ECMs or brushless AC fan motors are used in conjunction with air-cooled condensers and/or compressors.

Incentives are available for ECMs replacing SP motors or PSC motors on existing packaged condenser/compressor fans. This measure does not apply to evaporator fan motors.

Description of Baseline Condition

The baseline condition is an SP or PSC packaged compressor/condenser unit fan motor.

Description of Efficient Condition

The efficient condition is an ECM replacing a SP motor or PSC motor on a compressor/condenser unit.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1,000 * HOURS$

Where:

$Watts_{BASE}$ = Wattage of the existing SP fan motor (= 142 average)[2]

$Watts_{EE}$ = Wattage of the proposed motor (= 54)[2]

1,000 = Kilowatt conversion factor

HOURS = Average annual run hours (= 4,500)[3]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1{,}000 * CF$

Where:

CF = Coincidence factor (= 0.90)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[1]

Assumptions

A 50% SP motor and 50% PSC motor were assumed for the baseline.

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. Pennsylvania Public Utility Commission. *Technical Reference Manual*. June 2013.
3. Operating hours based on compressor/condenser run time and Wisconsin weather. This value is between 4,000 – 5,000 hours, so 4,500 hours was used.
4. Regional Technical Forum, UES Measures. "Commercial: Grocery - Compressor Head Fan Motor Retrofit to ECM." Measure Workbook 2.2, June 29, 2016. $260.00 for all "Compressor Head Fan Motor Retrofit to ECM" measures. Available online: http://rtf.nwcouncil.org/measures/measure.asp?id=106

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Reach In Refrigerated Case w/ Doors Replacing Open Multi Deck Case

	Measure Details
Measure Master ID	Reach In Refrigerated Case w/ Doors Replacing Open Multi Deck Case, 2509
Measure Unit	Per linear foot
Measure Type	Prescriptive
Measure Group	Refrigeration
Measure Category	Refrigerated Case Door
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	847
Peak Demand Reduction (kW)	0.0966
Annual Therm Savings (Therms)	98
Lifecycle Energy Savings (kWh)	12,697
Lifecycle Therm Savings (Therms)	1,470
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[8]
Incremental Cost ($/unit)	$574.87[9]

Measure Description

This measure is replacing existing open multi-deck cases with equivalent storage (in cubic feet or linear feet) of reach-in cases with doors. The estimated measure savings are conservative because case replacements use equivalent linear feet, but reach-in cases are designed to hold more cubic feet of product per linear foot (side-to-side measure) than multi-deck cases.

Description of Baseline Condition

The baseline is a 95% to 5% mix of cooler to freezer open multi-deck style cases.

Description of Efficient Condition

The replacement cases must have doors, be tied into a central refrigeration system, and be purchased new. New case upgrades that simply enclose and/or add doors to an existing multi-deck do not qualify for this incentive. New cases must be DOE 2012 Energy Compliant.

Annual Energy-Savings Algorithm

$$kWh_{SAVED} = [((P_{CE} – P_{LE} – P_{ME} – (P_{CE}F_{CR})) – (((P_{CP} * (1 – F_I) – P_{LP} – P_{MP} – P_{CP}F_{CR} (1 – F_I)))] * [((LF * (1/3{,}412) * HOURS) / COP_{REFRIG}) – ((24 * (CDD / (T_S – T_R)) * (12/3{,}412) * COP_{ROOFTOP} * (1/12{,}000))]$$

$$Therm_{SAVED} = [((P_{CE} – P_{LE} – P_{ME} – (P_{CE}F_{CR})) – (((P_{CP} * (1 – F_I) – P_{LP} – P_{MP} – (P_{CP}F_{CR} (1 – F_I)))] * [24 * (HDD / (T_S – T_R)) * (1/eff) * (1/100{,}000)]$$

Where:

P_{CE} = Total load of multideck case (= 1,500 Btuh per linear foot for coolers;[1] = 1,850 Btuh per linear foot for freezers)[2]

P_{LE} = Lighting load of existing case (= 6.7 Btuh per linear foot)[2]

P_{ME} = Motor load of existing case (= 7.3 Btuh per linear foot)[2]

F_{CR} = Amount of case load associated with conduction and radiation (= 13%)[5]

P_{CP} = Total load of new enclosed case (= 332 Btuh per linear foot for coolers; = 528 Btuh per linear foot for freezers)[3]

F_I = Amount of case load associated with infiltration reduction (= 68%)[4]

P_{LP} = Lighting load of new case (= 8.2 Btuh per linear foot)[3]

P_{MP} = Motor load of new case (= 2.7 Btuh per linear foot for coolers; = 3.5 Btuh per linear foot for freezers)[3]

LF = Case load factor, the compressor duty cycle needed to maintain case temperatures, deemed (= 62% for coolers; = 80% for freezers)[6]

3,412 = Conversion from kilowatt-hours to Btu

HOURS = Average annual operating hours of the light fixture measured in hours per year, deemed (= 8,760)[6]

COP_{REFRIG} = Coefficient of performance of refrigeration system: a measure of the refrigeration system efficiency equal to the ratio of net heat removal to total energy input, deemed (= 2.5 for coolers; = 1.3 for freezers)[1]

24 = Hours per day

CDD = Cooling degree days, the sum of the number of degrees the average daily temperature is greater than a base temperature for a given time period, deemed (= 535)[6]

T_S = Temperature of store, deemed (= 65°F)[6]

T_R = Temperature of refrigerated case that needs to be maintained (= 36.5°F for coolers; = -11°F for freezers)[7]

12 = COP conversion factor

$COP_{ROOFTOP}$ = Coefficient of performance of rooftop system: a measure of the efficiency of the rooftop system equal to the ratio of net heat removal to total energy input (= 3.2)[7]

12,000 = Btu to ton conversion factor

HDD = Heating degree days, the sum of the number of degrees the average daily temperature is less than a base temperature for a given time period, deemed (= 7,699)[6]

eff = Heating system efficiency, the average combustion efficiency of the boiler (= 78%)[7]

100,000 = Conversion factor from Btu to Dth

Summer Coincident Peak Savings Algorithm

$$kW_{SAVED} = [((P_{CE} – P_{LE} – P_{ME} – (P_{CE}F_{CR})) – (((P_{CP} * (1 – F_I) – P_{LP} – P_{MP} – P_{CP}F_{CR} (1 – F_I)))] * [((LF * (1/3{,}412) * HOURS) / COP_{REFRIG}) – ((24 * (CDD / (T_S – T_R)) * (12/3{,}412) * COP_{ROOFTOP} * (1/12{,}000))] * (1/8{,}760)$$

Where:

8,760 = Total annual operating hours of building

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[8]

Assumptions

Refrigerated case temperatures were calculated as the average of the most commonly used settings for cooler and freezer cases: 35°F to 38°F and -14°F to -8°F, respectively.[7]

Sources

1. Arthur D. Little, Inc. Energy Savings Potential for Commercial Refrigeration Equipment – Final Report. 1996.
2. Manufacturer’s specification sheet for open multideck style freezer case. Hussmann Excel F6L. November 2010.

3. Manufacturer's specification sheet for enclosed reach-in cases. Zero Zone RVCC30 and RVZC30. 2012.
4. California Edison Research and Thermal Test Center.
5. ASHRAE RP-1402.
6. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0. Updated March 22, 2010.
7. National Renewable Energy Lab. U.S. Department of Energy Building Technology Program. Advanced Energy Retrofit Guide: Practical Ways to Improve Energy Performance, Grocery Stores. June 2012.
8. California Energy Commission and California Public Utilities Commission. Database for Energy Efficient Resources (DEER) 2008. http://www.energy.ca.gov/deer/
9. California Public Utilities Commission. DEER Database for Energy-Efficiency Resources Version 2011 4.01. Cost Values and Summary Documentation.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

Retrofit Open Multi-Deck Cases with Doors

	Measure Details
Measure Master ID	Retrofit Open Refrigerated Cases with Doors, 3409
Measure Unit	Per linear foot
Measure Type	Prescriptive
Measure Group	Refrigeration
Measure Category	Refrigerated Case Door
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	615
Peak Demand Reduction (kW)	0.0702
Annual Therm Savings (Therms)	11
Lifecycle Energy Savings (kWh)	7,378
Lifecycle Therm Savings (Therms)	129
Water Savings (gal/yr)	0
Effective Useful Life (years)	12[7]
Incremental Cost ($/unit)	$126.53/ft[8]

Measure Description

Existing open multi-deck style cases can be retrofitted with doors. The doors are designed to fit right onto the open multi-deck style cases with minimal case modification. The measure incentives are based on a per-foot-case enclosed.

Description of Baseline Condition

The baseline is a 95% to 5% mix of cooler to freezer open multi-deck style cases.

Description of Efficient Condition

The efficient condition is installing doors on the cooler or freezer multi-deck style cases.

Annual Energy-Savings Algorithm

$$kWh_{SAVED} = (P_CF_I – P_L – P_M – (P_CF_{CR}F_I)) * (LF * (1/3{,}412) * HOURS * COP_{REFRIG}) – ((24 * (CDD / (T_S – T_R)) * (12/3{,}412) * COP_{ROOFTOP} * (1/12{,}000))$$

$$Therm_{SAVED} = P_CF_{CR}F_I * ((24 * (HDD / (T_S – T_R)) * (1/eff) * (1/100{,}000))$$

Where:

P_C = Total case load, the average energy consumption of the refrigerated case (= 1,500 Btuh for coolers;[1] = 1,850 Btuh for freezers)[2]

F_I = Amount of infiltration reduction, the fraction of the case energy associated with infiltration (= 68%)[3]

P_L = Lighting load of case, the average energy consumption of the lighting in the case (= 6.7 Btuh)[2]

P_M = Motor load of case, the average energy consumption of the evaporator motors in the case (= 5 Btuh)[2]

F_{CR} = Amount of case load energy associated with conduction and radiation (= 13%)[4]

LF = Case load factor, the compressor duty cycle needed to maintain case temperatures, deemed (= 62% for coolers; = 80% for freezers)[5]

3,412 = Conversion factor from kilowatt-hours to Btu

HOURS = Average annual operating hours of the light fixture, deemed (= 8,760)[5]

COP_{REFRIG} = Coefficient of performance of refrigeration system, a measure of the refrigeration system efficiency equal to the ratio of net heat removal to the total energy input, deemed (= 2.5 for coolers; = 1.3 for freezers)[1]

24 = Hours per day

CDD = Cooling degree days, the sum of the number of degrees that the average daily temperature is greater than a base temperature for a given time period (the State of Wisconsin uses a base temperature of 65°F, which is a standard value used in the HVAC industry), deemed (= 535)[5]

T_S = Temperature of store, deemed (= 65°F)[5]

T_R = Temperature of case, the refrigerated case temperature that needs to be maintained (= 36.5°F for coolers; = -11°F for freezers)[6]

12 = COP conversion factor

$COP_{ROOFTOP}$ = Coefficient of performance of rooftop system, a measure of the efficiency of the rooftop system equal to the ratio of net heat removal to the total energy input (= 3.2)[6]

12,000 = Btu to ton conversion factor

HDD = Heating degree days, the sum of the number of degrees that the average daily temperature is less than a base temperature for a given time period (the State of Wisconsin uses a base temperature of 65°F, which is a standard value used in the HVAC industry), deemed (= 7,699)[5]

eff = Heating system efficiency, the average combustion efficiency of the boiler (= 78%)[6]

100,000 = Conversion factor from Btu to Dth

Summer Coincident Peak Savings Algorithm

$$kW_{SAVED} = (P_CF_I - P_L - P_M - (P_CF_{CR}F_I)) * (LF * (1/3,412) * HOURS * (1/COP_{REFRIG})) - ((24 * (CDD / (T_S - T_R)) * (12/3,412) * COP_{ROOFTOP} * (1/12,000)) * 1/8,760$$

Where:

100,000 = Conversion factor from Btu to Dth

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 12 years)[7]

Assumptions

Refrigerated case temperatures were calculated as the average of the most commonly used settings for cooler and freezer cases, 35°F to 38°F and -14°F to -8°F, respectively.[6]

Sources

1. Arthur D. Little, Inc. *Energy Savings Potential for Commercial refrigeration Equipment – Final Report.* 1996.
2. Manufacturer's specification sheet for open multideck style freezer case. Hussmann Excel F6L. November 2010.
3. California Edison Research and Thermal Test Center.
4. ASHRAE RP-1402.
5. PA Consulting Group Inc. *State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0.* Updated March 22, 2010.
6. U.S. Department of Energy Building Technology Program. *Advanced Energy Retrofit Guide: Practical Ways to Improve Energy Performance, Grocery Stores.* National Renewable Energy Laboratory. June 2012.

7. California Energy Commission and California Public Utilities Commission. Database for Energy Efficient Resources (DEER) 2008. http://www.energy.ca.gov/deer/
8. Historical Focus on Energy project data, 2013. 2 projects, average cost is $126.53 per foot.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

Strip Curtains for Walk-In Freezers and Coolers

	Measure Details
Measure Master ID	Strip Curtains for Walk-In Freezers and Coolers, 3183 Strip Curtains for Walk-In Freezers and Coolers, SBP A La Carte, 3284
Measure Unit	Per linear foot
Measure Type	Prescriptive
Measure Group	Refrigeration
Measure Category	Strip Curtain
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	315 per linear foot
Peak Demand Reduction (kW)	0.036 per linear foot
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	1,260 per linear foot
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	4[1]
Incremental Cost ($/unit)	$50.00[4]

Measure Description

Strip curtains reduce the refrigeration load associated with the infiltration of non-refrigerated air into the refrigerated spaces of walk-in coolers or freezers. The most likely areas of application are grocery stores, supermarkets, restaurants, and refrigerated warehouse.

Description of Baseline Condition

The baseline condition is a walk-in cooler or freezer that with no strip curtain or an old, ineffective strip curtain installed.

Description of Efficient Condition

The efficient condition is adding a strip curtain or replacing the ineffective strip curtain on a walk-in cooler or freezer. Strip curtains must be at least 0.06 inches thick. Low temperature strip curtains must be used for low temperature applications.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = \Delta kWh/LF * LF$

Where:

LF = Linear feet of door width of installation

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = \Delta kW/LF * LF$

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 4 years)[1]

Deemed Savings

The annual deemed savings is calculated based on methods and deemed savings included in the 2013 Pennsylvania TRM.[2] For the Small Business Program, a single deemed measure is developed using the expected mix of program customers and situations.

In order to create the Small Business Program measure mix, the following assumptions based on facility type are assumed. See the Assumptions section for more background.

- Facility Types
    - Supermarket = 10%
    - Convenience Store = 30%
    - Restaurant = 60%
- Cooler and Freezer Mix
    - Coolers = 75%
    - Freezers = 25%
- Facilities that have existing ineffective strip curtains
    - 25% (75% have no existing strip curtains)

Comparison of Pennsylvania TRM to Focus on Energy Values by Facility Type*

Facility Type	PA TRM 2013 (Source 1)			Focus on Energy		
	Pre-Existing Curtains	Energy Savings (per sqft)**	Demand Reduction (per sqft)***	Measure Mix	Weighted Energy Savings (per sqft)	Weighted Demand Reduction (per sqft)
Supermarket - Cooler	Yes	37	0.0042	1.88%	0.69	0.00008
	No	108	0.0123	5.63%	6.08	0.00069
	Unknown	108	0.0123	0.00%	0.00	0.00000
Supermarket - Freezer	Yes	119	0.0136	0.63%	0.74	0.00009
	No	349	0.0398	1.88%	6.54	0.00075

Facility Type	PA TRM 2013 (Source 1)			Focus on Energy		
	Pre-Existing Curtains	Energy Savings (per sqft)**	Demand Reduction (per sqft)***	Measure Mix	Weighted Energy Savings (per sqft)	Weighted Demand Reduction (per sqft)
	Unknown	349	0.0398	0.00%	0.00	0.00000
Convenience Store - Cooler	Yes	5	0.0006	5.63%	0.28	0.00003
	No	20	0.0023	16.88%	3.38	0.00039
	Unknown	11	0.0013	0.00%	0.00	0.00000
Convenience Store - Freezer	Yes	8	0.0009	1.88%	0.15	0.00002
	No	27	0.0031	5.63%	1.52	0.00017
	Unknown	17	0.002	0.00%	0.00	0.00000
Restaurant - Cooler	Yes	8	0.0009	11.25%	0.90	0.00010
	No	30	0.0034	33.75%	10.13	0.00115
	Unknown	18	0.002	0.00%	0.00	0.00000
Restaurant - Freezer	Yes	34	0.0039	3.75%	1.28	0.00015
	No	119	0.0136	11.25%	13.39	0.00153
	Unknown	81	0.0092	0.00%	0.00	0.00000
Refrigerated Warehouse	Yes	254	0.029	0.00%	0.00	0.00000
	No	729	0.0832	0.00%	0.00	0.00000
	Unknown	287	0.0327	0.00%	0.00	0.00000
Focus on Energy Small Business Program Savings Values (per sqft)					**45.00**	**0.00514**

* Sum values may differ due to rounding.

* The 2013 Pennsylvania TRM uses the Tamm Equation to determine electricity savings: kWh = 365 * topen * (ηnew - ηold) * 20CD * A * {[(Ti - Tr)/Ti]gH}0.5 * 60 * (ρihi – ρrhr) / (3,413 * COPadj)

*** kW_{SAVED} = kWh_{SAVED} / 8,760

The unit of measurement for strip curtains is per linear foot of doorway width. It is assumed that all walk-in unit doors are 7 feet tall. The table below shows the energy savings per square foot to linear foot comparison for determining deemed savings.

Conversion of Energy Savings

Savings Type	Savings (per sqft)	Door Height (Ft)	Deemed Value per Linear Foot
Annual Electricity Savings (kWh/yr)	45	7	315
Demand Reduction (kW)	0.0051	7	0.036
Annual Natural Gas Savings (therms/yr)	0	7	0

Using the EUL, the table below shows updated savings values for strip curtains.

Deemed Annual Savings

Savings Type	Annual Savings	EUL	Lifecycle Savings
Annual Electricity Savings (kWh/yr)	315	4	1,260
Annual Natural Gas Savings (therms/yr)	0	4	0

Assumptions

The primary cause of air infiltration into walk-in coolers and freezers is the air density difference between two adjacent spaces of different temperatures. The total refrigeration load due to infiltration through the main door into the unit depends on the temperature differential between the refrigerated and non-refrigerated airs, the door area and height, and the duration and frequency of door openings.

The avoided infiltration depends on the barrier efficacy of the newly installed strip curtains, and on the efficacy of the supplanted infiltration barriers, if applicable. The calculation of the refrigeration load due to air infiltration and the energy required to meet that load is rather straightforward, but relies on critical assumptions regarding the aforementioned operating parameters. The calculation for this measure follows the Pennsylvania TRM[1] calculation for Measure 3.17: Strip Curtains for Walk-In Freezers and Coolers. The assumptions in that protocol are based on values that were determined by direct measurement and monitoring of over 100 walk-in units in the 2006-2008 evaluation for the California Public Utility Commission.

Within the TRM calculation, the kW demand reduction is simplistic, but should be noted as a major assumption. The below quote is from Page 259 of the 2013 Pennsylvania TRM;

> "The peak demand reduction is quantified by multiplying savings per square foot by area. The source algorithm is the annual energy savings divided by 8760. This assumption is based on general observation that refrigeration is constant for food storage, even outside of normal operating conditions. This is the most conservative approach in lieu of a more sophisticated model.
>
> $\Delta kW_{PEAK} = \Delta kWh / 8760$"

There is no code requiring strip curtains for remodeling walk-in coolers and freezers.

Assumptions for Facility Types and Technology

The assumed levels of facility types within the Small Business Program for Focus on Energy are based on the Program Implementer's experience between July 2012 and April 2013 (Staples Energy). Although data was not collected on existing walk-in coolers and freezers from the existing customer list, that list was categorized to differentiate restaurants, convenience stores (including liquor stores and florists), and supermarkets (including meat markets and fish markets).

The table below details the number of customers the Program Implementer visited in each category and the estimated number that will have walk-in refrigeration. The customer size in the small business sector indicates the amount of facilities that have walk-in refrigeration, and does not represent the standard mix for the total marketplace.

Percentage of Walk-In Refrigerators by Facility Type

Facility Type	Customer Visits	Percentage with Walk-In Refrigeration	Number with Walk-In Refrigeration	Percentage of Total Facilities
Restaurant	424	33%	139.92	59%
Convenience Store	96	70%	67.2	28%
Supermarket	39	80%	31.2	13%
Total	**559**		**238.32**	**100%**

The calculation uses a slightly more conservative number by reducing the supermarket total to 10% and increasing the convenience store and restaurant totals slightly.

The assumptions for the refrigerator/freezer mix were roughly determined from the same list of customers, broken out by type of facility. The assumptions included determining the numbers of freezers present at the following restaurant types: fast food, Asian cuisine, and fry kitchens. The supermarket freezer components are meat markets, fish markets, and an estimated amount of rural groceries.

Percentage of Walk-In Freezers by Facility Type*

Facility Type	Customer Visits	Number with Walk-In Freezer	Percentage with Walk-In Freezer	Percentage of Total Facilities
Restaurant	424	123	30%	22%
Convenience Store	96	0	0%	0%
Supermarket	39	19	50%	3%
Total	**559**	**142**		**25%**

*Percentages are rounded up

Sources

1. GDS Associates, Inc. The Measure Life Report for Residential and Commercial/Industrial Lighting and HVAC Measures. June 2007.
2. *Pennsylvania Technical Reference Manual*. 2013. Available online: http://www.puc.state.pa.us/filing_resources/issues_laws_regulations/act_129_information/technical_reference_manual.aspx
3. Commercial Facilities Contract Group. *2006-2008 Direct Impact Evaluation.* Available online: http://www.calmac.org/publications/ComFac_Evaluation_V1_Final_Report_02-18-2010.pdf
4. WESCO Distribution Pricing ($45.00) + Labor ($5.00) = $50.00

Revision History

Version Number	Date	Description of Change
01	04/22/2013	Initial submittal

Renewable Energy

Ground Source Heat Pump, Natural Gas and Electric Backup

	Measure Details
Measure Master ID	Ground Source Heat Pump: Electric Back-Up, 2820 Natural Gas Back-Up, 2821
Measure Unit	Per heat pump
Measure Type	Prescriptive
Measure Group	Renewable Energy
Measure Category	Geothermal
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	3,476
Peak Demand Reduction (kW)	0.8277
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	62,568
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	18[1]
Incremental Cost ($/unit)	Actual Program Data in Current Year[8]

Measure Description

This measure is installing residential-sized geothermal (ground-source) heat pump systems in non-residential applications. Geothermal heat pump systems use the earth as a source of heating and cooling through the installation of an exterior underground loop working in combination with an interior heat pump unit. The measure provides a centralized heating and cooling system, similar to that of a standard air-source heat pump.

Description of Baseline Condition

The baseline condition is an air-source heat pump of 13 SEER and 7.7 HSPF.[4]

Description of Efficient Condition

The efficient condition is a ground-source heat pump of 3.5 COP and 15 EER with either a multi-compressor or a multi-stage compressor, as well as an ECM air handler. Additionally, the procedures followed when installing the equipment must conform to the ACCA Standard 5 Quality Installation requirements.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (EFLH_{COOL} * Btu/h_{COOL} * (1/SEER_{BASE} – 1/(EER_{EE} * 1.02)))/1{,}000 + (EFLH_{HEAT} * Btu/h_{HEAT} * (1/HSPF_{BASE} – 1/(COP_{EE} * 3.412)))/1{,}000$

Where:

$EFLH_{COOL}$ = Full-load cooling hours (= 599)[5]

Btu/h_{COOL} = Cooling capacity of equipment (= 40,089 Btu/hour)[3]

$SEER_{BASE}$ = Seasonal energy efficiency ratio of baseline equipment (= 13)[4]

EER_{EE} = Energy efficiency ratio of efficient equipment (= 22.43 kBtu/kWh)[3]

1.02 = Factor to determine SEER based on its EER

1,000 = Kilowatt conversion factor

$EFLH_{HEAT}$ = Full-load heating hours (= 1,466)[6]

Btu/h_{HEAT} = Heating capacity of equipment (= 30,579 Btu/hour)[3]

$HSPF_{BASE}$ = Heating seasonal performance factor of baseline equipment (= 7.7 kBtu/kWh)[4]

COP_{EE} = Coefficient of performance of efficient equipment (= 4.18)[3]

3.412 = Conversion from Watt to Btu

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Btu/h_{COOL} * (1/EER_{BASE} – 1/EER_{EE})) / 1{,}000 * CF$

Where:

EER_{BASE} = Energy efficiency ratio of baseline equipment (= 12.75)[4]

CF = Coincidence factor (= 0.61)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 18 years)[1]

Assumptions

This system life expectancy is generally constrained by the heat pump exchanger and compressor equipment. The actual ground loop installation often has a much longer life expectancy.

The run-time differs for non-residential and residential applications due to internal heat gains, additional ventilation requirements for non-residential buildings, times of occupancy, and occupancy numbers. Heating run-times from the TRM for Pennsylvania 2013 Draft for Commercial HVAC were used and adjusted using EFLH from the U.S. DOE ENERGY STAR Air Source Heat Pump Calculator[5] to account for differences in weather conditions. This resulted in a 42% reduction in hours from ENERGY STAR – or 1,466 hours.

Equivalent Full-Load Heating Hours from Pennsylvania TRM and ENERGY STAR

City	PE TRM (hours)[4]	ENERGY STAR (hours)
Allentown	1,098	2,492
Erie	1,720	2,901
Harrisburg	1,406	2,371
Philadelphia	1,461	2,328
Pittsburgh	1,411	2,380
Scranton	1,501	2,532
Williamsport	1,483	2,502
Average	**1,440**	**2,501**

Equivalent Full-Load Heating Hours from Wisconsin TRM and ENERGY STAR

City	ENERGY STAR (hours)[8]	WI TRM (hours)
Green Bay	2,641	1,521
La Crosse	2,445	1,408
Madison	2,547	1,467
Milwaukee	2,548	1,467
Average	**2,545**	**1,466**

Equivalent Full-Load Heating and Cooling Hours for Average Commercial Building

Building Type	$EFLH_{HEAT}$[6]	$EFLH_{COOL}$[5]
Average Commercial	**1,466**	**599**

The installation of a ground-source heat pump is more likely to happen in the northern part of the state due to the lack of available natural gas. A lower coincidence factor than residential (0.68)[5] and non-residential (0.80)[7] air conditioning is used to account for the reduced occurrence of operation.

Coincidence Factors by Sector

Sector	Air Conditioner	GSHP
Residential	0.68[5]	0.50[3]
Non-Residential	0.80[7]	0.61

Sources

1. 2012 Illinois TRM. http://www.ilsag.info/technical-reference-manual.html
2. Energy Center of Wisconsin. *Update of Geothermal Analysis.* Pg. 19-21. August 31 2009.
3. California Energy Commission and California Public Utilities Commission. Database for Energy Efficient Resources (DEER) 2008. http://www.energy.ca.gov/deer/ .Revision History DEER model runs that were weather normalized for statewide use by population density.
4. International Energy Conservation Code. Table 503.2.3(1). 2009.
5. See similar measures A/C Split System, ≤ 65 MBh: SEER 14, 2194; SEER 15, 2192; and SEER 16+, 2193.
6. Technical Reference Manual for Pennsylvania 2013 Draft for Commercial HVAC were used and adjusted using EFLH from the U.S. DOE ENERGY STAR Air Source Heat Pump Calculator to account for differences in weather conditions.
7. See similar measures A/C Split System, ≤ 65 MBh: SEER 14, 2194; SEER 15, 2192; and SEER 16+, 2193.
8. Actual Program Data in Current Year

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

Vending & Plug Loads

Engine Block Heater Timer

	Measure Details
Measure Master ID	Timer, Engine Block Heater, 2810
Measure Unit	Per unit
Measure Type	Prescriptive
Measure Group	Vending & Plug Loads
Measure Category	Controls
Sector(s)	Agriculture
Annual Energy Savings (kWh)	576
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	8,640
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	$25.00[2]

Measure Description

Engine block heater timers save energy by reducing the time that engine block heaters operate. Typically, block heaters are plugged in throughout the night. Using timers allows the heater to come on at a preset time in the night, rather than being on throughout the night. Beginning in September 2015, this measure is primarily being used for a Future Farmers of America (FFA) fundraiser coordinated by the AgSG Implementer.

Description of Baseline Condition

The baseline conditions is an engine block heater in use without a timer.

Description of Efficient Condition

The efficient condition is an engine block heater in use with a timer preset to power heater on for eight fewer hours each night.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (P * hours * days * UF)$

Where:

P = Average power consumption of engine block heater (= 1 kW)[3]

hours = Reduction in block heater usage per night (= 8 hours)

days = Number of operating days per year (= 90)

UF = Usage factor (= 0.8)

Summer Coincident Peak Savings Algorithm

There are no peak savings since engine block heaters are not in use during the peak period.

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[1]

Assumptions

A list of typical block heaters and wattages is provided on the Wisconsin Public Service (WPS) – Tractor Heater Timers website.[3] Heater sizes listed range from 400 watts to 1,500 watts, so 1,000 watts was used for calculations based on professional experience; follow-up will be performed and revisions made as appropriate.

Also, according to the same WPS website, there is an 8 hour reduction in operating hours per night the heater operates. This is based on the assumption that a heater without a timer will operate for 10 hours per night (8:00 p.m. to 6:00 a.m.), while a heater with a timer will operate for two hours. Follow-up will be performed and revisions made as appropriate.

The heater operates 90 days per year. This is based on operating during the three coldest months of December, January, and February. There is no secondary source cited for this assumption. Follow-up will be performed and revisions made as appropriate.

It is assumed that 80% of the heaters provided by the program will be used properly (usage factor). This reflects the reality that not all timers provided will be used, and not all those that are used will be used correctly. There is no secondary source cited for this assumption; it is a qualitative guess based on professional experience and follow-up will be performed and revisions made as appropriate.

Substituting the above values into the savings equation yields the deemed savings value of 576 kWh per year.

Sources

1. Gutierrez, Alfredo. "Circulating Block Heater." Presentation at California Technical Forum. April 2015. Available online: http://static1.squarespace.com/static/53c96e16e4b003bdba4f4fee/t/556f7c9ee4b0b65c3515c80c/1433369758093/Circulating+Block+Heater+Presentation_ver+2.pdf and
Database for Energy Efficiency Resources. 2014. Available online: http://www.deeresources.com/
2. Implementer research, 2013. Average online cost of Engine Block Heat Timer.
3. Wisconsin Public Service. "Tractor Heater Timers." Accessed September 28, 2015. http://www.wisconsinpublicservice.com/business/farm_tractor.aspx

Revision History

Version Number	Date	Description of Change
01	10/01/2015	New measure

Residential Measures

Through the Residential Portfolio, Wisconsin Focus on Energy delivers information, incentives, and implementation support to help residential customers access energy-efficient technologies that help control their electricity and natural gas use. These efficient technologies include, but are not limited to, lighting, heating and cooling systems, home appliances, insulation and air sealing services, and residential renewable energy systems.

The redesigned 2017 Residential Portfolio includes five core programs designed to help different types of residential customers access these technologies, using different approaches to offer outreach and financial support.

1. All types of residential homeowners can take advantage of the **Retailer Lighting and Appliance Program**, in which they receive in-store discounts for purchasing high-efficiency light bulbs and home appliances.

Residential customers that live in a home with one (single family) to three units can participate in the following programs and obtain incentives for energy-saving measures.

1. The **Home Performance with ENERGY STAR Program** offers comprehensive energy assessments, incentives for whole-home improvements, energy-efficient heating and cooling equipment, and loans and/or incentives for renewable energy. There are three paths customers can take to a more efficient home:
    a. The **Whole Home Improvements Path** offers comprehensive energy assessment and incentives to make home improvements. This path targets customers with the ability to invest in energy efficiency in order to achieve deeper energy savings, and includes both building shell and HVAC equipment upgrades.
    b. The **Heating and Cooling Path** offers incentives for customers who are replacing heating and cooling equipment to make incremental energy efficiency improvements.
    c. The **Renewable Energy Path** offers financial incentives to customers who install geothermal and solar PV systems.
2. The **Simple Energy Efficiency Program** provides free energy-saving measures to customers.
3. Owners, managers, and residents of multifamily buildings (such as apartments and condominiums) are served through the **Multifamily Program**, which includes the following offerings:
    a. The **Multifamily Direct Install** path offers free installation of CFLs, LEDs, low-flow showerheads, and other energy-savings measures in tenant units, as well as walk-through assessments of the whole building.

   b. Those assessments can identify additional incentives that property owners and managers can take advantage of through the **Multifamily Energy Savings** path, which provides information, financial incentives, and implementation support to install measures in resident units and common areas.

4. Residential customers who are building a new home can receive assistance through the **New Homes Program**, which helps owners, builders, and energy experts construct energy efficient homes.

Boilers & Burners

Hot Water Boiler, 95%+ AFUE

	Measure Details
Measure Master ID	Hot Water Boiler, 95%+ AFUE, 1983, 3780
Measure Unit	Per boiler
Measure Type	Prescriptive
Measure Group	Boilers & Burners
Measure Category	Boiler
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	151
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	3,011
Effective Useful Life (years)	20[1]
Incremental Cost ($/unit)	$3,105.00[4]

Measure Description

Space heating boilers are pressure vessels that transfer heat to water for use primarily in space heating applications. Boilers either heat water using a heat exchanger that works like an instantaneous water heater, or by the addition of a separate tank with an internal heat exchanger that is connected to the boiler.

High-efficiency space heating boilers are applicable to any residential boiler used for space heating. They are not applicable to boilers used for process end uses, DHW, pools, or spas. The space heating boiler qualifications are listed in the table below.

Qualifications for Space Heating Boilers

Type	Input Rating	Required Efficiency
95% Efficient Boiler	≤ 300 MBh	AFUE ≥ 95%

Description of Baseline Condition

The baseline equipment is a hot water boiler with 82% AFUE.[2]

Description of Efficient Condition

Energy-efficient space heating boilers often feature high-efficiency and/or low-Nox burners, and typically have features such as forced air burners, relatively large heat exchange surfaces, and/or use heat recovery from stack gases.

Annual Energy-Savings Algorithm

$\text{Therm}_{\text{SAVED}} = \text{EFLH} * (1 - \text{EFF}_{\text{BASELINE}} / \text{EFF}_{\text{EE}})$

Where:

EFLH = Equivalent full-load hours (= 1,000)[3]

$\text{EFF}_{\text{BASELINE}}$ = AFUE of baseline measure (= 82%)

EFF_{EE} = AFUE of efficient measure (= 95%)

Summer Coincident Peak Savings Algorithm

There are no peak savings for this measure.

Lifecycle Energy-Savings Algorithm

$\text{Therm}_{\text{LIFECYCLE}} = \text{Therm}_{\text{SAVED}} * \text{EUL}$

Where:

EUL = Effective useful life (= 20 years)[1]

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. Energy Efficiency and Renewable Energy Office. *Annual Fuel Utilization Efficiency.* Section 10 CFR 430.23(n)(2). Available online: http://www.regulations.gov/#!documentDetail;D=EERE-2006-STD-0102-0009.

3. 800 therms consumed by 90% AFUE furnaces (i.e., 720 therms output) for all residential natural gas measures estimate from: Pigg and Nevius. *Electricity Use by New Furnaces.* 2000. Available online: http://www.ecw.org/sites/d3efault/files/230-1.pdf. Using average furnace size of 72,000 Btu (from 2012 SPECTRUM database of 13,000 furnaces), 1,000 full-load heating hours are estimated.
4. 2013, Program Implementer CLEAResult surveyed 40 Trade Allies and took the average reported cost for an 82% boiler and subtracted that amount from the average reported cost for a 95% boiler.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry
02	01/2015	MMIDs 1982 and 1978 deactivated and removed

Natural Gas Boiler, ≥ 90% AFUE

	Measure Details
Measure Master ID	Boiler, ≥ 90% AFUE, Natural Gas, 2747
Measure Unit	Per MBh
Measure Type	Custom
Measure Group	Boilers & Burners
Measure Category	Boiler
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	1.56
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	31.27
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Incremental Cost ($/unit)	$50.82/MBh[4]

Measure Description

High efficiency sealed combustion, condensing, and modulating boilers operate by taking advantage of condensing to lower energy consumption. Condensing boilers are designed to capture the latent heat of condensation in the form of water vapor in the exhaust stream. Capturing this latent heat produces high efficiency levels. For a boiler to operate in condensing mode, its return water temperature should be kept below 120°F. In order to capture as much latent heat as possible, condensing boilers are made from stainless steel or other corrosion resistant materials. Chimney liners must be installed for boilers that are replacing a naturally drafting unit that was vented through the same flue as a water heater. Flue closure protocols must be followed when the chimney that will used by the replacement unit was not in use for the previous equipment.

Description of Baseline Condition

The baseline equipment is an 82% AFUE boiler.[2]

Description of Efficient Condition

The efficient equipment is a 85-90%+ AFUE boiler[3] that is capable of modulating the firing rate, has integrated input/output reset control, and is used for space heating. Industrial process or DHW applications do not qualify. Redundant or backup boilers do not qualify.

Annual Energy-Savings Algorithm

These savings are per Mbh of input boiler capacity.

$Therm_{SAVED} = BC * EFLH * (1 - EFF_{BASELINE} / EFF_{EE}) / 100)$

Where:

BC = Boiler capacity in MBh (=1)
$EFLH$ = Equivalent full-load hours (= 1,759)[3]
$EFF_{BASELINE}$ = AFUE of baseline measure (=82%)
EFF_{EE} = AFUE of efficient measure (=85-90%)
100 = Conversion factor from MBtu to therms

Summer Coincident Peak Savings Algorithm

There are no peak savings for this measure.

Lifecycle Energy-Savings Algorithm

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 20 years)[1]

Assumptions

The boiler baseline efficiency is based on the EISA requirements of 82%.

Sources

1. California Energy Commission and California Public Utilities Commission. Database for Energy Efficient Resources (DEER) 2008. http://www.energy.ca.gov/deer/
2. Energy Efficiency and Renewable Energy Office. *Annual Fuel Utilization Efficiency*. Section 10 CFR 430.23(n)(2). Available online: http://www.regulations.gov/#!documentDetail;D=EERE-2006-STD-0102-0009.
3. Full load hours for all residential natural gas measures estimate from: Pigg and Nevius. *Electricity Use by New Furnaces.* 2000. Available online: http://www.ecw.org/sites/d3efault/files/230-1.pdf
4. Illinois Technical Reference Manual. 2013. Page 141. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry
02	01/2015	Savings changed from per unit to per MBh

Boiler Control, Outside Air Temperature Reset/Cutout Control

	Measure Details
Measure Master ID	Boiler, Outside Temperature Reset/Cutout Control, 2221
Measure Unit	Per MBh
Measure Type	Prescriptive
Measure Group	Boilers & Burners
Measure Category	Controls
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	1.48
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	7.41
Water Savings (gal/yr)	0
Effective Useful Life (years)	5
Incremental Cost ($/unit)	$612.00[5] per unit

Measure Description

Boiler reset controls automatically control the boiler water temperature based on outdoor temperature. This allows the water to run a little cooler during the fall and spring, and a little hotter during the coldest parts of the winter, improving boiler efficiency and indoor comfort by providing a better match between boiler output and space heating needs. Boiler cutout controls prevent a boiler from firing at a predetermined outside temperature set point to prevent overheating.

Description of Baseline Condition

The baseline condition is no input/output reset with an 87% TE boiler.

Description of Efficient Condition

Outside air temperature reset or cutout control incentives are for existing space heating boilers only. A new boiler with integrated boiler reset controls is not eligible. New boilers not equipped with these controls are eligible for retrofit. The system must be set so that the minimum temperature is not more than 10°F above the manufacturer’s recommended minimum return temperature, unless unusual circumstances require a higher setting. The system must have an outdoor air temperature sensor in a shaded location on the north side of the building. For controls on multiple boilers to qualify, a control strategy must stage the lag boiler(s) only after the first boiler stage(s) fail to maintain the boiler water temperature called for by the reset control.

Annual Energy-Savings Algorithm

$\text{Therm}_{\text{SAVED}} = \text{BC} * \text{EFLH}_{\text{HEAT}} / (\text{Eff} * 100) * \text{SF}$

Where:

BC = Boiler capacity in MBh (= 1)

$\text{EFLH}_{\text{HEAT}}$ = Equivalent full-load heating hours (= 1,759 for Residential- multifamily; = varies by city for Commercial, Industrial, Agriculture, and Schools & Government sectors, see table below)

Eqivalent Full-Load Heating and Cooling Hours by City

City	$\text{EFLH}_{\text{HEAT}}$[3,4]
Green Bay	1,852
La Crosse	1,966
Madison	1,934
Milwaukee	1,883

Eff = Combustion efficiency of the boiler (= 87%)

100 = Conversion factor from therm to MBtu

SF = Savings factor (= 8%)[2]

Summer Coincident Peak Savings Algorithm

There are no peak savings for this measure.

Lifecycle Energy-Savings Algorithm

$\text{Therm}_{\text{LIFECYCLE}} = \text{Therm}_{\text{SAVED}} * \text{EUL}$

Where:

EUL = Effective useful life (= 5 years)[1]

Sources

1. Average of Cadmus database March 2013 and Fannie Mae Estimated Useful Life Table: https://www.fanniemae.com/content/guide_form/4099f.pdf .
2. Michigan Energy Measures Database. Available online: http://www.michigan.gov/mpsc/0,1607,7-159-52495_55129---,00.html.
3. Pigg and Nevius. *Electricity Use by New Furnaces.* 2000. Available online: http://www.ecw.org/sites/d3efault/files/230-1.pdf

4. Several Cadmus metering studies reveal that ENERGY STAR calculator EFLH are over-estimated by 25%. The heating EFLH were adjusted by population-weighted HDD and TMY-3 values.
5. Illinois Technical Reference Manual. 2013. Page 187. Boiler outside air reset/cutout controls cost is $612.00 per set of controls. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry
02	01/2015	Savings changed from per unit to per MBh

Boiler Tune-Up

	Measure Details
Measure Master ID	Boiler Tune-Up, 2744
Measure Unit	Per tune-up
Measure Type	Prescriptive
Measure Group	Boilers & Burners
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	129
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	258
Water Savings (gal/yr)	0
Effective Useful Life (years)	2[1]
Incremental Cost ($/unit)	$0.83/MBh per tune-up[4]

Measure Description

Tune-ups are required for boilers to maintain optimal combustion efficiency. Boiler tune-ups must be completed according to the boiler tune-up checklist. This measure applies to non-process-related boilers. A boiler tune-up includes reducing excess air and stack temperature; cleaning burners, burner nozzles, combustion chamber, and boiler tubes; sealing the combustion chamber; and recalibrating boiler controls.

The inspector also checks combustion air intake. The proper combustion air-to-fuel ratio directly affects combustion efficiency. Inadequate air supply yields unburned combustibles (fuel, soot, smoke, and carbon monoxide) while excess air causes heat loss from increased flue gas flow, which lowers the boiler efficiency.

Description of Baseline Condition

The baseline measure is 82% boiler efficiency.

Description of Efficient Condition

The minimum burner size for measure eligibility is 110,000 Btu per hour. The incentive is available once in a 24-month period. The service provider must perform before and after combustion efficiency tests and record the results on the boiler tune-up incentive application. The burner must be adjusted to improve combustion efficiency as needed. The incentives are only available for space and water heating equipment.

Annual Energy-Savings Algorithm

$\text{Therm}_{\text{SAVED}}$= 0.346 * Boiler Size

Where:

0.346 = Therms savings per input MBh[2]

Boiler Size = Size of the boiler being tuned and cleaned (= 373 MBtu/hour)[3]

Summer Coincident Peak Savings Algorithm

There are no peak savings for this measure.

Lifecycle Energy-Savings Algorithm

$\text{Therm}_{\text{LIFECYCLE}} = \text{Therm}_{\text{SAVED}} * \text{EUL}$

Where:

EUL = Effective useful life (= 2 years)[1]

Sources

1. 2012 NYSERDA Natural Gas Database. http://www.nyserda.ny.gov/-/media/Files/Publications/PPSER/Program-Evaluation/2012ContractorReports/2012-CI-Natural-Gas-Report.pdf .
2. State of Wisconsin Public Service Commission. *Business Programs Deemed Savings Manual V1.0*. March 22, 2010. (based on an updated baseline efficiency of 82%).
3. Average boiler size of boilers tuned and cleaned in the ACES program 2008-2010.
4. Illinois Technical Reference Manual. 2013. Page 160. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Combination Boiler, Natural Gas, AFUE ≤ 0.95

	Measure Details
Measure Master ID	Boiler, 95%+ AFUE, With DHW, Natural Gas, 3559, 3778
Measure Unit	Per combination boiler
Measure Type	Prescriptive
Measure Group	Boilers & Burners
Measure Category	Boiler
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	277
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	5,540
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Incremental Cost ($/unit)	$2,803.00[2]

Measure Description

Space heating boilers are pressure vessels that transfer heat to water for use in space heating. Boilers either heat water using a heat exchanger that works like an instantaneous water heater or by adding/connecting a separate tank with an internal heat exchanger to the boiler. A combination boiler contains a separate heat exchanger that heats water for domestic hot water use.

Qualifying combination boilers must be whole-house units used for both space conditioning (boiler) and hot water heating with one appliance and energy source. Only participants who have a natural gas account with a participating natural gas utility are eligible for this rebate.

Description of Baseline Condition

The baseline condition is a boiler with the federal minimum of 82% AFUE[2] and a residential, natural gas-fueled, 0.575 EF storage water heater.[3] New federal efficiency standards that took effect in April 2015 raised the minimum EF for baseline units from 0.575 to 0.600. The criteria date was rounded to January 1, 2016 since the code took affect mid-year 2015.

Description of Efficient Condition

The efficient condition is a combination boiler unit with boiler AFUE of 95% or greater. The combination boiler must have a sealed combustion unit and be capable of modulating the firing rate. Measures that do not qualify for this incentive include boilers with a storage tank and redundant or backup boilers.

Annual Energy-Savings Algorithm

$\text{Therm}_{\text{SAVED}} = \text{Therm}_{\text{SAVED - BOILER}} + \text{Therm}_{\text{SAVED – WH}}$

$\text{Therm}_{\text{SAVED - BOILER}} = \text{BC} * \text{EFLH} (1 - \text{EFF}_{\text{BASE}} / \text{EFF}_{\text{EE}}) / 100$

$$\text{Therm}_{\text{SAVED – WH}} = ((\text{GPD} * 365 * 8.33 * 1 * \Delta T_{w})/100{,}000) * ((1/\text{RE}_{\text{BASE}}) - (1/\text{E}_{\text{C,EE}})) + ((\text{UA}_{\text{BASE}} / \text{RE}_{\text{BASE}}) - (\text{UA}_{\text{EE}} / \text{E}_{\text{C,EE}})) * (\Delta T_{s} * 8{,}760)/100{,}000$$

Where:

BC = Boiler capacity (= 110 MBtu/hour)[3]

EFLH = Equivalent full-load hours (= 1,000)[4]

EFF_{BASE} = Baseline AFUE (= 82%)[5]

EFF_{EE} = Efficient AFUE (= 95%)

100 = Conversion

GPD = Gallons of hot water used by the home (= 51.5 per day)[6]

365 = Days per year

8.33 = Density of water (lb/gal)

1 = Specific heat of water (Btu/lb °F)

ΔT_{W} = Average difference between cold water inlet temperature (52.3°F) and hot water delivery temperature (125°F) (= 72.7°F)[7]

100,000 = Conversion from Btu to therm

RE_{BASE} = Recovery efficiency of the baseline tank type water heater (= 76%)[8]

$\text{E}_{\text{C,EE}}$ = Combustion efficiency of combination boiler used to provide DHW (= 95%)[9]

UA_{BASE} = Overall heat loss coefficient of baseline tank-type water heater (= 14.0 Btu/hr-°F) [10]

UA_{EE} = Overall heat loss coefficient of combination boiler (=0 Btu/hr-°F)

ΔT_{S} = Temperature difference between stored hot water (125°F) and ambient indoor temperature (65°F) (= 60°F)

8,760 = Hours per year

Summer Coincident Peak Savings Algorithm

There is no peak demand reduction for this measure.

Lifecycle Energy-Savings Algorithm

$\text{Therm}_{\text{LIFECYCLE}} = \text{Therm}_{\text{SAVED}} * \text{EUL}$

Where:

EUL = Effective useful life (= 20 years)[1]

Assumptions

Because the efficiency of a residential water heater is measured in EF, the true thermal efficiency and overall heat loss coefficient (UA_{BASE}) is not available. A TE of 76% and a UA_{BASE} of 14 is assumed.

The overall heat loss of the combination heater is assumed to be 0 Btu/hr-°F due to the minimal amount of domestic hot water stored within the unit. The average difference of 60°F assumes pipe and ambient air temperatures of 125°F and 65°F, respectively.

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. NEEP Regional Evaluation, Measurement & Verification Forum, A Report on Costs in Six Northeast & Mid-Atlantic Markets. 2011. Navigant Consulting. Page A-10. Mid-sized (126 MBh) Residential Combination Heat/Hot Water Incremental Cost 95 CAE = $2,803.00.
3. Average input capacity of boilers under 300 Mbh in the 2013 SPECTRUM Database.
4. 800 therms consumed by 90% AFUE furnaces (i.e., 720 therms output) for all residential natural gas measures estimate from: Pigg and Nevius. Electricity Use by New Furnaces. 2000. Available online: http://www.ecw.org/sites/d3efault/files/230-1.pdf. Using average furnace size of 72,000 Btu (from 2012 SPECTRUM database of 13,000 furnaces), 1,000 full-load heating hours are estimated.
5. Title 42 - THE PUBLIC HEALTH AND WELFARE - 42 U.S.C. 6291-6309 (http://www.gpo.gov/fdsys/pkg/USCODE-2010-title42/html/USCODE-2010-title42-chap77-subchapIII-partA-sec6291.htm)
6. Calculated by using the linear relationship of y = 16.286x + 13, where x is the average number of people per home and y is the average gallons of hot water used per day. An average value of 2.361 people/home was used for Wisconsin, based on RECS 2009 data (http://www.eia.gov/consumption/residential/data/2009/). The linear relationship is used in the 2012 Indiana TRM (http://aceee.org/files/pdf/2012-indiana-emv-report.pdf) and the 2010 NY TRM (http://aceee.org/files/pdf/2012-indiana-emv-report.pdf).

7. Public Service Commission of Wisconsin. Request for Proposals. Issued for Mass Markets Portfolio Residential Energy Efficiency Program Implementation. July 26, 2011.
8. Air-Conditioning, Heating, and Refrigeration Institute. "RWH Search." http://www.ahridirectory.org/ahridirectory/pages/rwh/defaultSearch.aspx. Most common RE for non-heat pump water heaters.
9. ENERGY STAR. "ENERGY STAR Most Efficient 2015 — Boilers." https://www.energystar.gov/index.cfm?c=most_efficient.me_boilers
10. United States Department of Energy. Technical Support Document: Energy Efficiency Standards for Consumer Products, Residential Water Heaters, Including Regulatory Impact Analysis. 2000.

Revision History

Version Number	Date	Description of Change
01	11/03/2014	Original
02	12/17/2014	Changed ΔT_S to match residential indirect, provided assumptions for value used in calculation, and provided justification for UA_{EE} value

Building Shell

Air Sealing

	Measure Details
Measure Master ID	Air Sealing, 2745
Measure Unit	Per CFM leakage
Measure Type	Custom
Measure Group	Building Shell
Measure Category	Air Sealing
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by heating and cooling system
Peak Demand Reduction (kW)	Varies by heating and cooling system
Annual Therm Savings (Therms)	Varies by heating system
Lifecycle Energy Savings (kWh)	Varies by heating and cooling system
Lifecycle Therm Savings (Therms)	Varies by heating system
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Incremental Cost ($/unit)	Varies by project

Measure Description

Air sealing is the sealing of cracks, gaps, or other penetrations that allow unwanted outside air to enter or exit conditioned spaces. Air sealing reduces the load on heating and cooling equipment, and can increase comfort. Typical areas to seal are attics, basements, crawlspaces, and around doors and windows. Blower door tests may be required to estimate the CFM of leaks before and after air sealing is performed. Savings are determined either by pre- and post-blower door testing or pre- and post-billing analysis.

Description of Baseline Condition

The baseline condition is no air sealing.

Description of Efficient Condition

The efficient condition is air sealing of cracks, gaps, or other penetrations that allow unwanted outside air to enter or exit conditioned spaces.

Annual Energy-Savings Algorithm[2]

$kWh_{SAVED} = kWh_{SAVED\ COOL} + kWh_{SAVED\ HEAT}$

For systems with cooling installed:

$kWh_{SAVED\ COOL} = [\{((CFM50_{PRE} – CFM50_{POST}))/N_{COOL}) * 60 * 24 * CDD * 0.018\} /(1{,}000 * Cool_{EFF})] * LM$

For systems with electric heat:

$kWh_{SAVED\ HEAT} = [((CFM50_{PRE} – CFM50_{POST})/N_{HEAT}) * 60 * 24 * HDD * 0.018] /(3{,}412 * Heat_{EFF})$

For systems with natural gas heat:

$Therm_{SAVED} = [((CFM50_{PRE} – CFM50_{POST})/N_{HEAT}) * 60 * 24 * HDD * 0.018] /(100{,}000 * Heat_{EFF})$

Where:

$CFM50_{PRE}$ = Blower door test result before air sealing is performed

$CFM50_{POST}$ = Blower door test result after air sealing is performed

N_{COOL} = Conversion factor for CFM from 50 Pascal to natural conditions (= 18.5 assuming normal shielding)

60 = Constant to convert minutes to hours

24 = Hours per day

CDD = Cooling degree days (= 565; see table below)

0.018 = Specific heat capacity of air (Btu/cubic feet – ^{o}F)

1,000 = Kilowatt conversion factor

$Cool_{EFF}$ = Cooling system efficiency, BTW/W - hr (= 10 SEER if manufactured before 2006; = 13 SEER if manufactured in 2006 or later)

LM = Latent multiplier to convert the calculated sensible cooling savings to a value representing sensible and latent cooling loads (= 6.6 as an average of Chicago and Minneapolis)[2]

N_{HEAT} = Conversion factor for CFM from 50 Pascal to natural conditions, assuming normal shielding (= 18.5 if 1-story; = 16.5 if 1.5 stories; = 15.0 if 2 stories; = 14.1 if 2.5 stories; = 13.3 if 3-stories)[3]

HDD = Heating degree days (= 7,616; see table below)

Cooling Degree Days and Heating Degree Days by Location

Location	HDD[4]	CDD[4]
Milwaukee	7,276	548
Green Bay	7,725	516
Wausau	7,805	654
Madison	7,599	630
La Crosse	7,397	729
Minocqua	8,616	423
Rice Lake	8,552	438
Statewide Weighted	**7,616**	**565**

3,412 = Conversion factor from kW-hr to Btu

$Heat_{EFF}$ = Heating system efficiency (fraction of heat output per unit of energy input expressed as a decimal)

100,000 = Conversion factor from Btu to therms

For systems with electric heat, $Heat_{EFF} = HSPF/3.412$

- Heat pumps manufactured before 2006, $Heat_{EFF} = 6.8/3.412 = 1.99$
- Heat pumps manufactured in 2006 or later, $Heat_{EFF} = 7.7/3.412 = 2.26$
- Electric resistance, $Heat_{EFF} = 1.0$

Installed AFUE for systems with natural gas heat:

- $Heat_{EFF} = 0.92$ for condensing systems
- $Heat_{EFF} = 0.78$ for non-condensing systems

Summer Coincident Peak Savings Algorithm

For systems with central air conditioning:

$kW_{SAVED} = (kWh_{SAVED\ COOL}/EFLH_{COOL}) * CF$

Where:

$EFLH_{COOL}$ = Equivalent full-load cooling hours (= 380; see table below)

Supporting Inputs for Load Hours in Several Wisconsin Cities[5]

Location	$EFLH_{COOL}$
Green Bay	344
La Crosse	323
Madison	395
Milwaukee	457
Wisconsin Average	**380**

CF = Coincidence factor (= 0.66)[6]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 20 years)[1]

Sources

1. 2007 GDS residential measure life report: http://www.iar.unicamp.br /lab/luz/ld/Arquitetural/interiores/ilumina%E7%E3o%20industrial/measure_life_GDS.pdf
2. Harriman et al. "Dehumidification and Cooling Loads From Ventilation Air." ASHRAE Journal. (Added the latent and sensible loads to determine the total (using averages from Chicago and Minneapolis to represent Wisconsin), then divided by the sensible load.
3. Lawrence Berkeley National Laboratory. Building Performance Institute Building Analyst Technical Standards. Available online: http://www.bpi.org/tools_downloads.aspx?selectedTypeID=1&selectedID=2
4. ASHRAE Estimation of Degree-Days: Fundamentals, Chapter 14. (Calculated from TMY3 weather files of the seven Wisconsin locations using statewide weighted values calculated from 2010 U.S. Census data for Wisconsin.)
5. Illinois Statewide Technical Reference Manual. (used average EFLH/CDD and applied to Wisconsin CDD.)
6. Opinion Dynamics Corporation. Delaware Technical Resource Manual. April 30, 2012. Available online: http://www.dnrec.delaware.gov/energy/information/otherinfo/Documents/EM-and-V-guidance-documents/DELAWARE_TRM_August%202012.pdf

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Attic Insulation, Multifamily

	Measure Details
Measure Master ID	Insulation, Attic: Natural Gas Heat with Cooling, Existing Insulation ≤ R-11, 3707 Natural Gas Heat without Cooling, Existing Insulation ≤ R-11, 3708 Natural Gas Heat with Cooling, Existing Insulation R-12 to R-19, 3709 Natural Gas Heat, without Cooling, Existing Insulation R-12 to R-19, 3710 Electric Heat with Cooling, Existing Insulation ≤ R-11, 3711 Electric Heat without Cooling, Existing Insulation ≤ R-11, 3712 Electric Heat with Cooling, Existing Insulation R-12 to R-19, 3713 Electric Heat without Cooling, Existing Insulation R-12 to R-19, 3714
Measure Unit	Per square foot of roof (over conditioned space)
Measure Type	Prescriptive
Measure Group	Building Shell
Measure Category	Insulation
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	Varies by measure
Annual Therm Savings (Therms)	Varies by measure
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	Varies by measure
Water Savings (gal/yr)	0
Effective Useful Life (years)	25[1]
Incremental Cost ($/unit)	$0.94/sq ft[2]

Measure Description

This measure is installing additional attic insulation in an existing multifamily residence, which is assumed to be heated with either natural gas or electricity and may be electrically cooled.

An additional requirement of this measure is that the existing space have less than or equal to R-11 insulation or R-12 to R-19 (excluding assembly section), and be insulated to a minimum of R-38. This specific measure detail was determined through additional analysis and calculations in reference to the Illinois TRM attic insulation methodologies.[3] A framing factor was not included in the calculation, as attic insulation is typically deep enough to completely cover the framing, making the framing impacts negligible.

Attic with an existing R-value greater than R-19, attics with an efficient condition of significantly greater than R-38, and heating systems other than electric resistance or natural gas furnace/boiler will be treated as custom measures.

Description of Baseline Condition

There are two tiers of baseline condition for this measure incentive: Tier 1 is an attic insulated to R-11 or less and Tier 2 is an attic insulated to between R-12 and R-19.

Description of Efficient Condition

The efficient condition is an attic insulated to R-38 or greater.

Annual Energy-Savings Algorithm

The following equations are calculated when the corresponding systems are present. If not present, the respective savings values are considered zero.

$$\text{Therms}_{\text{SAVED}} = ((1 / R_{\text{BASE}} - 1 / R_{\text{EE}}\ ) * \text{HDD} * 24 * \text{Area}) / (100{,}000 * \text{AFUE})$$

$$\text{kWh}_{\text{SAVED}} = \text{kWh}_{\text{SAVED\_HEAT}} + \text{kWh}_{\text{SAVED\_COOL}}$$

$$\text{kWh}_{\text{SAVED\_HEAT}} = ((1 / R_{\text{BASE}} - 1 / R_{\text{EE}}) * \text{HDD} * 24 * \text{Area}) / (1{,}000 * \text{HSPF})$$

$$\text{kWh}_{\text{SAVED\_COOL}} = ((1 / R_{\text{BASE}} - 1 / R_{\text{EE}}) * \text{CDD} * 24 * \text{Area}) / (1{,}000 * \text{SEER})$$

Where:

R_{BASE} = Existing R-value of attic (= 11 or = 19)
R_{EE} = Proposed R-value of attic after retrofit (= 38)
HDD = Heating degree days (= 7,616; see table below)
24 = Hours per day
Area = Attic area to be insulated (in square feet)
100,000 = Conversion from Btu to therms
AFUE = Natural gas heating system efficiency (= 80%)[5]
1,000 = Kilowatt conversion factor
HSPF = Electric heating system efficiency (= 3.412 for electric resistance heat, the number of BTU in a watt-hour)
CDD = Cooling degree days (= 565; see table below)
SEER = Cooling system efficiency (= 13)[4]

Cooling and Heating Degree Days by City

Location	HDD[6]	CDD[6]
Milwaukee	7,276	548
Green Bay	7,725	516
Wausau	7,805	654
Madison	7,599	630
La Cross	7,397	729
Minocqua	8,616	423
Rice Lake	8,552	438
Statewide Weighted	**7,616**	**565**

Summer Coincident Peak Savings Algorithm [7]

$kW_{SAVED} = (kWh_{SAVED\_COOL} / EFLH_{COOL}) * CF$

Where:

$EFLH_{COOL}$ = Equivalent full-load cooling hours (= 410)[8]

CF = Coincidence factor (= 0.68)[3,8]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therms_{LIFECYCLE} = Therms_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 25 years)[1]

Deemed Savings

Deemed Natural Gas and Electricity Savings per Square Foot of Attic Insulation

Measure	MMID	Annual kWh	Annual Therms	Peak kW	Lifecycle kWh	Lifecycle Therms
Nat Gas Heat, with Cooling, R11 or Less	3707	0.0674	0.1476	0.0001	1.685	3.6900
Nat Gas Heat, without Cooling, R11 or Less	3708	-	0.1476	-	-	3.6900
Nat Gas Heat, with Cooling, R12-R19	3709	0.0274	0.0601	0.0001	0.685	1.5025
Nat Gas Heat, without Cooling, R12-R19	3710	-	0.0601	-	-	1.5025
Electric Heat, with Cooling, R11 or Less	3711	3.5280	-	0.0001	88.185	-
Electric Heat, without Cooling, R11 or Less	3712	3.4600	-	-	86.500	-
Electric Heat, with Cooling, R12-R19	3713	1.4370	-	0.0001	35.935	-
Electric Heat, without Cooling, R12-R19	3714	1.4100	-	-	35.250	-

Sources

1. GDS Associates. Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures. Table 1, Insulation. 2007.
2. 2008 Database for Energy-Efficient Resources, Revised DEER Measure Cost Summary. June 2, 2008. (cost for Wall 2x6 R-19 Batts + R-5 Rigid)
3. Illinois Energy Efficiency Statewide Advisory Group. Illinois Statewide Technical Reference Manual. Section 5.6.4 Wall and Ceiling/Attic Insulation. June 1, 2015. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf
4. Appliance Standards Awareness Project. Central Air Conditioners and Heat Pumps. Available online: http://www.appliance-standards.org/product/central-air-conditioners-and-heat-pumps
5. Federal AFUE standard is 78%, but most new furnaces installed are 90% and higher, so 80% was assumed (only a slight adjustment since these are likely older properties without many other improvements).
6. ASHRAE Estimation of Degree-Days: Fundamentals, Chapter 14. (TMY3 weather files of the seven Wisconsin locations)
7. U.S. Census data for Wisconsin. 2010. (Statewide weighted values)
8. Illinois Energy Efficiency Statewide Advisory Group. Illinois Statewide Technical Reference Manual. Section 5.6.1 Air Sealing. June 1, 2015. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf
9. Focus on Energy Deemed Savings Report: Evaluated Deemed Savings Changes. November 14, 2014.

Revision History

Version Number	Date	Description of Change
01	01/2016	New measure

Insulation, Attic, R-11 or R-19 to R-38

	Measure Details
Measure Master ID	Insulation and Air Sealing, Attic, R-11 to R-38, 3570 Insulation, Attic, R-19 to R-38, 3558
Measure Unit	Per residence
Measure Type	Prescriptive
Measure Group	Building Shell
Measure Category	Insulation
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	Varies by baseline
Peak Demand Reduction (kW)	Varies by baseline
Annual Therm Savings (Therms)	Varies by baseline
Lifecycle Energy Savings (kWh)	Varies by baseline
Lifecycle Therm Savings (Therms)	Varies by baseline
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Incremental Cost ($/unit)	$2,647.71[2]

Measure Description

This measure is installing attic insulation in an existing single-family residence, prefaced by sealing the attic to reduce air infiltration. The associated insulation measure characteristics are from the Focus on Energy single-family residential proposal calculator as provided in 2011,[4] and the air sealing characteristics are based on modeling of a house with the same assumed characteristics—natural gas heating and electric cooling—with kWh savings reduced by 7.5% based on a Cadmus survey revealing that 92.5% of Wisconsin homes have central cooling.[6]

An additional requirement of this measure is that the existing condition of the space have less than or equal to an effective insulation of R-11 (excluding assembly section) for tier 1, or R-19 for tier 2; and the space should be insulated to a minimum level of R-38. This specific measure detail was determined through additional analysis and calculations in reference to the Illinois TRM attic insulation methodologies.[5] In absence of measure detail, specific program installation guidelines developed by Focus on Energy for its Home Performance with ENERGY STAR Program will be referenced to ensure consistency.

Data from the Energy Center of Wisconsin, the U.S. Census Bureau, and the American Housing Survey were used to calculate best estimates of energy savings for installing attic insulation in single-family Wisconsin residences.

Description of Baseline Condition

The baseline is an attic insulated to R-11 or below for tier 1, and up to R-19 for tier 2. Based on adjustments for projects expected in Wisconsin, the baseline is assumed to be a CFM50 (cubic feet per minute air leakage, at a pressure of 50 Pascal) of 3,684.

Description of Efficient Condition

The efficient condition is an attic insulated to a minimum of R-38, with air sealing techniques (e.g., caulk) of attic leaks to a CFM50 of 3,377.

Annual Energy-Savings Algorithm

The following equations are used to determine savings from attic insulation.

For Cooling

$kWh_{SAVED} = ((1 / R_{BASE} – 1 / R_{EE}) * CDD * 24 * area) / 1,000 / SEER * AC\%$

For Heating

$Therm_{SAVED} = ((1 / R_{BASE} – 1 / R_{EE}) * HDD * 24 * area) / 100,000 / AFUE$

Where:

R_{BASE} = Existing R-value of attic (= 11 for tier 1; = 19 for tier 2)

R_{EE} = Proposed R-value of attic (= 38)

CDD = Cooling degree days (= 565; see table below)

24 = Hours per day

area = Attic area to be insulated (= 1,209 square feet)

1,000 = Kilowatt conversion factor

SEER = Cooling system efficiency (= 12)

AC% = Amount of homes with central cooling systems (=92.5%)[6]

HDD = Heating degree days (= 7,616; see table below)

Cooling and Heating Degree Days by Location

Location	HDD[7]	CDD[7]
Milwaukee	7,276	548
Green Bay	7,725	516
Wausau	7,805	654
Madison	7,599	630
La Crosse	7,397	729
Minocqua	8,616	423
Rice Lake	8,552	438
Statewide Weighted	**7,616**	**565**

100,000 = Conversion from Btu to therms

AFUE = Natural gas heating system efficiency (= 80%)

Annual Energy-Savings Algorithm (Air Sealing)[8]

For Cooling

$kWh_{SAVED} = [\{((CFM50_{EXISTING} - CFM50_{NEW}) / N) * 60 * 24 * CDD * 0.018\} / 1,000 * SEER] * LM * AC\%$

For Heating

$Therm_{SAVED} = [((CFM50_{EXISTING} - CFM50_{NEW}) / N) * 60 * 24 * HDD * 0.018] / (100,000 * AFUE)$

Where:

$CFM50_{EXISTING}$ = Existing airflow rate in cubic feet per minute (= 3,683.6)[9]

$CFM50_{NEW}$ = New airflow rate post-air sealing (= 3,377.0)[9]

N = Conversion factor for CFM from 50 Pascal to natural conditions (= 18.5 assuming normal shielding)

60 = Constant to convert minutes to hours

0.018 = Specific heat capacity of air (Btu/cubic feet –°F)

LM = Latent multiplier used to convert the calculated sensible cooling savings to a value representing sensible and latent cooling loads (= see table below)[10]

Latent Multiplier by Location

Location	LM
Eau Claire	8.0
Green Bay	7.7
La Crosse	8.0
Madison	6.5
Milwaukee	8.3

Summer Coincident Peak Savings Algorithm[8]

$kW_{SAVED} = (kWh_{SAVED} / EFLH_{COOL}) * CF$

Where:

$EFLH_{COOL}$ = Equivalent full-load hours of air conditioning (= 410)[6]

CF = Coincidence factor (=0.68)[6]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 20 years)[1]

Deemed Savings

Deemed Savings by Baseline R-Value

Baseline	MMID	Annual kWh	Annual Therms	Peak Coincident kW	Lifecycle kWh	Lifecycle Therms
R-11 (tier 1)	3570	231	219	0.3831	4,620	4,380
R-19 (tier 2)	3558	183	114	0.3035	3,660	2,280

Assumptions

The assumed attic area of 1,209 square feet represents the average across all residential attic insulation projects undertaken in the Residential Rewards Program in 2012 and 2013. The previous value of 922 was based on a weighted average of housing unit areas and number of floors from a 2011 American Housing Survey day for Milwaukee.

Federal AFUE standard is 78%, but most new furnaces installed are 90% and higher, so we increased the assumption slightly to 80% (only a slight adjustment since these are likely older homes without many other improvements). SEER 12 is the assumption used for the ECM measure through the Focus on Energy Single Family Residential Program.

The default savings are based on existing heating and cooling equipment efficiencies of 80% AFUE and SEER 12, respectively.

Baseline and efficient R-values are conservative estimates based on the minimum program requirements. Where possible, savings should be calculated based on the square footage of actual existing and final R-values.

Sources

1. 2007 GDS Measure Life Study. http://www.iar.unicamp.br/lab/luz/ld/Arquitetural/interiores/ilumina%E7%E3o%20Industrial/measure_life_GDS.pdf. Attic insulation has an EUL of 25 and air sealing an EUL of 20, so 20 years was used to avoid over-counting lifecycle savings.
2. Attic Insulation IC of $0.99 per sq ft + NREL National Residential Efficiency Measures Database (for air sealing).
3. Wisconsin Focus on Energy. Cost-Effectiveness Calculator, Mass Markets – Residential SF Program. July 2011.
4. Illinois Energy Efficiency Statewide Advisory Group. Illinois Statewide Technical Reference Manual. Section 5.6.4 Wall and Ceiling/Attic Insulation. February 2014.
5. Wisconsin Focus on Energy. Evaluated Deemed Savings Changes. October 21, 2014.
6. ASHRAE Estimation of Degree –Days: Fundamentals, Chapter 14. (Calculated from TMY3 weather files of the seven Wisconsin locations, with statewide weighted values calculated using 2010 U.S. Census data for Wisconsin.)
7. Illinois Energy Efficiency Statewide Advisory Group. Illinois Statewide Technical Reference Manual. Section 5.6.1 Air Sealing. February 2014.
8. Calculated from EnergyGauge modeling completed using data from a survey of 136 existing homes in Illinois that participated in a CLEAResult home performance program. The model showed CFM50 of 3,683.635 pre-blower door test and 2,588.414 post-test, for a home of 1,209 square feet. To guard against overly aggressive savings estimates, CFM reduction was decreased by 72%, leading to a post-test figure of 3,376.973.
9. Harriman et al. "Dehumidification and Cooling Loads from Ventilation Air." ASHRAE Journal. (Added the latent and sensible loads to determine the total (using averages from Chicago and Minneapolis to represent Wisconsin), then divided by the sensible load.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

Wall Insulation, Multifamily

	Measure Details
Measure Master ID	Insulation, Wall: Natural Gas Heat with Cooling, 3703 Natural Gas Heat without Cooling, 3704 Electric Heat with Cooling, 3705 Electric Heat without Cooling, 3706
Measure Unit	Per square foot of exterior wall
Measure Type	Prescriptive
Measure Group	Building Shell
Measure Category	Insulation
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	Varies by measure
Annual Therm Savings (Therms)	Varies by measure
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	Varies by measure
Water Savings (gal/yr)	0
Effective Useful Life (years)	25[1]
Incremental Cost ($/year)	$0.94/sq ft[2]

Measure Description

This measure is installing insulation to above-grade exterior walls in an existing multifamily residence. This measure includes any increase in R-value due to installed insulation, including but is not limited to fiberglass batts, spray foam, loose fill cellulose, metalized polymers, or other material that meets local and state building codes. Sill boxes are to be considered as part of the exterior wall. A combination of insulation materials may be used, provided they meets the required efficient condition (for example, 2x4 construction will likely not meet R-20 with just cavity insulation and will likely require continuous insulation also).

Buildings with existing exterior wall insulation greater than R-5, exterior walls with an efficient condition of significantly greater than R-20, and application in buildings with heating systems other than electric resistance or gas furnace/boiler will still be treated as custom.

Description of Baseline Condition

The baseline condition is minimal wall insulation such that the existing R-value is at or less than R-5.

Description of Efficient Condition

The efficient condition is exterior wall insulation that complies with International Energy Conservation Code 2009.[3] IECC 2009 lists R-21 exterior wall insulation for climate zone 7 (roughly the northern quarter of the state) and R-20 for climate zone 6 (remainder of the state). R-20 was selected to provide one common value statewide.

The use of R-13 cavity insulation plus R-5 insulated sheathing is considered equal to R-20 for climate zone 6 by IECC 2009. Since most of Wisconsin is in this climate zone, this is an acceptable alternative.

IECC 2009 provides an alternate compliance path which allows for a nonfenestration U-factor of 0.057 or less to used instead of the R-20 or R-21 insulation to allow for alternative exterior wall construction types.[4] This is also an acceptable alternative.

Annual Energy-Savings Algorithm

$Therms_{SAVED} = ((1 / R_{BASE} - 1 / R_{EE}) * Area * (1 - FramingF)) * 24 * HDD / (100{,}000 * AFUE)$

$kWh_{SAVED} = kWh_{SAVED\_HEAT} + kWh_{SAVED\_COOL}$

$kWh_{SAVED\_HEAT} = ((1 / R_{BASE} – 1 / R_{EE}) * Area * (1 – FramingF)) * 24 * HDD / (1{,}000 * HSPF)$

$kWh_{SAVED\_COOL} = ((1 / R_{BASE} - 1 / R_{EE}) * Area * (1 - FramingF)) * 24 * CDD / (1{,}000 * SEER)$

Where:

R_{BASE} = Existing condition insulation R-value (= 5)
R_{EE} = Efficient condition insulation R-value (= 20)
Area = Wall area to be insulated in square feet
FramingF = Adjustment to account for area of framing (= 25%)[5]
HDD = Heating degree days (= 7,616; see table below)
AFUE = Natural gas heating system efficiency (= 80%)
HSPF = Electric heating system efficiency (= 3.412 for electric resistanc heat)
CDD = Cooling degree days (= 565; see table below)
SEER = Cooling system efficiency (= 13)

Heating and Cooling Degree Days by Location

Location	HDD[6]	CDD[6]
Milwaukee	7,276	548
Green Bay	7,725	516
Wausau	7,805	654
Madison	7,599	630
La Cross	7,397	729
Minocqua	8,616	423
Rice Lake	8,552	438
Statewide Weighted	**7,616**	**565**

Summer Coincident Peak Savings Algorithm[7]

$kW_{SAVED} = (kWh_{SAVED\_COOL} / EFLH_{COOL}) * CF$

Where:

$EFLH_{COOL}$ = Equivalent full-load cooling hours (= 410)[8]

CF = Coincidence factor (= 0.68)[8]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therms_{LIFECYCLE} = Therms_{SAVED} * EUL$

Where:

EUL = Effective useful life (=25 years)[4]

Deemed Savings

Deemed Savings for Wall Insulation

Measure	MMID	Annual kWh	Annual Therms	Peak kW	Lifecycle kWh	Lifecycle Therms
Nat Gas Heat with Cooling	3703	0.117	0.257	0.0002	2.93	6.43
Nat Gas Heat without Cooling	3704	-	0.257	-	-	6.43
Electric Heat with Cooling	3705	6.114	-	0.0002	153.60	-
Electric Heat without Cooling	3706	6.027	-	-	150.70	-

Sources

1. GDS Associates. Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures. Table 1, Insulation. 2007.
2. *2008 Database for Energy-Efficient Resources, Revised DEER Measure Cost Summary*. June 2, 2008. (cost for Wall 2x6 R-19 Batts + R-5 Rigid).
3. International Energy Conservation Code 2009, Chapter 4 – Residential Energy Efficiency, Tables 402.1.1 and 402.1.3.
4. Illinois Energy Efficiency Statewide Advisory Group. *Illinois Statewide Technical Reference Manual*. Section 5.6.4 Wall and Ceiling/Attic Insulation. Section 5.6.1 Air Sealing. June 1, 2015. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf
5. *ASHRAE Estimation of Degree-Days: Fundamentals*, Chapter 14. (TMY3 weather files of the seven Wisconsin locations); 2010 US Census data for Wisconsin. (statewide weighted values)
6. Wisconsin Focus on Energy. *Deemed Savings Changes*. November 14, 2014. Available online: https://focusonenergy.com/sites/default/files/FoE_Deemed_WriteUp%20CY14%20Final.pdf

Revision History

Version Number	Date	Description of Change
01	01/2016	New measure

Domestic Hot Water

Kitchen Aerators, Single Family

	Measure Details
Measure Master ID	Faucet Aerator, Direct Install, 1.5 GPM, Kitchen: Natural Gas, 2120, 2136 Electric, 2126 Faucet Aerator, Pack Based, 1.5 GPM, Kitchen, 3862
Measure Unit	Per aerator
Measure Type	Prescriptive
Measure Group	Domestic Hot Water
Measure Category	Aeration
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	Varies by measure
Annual Therm Savings (Therms)	Varies by measure
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	Varies by measure
Water Savings (gal/yr)	2,897 (MMIDs 2120, 2126, and 2136); 1,564 (MMID 3862)
Effective Useful Life (years)	10[1]
Incremental Cost	$9.50[15]

Bathroom Aerators

	Measure Details
Measure Master ID	Faucet Aerator, Direct Install, 1.0 GPM, Bathroom, Residential: Natural Gas, 2121, 2137 Electric, 2127 Faucet Aerator, Pack Based, 1.0 GPM, Bathroom, Residential, 3863
Measure Unit	Per aerator
Measure Type	Prescriptive
Measure Group	Domestic Hot Water
Measure Category	Aeration
Sector(s)	Residential- multifamily, Residential- single family
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	Varies by measure
Annual Therm Savings (Therms)	Varies by measure
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	Varies by measure

	Measure Details
Water Savings (gal/yr)	829 (MMIDs 2121, 2127, and 2137); 448 (MMID 3862)
Effective Useful Life (years)	10[1]
Incremental Cost	$13.24[16]

Shower Aerators, Single Family

	Measure Details
Measure Master ID	Showerhead, Direct Install, 1.5 GPM: Natural Gas, 2123 Electric, 2129 Showerhead, Pack Based, 1.5 GPM, 3864
Measure Unit	Per showerhead
Measure Type	Prescriptive
Measure Group	Domestic Hot Water
Measure Category	Showerhead
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	Varies by measure
Annual Therm Savings (Therms)	Varies by measure
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	Varies by measure
Water Savings (gal/yr)	2,362 (MMIDs 2123 and 2129); 1,706 (MMID 3864)
Effective Useful Life (years)	10[7]
Incremental Cost	$5.00[17]

Measure Description

This measure is installing a 1.5 GPM or 1.0 GPM faucet or shower aerator in place of a higher flow rated aerator. Direct install measure savings are based on the Program Implementer or their subcontractor performing the installation. Pack-based measure savings are based on the homeowner/tenant performing the installation. With pack-based measures, the aerator is provided as part of a package, so an installation rate less than 100% is applied.

Description of Baseline Condition

The baseline equipment is 2.2 GPM aerator for the kitchen or bathroom, and a 2.5 GPM aerator for the showerhead.

Description of Efficient Condition

The efficienct measure is a 1.5 GPM or 1.0 GPM low-flow aerator, installed by the Program Implementer or their subcontractor (direct install) or provided as part of an energy efficiency package (pack based).

Annual Energy-Savings Algorithm

Aerators

$$Gallons_{SAVED} = (GPM_{EXISTING} - GPM_{NEW}) * PH / FH * LU * 365 * IR$$

$$kWh_{SAVED} = Gallons_{SAVED} * 8.33 * 1 * (T_{POINT\ OF\ USE} - T_{ENTERING}) / RE_{ELECTRIC} / 3{,}412$$

$$Therm_{SAVED} = Gallons_{SAVED} * 8.33 * 1 * (T_{POINT\ OF\ USE} - T_{ENTERING}) / RE_{GAS} / 100{,}000$$

Showerheads

$$Gallons_{SAVED} = (GPM_{EXISTING} - GPM_{NEW}) * PH * SPD / FH * SLU * 365 * IR$$

$$kWh_{SAVED} = Gallons_{SAVED} * 8.33 * 1 * (T_{POINT\ OF\ USE} - T_{ENTERING}) / RE_{ELECTRIC} / 3{,}412$$

$$Therm_{SAVED} = Gallons_{SAVED} * 8.33 * 1 * (T_{POINT\ OF\ USE} - T_{ENTERING}) / RE_{GAS} / 100{,}000$$

Where:

$Gallons_{SAVED}$ = First-year water savings, gallons

$GPM_{EXISTING}$ = Baseline flowrate (= 2.2 GPM for kitchen and bathroom aerators; = 2.5 GPM for showerheads)[4]

GPM_{NEW} = Efficient flowrate (= 1.5 GPM for kitchen aerators and showerheads; = 1.0 GPM for bathroom aerators)

PH = Persons per house (= 2.52 single family; = 1.93 multifamily)[1]

FH = Fixtures per house (for single family = 1.0 for kitchen aerator, = 2.13 for bathroom aerators, = 1.64 for showerheads; for multifamily = 1.0 for kitchen aerators, = 1.11 for bathroom aerators, = 1.0 for showerheads)[1]

LU = Length of use in minutes per person per day (= 4.5 for kitchen aerators; = 1.6 for bathroom aerators)[5]

365 = Conversion from days to years

IR = Installation rate (= 1.0 for aerators direct install; = 0.90 for showerheads direct install;[8] = 0.54 for aerators pack based;[10,11] = 0.65 for showerheads pack based)[11,12]

8.33 = Density of water, lbs/gallon

1 = Specific heat of water, Btu/lb °F

$T_{POINT\ OF\ USE}$ = Temperature of water at point of use (= 93°F for kitchen aerators; = 86°F for bathroom aerators; = 101°F for showerheads)[5]

$T_{ENTERING}$ = Temperature of water entering water heater (= 52.3°F)[2]

$RE_{ELECTRIC}$ = Recovery efficiency of electric water heater (= 98%)[3]

3,412 = Conversion from Btus to kWhs

RE_{GAS} = Recovery efficiency of natural gas water heater (= 76%)[3]

100,000 = Conversion from Btus to therms

SPD = Showers per person per day (= 0.6)[5]

SLU = Shower length in minutes (= 7.8)[13]

Summer Coincident Peak Savings Algorithm

Aerators

$kW_{SAVED}= kWh_{SAVED} * CF / (PH * LU * 365 / 60 / FH)$

$CF = \%Peak_{AERATOR} * LU / 180$

Showerheads

$kW_{SAVED} = kWh_{SAVED} * CF / (PH * SPD * SLU * 365 / 60 / FH)$

$CF = \%Peak_{SHOWER} * SLU * SPD / 180$

Where:

kWh_{SAVED} = Calculated savings value above on a per faucet basis

CF = Coincidence factor (= 0.0033 for kitchen aerators; = 0.0012 for bathroom aerators; = 0.0023 for showerheads)

60 = Conversion from minutes to hours

$\%Peak_{AERATOR}$ = Amount of time faucet aerators used during peak period (= 13%)[6]

180 = Number of minutes during peak period

$\%Peak_{SHOWER}$ = Amount of time showers used during peak period (= 9%)[6]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 10 years)[7]

Deemed Savings

The following table lists the deemed energy savings and demand reduction for each measure.

Deemed Savings and Incremental Costs

Measure	MMID	Single Family			Multifamily		
		Peak kW	Annual / Lifecycle kWh	Annual / Lifecycle therms	Peak kW	Annual / Lifecycle kWh	Annual / Lifecycle therms
Direct Install							
Kitchen Aerator, NG	2120, 2136	-	-	13 / 130	-	-	-
Kitchen Aerator, Elec	2126	0.0140	294 / 2,940	-	-	-	-
Bathroom Aerator, NG	2121, 2137	-	-	3.1 / 31	-	-	-4.5 / 45
Bathroom Aerator, Elec	2127	0.0073	70 / 700	-	-	-	-
Shower Aerator, NG	2123	-	-	12.6 / 126	-	-	-
Shower Aerator, Elec	2129	0.0151	287 / 2,870	-	-	-	-
Pack-Based							
Kitchen Aerator	3862	0.0014	30.1 / 301	5.7 / 57	-	-	-
Bathroom Aerator	3863	0.0007	7.1 / 71	1.3 / 13	-	-	-
Shower Aerator	3864	0.0021	39.3 / 393	7.4 / 74	-	-	-

Assumptions

For pack-based measures, 54% is the average installation rate for aerators;[10,11] while 65% is the average installation rate for showerheads.[11,12] These installation rates were applied to account for some water measures not actually being installed. Direct install measures are typically assumed to have an in-service rate of 100%, but showerhead assumptions were adjusted to 90% to account for evaluation survey findings indicating that some showerheads were removed or never installed.[8]

Pack-based measures claim both natural gas and electric savings, weighted at 81% and 19%, respectively. This weighting corresponds to findings from a data collection effort including nearly 10,000 homes in Wisconsin reveavling that 81% of homes had a natural gas domestic water heater and 19% had electric.[14]

The peak percentage values of 9% and 13% for showerheards and aerators, respectively, were determined from Figure 2 of a study conducted by Aquacraft, Inc.[6] The peak values were taken from the time period from 1:00 p.m. to 4:00 p.m.

The shower length was determined using the U.S Department of Energy's DHW Event Schedule Generator[13], using the average water main temperature of all locations measured in Wisconsin, weighted by city populations.

Sources

1. DEER 2014 and GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts. Prepared for GasNetworks; Table B-2a, measure C-WH-15. Found online here: http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx and http://ma-eeac.org/wordpress/wp-content/uploads/5_Natural-Gas-EE-Potenial-in-MA.pdf
2. U.S. Department of Energy. Domestic Hot Water Scheduler. Average water main temperature of all locations measured in Wisconsin by scheduler, weighted by city populations.
3. U.S. Department of Energy National Renewable Energy Laboratory. Building America Research Benchmark Definition. pg. 12. January 2010. Available online: http://www.nrel.gov/docs/fy10osti/47246.pdf
4. National Efficiency Standards and Specifications for Residential and Commercial Water-Using Fixtures and Appliances. Available online: https://www3.epa.gov/watersense/docs/matrix508.pdf
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12. Cadmus. Colorado Showerhead Program Evaluation. December 7, 2011. https://www.xcelenergy.com/staticfiles/xe/Regulatory/Regulatory%20PDFs/CO-DSM/2011-CO-Showerhead-Program-Evaluation.pdf
13. U.S. Department of Energy. DHW Scheduler. Available online: http://energy.gov/eere/buildings/downloads/dhw-event-schedule-generator
14. Wisconsin Focus on Energy. Home Performance emHome Data Extract, January 1, 2015 through November 15, 2015.
15. DEER 2015. California Database for Energy Efficient Resources. $6.70 labor + $2.80 materials = $9.50. Available online: http://www.deeresources.com/index.php/ex-ante-database.
16. DEER 2015. California Database for Energy Efficient Resources, $6.70 labor + $6.54 materials = $13.24. Available online: http://www.deeresources.com/index.php/ex-ante-database.
17. $5.00 = WESCO Distribution Pricing ($3.11) + Labor ($1.89)

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry
02	01/2015	Combined separate entries

Kitchen, Bath, and Shower Aerators

	Measure Details
Measure Master ID	Faucet Aerator: 1.5 GPM, Kitchen, 3026 (Electric), 3025 (Natural Gas) 1.0 GPM, Kitchen, 3506 (Electric), 3507 (Natural Gas) 0.5 GPM, Kitchen, 3509 (Electric), 3510 (Natural Gas) 1.5 GPM, Bathroom, 3028 (Electric), 3027 (Natural Gas) 1.0 GPM, Bathroom, 2143 (Electric) 0.5 GPM, Bathroom, 3508 (Natural Gas) 1.5 GPM, Shower, 3030 (Electric), 3029 (Natural Gas)
Measure Unit	Per aerator
Measure Type	Prescriptive
Measure Group	Domestic Hot Water
Measure Category	Aeration
Sector(s)	Residential- single family, Residential- multifamily
Annual Energy Savings (kWh)	Varies by location and sector
Peak Demand Reduction (kW)	Varies by location and sector
Annual Therm Savings (Therms)	Varies by location and sector
Lifecycle Energy Savings (kWh)	Varies by location and sector
Lifecycle Therm Savings (Therms)	Varies by location and sector
Water Savings (gal/yr)	Varies by location
Effective Useful Life (years)	10[7]
Incremental Cost ($/unit)	Varies by measure, see Appendix D

Measure Description

This measure is installing low-flow kitchen, bathroom, and/or shower aerators in existing buildings or new construction. It saves either natural gas or electric consumption depending on the water heating fuel source. It also saves on total water consumption.

Description of Baseline Condition

The baseline equipment is a kitchen aerator at 2.2 GPM, a bathroom aerator at 2.2 GPM, and a showerhead at 2.5 GPM.

Description of Efficient Condition

The efficient condition is a kitchen aerator at 1.5, 1.0, or 0.5 GPM, a bathroom aerator at 1.5, 1.0, or 0.5 GPM, and showerhead at 1.5 GPM.

Annual Energy-Savings Algorithm

$kWh_{SAVED}= ((\Delta Gallons * 8.33 * 1 * (T_{POINT\ OF\ USE} - T_{ENTERING}))/ RE_{ELECTRIC})/3,412$

$Therm_{SAVED}= ((\Delta Gallons * 8.33 * 1 * (T_{POINT\ OF\ USE} - T_{ENTERING}))/ RE_{GAS})/100,000$

Aerators

$Gallon_{SAVED} = (GPM_{EXISTING} - GPM_{NEW}) * (PH/FH) * FLU * 365$

Showerheads

$Gallon_{SAVED} = (GPM_{EXISTING} - GPM_{NEW}) * ((PH * SPD)/FH) * SLU * 365$

Where:

$\Delta Gallons$ = First-year water savings, gallons

8.33 = Density of water, lbs/gallon

1 = Specific heat of water, Btu/lb °F

$T_{POINT\ OF\ USE}$ = Temperature of water at point of use (= 93°F for kitchen aerators; = 86°F for bathroom aerators; = 101°F for showerheads)[5]

$T_{ENTERING}$ = Temperature of water entering water heater (= 52.3°F)[2]

$RE_{ELECTRIC}$ = Recovery efficiency of electric water heater (= 98%)[3]

3,412 = Conversion from Btus to kWhs

RE_{GAS} = Recovery efficiency of natural gas water heater (= 76%)[3]

100,000 = Conversion from Btus to therms

$GPM_{EXISTING}$ = Baseline flow rate (= 2.2 GPM for kitchen and bathroom aerators; = 2.5 GPM for showerheads)[4]

GPM_{NEW} = Efficient flow rate (= 1.5, 1.0, or 0.5 GPM for kitchen and bathroom aerators; = 1.5 GPM for showerheads)

PH = Single-family persons per house (= 2.52)[1] / multifamily unit (=1.93)[1]

FH = Single-family fixtures per house (= 1.0 for kitchen aerator; = 2.13 for bathroom aerators; = 1.64 for showerheads)[1] / multifamily unit (= 1.0 for kitchen aerators; = 1.11 for bathroom aerators; = 1.0 for showerheads)[1]

FLU = Length of use in minutes per person per day (= 4.5 for kitchen aerators; = 1.6 for bathroom aerators)[5]

365 = Conversion from days to years

SPD = Showers per person per day (= 0.6)[5]

SLU = Shower length of use (= 7.8 minutes/shower)[5]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} * CF / (PH * LU * 365 \text{ days} / (60 \text{ mins/hr}) / FH)$

Where:

CF = Coincidence factor (= 0.0032 for kitchen aerators; = 0.0011 for bathroom aerators; = 0.0039 for showerheads)[6]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 10 years)[7]

Sources

1. DEER 2014 and GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts. Prepared for GasNetworks; Table B-2a, measure C-WH-15. Online here: http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx and http://ma-eeac.org/wordpress/wp-content/uploads/5_Natural-Gas-EE-Potenial-in-MA.pdf
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3. National Renewable Energy Laboratory. Building America Research Benchmark Definition. Pg. 12. 2009. Available online: http://www.nrel.gov/docs/fy10osti/47246.pdf.
4. Federal minimum at 80 psi.
5. Cadmus. Michigan Water Meter Study. 2012.
6. DeOreo, William B. The End Uses of Hot Water in Single Family Homes From Flow Trace Analysis. Figure 2, pg. 10. Available online: http://s3.amazonaws.com/zanran_storage/www.aquacraft.com/ContentPages/47768067.pdf The peak percentage values of 9% and 13% for showerheads and aerators, respectively, determined from the load shape in Figure 2 for the hours between 1:00 p.m. and 4:00 p.m.
7. Wisconsin PSC EUL Database. 2013. See Appendix C.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry
02	01/2015	Added measures/flow rates
03	10/2016	Removed 2137, which has new workpaper

DHW Temperature Turn Down, Direct Install, Electric and Natural Gas

	Measure Details
Measure Master ID	DHW Temperature Turn Down, Direct Install: Natural Gas, 2141 Electric, 2147
Measure Unit	Per turn down
Measure Type	Prescriptive
Measure Group	Domestic Hot Water
Measure Category	Controls
Sector(s)	Residential- single family, Residential- multifamily
Annual Energy Savings (kWh)	743
Peak Demand Reduction (kW)	0.085
Annual Therm Savings (Therms)	68
Lifecycle Energy Savings (kWh)	11,145
Lifecycle Therm Savings (Therms)	748
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]

Measure Description

The measure is the Program Implementer or a subcontractor of the Program Implementer turning the water heater temperature down to 120°F. Assumptions are based on direct installation, not on a time-of-sale purchase.

There are two main effects of hot water storage temperature on energy use. The primary effect is due to standby loss, which increases with hot water temperature. The secondary effect is that hotter stored water affects hot water end-uses. This happens in two ways. For batch appliances, such as most clothes washers, more energy is used for hot and warm wash cycles because a fixed number of gallons is drawn for each load. For mixed end-uses (showers, sinks, bathtubs), when the stored water is hotter, less of it is mixed with cold water to achieve the target use temperature. Since the majority of hot water use is mixed temperature, a modest change in the hot water temperature (of 10°F to 20°F) has a relatively small impact on the energy required to heat the delivered hot water.

The reduction in standby loss also affects internal gains. For electric hot water, the reduction in internal gains from a turn-down results in slightly smaller cooling load; assuming that most water heaters in Wisconsin are in basements, and that basements have little or no direct air conditioning, this effect can be ignored. Heating effects are ignored for electric water heaters, assuming a predominance of natural gas heat; however, it should be accounted for at an appropriate efficiency in residence with a heat pump or electric resistance heat.

Description of Baseline Condition

The baseline is a hot water temperature set above 120°F.

Description of Efficient Condition

The efficient condition is for residential electric water heaters serving single residential units and multiple dwelling units to be set to 120°F.

Annual Energy-Savings Algorithm

Electric Measures

$kWh_{SAVED} = [(HW_{BASE} + SB_{BASE}) – (HW_{EFF} + SB_{EFF})] * 365 * (1/3,412) * Units$

$HW = GPD * C_P * (T_{WH} – T_{ENTERING}) * 1/RE * [1 – UA * (T_{WH} – T_{ROOM}/Input)] * Units$

$SB = UA * 24 * (T_{WH} – T_{ROOM}) * Units$

$UA = [(1/EF)-(1/RE)]/[67.5 * ((24/Q_{OUT}) – (1/(RE * Input)))]$

Where:

HW_{BASE} = Hot water baseline load (= 24,912 Btu/day)

SB_{BASE} = Standby baseline load (= 4,125 Btu/day)

HW_{EFF} = Hot water efficient load (= 24,111 Btu/day)

SB_{EFF} = Standby efficient load (= 3,536 Btu/day)

365 = Number of days per year

3,412 = Conversion from Btu to kWh

Units = Number of dwelling units served by water heater (= 1 single family, = 5 multifamily central unit)

GPD = Gallons of hot water use per day (= 38.1 for baseline measure; = 42.3 for efficient measure)

C_P = Heat capacity of water (= 8.33 Btu/gallon/°F)

T_{WH} = Temperature in tank (= 130°F for baseline measure; = 120°F for efficient measure)

$T_{ENTERING}$ = Cold water mains temperature (= 52.3°F)[2]

RE = Water heater recovery efficiency (=0.98)[3]

UA = Water heater equivalent heat loss factor (= 2.45 Btu/hr-°F)

T_{ROOM} = Ambient temperature surrounding tank (= 65°F)

Input = Firing rate (= 15,350 Btu/hr)

24 = Number of hours per day

EF = Energy factor (= 0.904)[4]

67.5 = Ambient Air Temperature

Q_{OUT} = Energy content of water drawn from water heater during 24 hour test (= 41,094 Btu/day)[4]

Therm Measures

$Therm_{SAVED} = [(HW_{BASE} + SB_{BASE}) – (HW_{EFF} + SB_{EFF})] * 365 * 1/1{,}000 * Units$

$HW = GPD * C_P * (T_{WH} – T_{ENTERING}) * 1/RE * [1 – UA * (T_{WH} – T_{ROOM}/Input)] * Units$

$SB = UA * 24 * (T_{WH} – T_{ROOM}) * Units$

$UA = [(1/EF)-(1/RE)] / [67.5 * ((24/Q_{OUT}) – (1/ (RE * Input)))]$

Where:

HW_{BASE} = Hot water baseline load (= 31,887 Btu/day)

SB_{BASE} = Standby baseload (= 17,752 Btu/day)

HW_{EFF} = Hot water efficient load (= 30,900 Btu/day)

SB_{EFF} = Standby efficient load (= 15,021 Btu/day)

RE = Water heater recovery efficiency (=0.76)[3]

UA = Water heater equivalent heat loss factor (= 11.38 Btu/hr-°F)

Input = Firing rate (= 40,000 Btu/hr)[4]

EF = Energy factor (= 0.575)[4]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (kWh_{SAVED} / 8{,}760) * CF * Units$

Where:

8,760 = Number of hours in one year

CF = Coincidence factor (= 1)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[1]

Assumptions

The gallons per day assumptions were as follows:

- Total hot water use at the tap = 51.5 GPD.[4] The hot water use is broken into two components: unmixed (primarily for clothes washers and dishwashers) and mixed (for showers and sinks). It is assumed that 10 GPD is unmixed and 41.5 GPD is mixed (unmixed is direct draw from the water heater, and does not vary with stored hot water temperature; mixed is delivered at the fixture at 105°F, so the total draw from the water heater varies with stored water temperature).
- The water heater draw is given as:
    - $GPD_{BASE} = 10 + 41.5 * (105 - 52.3)/(130 - 52.3) = 38.1$ GPD
    - $GPD_{EFF} = 10 + 41.5 * (105 - 52.3)/(120 - 52.3) = 42.3$ GPD
- As the set temperature goes down, the hot water consumption at the tank goes up. As the stored temperature is reduced, more hot and less cold must be mixed to reach the target of 105°F at the showerhead or sink.
- An average value of 2.36 people per home was used for Wisconsin, based on RECS 2009 data and calculated using the linear relationship from the 2012 Indiana TRM and the 2010 NY TRM of $y = 16.286x + 13$, where x is the average number of people per home (2.36) and y is the average gallons of hot water used per day.
- For multifamily central DHW units, the BTU input size was changed from 40,000 to 200,000 based on field experience and a one-year project sample of DHW heater replacements for multifamily buildings from December 1, 2012 through December 1, 2013. The overall average size was 217,000 BTUs, with the most common size of 200,000 BTUs, which was used as a conservative estimate.
- Based on an individual water heater size of 40,000 BTUs, five dwelling units were used as the average units per water heater (200,000 / 40,000 = 5 units). This number of units was used as a multiplier for the single unit pre- and post- GPD numbers.

Sources

1. 2007 GDS study for New England working group: http://www.iar.unicamp.br/lab/luz/ld/Arquitetural/interiores/ilumina%E7%E3o%20industrial/measure_life_GDS.pdf .
2. U.S. Department of Energy. *DHW Scheduler*. Used average water main temperature of all Wisconsin locations, weighted by city population.
3. National Renewable Energy Laboratory. *Building America Research Benchmark Definition*. Pg. 12. 2009. Available online: http://www.nrel.gov/docs/fy10osti/47246.pdf.
4. Lawrence Berkley National Laboratory. *Water Heater Energy Consumption*. http://hes-documentation.lbl.gov/calculation-methodology/calculation-of-energy-consumption/water-heater-energy-consumption
5. U.S. Department of Energy. Federal standard for residential water heaters effective in 2004.

Revision History

Version Number	Date	Description of Change
01	01/01/2012	New measure
02	03/09/2013	Updated to new template and added lifecycle savings
03	04/22/2013	Revisions/comments
04	12/15/2013	Added multifamily sector and larger DHW heater savings
05	10/16/2016	Removed MMIDs 2125 and 2131

Pipe Insulation, Multifamily

	Measure Details
Measure Master ID	Insulation, Piping: Hot Water Space Heating: 0.5-inch and 0.75-inch Pipe, Natural Gas, 3685; Electric, 3689 1-inch and 1.25-inch Pipe, Natural Gas, 3686; Electric, 3690 1.5-inch and 2-inch Pipe, Natural Gas, 3687; Electric, 3691 3-inch and 4-inch Pipe, Natural Gas, 3688; Electric, 3692 Steam Space Heating: 0.5-inch and 0.75-inch Pipe, Natural Gas, 3751; Electric, 3755 1-inch and 1.25-inch Pipe, Natural Gas, 3752; Electric, 3756 1.5-inch and 2-inch Pipe, Natural Gas, 3753; Electric, 3757 3-inch and 4-inch Pipe, Natural Gas, 3754; Electric, 3758 Domestic Hot Water: 0.5-inch and 0.75-inch Pipe, Natural Gas, 3695; Electric, 3699 1-inch and 1.25-inch Pipe, Natural Gas, 3696; Electric, 3700 1.5-inch and 2-inch Pipe, Natural Gas, 3697; Electric, 3701 3-inch and 4-inch Pipe, Natural Gas, 3698; Electric, 3702
Measure Unit	Per linear foot of piping
Measure Type	Prescriptive
Measure Group	Domestic Hot Water
Measure Category	Insulation
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by measure
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	Varies by measure
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	Varies by measure, see Appendix D

Measure Description

Pipes are often uninsulated because the original insulation was damaged or removed, the original insulation was removed as part of an asbestos abatement program and never replaced, or the new pipe was installed but insulation not completed. Insulating pipes reduces heat losses to unheated building areas and decreases problems with overheating in areas with uninsulated pipe. Piping is in a conditioned space, likely a basement or mechanical room.

Description of Baseline Condition

The baseline condition is piping for a space heating hot water system, steam loop system, or domestic hot water system with no insulation. Domestic hot water piping is assumed to be copper, while space heating piping is assumed to be either copper or steel.

Description of Efficient Condition

The efficient condition is piping with fiberglass insulation, K-value 0.27 Btu-in/hr-ft^2-°F, which is approximately R-5 for a 1.5-inch thickness, R-3.5 for 1.0-inch thickness, and R-2 for 0.5-inch thickness. Foam insulation, K-value 0.30 Btu-in/hr-ft^2-°F, is also acceptable for domestic hot water systems. Specific requirements by system type are:

- Hot water space heating systems must have 1.0-inch thick insulation for 3-inch and smaller pipe, and 1.5-inch thick insulation for greater than 3-inch pipe
- Steam space heating systems must have 1.5-inch thick insulation
- Domestic hot water systems must have at least 0.5-inch thick insulation for less than 2-inch pipe, and at least 1.0-inch thick insulation for 2-inch and larger pipe

Annual Energy-Savings Algorithm

$Therms_{SAVED} = Insul_{SAVINGS} * Length * HOU / (Thermal\ Efficiency * 100{,}000)$

$kWh_{SAVED} = Insul_{SAVINGS} * Length * HOU / (Thermal\ Efficiency * 3{,}412)$

Where:

$Insul_{SAVINGS}$ = Energy savings from insulating pipe (= varies by pipe size; see tables below)

Length = Length of insulated pipe in feet

HOU = Annual hours of operation (= 4,000 for space heat;[3] = 8,760 for domestic hot water)

Thermal Efficiency = Thermal efficiency as a decimal (= 0.8 for natural gas; = 0.98 for electric)[4]

100,000 = Conversion from Btu to Therms

3,412 = Conversion from Btu to kWh

Insulation Savings for Space Heating Hot Water Pipe[5]

Pipe Outside Diameter (in)	Insulation Thickness (in)	% Copper Pipe	% Steel Pipe	Heat Loss, Btu/ hour-linear ft		
				Bare Pipe	Insulated Pipe	Insul$_{SAVINGS}$
0.5	1.0	50.0%	50.0%	60.36	11.94	48.42
0.75	1.0	50.0%	50.0%	73.18	14.37	58.81
1	1.0	50.0%	50.0%	89.13	14.92	74.21
1.25	1.0	50.0%	50.0%	109.65	19.21	90.44
1.5	1.0	50.0%	50.0%	123.85	19.44	104.41
2	1.0	50.0%	50.0%	151.60	22.73	128.87
3	1.0	50.0%	50.0%	216.55	30.94	185.61
4	1.5	50.0%	50.0%	273.70	28.03	245.67

Insulation Savings for Space Heating Steam Pipe[5]

Pipe Outside Diameter (in)	Insulation Thickness (in)	% Copper Pipe	% Steel Pipe	Heat Loss, Btu/ hour-linear ft		
				Bare Pipe	Insulated Pipe	Insul$_{SAVINGS}$
0.5	1.5	50.0%	50.0%	93.65	14.49	79.16
0.75	1.5	50.0%	50.0%	113.65	16.79	96.86
1	1.5	50.0%	50.0%	138.60	18.24	120.37
1.25	1.5	50.0%	50.0%	170.75	20.37	150.39
1.5	1.5	50.0%	50.0%	192.90	23.06	169.84
2	1.5	50.0%	50.0%	236.40	26.33	210.07
3	1.5	50.0%	50.0%	338.15	34.81	303.34
4	1.5	50.0%	50.0%	427.70	41.96	385.75

Insulation Savings for Domestic Hot Water Pipe[5]

Pipe Outside Diameter (in)	% 0.5 Inch Insulation	% 1.0 Inch Insulation	Heat Loss, Btu/ hour-linear ft		
			Bare Pipe	Insulated Pipe	Insul$_{SAVINGS}$
0.5	50.0%	50.0%	25.56	8.07	17.50
0.75	50.0%	50.0%	30.88	9.37	21.52
1	50.0%	50.0%	37.48	10.43	27.05
1.25	50.0%	50.0%	45.96	13.08	32.88
1.5	50.0%	50.0%	51.81	14.09	37.72
2	0.0%	100.0%	63.27	12.78	50.49
3	0.0%	100.0%	90.04	17.35	72.69
4	0.0%	100.0%	113.60	20.75	92.85

Summer Coincident Peak Savings Algorithm

To be consistent with single family residential pipe insulation measures, domestic hot water piping insulation does not have demand reduction. Heating hot water and steam piping are only in use during the winter, and therefore also have no demand reduction.

Lifecycle Energy-Savings Algorithm

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[1]

Deemed Savings

The following tables list the natural gas and electricity deemed savings per linear foot of insulation.

Natural Gas Deemed Savings Per Linear Foot

Measure	MMID	Measure Group	Annual kWh	Annual therms	Lifecycle kWh	Lifecycle therms	Incrm. Cost
Hot Water Space Heat							
0.5” and 0.75” Pipe	3685	Space Heating	-	2.68	-	40.2	$9.40
1” and 1.25” Pipe	3686	Space Heating	-	4.12	-	61.7	$9.40
1.5” and 2” Pipe	3687	Space Heating	-	5.83	-	87.5	$9.40
3” and 4” Pipe	3688	Space Heating	-	10.78	-	161.7	$10.53
Steam Space Heat							
0.5” and 0.75” Pipe	3751	Space Heating	-	4.40	-	66.0	$11.65
1” and 1.25” Pipe	3752	Space Heating	-	6.77	-	101.5	$11.65
1.5” and 2” Pipe	3753	Space Heating	-	9.50	-	142.5	$11.65
3” and 4” Pipe	3754	Space Heating	-	17.23	-	258.4	$11.65
Domestic Hot Water							
0.5” and 0.75” Pipe	3695	Dom. Hot Water	-	2.14	-	32.0	$7.15
1” and 1.25” Pipe	3696	Dom. Hot Water	-	3.28	-	49.2	$7.15
1.5” and 2” Pipe	3697	Dom. Hot Water	-	4.83	-	72.4	$8.28
3” and 4” Pipe	3698	Dom. Hot Water	-	9.06	-	135.9	$9.40

Electricity Deemed Savings Per Linear Foot

Measure	MMID	Measure Group	Annual kWh	Annual therms	Lifecycle kWh	Lifecycle therms	Incrm. Cost[2]
Hot Water Space Heat							
0.5” and 0.75” Pipe	3689	Space Heating	64.1	-	962.0	-	$9.40
1” and 1.25” Pipe	3690	Space Heating	98.5	-	1,477.0	-	$9.40
1.5” and 2” Pipe	3691	Space Heating	139.5	-	2,093.0	-	$9.40
3” and 4” Pipe	3692	Space Heating	258.0	-	3,869.0	-	$10.53
Steam Space Heat							
0.5” and 0.75” Pipe	3755	Space Heating	105.3	-	1,579.0	-	$11.65
1” and 1.25” Pipe	3756	Space Heating	161.9	-	2,429.0	-	$11.65
1.5” and 2” Pipe	3757	Space Heating	227.2	-	3,409.0	-	$11.65
3” and 4” Pipe	3758	Space Heating	412.2	-	6,182.0	-	$11.65
Domestic Hot Water							
0.5” and 0.75” Pipe	3699	Dom. Hot Water	51.1	-	766.5	-	$7.15
1” and 1.25” Pipe	3700	Dom. Hot Water	78.5	-	1,177.5	-	$7.15
1.5” and 2” Pipe	3701	Dom. Hot Water	115.5	-	1,733.2	-	$8.28
3” and 4” Pipe	3702	Dom. Hot Water	216.8	-	3,252.6	-	$9.40

Assumptions

For each pair of pipe diameters, the calculations are based on the average insulation savings.

The pipe insulation is being applied to multifamily central heating system supply and return pipes and multifamily domestic hot water piping.

The following assumptions were used to calculate savings for this measure:

- Space heating boiler supplies 180°F hot water or 5 PSI steam.
- Water heater supplies 125°F hot water (consistent with hot water supply temp for MMID 2760, domestic hot water plant replacement).
- Piping is in a basement or mechanical room that is heated to 65°F (assumption from TRM for MMID 2128, direct install domestic hot water piping insulation).
- Both copper and steel pipe are used for space heating, so space heating savings are based on 50% copper pipe and 50% steel pipe. All domestic hot water piping is assumed to be copper.

- For smaller pipe sizes that are only required to have 1/2-inch insulation, many installations may elect to use up to 1-inch insulation. Therefore, savings are based on a 50/50 split of 1/2-inch and 1-inch insulation.
- Incremental costs[2] are $7.15 per foot for 1/2-inch insulation, $9.40 per foot for 1-inch insulation, and $11.65 per foot for 1.5-inch insulation. When two different insulation thicknesses are used within a single measure (MMIDs 3688, 3697, 3692, and 3701), the corresponding incremental costs are weighted 50/50.

Sources

1. GDS Associates. Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures. Table 1, Pipe Wrap. 2007.
2. Illinois Energy Efficiency Statewide Advisory Group. Illinois Statewide Technical Reference Manual. Section 4.4.14 Pipe Insulation. June 1, 2015. (lists costs for 1-inch and 2-inch pipe insulation, interpolated to determine the cost of 1/2-inch and 1.5-inch pipe insulation.
3. Heating season considered as November 1 to April 15, which is 166 days. (166 days * 24 hours/day = 3,984, which was rounded to 4,000 to be consistent with business measure for steam pipe insulation (MMID 2430 in October 2015 WI TRM)).
4. Code of Federal Regulations Energy Efficiency Standards, Title 10 Part 431 Section 87.
5. North American Insulation Manufacturers Association. 3E Plus software. Available online: www.pipeinsulation.org.

Revision History

Version Number	Date	Description of Change
01	01/2016	New measure

Retail Store Markdown, Low-Flow Showerheads

	Measure Details
Measure Master ID	Showerheads, Retail Store Markdown, 3017
Measure Unit	Per showerhead
Measure Type	Prescriptive
Measure Group	Domestic Hot Water
Measure Category	Showerhead
Sector(s)	Residential- single family, Residential- multifamily
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	Varies by sector
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	Varies by sector
Water Savings (gal/yr)	2,632
Effective Useful Life (years)	10[1]
Incremental Cost ($/unit)	$5.00[8]

Measure Description

This measure is installing a showerhead with a flow rate of 1.75 GPM or less in a residential location, based on a time-of-sale purchase.

The energy and therm savings were adjusted based on the saturation of fuel types for water heating in Wisconsin (30% electric and 61% natural gas). Therefore, the savings values do not reflect the actual energy or natural gas savings on a per-unit basis.

Description of Baseline Condition

The baseline equipment is a showerhead with flow rate of 2.5 GPM.

Description of Efficient Condition

The efficient equipment is low-flow showerhead (≤ 1.75 GPM) installed in a residential location. The GPM used for the efficient showerhead in the calculations is a weighted average from sales data as of October 2013.

Annual Energy-Savings Algorithm

Water Savings

$\text{Gallon}_{\text{SAVED}} = (\text{GPM}_{\text{BASE}} - \text{GPM}_{\text{EE}}) * ((\text{PH} * \text{SPD})/\text{FH}) * \text{SLU} * 365$

Electric Water Heaters

$\text{kWh}_{\text{SAVED}} = (((\text{Gallon}_{\text{SAVED}} * 8.33 * 1 * (\text{T}_{\text{POINT OF USE}} - \text{T}_{\text{ENTERING}}))/\text{RE})/3{,}412) * \text{WHS}$

Natural Gas Water Heaters

$\text{Therm}_{\text{SAVED}} = (((\text{Gallon}_{\text{SAVED}} * 8.33 * 1 * (\text{T}_{\text{POINT OF USE}} - \text{T}_{\text{ENTERING}}))/\text{RE})/100{,}000) * \text{WHS}$

Where:

GPM_{BASE} = Baseline flow rate (= 2.5 GPM)[2]

GPM_{EE} = Efficient flow rate (= 1.54 GPM)

PH = Single-family persons per house (= 2.52)[7] / multifamily unit (=1.93)[7]

SPD = Showers per person per day (= 0.6)[4]

365 = Number of days per year

8.33 = Density of water, lbs/gallon

1 = Specific heat of water, Btu/lb °F

$\text{T}_{\text{POINT OF USE}}$ = Temperature of water at point of use (= 101°F)[4]

$\text{T}_{\text{ENTERING}}$ = Temperature of water entering water heater (= 52.3°F)[5]

RE = Average estimated recovery efficiency of electric water heater (= 98%)[6]

3,412 = Conversion from Btu to kWh

WHS = Water heater saturation (= 30% for electric;= 61% for natural gas)[3]

FH = Fixtures/house (= 1.47)[3]SLU = Shower length in minutes (= 7.8)[4]

100,000 = Conversion from Btu to therms

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} * CF /(PH * SLU * 365 * SPD) / 60 / FH)$

Where:

CF = Coincidence factor (= 0.0039%)[7]

SLU = Shower length in minutes (= 7.8)[4]

60 = Number of minutes per hour

FH = Fixtures/house (= 1.47)[3]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 10 years)[1]

Sources

1. Based on the effective useful life of 10 years, in California Joint Utility Low Income Energy Efficiency Program Costs and Bill Savings Standardization Report Final Report February 1, 2001 (Revised as of March 5, 2001). The effective useful life (EUL) is defined as the median number of years that a measure is in place and operable. See also Measure Life Report Residential and Commercial/Industrial Lighting and HVAC Measures, prepared for The New England State Program Working Group (SPWG) for use as an Energy Efficiency Measures/Programs Reference Document for the ISO Forward Capacity Market (FCM) by GDS Associates, Inc., June 2007 Federal minimum at 80 psi. Available online here: http://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/766a83dce56eca35852576da006d79a7/$FILE/60_DAy_Gas_TecMarket_Energy_Savings_Manual_Final_1-0.pdf and http://www.calmac.org/%5C/publications/Bill_Savings_Final_Report_revised_3-12-01.pdf and http://www.iar.unicamp.br/lab/luz/ld/Arquitetural/interiores/ilumina%E7%E3o%20industrial/measure_life_GDS.pdf
2. Residential Energy Consumption Survey. 2009 RECS Micro Survey Data. Structural and Geographic Characteristics, Wisconsin.
3. Cadmus. Michigan Water Meter Study. 2012.
4. U.S. Department of Energy. *DHW Scheduler*. Average water main temperature of all locations measured in Wisconsin by scheduler, weighted by city populations.

5. National Renewable Energy Laboratory. *Building America Research Benchmark Definition*. Pg. 12. 2009. Available online: http://www.nrel.gov/docs/fy10osti/47246.pdf.
6. Calculated assuming 9% of showers take place during peak hours (9% * 7.8 minutes per day / 180 minutes in peak period) = 0.0039.
7. DEER 2014 and GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts. Prepared for GasNetworks; Table B-2a, measure C-WH-15. Found online here: http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx and http://ma-eeac.org/wordpress/wp-content/uploads/5_Natural-Gas-EE-Potenial-in-MA.pdf
8. $5.00 = WESCO Distribution Pricing ($3.11) + Labor ($1.89)

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Domestic Hot Water Plant Replacement

	Measure Details
Measure Master ID	DHW Plant Replacement, 2760
Measure Unit	Per plant (or per apartment)
Measure Type	Hybrid
Measure Group	Domestic Hot Water
Measure Category	Other
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	324 (reference savings)
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	3,564
Water Savings (gal/yr)	0
Effective Useful Life	15[1]
Incremental Cost ($/unit)	$27.95/MBh[8]

Measure Description

This measure is upgrading an entire DHW plant in a building with central DHW.

Commercial water heaters with greater than 75,000 Btu/hour have a TE rating, which typically varies from around 80% for standard efficiency natural gas water heaters to 90% or greater for condensing water heaters.

Description of Baseline Condition

The baseline condition is a DHW plant with TE of 80%.

Description of Efficient Condition

The efficient condition is installing new water heater, which must be:

- A commercially sized HESCCM,
- An HESCC stand-alone water heater, or
- An indirect storage tank off a HESCCM boiler(s).

The new commercial water heaters must have a TE of 90% or greater. Fuel switching is not included in this measure. The additional requirements are:

- Building must have a central DHW system.
- Entire DHW system must be replaced: single water heater replacement in a multiple water heater system do not qualify.

Annual Energy-Savings Algorithm

The Building America Multi-Family Central Water Heating Evaluation Tool[2] was used to determine the deemed savings for this measure. With the exception of the inputs listed below, the tool's default values were used to calculate savings:

$Therm_{SAVED} = Therm_{BASE} - Therm_{EE}$

$Therm_{BASE} = [(GPD * N_{APTS} * 8.33 * C_P * \Delta T * 365)/(\eta_{BASE} * 100{,}000)] + [(Q_{LOSS\text{-}BASE} * N_{WH} * 24 * 365)/(100{,}000)]$

$Therm_{EE} = [(GPD * N_{APTS} * 8.33 * C_P * \Delta T * 365)/(\eta_{EE} * 100{,}000)] + [(Q_{LOSS\text{-}EE} * N_{WH} * 24 * 365)/(100{,}000)]$

Where:

GPD = Gallons per day (= 43.9)[3]

N_{APTS} = Total number of dwelling units served by system (= 11.5)[4]

8.33 = Conversion from gallons to mass

C_P = Specific heat constant pressure (= 1.0 Btu/lb-°F)

ΔT = Hot water setpoint of 125°F minus inlet water temperature of 52.3°F (= 72.7°F)[5]

365 = Number of days per year

η_{BASE} = Baseline TE (= 80%)

100,000 = Conversion from Btu to therm

$Q_{LOSS\text{-}BASE}$ = Baseline standby heat loss (= 1,233 Btu/hour)[6]

N_{WH} = Total number of DWH tanks (= 1)

24 = Number of hours per day

η_{EE} = Efficient TE (=90%)

$Q_{LOSS\text{-}EE}$ = Efficient standby heat loss (=929 Btu/hour)[7]

Summer Coincident Peak Savings Algorithm

There are no peak savings for this measure.

Lifecycle Energy-Savings Algorithm

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[1]

Assumptions

The water usage and recirculation loop condition parameters of the Building America Evaluation Tool were set to "medium" and "normal," respectively, to represent typical applications and reflect the prescriptive nature of the measure. The total heating capacity and standby losses were scaled from the default value of 600,000 Btuh and 15,000 Btuh to 230,000 Btuh and 5,750 Btuh, respectively, to reflect the change in number of apartment units from the default of 30 to 11.5.

Sources

1. Engineering judgement.
2. National Renewable Energy Laboratory. *Strategy Guideline: Proper Water Heater Selection*. August 2012. Available online: http://www.nrel.gov/docs/fy12osti/55074.pdf. Evaluation tool described in report is online: http://apps1.eere.energy.gov/buildings/publications/docs/building_america/multifamily_central_dhw_evaluationtool_v1-0.xls
3. The gallons per day is calculated by using the linear relationship of y = 16.286x + 13, where x is the average number of people per home and y is the average gallons of hot water used per day. An average value of 1.9 people per home was used for Wisconsin, based on RECS 2009 data. The linear relationship is used in the 2012 Indiana TRM and the 2010 NY TRM.
4. The Wisconsin multifamily number of units per apartment was estimated at 11.5 units based on: 2009 U.S. Census, table 989. Housing Units by Units in Structure and State. Available online: https://www.census.gov/compendia/statab/cats/construction_housing/housing_units_and_characteristics.html.
5. United States Department of Energy. *DHW Scheduler.* Average water main temperature of all locations measured in Wisconsin by scheduler, weighted by city populations. The water heater set point is assumed to be 125°F. Wisconsin building code 704.06 requires landlords to set water heaters to 125°F: https://docs.legis.wisconsin.gov/statutes/statutes/704/06. Water heater setpoints typically range between 120°F and 140°F, because temperatures below 120°F are susceptible to Legionella bacteria (which lead to Legionnaires Disease) and heaters set to temperatures above 140°F can quickly scald users: http://www.nrel.gov/docs/fy12osti/55074.pdf. Most TRMs assume water heater setpoints of 120°F, 125°F, or 130°F, though most of these are unsourced engineering assumptions.
6. Federal standard for natural gas storage water heater with 80 gallon storage and 199 kBtu/hour heat input.
7. Average standby loss of AHRI certified natural gas storage water heaters with TE > 94%, storage volume between 80 and 100 gallons, and heat input less than 200 kBtu/hour.
8. Actual Program Data, 2014-2016. Average actual cost of $27.95 per MBh.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Condensing Water Heater, Natural Gas, 90%+

	Measure Details
Measure Master ID	Condensing Water Heater, Natural Gas, 90%+, 1986 Condensing Water Heater, Natural Gas, 90%+, Claim Only, 3584
Measure Unit	Per water heater
Measure Type	Prescriptive
Measure Group	Domestic Hot Water
Measure Category	Water Heater
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	-50
Peak Demand Reduction (kW)	-0.0050
Annual Therm Savings (Therms)	46
Lifecycle Energy Savings (kWh)	-600
Lifecycle Therm Savings (Therms)	552
Water Savings (gal/yr)	0
Effective Useful Life (years)	15
Incremental Cost ($/unit)	MMID 1986 = $440.00;[6] MMID 3584 = $685.00[7]

Measure Description

This measure is installing high-efficiency, commercial-sized, condensing tank-type water heaters. These heaters are used for whole-house domestic water heating in the residential sector. Commercial-sized water heaters have a minimum input rating of 75,000 Btuh and have a TE rating of 80%. While these appliances have a commercial rating, they are often installed in residential homes.

The rebate is for customers who install condensing water heaters with a TE rating of at least 90% in a residential home.

Description of Baseline Condition

Savings are calculated using the federal code standard minimum of 0.600 if purchased after January 1, 2016. This updated baseline reflects the new federal standard that took effect April 2015, with the criteria date rounded to January 1, 2016.2 The calculation assumes a 50 gallon tank.

Description of Efficient Condition

The efficient condition is upgrading from the code-standard minimum natural gas storage residential water heater to a higher efficiency 90% TE commercial natural gas storage-type water heater. Natural gas storage water heaters are used to supply DHW.

Annual Energy-Savings Algorithm

Because the efficiency of traditional natural gas storage water heaters is measured using an EF and the efficiency of condensing water heaters is measured using the TE, different algorithms are used to calculate the baseline energy use and efficient energy use.

$\text{Therm}_{\text{SAVED}} = \text{Therm}_{\text{BASELINE}} - \text{Therm}_{\text{MEASURE}}$

$\text{Therm}_{\text{BASELINE}} = [\dot{M} * C_P * (T_{\text{TANK}} – T_{\text{INLET}})/EF] * (365/100{,}000)$

Where:

$\dot{M}$ = Mass of water drawn (= 429 lbs/day)

c_P = Specific heat of water (= 1 Btu/lb-°F)

T_{TANK} = Water heater thermostat set point temperature (= 125°F)[3]

T_{INLET} = Inlet water temperature (= 52.3°F)[4]

EF = Energy factor (= 0.600 after January 1, 2016)

365 = Number of days per year

100,000 = Conversion factor from Btu to therms

The following shows this equation solved for the post January 1, 2016 scenario:

ThermBASELINE = [(429 lbs/day * 1 Btu/lb°F * (125°F – 52.3°F))/0.600] * (365 / 100,000)

Mass flow was calculated as the product of the density of water and the gallons of water used per day: 8.33 lbs/gal * 51.5 GPD = 429 lbs/day. The gallons per day was calculated using the linear relationship of y = 16.286x + 13, where x is the average number of people per home and y is the average gallons of hot water used per day. The linear relationship is used in the 2012 Indiana TRM and the 2010 NY TRM. An average value of 2.365 people per home was used for Wisconsin, based on RECS 2009 data.

Measure Case Energy Usage

While residential storage water heater efficiency is measured in EF, which includes standby losses, commercial-sized storage water heater efficiency is measured in TE. While the efficiency equation for TE is similar to EF, it only measures the amount of energy used to heat the water consumed, and not the amount of energy needed for standby losses. The total energy usage a water heater consumes can be defined as:

$\text{Therm}_{\text{MEASURE}} = Q_{\text{USAGE}} + Q_{\text{STANDBY}}$

$Q_{\text{USAGE}} = [\dot{M} * CP * (T_{\text{TANK}} – T_{\text{INLET}})]/TE$

$Q_{\text{STANDBY}} = UA * (T_{\text{TANK}} – T_{\text{AMB}}) * [24 – ((Q_{\text{USAGE}}/(RE*P_{\text{ON}}))]$

The amount of energy used to heat the water consumed is solved for below:

Q_{USAGE} = [(429 lbs/day * 1 Btu/lb°F * (125°F – 52.3°F))/0.90] * (365 / 100,000)

Where:

TE = Thermal efficiency of measure (= 0.90)

UA = Standby heat loss coefficient (= 3.319 Btu/hr- °F)

T_{AMB} = Ambient temperature (= 65°F)[5]

24 = Number of hours per day

RE = Recovery efficiency (= 0.90, assume TE as a proxy)[6]

P_{ON} = Rated input power (= 76,000 Btu/hour, conservative)[5]

The standby loses are solved for below:

$Q_{STANDBY}$ = 3.319 Btu/hr-°F * (125°F - 65°F) * [24 – ((133 therms /(0.90 * 76,000 Btu/hr) * (365 /100,000)]

Combining these equations, the total energy usage a water heater consumes is solved for below:

$Therm_{MEASURE}$ = 126 therms/year + 17 therms/year = 144 therms/year

The measure savings is the difference in energy used by the baseline case and the efficient case:

$Therm_{SAVED}$ = 198 therms – 144 therms = 54 therms/year

Electrical Energy Savings

The condensing water heaters must be power vented to qualify for a program incentive. Power-vented equipment include an electrical fan to exhaust flue gases, which therefore has a negative electrical impact. As shown in the RFP TRC calculator, the estimated electrical impact of power-vented equipment is 50 kWh and 0.005 kW per year.

Summer Coincident Peak Savings Algorithm

The estimated electrical peak impact of power-vented equipment is 0.0050 kW for single family.

Lifecycle Energy-Savings Algorithm

$Therm_{LIFECYCLE}$ = $Therm_{SAVED}$ * EUL

Where:

EUL = Effective useful life (=Singlefamily 15; Multifamily 12)[1]

Assumptions

The electric values (kWh and kW) were reviewed from the supplied RFP calculator, which align with expected savings.

Sources

1. Single family: CALMAC 2000 workshop report. Available online here: http://www.cpuc.ca.gov/NR/rdonlyres/7E3A4773-6D35-4D21-A7A2-9895C1E04A01/0/EEPolicyManualV5forPDF.pdf. Multifamily: Fannie Mae Estimated Useful Life Table: https://www.fanniemae.com/content/guide_form/4099f.pdf and PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. The water heater setpoint is assumed to be 125°F, as Wisconsin building code 704.06 requires landlords to set water heaters to 125°F: https://docs.legis.wisconsin.gov/statutes/statutes/704/06. Water heater setpoints typically range between 120°F and 140°F because temperatures below 120°F are susceptible to Legionella bacteria (which lead to Legionnaires Disease) and heaters set to temperatures above 140°F can quickly scald users: http://www.nrel.gov/docs/fy12osti/55074.pdf. Additionally, a review of TRMs from geographically similar regions (including Connecticut 2012, Mid-Atlantic v3.0, Illinois v2.0, and Indiana v1.0) found assumed hot water setpoints between 120°F and 130°F.
3. U.S. Department of Energy. DHW Scheduler. (The average water main temperature is for all locations measured in Wisconsin, weighted by city population.)
4. U.S. Department of Energy, Energy Efficiency and Renewable Energy. Residential Water Heater Technical Support Document for the January 17, 2001, Final Rule. Appendix D-2: Water Heater Analysis Model. Last updated October 17, 2013. Available online: http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/water_heater_fr.pdf.
5. Pacific Gas and Electric Company. Applied Technology Services Performance Testing and Analysis Unit ATS Report #: 491-08.5, PY2008 Emerging Technologies Program. Pg. 8. 2008. Available online: http://www.etcc-ca.com/sites/default/files/OLD/images/stories/reswhtestreport1.pdf.
6. Illinois Technical Reference Manual, Commercial and Industrial. 2015. Page 87. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_5/Final/IL-TRM_Effective_060116_v5.0_Vol_2_C_and_I_021116_Final.pdf.
7. Per Ohio TRM dated 8/6/10 (pg 123): condensing storage DHW incremental cost is $685.00 per water heater

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Water Heater, ≥ 0.82 EF, Tankless, Residential, Natural Gas

	Measure Details
Measure Master ID	Water Heater, ≥ 0.82 EF, Tankless, Residential, Natural Gas, 2652 Water Heater, ≥ 0.82 EF, Tankless, Residential, Natural Gas, Claim Only, 3588
Measure Unit	Per water heater
Measure Type	Prescriptive
Measure Group	Domestic Hot Water
Measure Category	Water Heater
Sector(s)	Residential- single family, Residential- multifamily
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	44
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	572
Water Savings (gal/yr)	0
Effective Useful Life (years)	13 [1]
Incremental Cost ($/unit)	$605.00[6]

Measure Description

This measure is installing an ENERGY STAR-qualified, small tankless water heater with an EF of 0.82 or greater and an input rating less than or equal to 75,000 Btu/hour. In addition, qualifying tankless water heaters must be whole-house units used for domestic water heating, and must be natural gas fueled.

Residential tankless water heaters are defined as equipment having a nominal input between 50,000 and 200,000 Btu/hour and a rated storage volume of 2 gallons or less.

Description of Baseline Condition

New federal efficiency standards that take effect in April 2015 raise the minimum EF for baseline units from 0.575 to 0.600. The criteria date was rounded to January 1, 2016 since the code takes affect mid-year 2015.

Description of Efficient Condition

Qualifying tankless water heaters must meet the qualifications listed in the table below.

Qualification Requirements for Tankless Water Heaters

Sector	Input Rating	EF
Multifamily	≤ 75,000 Btu/hour	≥ 0.82
Single Family	≥ 50,000 Btu/hour ≤ 200,000 Btu/hour	≥ 0.82

Annual Energy-Savings Algorithm

$\text{Therm}_{\text{SAVED}} = (T_{\text{WH}} – T_{\text{ENTERING}}) * \text{GPD} * 8.33 * 1 * 365 * [(1/\text{EF}_{\text{BASE}}) – (1/\text{EF}_{\text{EFF}})] * (1/100{,}000)$

Where:

T_{WH} = Water heater temperature set point (= 125°F)[2]

T_{ENTERING} = Temperature of water entering water heater (= 52.3°F)[3]

GPD = Gallons of hot water used by the home per day (= 44.4 for multifamily; = 51.5 for single family)[4]

8.33 = Density of water, lbs/gal

1 = Specific heat of water, Btu/lb-°F

365 = Days per year

EF_{BASE} = Baseline energy factor (= 0.575 for units sold before January 1, 2016; = 0.600 for units sold after January 1, 2016)[5]

EF_{EFF} = Efficiency energy factor (= 0.820)

100,000 = Conversion from Btu to therms

Summer Coincident Peak Savings Algorithm

There are no peak savings for this measure.

Lifecycle Energy-Savings Algorithm

$\text{Therm}_{\text{LIFECYCLE}} = \text{Therm}_{\text{SAVED}} * \text{EUL}$

Where:

EUL = Effective useful life (= 13 years)[1]

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. The water heater setpoint is assumed to be 125°F, as Wisconsin building code 704.06 requires landlords to set water heaters to 125°F: https://docs.legis.wisconsin.gov/statutes/statutes/704/06. Water heater setpoints typically range between 120°F and 140°F because temperatures below 120°F are susceptible to Legionella bacteria (which lead to Legionnaires Disease) and heaters set to temperatures above 140°F can quickly scald users: http://www.nrel.gov/docs/fy12osti/55074.pdf. Most TRMs assume water heater set points of 120°F, 125°F, or 130°F, though most of these are unsourced engineering assumptions. (Residential water heater setpoint resources include: Connecticut 2012 TRM PSD: 130°F for natural gas DWH and 125°F for tank wrap, HPWH, and temperature reduction; Mid-Atlantic TRM v3.0: 130°F for tank wrap and pipe insulation; Illinois TRM v2.0: 125°F for pipe insulation, natural gas water heater, HPWH, and tank wrap and 120°F for temperature reduction; and Indiana TRM v1.0: 130°F for pipe insulation.)
3. United States Department of Energy. *DHW Scheduler*. (Average water main temperature for all Wisconsin locations as measured by scheduler and weighted by city population).
4. The gallons per day was calculated by using the linear relationship of y = 16.286x + 13, where x is the average number of people per home and y is the average gallons of hot water used per day. An average value of 1.93 people per home was used for Wisconsin multifamily and 2.36 for single family, based on RECS 2009 data. The linear relationship is used in the 2012 Indiana TRM and the 2010 NY TRM.
5. Calculated as 0.67 - 0.0019 * 50 = 0.575, per the 2001 federal standard that took effect in 2004. The new federal standard baseline was adopted in 2010 and took effect in April 2015; this was calculated as 0.675 - 0.0015 * 50 = 0.600. Both calculations assume a 50 gallon tank.
6. Ohio TRM, 2010. Page 123. Tankless DHW EF > 0.82 incremental cost is $605.00 per water heater. Available online: http://s3.amazonaws.com/zanran_storage/amppartners.org/ContentPages/2464316647.pdf

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Water Heater, Indirect

	Measure Details
Measure Master ID	Water Heater: Indirect, 95% or greater, 1988, 3784 Electric, EF ≥ 0.93, 1989 Indirect, Claim Only, 3585 Electric, EF ≥ 0.93, Claim Only, 3586
Measure Unit	Per water heater
Measure Type	Prescriptive
Measure Group	Domestic Hot Water
Measure Category	Water Heater
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	93
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	1,395
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	Varies by measure, see Appendix D.[2]

Measure Description

Indirect water heaters are applicable to any indirectly fueled water heater, and must be paired with a high-efficiency boiler. In addition, qualifying indirect water heaters must be whole-house units or used for domestic water heating.

Unlike other water heaters, indirect water heaters use a boiler as the heat source. The water heater may also have a direct energy source for non-heating seasons when the boiler is shut off and thus not able to meet the water heating demands.[3]

Description of Baseline Condition

The base case is a residential, gas-fueled, storage water heater with an EF of 0.575.[4] New federal efficiency standards that took effect in April 2015 raised the minimum EF for baseline units from 0.575 to 0.600. The criteria date was rounded to January 1, 2016 since the code takes affect mid-year 2015.

Description of Efficient Condition

Indirect water heaters must be connected to a boiler with an AFUE of 95% or greater.

Annual Energy-Savings Algorithm

$$Therms_{SAVED} = ((GPD * 365 * 8.33 * 1 * \Delta T_{w})/100{,}000) * ((1/RE_{BASE}) – (1/E_{C,EE})) + ((UA_{BASE} / RE_{BASE}) – (UA_{EE} / E_{C,EE})) * (\Delta T_{s} * 8{,}760)/100{,}000$$

Where:

GPD = Average daily hot water consumption (= 51.5 gallons per day)[5]

365 = Days per year

8.33 = Density of water (lb/gallon)

1 = Specific heat of water (Btu/lb °F)

ΔT_{w} = Average difference between the cold water inlet temperatures (52.3°F) and the hot water delivery temperature (125°F) (= 72.7°F)[6]

100,000 = Conversion factor (Btu/therm)

RE_{BASE} = Recovery efficiency of the baseline tank type water heater (= 76%)[6]

$E_{C,EE}$ = Combustion efficiency of energy-efficient boiler used to heat indirect water heater (= 95%)[7]

UA_{BASE} = Overall heat loss coefficient of base tank type water heater (= 14.0 Btu/hr-°F)[8]

UA_{EE} = Overall heat loss coefficient of indirect water heater storage tank (= 6.1 Btu/hr-°F; see table below)[9]

Typical Values for UA_{EE}

Volume (gal)	H (bare tank) inches	Diameter (bare tank) inches	Insulation	UA (Btu/hr-°F)
40	44	17	1 in foam	4.1
			2 in foam	2.1
80	44	24	1 in foam	6.1
			2 in foam	3.1
120	65	24	1 in foam	8.4
			2 in foam	5.4

ΔT_{S} = Temperature difference between the stored hot water temperature (125°F) and the ambient indoor temperature (65°F) (= 60°F)

8,760 = Conversion factor (hours/year)

Summer Coincident Peak Savings Algorithm

Indirect water heaters consume no electrical energy; therefore, they have no impact on demand reduction.

Lifecycle Energy-Savings Algorithm

$\text{Therms}_{\text{LIFECYCLE}} = \text{Therms}_{\text{SAVED}} * \text{EUL}$

Where:

EUL = Effective useful life (15 years)[1]

Assumptions

Because the efficiency of residential water heater is measured in EF, the true EF and UA_{BASE} is not available. A thermal efficiency of 76% and a UA_{BASE} of 14 is assumed.

The average difference of 60°F assumes pipe and ambient air temperatures of 125°F and 65°F, respectively.

Sources

1. 2009 GDS Residential Study,MA Natural Gas Potential http://ma-eeac.org/wordpress/wp-content/uploads/5_Natural-Gas-EE-Potenial-in-MA.pdf .
2. New York Statewide Residential Gas High Efficiency Heating Equipment Programs: Evaluation of 2009-2011 Programs. Average of mean and median costs using both approaches, in Table 1-4. Available online: http://www.coned.com/energyefficiency/PDF/EEPS%20CY1%20NY%20HEHE%20Evaluation%20Report%20FINAL%20APPROVED%202014-08-21.pdf
3. Public Service Commission of Wisconsin. Focus on Energy Evaluation, Residential Programs: CY09 Deemed Savings Review. March 26, 2010.
4. U.S. Department of Energy. Federal standard for residential water heaters effective in 2004.
5. Calculated by using the linear relationship of y=16.286x + 13, where x is the average number of people per home and y is the average gallons of hot water used per day. An average value of 2.361 people/home was used for Wisconsin, based on RECS 2009 data. The linear relationship is used in the 2012 Indiana TRM and the 2010 NY TRM.
6. Air-Conditioning, Heating, and Refrigeration Institute. “RWH Search.” Most common RE for non-heat pump water heaters. http://www.ahridirectory.org/ahridirectory/pages/rwh/defaultSearch.aspx
7. Assumed the combustion efficiency is a proxy for AFUE, with program minimum of 95% AFUE.

8. United States Department of Energy. Technical Support Document: Energy Efficiency Standards for Consumer Products, Residential Water Heaters, Including Regulatory Impact Analysis. 2000.
9. New York Technical Reference Manual. Indirect Water Heaters, pg. 87. 2010.

Revision History

Version Number	Date	Description of Change
01	01/01/2012	New measure
02	10/30/2014	Updated therms based on 72.7°F temperature

HVAC

Smart Thermostat

	Measure Details
Measure Master ID	Smart Thermostat: Existing Natural Gas Boiler, 3609 Existing Natural Gas Furnace, 3610 Existing Air Source Heat Pump, 3611
Measure Unit	Per thermostat
Measure Type	Prescriptive
Measure Group	HVAC
Measure Category	Controls
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	Varies by existing heating system
Peak Demand Reduction (kW)	Varies by existing heating system
Annual Therm Savings (Therms)	Varies by existing heating system
Lifecycle Energy Savings (kWh)	Varies by existing heating system
Lifecycle Therm Savings (Therms)	Varies by existing heating system
Water Savings (gal/yr)	0
Effective Useful Life (years)	10[1]
Incremental Cost ($/unit)	$250.00[14]

Measure Description

Users can set standard programmable thermostats to adjust temperature setpoints at different times of the day, changing temperatures during unoccupied periods to allow for energy savings. The user can also communicate remotely with a smart thermostat through Wi-Fi, which allows for remote programming and can detect when the house is unoccupied through sensors or an application that tracks the homeowner’s location through their phone. This occupancy sensor capacity allows the thermostat to reduce energy use without requiring active programming or regular attention from the user, thus optimizing thermostat-based energy savings independent of user interaction. Some smart thermostats can also optimize efficiency through auto-adjustments based on outdoor temperature and humidity, and “learning” standard occupancy behaviors and temperature preferences (eliminating the need for programming).

Description of Baseline Condition

The baseline condition is a manual or standard programmable thermostat installed in a home with an existing natural gas furnace, natural gas boiler, or air-source heat pump.

See the Assumptions section for detail on weighted averages applied to savings to account for the combination of manual and programmable thermostats in the baseline Wisconsin population.

Description of Efficient Condition

The efficient condition is a smart thermostat installed in a home to replace the existing thermostat. To qualify as a “smart,” the thermostat must be Wi-Fi capable (with the Wi-Fi connection established by the customer), and have occupancy-sensing capability, such as motion sensors and/or geofencing.

Annual Energy-Savings Algorithm

The savings algorithms associated with this measure involve calculating the heating and cooling energy use, then applying a percentage savings achieved by installing a smart thermostat.[2]

$$\text{Therm}_{\text{SAVED}} = \text{HOURS}_{\text{HEATING}} * \text{CAP} / \text{AFUE} / 100 * \text{ESF}_{\text{HEATING}}$$

$$\text{kWh}_{\text{SAVED HEATING}} = \text{EFLH}_{\text{HEAT}} * \text{CAP} / \text{HSPF} / 3.412 * \text{ESF}_{\text{HEATING}}$$

$$\text{kWh}_{\text{SAVED COOLING}} = (1/\text{SEER}) * \text{EFLH}_{\text{COOL}} * \text{MBtuH} * \text{AC\%} * \text{ESF}_{\text{COOLING}}$$

Where:

$\text{HOURS}_{\text{HEATING}}$ = Annual home heating hours (= 1,158 hours for natural gas furnace and furnace/AC;[5] = 1,000 hours for boiler)[6]

CAP = Heating system capacity (= 72 MBtuH for furnace;[3] = 110 MBtuH for boiler;[4] = 37.2 MBtuH for ASHP)

AFUE = AFUE of system (= 90% for natural gas furnace; = 80% for boiler)

100 = Conversion

$\text{ESF}_{\text{HEATING}}$ = Heating energy savings fraction (= 9.9% for furnace and boiler;[8] = 12.0% for ASHP)[9]

$\text{EFLH}_{\text{HEAT}}$ = Eqivalent full-load heating hours (= 1,890)[7]

HSPF = Heating seasonal performance factor (= 7.1)

3.412 = Btu to Watt

SEER = Seasonal energy efficiency rating (= 12)

$\text{EFLH}_{\text{COOL}}$ = Equivalent full-load cooling hours (= 410 for natural gas furnace;[6] = 321 for ASHP)

MBtuH = Cooling system capacity (=29.1 MBtuH)[10]

AC% = Air conditioner efficiency % (= 92.5% for natural gas furnace;[5] = 100% for ASHP; = 0% for boiler)

$ESF_{COOLING}$ = Cooling energy savings fraction (= 8.3%)[8]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} / EFLH_{COOL} * CF$

Where:

CF = Coincidence factor (=68%)[5]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 10 years)[1]

Deemed Savings

Annual and Lifecycle Electric Savings by Measure

Type of Savings (kWh)	Measure (with existing heating equipment)		
	Smart Thermostat Installed in Home Heated by Natural Gas Boiler, MMID 3609	Smart Thermostat Installed in Home Heated by Natural Gas Furnace, MMID 3610	Smart Thermostat Installed in Home Heated by Air Source Heat Pump, MMID 3611
Annual	0	76.33	430.87
Lifecycle	0	763.3	4,308.7

Annual and Lifecycle Natural Gas Savings by Measure

Type of Savings (kWh)	Measure (with existing heating equipment)		
	Smart Thermostat Installed in Home Heated by Natural Gas Boiler, MMID 3609	Smart Thermostat Installed in Home Heated by Natural Gas Furnace, MMID 3610	Smart Thermostat Installed in Home Heated by Air Source Heat Pump, MMID 3611
Annual	136.13	91.71	0
Lifecycle	1,361.3	917.1	0

Annual Summer Coincident Peak Savings by Measure

Type of Savings (kWh)	Measure (with existing heating equipment)		
	Smart Thermostat Installed in Home Heated by Natural Gas Boiler, MMID 3609	Smart Thermostat Installed in Home Heated by Natural Gas Furnace, MMID 3610	Smart Thermostat Installed in Home Heated by Air Source Heat Pump, MMID 3611
Annual	0	0.127	0.175

Assumptions

Measure cost and savings assume a tech-based upgrade as opposed to end-of-life replacement, so the baseline condition would have continued with existing equipment.

The GDS Associates document cited for EUL is also used by the Illinois TRM for programmable thermostats.

The $250 incremental measure cost was based on typical online and retail stores prices for Nest, Ecobee3, and Honeywell Lyric thermostats.

As a proxy for the Wisconsin service territory, the percentages of Indiana homes with a manual thermostat and a programmable thermostat identified in a Cadmus study[8] was used.

Percentages of Indiana Homes with Manual Versus Programmable Thermostat

Type of Thermostat	Percentage of Population	
	Heating	Cooling
Manual	48.5%	47.1%
Programmable	51.5%	52.9%

This savings for a programmable thermostat baseline was estimated by averaging the savings found by the Cadmus Indiana study[8] with that found by a 2007 study in Connecticut;[12] then calculating the additional percentage savings a smart thermostat would achieve using the smart thermostat savings from the Indiana study.

Heating and Cooling Energy Savings Fractions by Thermostat Replacement Type

Thermostat Replacement Type	$ESF_{HEATING}$	$ESF_{COOLING}$
Manual to Smart[8]	13.4%	16.1%
Manual to Programmable[8]	7.8%	15.0%
Manual to Programmable[12]	6.8%	N/A
Averaged Manual to Programmable	7.3%	15.0%
Programmable to Smart	6.6%	1.3%

The savings percentages are a weighted average to represent the combination of manual and programmable thermostats that comprise the baseline population in Wisconsin. This was achieved by multiplying the percentage of homes with a manual thermostat by the energy savings fraction achieved by a smart thermostat (over a manual) and the percentage of homes with a programmable thermostat, then multiplying by the energy savings fraction estimated for a smart thermostat replacing a programmable thermostat.

Weighted Heating and Cooling Energy Savings Fractions

Type of Energy Savings Fraction	Weighted Percentage
$ESF_{HEATING}$	9.9%
$ESF_{COOLING}$	8.3%

For ASHPs, the *Oregon Heat Pump Control Pilot Evaluation*[9] revealed savings of 12.0%, which is assumed to be correct. This may be evaluated in the future based on additional studies as they become available.

As the region most similar to Wisconsin, the Northern Indiana pilot study was used as the primary source for savings values used in this workpaper.

The capacity of residential heat pumps installed in Wisconsin is assumed to be 3.1 tons, based on an analysis of 75 ASHPs installed between 2013 and 2015 for the Focus on Energy Residential Prescriptive Program. At 12,000 Btu per hour per ton, the assumed average capacity is 37,200 Btu per hour.

The default efficiency levels are based on existing heating and cooling equipment efficiencies of 80% AFUE boilers, 90% AFUE natural gas furnaces, SEER 12 central ACs, and HSPF 7.1 ASHPs. Current baselines for boilers, furnaces, AC systems, and ASHPs assume 82% AFUE, 92% AFUE, SEER 13, and HSPF 7.7, respectively, based on current installation standards in Wisconsin (and assuming that the average customer in Wisconsin is slightly below the baseline due to some homes still using older equipment).

The peak kW savings algorithm was based on the Attic Air Sealing measure in the Illinois TRM. This is because all other kW algorithms used for Focus on Energy residential prescriptive measures are based on efficiency changes, while the Attic Air Sealing measure, like this Smart Thermostat measure, involves decreasing the HVAC system run time.

Supporting inputs for cooling load hours (furnaces) in several Wisconsin cities are shown in the table below. Cooling hours are based on an air conditioner in the *Deemed Savings Report,*[5] adjusted for the larger capacity system (e.g., 410 hours at 2.425 tons is equivalent to 321 hours at 3.1 tons).

Supporting Inputs for Equivalent Full-Load Cooling Hours by City

Location	$EFLH_{COOL}$	Weighting by Participant
Green Bay	344	22%
Lacrosse	323	3%
Madison	395	18%
Milwaukee	457	48%
Wisconsin Average	380	9%
Weighted Average	**410**	**100%**

Supporting inputs for heating load hours (ASHPs) in several Wisconsin cities are shown in the table below.

Supporting Inputs for Equivalent Full-Load Heating Hours by City[13]

Location	$EFLH_{HEAT}$	Weighting by Participant
Green Bay	1,852	22%
Lacrosse	1,966	3%
Madison	1,934	18%
Milwaukee	1,883	48%
Wisconsin Average	1,909	9%
Weighted Average	**1,890**	**100%**

Sources

1. GDS Associates. Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures. Table 1, HVAC Controls. 2007. Used programmable thermostat EUL as the closest proxy for smart thermostats.
2. *Indiana Technical Resource Manual, Version 1.0.* Programmable Thermostats (Time of Sale, Direct Install). January 10, 2013.
3. SPECTRUM Focus Prescriptive Database. 2012. Average furnace size of 13,000 lb.
4. SPECTRUM Focus Prescriptive Database. 2013. Average input capacity of boilers under 300 Mbh.

5. *Focus on Energy Deemed Savings Report: Evaluated Deemed Savings Changes*. November 14, 2014.
6. 800 therms consumed by 90% AFUE furnaces (i.e., 720 therms output) for all residential natural gas measures estimate from: Pigg and Nevius. Electricity Use by New Furnaces. 2000. Available online: http://www.ecw.org/sites/d3efault/files/230-1.pdf. Using average furnace size of 72,000 Btu (from 2012 SPECTRUM database of 13,000 furnaces), 1,000 full-load heating hours are estimated.
7. Focus on Energy. *Technical Reference Manual*. August 15, 2014. (Several Cadmus metering studies reveal that ENERGY STAR calculator overestimates EFLH by 25%. The $EFLH_{HEAT}$ are adjusted by population-weighted HDD and TMY-3 values).
8. Cadmus. *Evaluation of the 2013-2014 Programmable and Smart Thermostat Program*. Prepared for Northern Indiana Public Service Company. January 22, 2015.
9. Apex Analytics. *Nest Thermostat Heat Pump Control Pilot Evaluation*. Prepared for Energy Trust of Oregon. October 10, 2014.
10. P.A. Consulting Group. *Focus on Energy Evaluation, Residential Programs: CY09 Deemed Savings Review*. March 26, 2010. Available online: https://focusonenergy.com/sites/default/files/cy09residentialdeemedsavingsreview_evaluationreport.pdf
11. Illinois Energy Efficiency Statewide Advisory Group. *Illinois Statewide Technical Reference Manual.* Section 5.6.1 Air Sealing. February 2014.
12. RLW Analytics. *Validating the Impact of Programmable Thermostats.* Prepared for GasNetworks. January 2007.
13. Several Cadmus metering studies reveal that the ENERGY STAR calculator EFLH are over-estimated by 25%. The $EFLH_{HEAT}$ were adjusted by population-weighted HDD and TMY-3 values.
14. 2015 Retail Research. Average cost of Smart Thermostats available 2015.

Revision History

Version Number	Date	Description of Change
01	03/2015	Initial TRM entry

Smart Thermostat, Installed with Home Heating Measure

	Measure Details
Measure Master ID	Smart Thermostat: Installed with 95% AFUE Natural Gas Furnace, 3612 Installed with 95% AFUE Natural Gas Boiler, 3613 Installed with Furnace and A/C, 3614 Installed with Air-Source Heat Pump, 3615
Measure Unit	Per thermostat
Measure Type	Prescriptive
Measure Group	HVAC
Measure Category	Controls
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	Varies by heating system installed
Peak Demand Reduction (kW)	Varies by heating system installed
Annual Therm Savings (Therms)	Varies by heating system installed
Lifecycle Energy Savings (kWh)	Varies by heating system installed
Lifecycle Therm Savings (Therms)	Varies by heating system installed
Water Savings (gal/yr)	0
Effective Useful Life (years)	10[1]
Incremental Cost ($/unit)	$250.00[13]

Measure Description

Users can set standard programmable thermostats to adjust temperature setpoints at different times of the day, changing temperatures during unoccupied periods to allow for energy savings. The user can also communicate remotely with a smart thermostat through Wi-Fi, which allows for remote programming and can detect when the house is unoccupied through sensors or an application that tracks the homeowner’s location through their phone. This occupancy sensor capacity allows the thermostat to reduce energy use without requiring active programming or regular attention from the user, thus optimizing thermostat-based energy savings independent of user interaction. Some smart thermostats can also optimize efficiency through auto-adjustments based on outdoor temperature and humidity, and “learning” standard occupancy behaviors and temperature preferences (eliminating the need for programming).

Description of Baseline Condition

The baseline condition is a manual or standard programmable thermostat installed in a home with new, program qualified, natural gas furnace, natural gas boiler, furnace/AC combo, or air-source heat pump.

See the Assumptions section for detail on weighted averages applied to savings to account for the combination of manual and programmable thermostats in the baseline Wisconsin population.

Description of Efficient Condition

The efficient condition is a smart thermostat installed in a home to replace the existing thermostat. To qualify as a "smart," the thermostat must be Wi-Fi capable (with the Wi-Fi connection established by the customer), and have occupancy-sensing capability, such as motion sensors and/or geofencing.

Annual Energy-Savings Algorithm

The savings algorithms associated with this measure involve calculating the heating and cooling energy use, then applying a percentage savings achieved by installing a smart thermostat.[2]

$$\text{Therm}_{\text{SAVED}} = \text{HOURS}_{\text{HEATING}} * \text{CAP} / \text{AFUE} / 100 * \text{ESF}_{\text{HEATING}}$$

$$\text{kWh}_{\text{SAVED HEATING}} = \text{EFLH}_{\text{HEAT}} * \text{CAP} / \text{HSPF} / 3.412 * \text{ESF}_{\text{HEATING}}$$

$$\text{kWh}_{\text{SAVED COOLING}} = (1/\text{SEER}) * \text{EFLH}_{\text{COOL}} * \text{MBtuH} * \text{AC\%} * \text{ESF}_{\text{COOLING}}$$

Where:

$\text{HOURS}_{\text{HEATING}}$ = Home heating hours (= 1,158 hours for natural gas furnace and furnace/AC;[5] = 1,000 hours for boiler)[6]

CAP = Heating system capacity (= 72 MBtuH for furnace;[3] = 110 MBtuH for boiler;[4] = 37.2 MBtuH for ASHP)

AFUE = AFUE of system if natural gas furnace or furnace/AC

100 = Conversion

$\text{ESF}_{\text{HEATING}}$ = Heating energy savings fraction (= 9.9% for furnace and boiler;[8] = 12.0% for ASHP)[9]

$\text{EFLH}_{\text{HEAT}}$ = Equivalent full-load heating hours (= 1,890)[7]

HSPF = Heating seasonal performance factor (= 8.4)

3.412 = Watt to Btu conversion

SEER = Seasonal energy efficiency rating (= 13 for 95% natural gas furnace; = 16 for furnace/AC)

$\text{EFLH}_{\text{COOL}}$ = Equivalent full-load cooling hours (= 410 for natural gas furnace and furnace/AC;[5] = 321 for ASHP)

MBtuH = Cooling system capacity (=29.1 MBtuH)[10]

AC% = Air Conditioner efficiency (= 92.5% for 95% natural gas furnace;[5] = 100% for furnace/AC or ASHP; = 0% for boiler)

$ESF_{COOLING}$ = Cooling energy savings fraction (= 8.3%)[8]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} / EFLH_{COOL} * CF$

Where:

CF = Coincidence factor (=68%)[5,11]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 10 years)[1]

Deemed Savings

Annual and Lifecycle Electric Savings by Measure

Type of Savings (kWh)	Measure			
	Smart Thermostat Installed with 95% Natural Gas Boiler, MMID 3613	Smart Thermostat Installed with 95% AFUE Natural Gas Furnace, MMID 3612	Smart Thermostat Installed with Furnace/AC Combo, MMID 3614	Smart Thermostat Installed with Air Source Heat Pump, MMID 3615
Annual	0	70.46	61.89	356.32
Lifecycle	0	704.6	618.9	3,563.2

Annual and Lifecycle Natural Gas Savings by Measure

Type of Savings (therms)	Measure			
	Smart Thermostat Installed with 95% Natural Gas Boiler, MMID 3613	Smart Thermostat Installed with 95% AFUE Natural Gas Furnace, MMID 3612	Smart Thermostat Installed with Furnace/AC Combo, MMID 3614	Smart Thermostat Installed with Air Source Heat Pump, MMID 3615
Annual	114.63	86.89	86.89	0
Lifecycle	1,146.3	868.9	868.9	0

Annual Summer Coincident Peak Savings by Measure

Type of Savings (kW)	Measure			
	Smart Thermostat Installed with 95% Natural Gas Boiler, MMID 3613	Smart Thermostat Installed with 95% AFUE Natural Gas Furnace, MMID 3612	Smart Thermostat Installed with Furnace/AC Combo, MMID 3614	Smart Thermostat Installed with Air Source Heat Pump, MMID 3615
Annual	0	0.117	0.103	0.131

Assumptions

The GDS Associates document cited for EUL is also used by the Illinois TRM for programmable thermostats.

The $250 incremental measure cost was based on typical online and retail stores prices for Nest, Ecobee3, and Honeywell Lyric thermostats.

As a proxy for the Wisconsin service territory, the percentages of Indiana homes with a manual thermostat and a programmable thermostat identified in a Cadmus study[8] was used.

Percentages of Indiana Homes with Manual Versus Programmable Thermostat

Type of Thermostat	Percentage of Population	
	Heating	Cooling
Manual	48.5%	47.1%
Programmable	51.5%	52.9%

This savings for a programmable thermostat baseline was estimated by averaging the programmable savings found by the Cadmus Indiana study[8] with that found by a 2007 study in Connecticut;[12] then calculating the additional percentage savings a smart thermostat would achieve using the smart thermostat savings from the Indiana study.

Heating and Cooling Energy Savings Fractions by Thermostat Replacement Type

Thermostat Replacement Type	$ESF_{HEATING}$	$ESF_{COOLING}$
Manual to Smart[8]	13.4%	16.1%
Manual to Programmable[8]	7.8%	15.0%
Manual to Programmable[12]	6.8%	N/A
Averaged Manual to Programmable	7.3%	15.0%
Programmable to Smart	6.6%	1.3%

The savings percentages are a weighted average to represent the combination of manual and programmable thermostats that comprise the baseline population in Wisconsin. This was achieved by multiplying the percentage of homes with a manual thermostat by the energy savings fraction achieved by a smart thermostat (over a manual) and the percentage of homes with a programmable thermostat, then multiplying by the energy savings fraction estimated for a smart thermostat replacing a programmable thermostat.

Weighted Heating and Cooling Energy Savings Fractions

Type of Energy Savings Fraction	Weighted Percentage
$ESF_{HEATING}$	9.9%
$ESF_{COOLING}$	8.3%

For ASHPs, the *Oregon Heat Pump Control Pilot Evaluation*[9] revealed savings of 12.0%, which is assumed to be correct. This may be evaluated in the future based on additional studies as they become available.

As the region most similar to Wisconsin, the Northern Indiana pilot study was used as the primary source for savings values used in this workpaper.

The capacity of residential heat pumps installed in Wisconsin is assumed to be 3.1 tons, based on an analysis of 75 ASHPs installed between 2013 and 2015 for the Focus on Energy Residential Prescriptive Program. At 12,000 Btu per hour per ton, the assumed average capacity is 37,200 Btu per hour.

Installed furnace/AC combos are required to have a SEER 16 AC rating, while installed natural gas furnaces are assumed to have central AC rated at the federal minimum of 13 SEER.

As the 2014 *Focus on Energy Deemed Savings Report* revealed that 92.5% of customers with natural gas furnaces also have central air conditioning, the $kWh_{SAVED\ COOLING}$ and kW_{SAVED} values are multiplied by 0.925 for customers installing a smart thermostat with their new natural gas furnace without a 16 SEER AC.

Customers with boilers are not assumed to have central air conditioning on the same thermostat, and thus no kWh or kW savings are associated with a smart thermostat installed with a 95% boiler.

The peak kW savings algorithm was based on the Attic Air Sealing measure in the Illinois TRM. This is because all other kW algorithms used for Focus on Energy residential prescriptive measures are based on efficiency changes, while the Attic Air Sealing measure, like this Smart Thermostat measure, involves decreasing the HVAC system run time.

Supporting inputs for cooling load hours (furnaces) in several Wisconsin cities are shown in the table below. Cooling hours are based on an air conditioner in the *Deemed Savings Report,*[5] adjusted for the larger capacity system (e.g., 410 hours at 2.425 tons is equivalent to 321 hours at 3.1 tons).

Supporting Inputs for Equivalent Full-Load Cooling Hours by City

Location	$EFLH_{COOL}$	Weighting by Participant
Green Bay	344	22%
Lacrosse	323	3%
Madison	395	18%
Milwaukee	457	48%
Wisconsin Average	380	9%
Weighted Average	**410**	**100%**

Supporting inputs for heating load hours (ASHPs) in several Wisconsin cities are shown in the table below.

Supporting Inputs for Equivalent Full-Load Heating Hours by City

Location	$EFLH_{HEAT}$	Weighting by Participant
Green Bay	1,852	22%
Lacrosse	1,966	3%
Madison	1,934	18%
Milwaukee	1,883	48%
Wisconsin Average	1,909	9%
Weighted Average	**1,890**	**100%**

Sources

1. GDS Associates. Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures. Table 1, HVAC Controls. 2007. Used programmable thermostat EUL as the closest proxy for smart thermostats.
2. *Indiana Technical Resource Manual, Version 1.0*. Programmable Thermostats (Time of Sale, Direct Install). January 10, 2013.
3. SPECTRUM Focus Prescriptive Database. 2012. Average furnace size of 13,000 lb.
4. SPECTRUM Focus Prescriptive Database. 2013. Average input capacity of boilers under 300 Mbh.
5. *Focus on Energy Deemed Savings Report: Evaluated Deemed Savings Changes.* November 14, 2014.

6. 800 therms consumed by 90% AFUE furnaces (i.e., 720 therms output) for all residential natural gas measures estimate from: Pigg and Nevius. Electricity Use by New Furnaces. 2000. Available online: http://www.ecw.org/sites/d3efault/files/230-1.pdf. Using average furnace size of 72,000 Btu (from 2012 SPECTRUM database of 13,000 furnaces), 1,000 full-load heating hours are estimated.
7. Focus on Energy. *Technical Reference Manual*. August 15, 2014. (Several Cadmus metering studies reveal that ENERGY STAR calculator overestimates EFLH by 25%. The $EFLH_{HEAT}$ are adjusted by population-weighted HDD and TMY-3 values).
8. Cadmus. *Evaluation of the 2013-2014 Programmable and Smart Thermostat Program*. Prepared for Northern Indiana Public Service Company. January 22, 2015.
9. Apex Analytics. *Nest Thermostat Heat Pump Control Pilot Evaluation*. Prepared for Energy Trust of Oregon. October 10, 2014.
10. PA Consulting Group. *Focus on Energy Evaluation, Residential Programs: CY09 Deemed Savings Review*. March 26, 2010. Available online: https://focusonenergy.com/sites/default/files/cy09residentialdeemedsavingsreview_evaluationreport.pdf
11. Illinois Energy Efficiency Statewide Advisory Group. *Illinois Statewide Technical Reference Manual.* Section 5.6.1 Air Sealing. February 2014.
12. RLW Analytics. *Validating the Impact of Programmable Thermostats.* Prepared for GasNetworks. January 2007.
13. 2015 Retail Research. Average cost of Smart Thermostats available 2015.

Revision History

Version Number	Date	Description of Change
01	03/2015	Initial TRM entry

Single Package Vertical HVAC Unit

	Measure Details
Measure Master ID	Single Package Vertical HVAC Unit: ≥ 90%+ Thermal Efficiency, Natural Gas, 3694 ≥ 90%+ Thermal Efficiency, ≥ 10.0 EER Cooling, Natural Gas, 3693
Measure Unit	Per furnace
Measure Type	Prescriptive
Measure Group	HVAC
Measure Category	Furnace
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	Varies by measure
Annual Therm Savings (Therms)	Varies by measure
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	Varies by measure
Water Savings (gal/yr)	0
Effective Useful Life (years)	23[1]
Incremental Cost ($/unit)	$550.00[2]

Measure Description

Conventional natural gas furnaces produce by-products, such as water vapor and carbon dioxide, which are usually vented out through a chimney along with a considerable amount of heat. This occurs not only when the furnace is in use, but also when it is turned off. Newer designs increase energy efficiency by reducing the amount of heat that escapes and by extracting heat from the flue gas before it is vented. These furnaces use much less energy than conventional furnaces.

Description of Baseline Condition

The current federal furnace standard is 78% AFUE without an ECM. Single package vertical units rated by AHRI generally have a thermal efficiency rating of 80% or 82%.[3] Roughly equal quantities of 80% and 82% units are available,[3] so a baseline of 81% thermal efficiency is used. A review of specification sheets for the 80% to 82% efficient models indicated they are only available with standard permanent split capacitor motor (PSC). Per ASHRAE Standard 90.1-2007, the minimum cooling efficiency for new single package vertical units is 9.0 EER.[5]

Description of Efficient Condition

The efficient condition is a single package vertical furnace with a thermal efficiency of 90% or higher and a multi-speed ECM motor installed in a multifamily building and used for space heating only.

Additional savings for qualified cooling efficiency requires a single package vertical unit with an EER of 10.0 or higher.

Annual Energy-Savings Algorithm

$\text{Therms}_{\text{SAVED}} = \text{CAP} * \text{Hours}_{\text{HEATING}} * (1/\eta_{\text{BASE}} - 1/\eta_{\text{EE}}) * (1/100)$

$\text{kWh}_{\text{SAVED}} = \text{kWh}_{\text{SAVED HEATING}} + \text{kWh}_{\text{SAVED CIRC}} + \text{kWh}_{\text{SAVED COOLING}}$

$\text{kWh}_{\text{SAVED HEATING}}$ (applies to all systems as ECM savings from heating season) = $\text{Hours}_{\text{HEATING}} * \Delta\text{kW}_{\text{HEAT}}$

$\text{kWh}_{\text{SAVED CIRC}}$ (applies to all systems as ECM savings from cooling season, since AHRI data indicates that all listed natural gas single package vertical units have cooling) = $\text{Hours}_{\text{CIRC}} * \Delta\text{kW}_{\text{CIRC}}$

$\text{kWh}_{\text{SAVED COOLING}}$ (applies if the system meets the requirement for high-efficiency cooling) = $\text{Tons} * \text{EFLH}_{\text{COOL}} * \text{Cooling}_{\text{QUALIFIES}} * 12 \text{ kBtu/ton} * (1/\text{EER}_{\text{BASE}} – 1/\text{EER}_{\text{ECM}})$

Where:

CAP = Heating capacity (= 40.4 MBtu/hr)[3]

$\text{Hours}_{\text{HEATING}}$ = Heating hours(= 1,158)[4]

η_{BASE} = Baseline efficiency (= 81% thermal efficiency)[3]

η_{EE} = Energy efficient unit efficiency (= 90% thermal efficiency)[3]

100 = Conversion factor from therm to MBtu

$\Delta\text{kW}_{\text{HEAT}}$ = Heating demand (=0.116 kW)[4]

$\text{Hours}_{\text{CIRC}}$ = Annual hours on circulate setting (= 1,020)[4]

$\Delta\text{kW}_{\text{CIRC}}$ = Demand on circulate setting (= 0.207 kW)[4]

Tons = Cooling capacity (= 1.548 tons)[3]

$\text{EFLH}_{\text{COOL}}$ = Equivalent full-load cooling hours (= 410)[4]

$\text{Cooling}_{\text{QUALIFIES}}$ = Binary variable indicating whether the efficient unit meets the minimum qualifying EER of 10.0 (1 = yes; 0 = no)

12 kBtu/ton = Conversion factor from EER to kW/ton

EER_{BASE} = Energy efficiency rating of efficient unit (= 9.0)[5]

EER_{ECM} = Energy efficiency rating of efficient unit (= 10.7)[3]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED\ COOLING}$ = Tons * 12 kBtu/ton * (1/EER_{BASE} – 1/EER_{ECM}) * CF

Where:

CF = Coincidence factor (= 68%)[4]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE}$ = kWh_{SAVED} * EUL

$Therms_{LIFECYCLE}$ = $Therms_{SAVED}$ * EUL

Where:

EUL = Effective useful life (=23 years)[1]

Deemed Savings

Deemed Savings for Single Package Vertical HVAC Units

	≥ 90%+ Thermal Efficiency, Natural Gas, 3694	≥ 90%+ Thermal Efficiency, ≥ 10.0 EER Cooling, Natural Gas, 3693
Annual Energy Savings (kWh)	345	480
Peak Demand Reduction (kW)	0	0.223
Annual Therm Savings (Therms)	57.8	57.8
Lifecycle Energy Savings (kWh)	7,946	11,038
Lifecycle Therm Savings (Therms)	1,328	1,328

Sources

1. Energy Center of Wisconsin. Energy Efficiency and Customer-Sited Renewable Energy: Achievable Potential in Wisconsin 2006-2015, Volume II. Technical Appendix. Page 192. November 2005. Available online: https://seventhwave.org/publications/energy-efficiency-and-customer-sited-renewable-energy-achievable-potential-wisconsin
2. MESP program manager discussion with vendor of single package vertical units early 2015. Vendor noted an incremental cost of $500.00 to $600.00 to upgrade from a 80% to 90% efficient unit. Used $550.00 as the midpoint of this range.
3. Air Conditioning, Heating, and Refrigeration Institute. “Single Package Vertical Systems – AC” category under Commercial, filtered to thermal efficiency > 0 (eliminate cooling only and electric heat models). Accessed September 8, 2015. https://www.ahridirectory.org/ahridirectory/pages/home.aspx

4. Cadmus. *Focus on Energy, Evaluated Deemed Savings Changes Report.* November 14, 2014.
5. ASHRAE Standard 90.1-2007, Table 6.8.1D for SPVAC (single package vertical air conditioning).

Revision History

Version Number	Date	Description of Change
01	10/08/2015	Initial entry
02	01/11/2016	Revised per Cadmus comments
03	01/21/2016	Revised per PSC comments

A/C Split System, ≤ 65 MBh, SEER 14/15/16+

	Measure Details
Measure Master ID	A/C Split System, ≤ 65 MBh: SEER 14, 2194 SEER 15, 2192 SEER 16+, 2193
Measure Unit	Per system
Measure Type	Prescriptive
Measure Group	HVAC
Measure Category	Rooftop Unit / Split System AC
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by SEER level
Peak Demand Reduction (kW)	Varies by SEER level
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by SEER level
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[7]
Incremental Cost ($/unit)	Varies by measure, see Appendix D

Measure Description

A split-system air conditioner has a compressor and condenser located outside of the building, and has an evaporator mounted inside the building in an air handler or blower. The system is connected by pipes that cycle refrigerant between the two heat exchangers. Energy savings result from installing a more efficient unit than the market standard. Additional savings are incurred because the unit must be installed with proper RCA. Proper adjustment of the RCA results in more efficient operation. Installation by a qualified contractor and regular servicing are required to maintain proper RCA.

Description of Baseline Condition

The baseline condition is a SEER 13 unit.[1]

Description of Efficient Condition

The efficient condition is an air conditioning split system ≤ 65 MBh with SEER 14 or greater. Both the condenser and evaporator coils must be replaced. The refrigerant line diameters must meet manufacturer specifications.

The condenser model and serial number, evaporator model and serial number, and AHRI reference number are required for all installations.

System efficiency is based solely on the evaporator and condenser coils; the SEER may not be increased by factoring in the efficiency of a variable speed forced air heating system fan, except where a two-stage air conditioner is installed.

All efficiency ratings will be verified using the AHRI database.[2]

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (CAP / 1{,}000) * (1 / SEER_{BASE} – 1 / SEER_{EE}) * EFLH_{COOL}$

Where:

CAP = Rated cooling capacity of the energy-efficient unit (= 29,100 in BtuHcool)[4]

1,000 = Kilowatt conversion factor

$SEER_{BASE}$ = Seasonal energy efficiency rating of baseline unit (= 13)

$SEER_{EE}$ = Seasonal energy efficiency rating of efficient unit (= 14, 15, or 16)

$EFLH_{COOL}$ = Equivalent full-load cooling hours (= 380; see table below)[6]

Equivalent Full-Load Cooling Hours by Location

Location	$EFLH_{COOL}$
Green Bay	344
La Crosse	323
Madison	395
Milwaukee	457
Wisconsin Average	**380**

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (CAP / 1{,}000) * (1 / EER_{BASE} – 1 / EER_{EE}) * CF$

Where:

EER_{BASE} = Energy efficiency rating of baseline unit (=11 for SEER 13 unit)

EER_{EE} = Energy efficiency rating of efficient unit (= 11.7 for 14 SEER; = 12.2 for 15 SEER; = 12.7 for 16 SEER)

CF = Coincidence factor (= 0.66)[5]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[7]

Deemed Savings

Deemed Savings by SEER Level

SEER	MMID	Annual kWh Savings	kW Savings	Lifecycle kWh Savings
14	2194	60.7	0.104	1,093
15	2192	113.3	0.172	2,040
16+	2193	159.4	0.234	2,869

Assumptions

For the typical cooling capacity (size) of the unit, 2.425 tons was used.[3] This is equivalent to 29,100 Btu/hour (12,000 Btu/hour is equivalent to 1 ton).

Additional savings incurred from proper adjustment of the RCA is highly variable, and was unaccounted for in the savings algorithm.

Sources

1. Appliance Standards Awareness Project. “Central Air Conditioners and Heat Pumps.” Available online: http://www.appliance-standards.org/product/central-air-conditioners-and-heat-pumps.
2. Air-Conditioning, Heating, and Refrigeration Institute. “Directory of Certified Product Performance.” Last updated 2013. Available online: www.ahridirectory.org.
3. *Focus on Energy Evaluation, Residential Programs: CY09 Deemed Savings Review*. March 26, 2010.
4. Morgan Marketing Partners. *Michigan Energy Measures Database*. Details online: http://www.michigan.gov/mpsc/0,1607,7-159-52495_55129---,00.html.
5. Opinion Dynamics Corporation. *Delaware Technical Reference Manual*. April 30, 2012. Available online: http://www.dnrec.delaware.gov/energy/information/otherinfo/Documents/EM-and-V-guidance-documents/DELAWARE_TRM_August%202012.pdf.

6. Several Cadmus metering studies reveal that $EFLH_{COOL}$ is over-estimated in the ENERGY STAR calculator by 30%. These values were adjusted by population-weighted CDD TMY-3 values.
7. Measure Life Study prepared for The Massachusetts Joint Utilities: http://rtf.nwcouncil.org/subcommittees/nonreslighting/Measure%20Life%20Study_MA%20Joint%20Utilities_2005_ERS-1.pdf

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Laundry

ENERGY STAR Multifamily Common Area Clothes Washers

	Measure Details
Measure Master ID	Clothes Washer, Common Area, ENERGY STAR, Electric, 2756 Clothes Washer, Common Area, ENERGY STAR, Natural Gas, 2757
Measure Unit	Per clothes washer
Measure Type	Prescriptive
Measure Group	Laundry
Measure Category	Clothes Washer
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by fuel source
Peak Demand Reduction (kW)	Varies by fuel source
Annual Therm Savings (Therms)	Varies by fuel source
Lifecycle Energy Savings (kWh)	Varies by fuel source
Lifecycle Therm Savings (Therms)	Varies by fuel source
Water Savings (gal/yr)	13,978
Effective Useful Life (years)	11[1]
Incremental Cost ($/unit)	$325.40[4]

Measure Description

ENERGY STAR is a standard for energy-efficient consumer appliances. This standard increases savings for clothes washers in multifamily buildings, which are derived from factors such as hot water fuel, dryer type, and location (in-unit or common area).

This measure describes clothes washers in common areas. For washers installed in individual units of a multifamily building, see the residential single-family clothes washer measure.

Description of Baseline Condition

The baseline condition is a non-ENERGY STAR commercial clothes washer.

Description of Efficient Condition

The efficient condition is an ENERGY STAR commercial clothes washer.

Annual Energy-Savings Algorithm

Clothes Washer with Electric DHW

$kWh_{SAVED} = [\Delta kWh(EG) * \%EG + \Delta kWh(EE) * \%EE + \Delta kWh(EnD) * \%EnD] * Cycles/year$

$\text{Therm}_{\text{SAVED}}$ = [ΔTherm(EG) * %EG] * Cycles/year

Clothes Washer with Natural Gas DHW

$\text{kWh}_{\text{SAVED}}$ = [ΔkWh(GE) * %GE + ΔkWh(GG) * %GG + ΔkWh(GnD) * %GnD] * Cycles/year

$\text{Therm}_{\text{SAVED}}$ = [ΔTherm(GG) * %GG + ΔTherm(GE) * %GE + ΔTherm(GnD) * %GnD] * Cycles/year

Where:

Mix of dryers for clothes washers with electric DHW[2]

EG = Electric DHW and natural gas dryer (= 8.0%)
EE = Electric DHW and electric dryer (= 92.0%)
EnD = Electric DHW with no dryer (= 0.0%)
Cycles/year = Wash cycles per year (= 1,241)[2]

Mix of dryers for clothes washers with natural gas DHW[2]

GG = Natural gas DHW and natural gas dryer (= 26.5%)
GE = Natural gas DHW and electric dryer (= 74.5%)
Gnd = Natural gas DHW with no dryer (=0.0%)
Cycles/year = Wash cycles per year (= 1,241)[2]

Electric and natural gas savings for mixes of dryer and DHW types[2]

ΔkWh(GE) = Electric savings per cycle in kWh (= 1.45)
ΔkWh(EG) = Electric savings per cycle in kWh (= 0.25)
ΔkWh(EE) = Electric savings per cycle in kWh (= 1.70)
ΔkWh(EnD) = Electric savings per cycle in kWh (=1.70)
ΔTherm(GG) = Natural gas savings per cycle in therms (= 0.066)
ΔTherm(GE) = Natural gas savings per cycle in therms (= 0.011)
ΔTherm(EG) = Natural gas savings per cycle in therms (= 0.055)
ΔTherm(GnD) = Natural gas Savings per cycle in therms (= 0.011)

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = $\text{kWh}_{\text{SAVED}}$/(Cycles/year * Hours/cycle) * CF

Where:

Hours/cycle = 1 (estimated)
CF = Coincidence factor (= 0.045)[2]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 11 years)[1]

Deemed Savings

Deemed Savings by Measure

	CAE (MMID 2756)	CAG (MMID 2757)
Annual Deemed Electricity Savings (kWh)	1,971	1,331
Deemed Summer Peak Electricity Demand Reduction (kW)	0.071	0.048
Lifecycle Deemed Electricity Energy Savings (kWh)	21,681	14,641
Annual Deemed Natural Gas Energy Savings (therms)	5.3	31.9
Lifecycle Deemed Natural Gas Energy Savings (Therms)	58	351
Annual Demand Water Savings (gallons)	13,978	13,978
Lifecycle Deemed Water Savings (gallons)	195,692	195,692

Sources

1. Energy Savings Potential and RD&D Opportunities for Commercial Building Appliances: U.S. Department of Energy Energy Efficiency and Renewable Energy Building Technologies Program, Navigant Consulting, Inc. 2009. http://apps1.eere.energy.gov/buildings/publications/pdfs/corporate/commercial_appliances_report_12-09.pdf
2. California Public Utilities District. *Res Retro HIM Evaluation Report*. Weighted by quantity of each efficiency level from MESP Spectrum.
3. RECs Database - Wisconsin Multifamily unit counts.
4. Illinois Technical Reference Manual. 2013. Page 141. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Lighting

CFL, Direct Install, 14.2 Watt Replacing BR30

	Measure Details
Measure Master ID	CFL, Direct Install, 14.2 Watt, BR30, 3731
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Compact Fluorescent (CFL)
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	43
Peak Demand Reduction (kW)	0.0056
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	473
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	11[1]
Incremental Cost ($/unit)	$3.35[2]

Measure Description

ENERGY STAR-rated CFL replacement BR30 lamps save energy by reducing the total input wattage of the luminaire compared to the same luminaire operating with standard wattage incandescent BR30 lamps. This measure provides an energy-efficient alternative to using incandescent BR30 lamps in individual units.

Description of Baseline Condition

The baseline is 65-watt incandescent BR30 reflector lamps. BR30 shaped lamps are exempt from EISA lumen per watt standards.

Description of Efficient Condition

The efficient equipment is an ENERGY STAR-rated BR30 CFL lamp at 14.2 watts or less.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) * HOU / 1{,}000$

Where:

$Watts_{BASE}$ = Power consumption of baseline incandescent fixtures (= 65 watts)

$Watts_{EE}$ = Power consumption of efficient CFL product (= 14.2 watts)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 840 in unit)[3]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{LED}) / 1{,}000 * CF$

Where:

CF = Coincidence factor (= 0.11 in unit)[3]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 11 years)[1]

Deemed Savings

Average Annual Deemed Savings for In Unit CFL BR30 Lamp

Measure	MMID	Multifamily	
		kWh	kW
Direct Install 14.2 Watt CFL Lamp Replacing BR30 Incandescent	3731	43	0.0056

Average Lifecycle Deemed Savings for In Unit CFL BR30 Lamp

Measure	MMID	Multifamily
Direct Install 14.2 Watt CFL Lamp Replacing BR30 Incandescent	3731	473

Sources

1. Average rated life of product (based on TCP 803014) divided by in unit hours-of-use (~10,000 / 840 = 11.9 years, rounded down to 11 years to account for possible persistence and/or shortened life. Rated life sourced from ENERGY STAR® listing: http://www.energystar.gov/productfinder/product/certified-light-bulbs/details/2220599. Accessed October 2015.
2. Evaluator Online Research, March 2016. Average costs from online research at 1000bulbs.com. Available online: https://www.1000bulbs.com/search/?q=BR30+cfl.
3. Cadmus. Field Study Research of Residential Lighting. October 18, 2013. Results published in the 2014 Focus on Energy Deemed Savings Report: https://focusonenergy.com/sites/default/files/FoE_Deemed_WriteUp%20CY14%20Final.pdf

Revision History

Version Number	Date	Description of Change
01	10/13/2015	New measure

CFL, Direct Install, 20 Watt

	Measure Details
Measure Master ID	CFL, Direct Install, 20 Watt, 3487
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Compact (CFL)
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	27
Peak Demand Reduction (kW)	0.0025
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	164
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	6[1]
Incremental ($/unit)	$5.00[3]

Measure Description

This measure is the Program Implementer or a subcontractor of the Program Implementer installing a 20-watt ENERGY STAR-qualified screw-in CFL in place of an incandescent screw-in bulb. The incremental cost of the CFL compared to the incandescent light bulb is the full installed cost. Savings are based on a direct installation, not a time-of-sale purchase.

Description of Baseline Condition

The baseline equipment is an incandescent 53-watt or 75-watt equivalent light bulb. Savings are evaluated using a baseline wattage of 53 watts for both scenarios.

Description of Efficient Condition

This measure applies to standard screw-based 20-watt CFL lamps.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1,000 * HOU$

Where:

$Watts_{BASE}$ = Baseline wattage (= 53)

$Watts_{EE}$ = Efficient wattage (= 20)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use per year (= 829)[2]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1{,}000 * CF$

Where:

CF = Coincidence factor (= 0.075)[2]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 6 years)[1]

Sources

1. Average of 2013 Cadmus database, CALMAC 2001, 2007 GDS, DEER 2008.
2. Cadmus. Focus on Energy Evaluated Deemed Savings Changes. November 26, 2013.
3. Historical value.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

CFL Fixture, 12 Hours, CALP

	Measure Details
Measure Master ID	CFL Fixture, 12 Hours, CALP: Interior, 3198 Exterior, 3199
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Compact (CFL)
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	278
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by installation year
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	13[1]
Incremental Cost ($/unit)	$1.62[2]

Measure Description

Hardwired CFL incentives apply only to complete new fixtures or modular (pin or GU-24 based) retrofits with hardwired electronic ballasts. Incentives are for the replacement of incandescent fixtures only, and replacements must result in a net decrease in energy use. CFLs provide the same or better light output than incandescent lamps while using 75% less energy.

Description of Baseline Condition

The baseline equipment is a one or two lamp, 60-watt incandescent fixture on a switch, photocell, or timer that is used for 12 or more hours per day.

Description of Efficient Condition

Hardwired CFL incentives apply only to complete new fixtures or modular (pin or GU-24 based) retrofits with hardwired electronic ballasts. Incentives are for the replacement of incandescent fixtures only.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{INCANDESCENT} – kWh_{CFL}$

Where:

$kWh_{INCANDESCENT}$ = kWh use incandescent fixture (baseline)

kWh_{CFL} = kWh use CFL fixture (new fixture)

Summer Coincident Peak Savings Algorithm

There are no peak savings are this measure.

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 13 years)[1]

Deemed Savings

EISA Compliant Lifecycle Savings*

Measure	Installation Year			
	2013	2014	2015	2016 and Beyond
Multifamily CALP CFL Fixture, 12 hour	2,411.2 kWh 0.0000 kW	2,306.9 kWh 0.0000 kW	2,254.8 kWh 0.0000 kW	2,254.8 kWh 0.0000 kW

* Pre-EISA savings ended on July 1, 2014; six months after EISA phased out the standard 60-watt A-19 incandescent lamp.

Assumptions

A weighted average of one and two lamp fixtures with 60-watt incandescent lamps being replaced with a fixture containing –one or two 13-watt CFLs operating at least 12 hours per day was used to determine savings. Weighting based on historical project data and estimates.

Sources

1. PA Consulting Group Inc. Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs: Measure Life Study, Final Report. August 25, 2009.
2. CFL, Standard Bulb, 750-1049 Lumen. Evaluator research for ENERGY STAR, March 2016. Average costs from online research including Lowes, Home Deport, and 1000bulbs.com.

Revision History

Version Number	Date	Description of Change
01	06/2013	Initial TRM entry

CFL Fixture, Interior or Exterior, 24 Hours, CALP

	Measure Details
Measure Master ID	CFL Fixture, Interior or Exterior, 24 Hour, CALP, 3197
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Linear
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	555
Peak Demand Reduction (kW)	0.0634
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by installation year
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	13[1]
Incremental Cost ($/unit)	$66.33[2]

Measure Description

Hardwired CFL incentives apply only to complete new fixtures or modular (pin or GU-24 based) retrofits with hardwired electronic ballasts. Incentives are for the replacement of incandescent fixtures only and must result in a net decrease in energy use. CFLs provide the same or better light output than incandescent lamps while using 75% less energy.[2]

Description of Baseline Condition

The baseline equipment is a 1-lamp or 2-lamp 60-watt incandescent fixture that is “on” 24 hours per day in an existing multifamily building.

Description of Efficient Condition

Hardwired CFL incentives apply only to complete new fixtures or modular (pin or GU-24 based) retrofits with hardwired electronic ballasts. Incentives are for the replacement of incandescent fixtures only.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{INCANDESCENT} – kWh_{NEW\ MEASURE\ CFL}$

Where:

$kWh_{INCANDESCENT}$ = Baseline unit annual energy use

$kWh_{NEW\ MEASURE\ CFL}$ = Efficient unit annual energy use

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = Wattage / 1,000

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 13 years)[1]

Deemed Savings

EISA Compliant Lifecycle Savings*

Measure	Installation Year			
	2013	2014	2015	2016 and Beyond
Multifamily CALP CFL Fixture, 24 Hour	4,822.4 kWh 0.0634 kW	4,613.9 kWh 0.0634 kW	4,509.6 kWh 0.0396 kW	4,509.6 kWh 0.0396 kW

* Pre-EISA savings ended on July 1, 2014, 6 months after EISA phased out the standard 60-watt A-19 incandescent lamp.

Assumptions

A weighted average between 1-lamp and 2-lamp fixtures with 60-watt incandescent lamps being replaced with a fixture containing one or two– 13-watt CFLs (based on historical project data and estimates).

Sources

1. PA Consulting Group Inc. *Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs: Measure Life Study, Final Report*. August 25, 2009.
2. Actual cost from 2015-16 program data, 158 applications.

Revision History

Version Number	Date	Description of Change
01	06/20/2013	Initial draft

CFL Reflector Lamps

	Measure Details
Measure Master ID	CFL, Reflector Flood Lamps, ≤ 32 Watts, 2246
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Compact (CFL)
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	45
Peak Demand Reduction (kW)	0.004
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	225
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Incremental Cost ($/unit)	$3.00[4]

Measure Description

CFLs are designed to replace an incandescent lamp and fit into most existing in-unit light fixtures used for incandescent lamps (E26 base). This measure includes flood-type screw-based CFL lamps. CFLs use less power and have a longer rated life than their incandescent equivalents.

Description of Baseline Condition

The baseline equipment is an incandescent light bulb.

Description of Efficient Condition

The efficient condition is CFL lamps replacing incandescent lamps. The replacement lamp must be screw based, up to 30 watts, and with an integrated reflector.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1,000 * HOU$

Where:

$Watts_{BASE}$ = Wattage of baseline incandescent lamp
$Watts_{EE}$ = Wattage of efficient CFL lamp
1,000 = Kilowatt conversion factor
HOU = Annual operating hours (= varies by sector; see table below)

Annual Operating Hours by Sector

Sector	HOU[1]
Multifamily	5,950
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239
Residential- single family[2]	734

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{EE})/1{,}000 * CF$

Where:

CF = Coincidence factor (= 0.075)[2]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (Single family=5 Nonresidential= 12)[1]

Assumptions

The savings for this measure were evaluated using a combination of the ENERGY STAR QPL for CFL bulbs and information from the U.S. DOE EERE data book.[3] Baseline and efficient wattage values were determined for a set of lumens bins prescribed by the U.S. DOE in the EERE data book. The overall energy-savings value and an overall demand reduction value are weighted values determined based on the relative number of qualified products from the ENERGY STAR QPL. A summary of the analysis is shown in the table below.

Baseline and Efficient Wattages, and Savings, by Lumen Range

Lumens Range [L]	$Watts_{BASE}$	$Watts_{EE}$	Energy Savings (kWh)	Demand Reduction (kW)	Weight
420-560	45	12	27	0.002	5%
561-837	65	15	42	0.004	59%
838-1,203	75	21	45	0.004	8%
1,204-1,681	90	23	55	0.005	28%

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. Cadmus. Field Study Research of Residential Lighting. October 18, 2013. Results published in the 2014 Focus on Energy Deemed Savings Report: https://focusonenergy.com/sites/default/files/FoE_Deemed_WriteUp%20CY14%20Final.pdf
3. ENERGY STAR. *Qualified Product List*. October 25, 2013. Available online: https://data.energystar.gov/Government/ENERGY-STAR-Certified-Light-Bulbs/8qjd-zcsy.
4. Online research on 1000bulbs.com comparing 250 watt PAR38 Halogen ($15.00 average) with 50-65 watt CFL ($18.00 average).

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

CFL, Reflector, 15 Watt, Retail Store Markdown

	Measure Details
Measure Master ID	CFL, Reflector, 15 Watt, Retail Store Markdown, 3552
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Compact (CFL)
Sector(s)	Residential- single family, Residential- multifamily
Annual Energy Savings (kWh)	51
Peak Demand Reduction (kW)	0.0059
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	404
Lifecycle Therm Savings (Therms)	0
Effective Useful Life (years)	8[1]
Incremental Cost ($/unit)	$2.80[2]

Measure Description

This measure is installing an ENERGY STAR-certified CFL reflector that is purchased through a retail outlet to replace an incandescent bulb. Savings are based on a time-of-sale purchase for installation in a residential location.

Description of Baseline Condition

The baseline is an incandescent 65-watt reflector. Reflectors are exempt from EISA legislation.[4]

Description of Efficient Condition

The efficient equipment is a standard screw-based 15-watt ENERGY STAR-certified CFL reflector.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1,000 * HOU$

Where:

$Watts_{BASE}$ = Power consumption of baseline measure (= 65 watts)

$Watts_{EE}$ = Power consumption of efficient measure (= 15 watts)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 1,011)[3]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED}= (Watts_{BASE} – Watts_{EE}) / 1,000 * CF$

Where:

CF = Coincidence factor (= 0.1189)[3]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 8 years)[1]

Assumptions

A 65-watt baseline is used based on 2014 Focus on Energy Residential Lighting CFL study revealing that 65-watt replacements represented 96% of reflector sales. The table below shows total 2014 reflector sales by baseline wattage.

2014 Reflector Sales by Baseline Wattage

Baseline Wattage	Total Reflector Units Sold in 2014	Percentage of Total Reflector Sales
50	6,433	1%
65	71,5395	96%
75	2,137	0%
100	19,503	3%
Total	**743,468**	**N/A**

Hours-of-use is a weighted average of single-family residential, multifamily, and commercial use. The weighting for these variables are given in the table below.[3]

Variable Weightings by Home Type

Housing Type	Weighting	HOU per Day	Coincidence Factor
Single Family	74.7%	2.27	7.5%
Multifamily	25.3%	2.01	5.5%
Residential	**93%**	**2.20**	**6.99%**
Commercial	7%	10.2	77%

Sources

1. EUL based on similar measure; CFL, reflector replacing incandescent.
2. Evaluator research for ENERGY STAR®, March 2016. Average costs from online research including Lowes, Home Deport, and 1000bulbs.com.
3. Cadmus. Focus on Energy Evaluated Deemed Savings Changes. November 14, 2014.
4. EISA 2007 legislation. https://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/eisa_2007.pdf

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

CFL, Standard Bulb, 9 Watts, 14 Watts, 19 Watts, or 23 Watts

	Measure Details
Measure Master ID	CFL, Direct Install: 9 Watts, 2132 14 Watts, 2133 19 Watts, 2134 23 Watts, 2135 CFL, Pack-Based, 23 Watts, 3860
Measure Unit	Per bulb
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Compact (CFL)
Sector(s)	Residential- single family, Residential- multifamily
Annual Energy Savings (kWh)	Varies by wattage and sector
Peak Demand Reduction (kW)	Varies by wattage and sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by wattage and sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	6[1]
Incremental Cost	Varies by wattage, see Appendix D

Measure Description

This measure is installing a 9-watt, 14-watt, 19-watt, or 23-watt ENERGY STAR-qualified screw-in CFL in place of an incandescent screw-in bulb. Direct install measure savings are based on the assumption that the Program Implementer or their subcontractor performs the installation. Pack-based measure savings are based on the assumption that the lamp was provided as part of a package, so an installation rate less than 100% is applied.

Description of Baseline Condition

The baseline equipment is an incandescent or halogen light bulb.

Description of Efficient Condition

The efficient equipment is a standard screw-based CFL lamp, either installed by the Program Implementer or their subcontractor (direct install), or provided as part of an energy efficiency package (pack-based).

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1,000 * HOU * ISR$

Where:

$Watts_{BASE}$ = Baseline wattage (= 29, 43, 53, or 72)

$Watts_{EE}$ = Efficient wattage (= 9, 14, 19, or 23)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 829 for single family; = 734 for multifamily)[2,3]

ISR = In-service rate (= 100% for direct install; = 76% for pack-based)[4,5]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1,000 * CF * ISR$

Where:

CF = Coincident factor (= 0.075 for single family; = 0.055 for multifamily)[2,3]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 6 years)[1]

Deemed Savings

The following table lists the deemed energy savings and demand reduction for each measure.

Deemed Savings and Incremental Costs

Measure	MMID	Single Family			Multifamily			Incremental Cost
		Annual kWh	Peak kW	Lifecycle kWh	Annual kWh	Peak kW	Lifecycle kWh	
Direct Install								
9 watt	2132	17	0.0015	99	15	0.0010	88	$1.21
14 watt	2133	24	0.0022	144	21	0.0020	128	$0.37
19 watt	2134	28	0.0026	169	26	0.0020	156	$0.38
23 watt	2135	41	0.0037	244	36	0.0030	216	$1.03
Pack-Based								
23 watt	3860	31	0.0028	186	-	-	-	$1.03

Assumptions

For pack-based measures, the in-service rate of 76% is the average for CFLs found in the referenced sources.[4,5] This installation rate accounts for the fact that some bulbs may not actually get installed. Direct install measures, by definition, have an installation rate of 100%.

Sources

1. Average of 2013 Cadmus database, CALMAC 2001, 2007 GDS, DEER 2008.
2. Cadmus. *Focus on Energy Evaluated Deemed Savings Changes: 2013 Final Report*. November 26, 2013. Available online: https://focusonenergy.com/sites/default/files/FOC_XC_Deemed_WriteUp_12122013%20%282%29.pdf.
3. Cadmus. Focus on Energy Evaluated Deemed Savings Changes: 2014 Final Report. November 14, 2014. Available online: https://focusonenergy.com/sites/default/files/FoE_Deemed_WriteUp%20CY14%20Final.pdf.
4. Cadmus. *Colorado Energy Savings Kits Program Evaluation: Final Report*. August 28, 2012. Available online: https://www.xcelenergy.com/staticfiles/xe/Regulatory/Regulatory%20PDFs/CO-DSM/CO-2012-Energy-Savings-Kits-Final-Evaluation.pdf
5. Cadmus. *Ameren Missouri Efficient Products Impact and Process Evaluation: Program Year 2014*. May 15, 2015. Available online: https://www.efis.psc.mo.gov/mpsc/commoncomponents/view_itemno_details.asp?caseno=EO-2012-0142&attach_id=2015027784

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

CFL, Standard Bulb, 13 Watt

	Measure Details
Measure Master ID	CFL, Direct Install, 13 Watt, 3413 CFL, Pack-Based, 13 Watt, 3859
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Compact (CFL)
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	25 (MMID 3413), 19 (MMID 3859)
Peak Demand Reduction (kW)	0.0023 (MMID 3413), 0.0016 (MMID 3859)
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	149 (MMID 3413), 114 (MMID 3859)
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	6[1]
Incremental Cost	$0.37[5]

Measure Description

This measure is installinga 13-watt ENERGY STAR-qualified screw-in CFL in place of an incandescent screw-in bulb. Direct install measure savings are based on assumption that the Program Implementer or thier subcontractor performs the installation. Pack-based measure savings are based on assumption that the lamp was provided as part of a package, so an installation rate less than 100% is applied. The incremental cost of the CFL compared to the incandescent light bulb is the full installed cost.

Description of Baseline Condition

The baseline equipment is an incandescent 43-watt or 60-watt light bulb.

Description of Efficient Condition

The efficient equipment is standard screw-based 13-watt CFL lamps, either installed by the Program Implementer or their subcontractor (direct install), or provided as part of an energy efficiency package (pack-based).

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1,000 * HOU * ISR$

Where:

$Watts_{BASE}$ = Baseline wattage (= 43 or 60)

$Watts_{EE}$ = Efficient wattage (= 13)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 829)[2]

ISR = In-service rate (= 100% for direct install; = 76% for pack-based)[3,4]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1,000 * CF * ISR$

Where:

CF = Coincidence factor (= 0.075)[2]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 6 years)[1]

Deemed Savings

Single Family Savings

$Watts_{EE}$	MMID	Annual kWh_{SAVED}	kW_{SAVED}	Lifecycle kWh_{SAVED}
13	Direct Install, 3413	25	0.0023	149
13	Pack-Based, 3859	19	0.0016	114

Assumptions

For pack-based measures, the installation rate of 76% is the average for CFLs found in referenced sources.[3,4] This installation rate accounts for the fact that some bulbs may not actually get installed. Direct install measures, by definition, have an installation rate of 100%.

Sources

1. Average of 2013 Cadmus database, CALMAC 2001, 2007 GDS, DEER 2008.
2. Cadmus. *Focus on Energy Evaluated Deemed Savings Changes*. November 26, 2013. Available online: https://www.focusonenergy.com/sites/default/files/FOC_XC_Deemed_WriteUp_12122013%20(2).pdf
3. Cadmus. *Colorado Energy Savings Kits Program Evaluation: Final Report*. August 28, 2012. Available online: https://www.xcelenergy.com/staticfiles/xe/Regulatory/Regulatory%20PDFs/CO-DSM/CO-2012-Energy-Savings-Kits-Final-Evaluation.pdf
4. Cadmus. *Ameren Missouri Efficient Products Impact and Process Evaluation: Program Year 2014*. May 15, 2015. Available online: https://www.efis.psc.mo.gov/mpsc/commoncomponents/view_itemno_details.asp?caseno=EO-2012-0142&attach_id=2015027784
5. Light bulb sales data obtained by Cadmus for California- 2010 through 2012. Note that the CFL average lamp costs include incented lamps.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

CFL, Standard Bulb, Retail Store Markdown

	Measure Details
Measure Master ID	CFL, Standard Bulb, Retail Store Markdown: 310-749 Lumens, 3548 750-1,049 Lumens, 3549 1,050-1,489 Lumens, 3550 1,490-2,600 Lumens, 3551
Measure Unit	Per bulb
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Compact (CFL)
Sector(s)	Residential- single family, Residential- multifamily
Annual Energy Savings (kWh)	Varies by light output
Peak Demand Reduction (kW)	Varies by light output
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by light output
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	8[1]
Incremental Cost	Varies by measure, see Appendix D

Measure Description

This measure is installing an ENERGY STAR-certified standard screw-in CFL purchased through a retail outlet in place of an incandescent or halogen screw-in bulb. Assumptions are based on a time-of-sale purchase for installation in a residential location.

Description of Baseline Condition

The baseline equipment is an incandescent light bulb (standard or EISA compliant halogen). The baseline wattage is determined using the lumens equivalence method in conjunction with the lumen output of the efficient bulb.

Description of Efficient Condition

The efficient measure is a standard ENERGY STAR-certified CFL.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1,000 * HOU$

Where:

$Watts_{BASE}$ = Baseline wattage (= see table below)

$Watts_{EE}$ = Efficient wattage (= see table below)

Baseline and Efficient Wattages

$Watts_{BASE}$	$Watts_{EE}$
29	9
43	13
53	18
72	23

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 1,011)[2]

Summer Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1,000 * CF$

Where:

CF = Coincidence factor (= 0.1189)[2]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 8 years)[1]

Deemed Savings

Deemed Savings by Measure

MMID	Annual kWh_{SAVED}	kW_{SAVED}	Lifecycle kWh_{SAVED}
3548	20	0.0024	162
3549	30	0.0036	243
3550	35	0.0042	283
3551	50	0.0058	396

Assumptions

Incremental costs by lumen bin for CFL standard bulb[3]:

- 310-749 lumens = $1.21
- 750-1,049 lumens = $0.37
- 1,050-1,489 lumens = $0.38
- 1,490-2,600 lumens = $1.03

Sources

1. Similar measure ID 2959, CFL Retail Store Markdown.
2. Cadmus. *Focus on Energy Evaluated Deemed Savings Changes*. November 14, 2014.
3. Light bulb sales data obtained by Cadmus for California- 2010 through 2012. Note that the CFL average lamp costs include incented lamps.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

8-Foot Linear Fluorescent T8 Replacement System Parking Garage

	Measure Details
Measure Master ID	T8 2-Lamp, 4-Foot, HPT8 or RWT8: Replacing T12 1-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage, 3144 Replacing T12 1-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage, 3145 Replacing T12HO 1-Lamp, 8-Foot, BF > 1.00, Parking Garage, 3148 Replacing T12HO 1-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage, 3149 Replacing T12HO 1-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage, 3150 T8 4-Lamp, 4-Foot, HPT8 or RWT8: Replacing T12 2-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage, 3146 Replacing T12 2-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage, 3147 Replacing T12HO 2-Lamp, 8-Foot, BF > 1.00, Parking Garage, 3151 Replacing T12HO 2-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage, 3152 Replacing T12HO 2-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage, 3153 Replacing T12VHO 2-Lamp, 8-Foot, BF > 1.00, Parking Garage, 3154 Replacing T12VHO 2-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage, 3155 Replacing T12VHO 2-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage, 3156
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Linear
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	Varies by measure
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	Varies by measure, see Appendix D

Measure Description

High performance (HP) and reduced wattage (RW) 4-foot linear fluorescent lighting fixtures that use low ballast factors, high wattage lamps, or reduced wattage lamps are an energy-efficient alternative to 8-foot standard wattage T12, T12HO, and T12VHO linear fluorescent fixtures commonly found in parking garages within multifamily buildings. These products can be installed on a two-to-one basis to replace 1-lamp or 2-lamp T12 luminaires without sacrificing lighting quality.

Description of Baseline Condition

For existing building parking garages, the baseline measure is 8-foot, 1-lamp or 2-lamp, standard T12, T12HO, and T12VHO linear fluorescent fixtures.

Description of Efficient Condition

The efficient measure is 2-lamp or 4-lamp, 4-foot, high performance T8 fixtures with normal and low ballast factor, and reduced wattage, 25-watt and 28-watt T8s with high, normal, and low ballast factors.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{8' T12} - kWh_{HP/RW}$

Where:

$kWh_{8' T12}$ = Annual electricity consumption of an 8-foot, T12, T12HO, or T12VHO lamp linear fluorescent fixture

$kWh_{HP/RW}$ = Annual electricity consumption of a 4-foot linear fluorescent high performance or reduced wattage fixture

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = Wattage / 1,000 * CF$

Where:

Wattage = Wattage used

1,000 = Kilowatt conversion factor

CF = Demand coincidence factor (= 1.0) [3]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[1]

Deemed Savings

Annual Deemed Savings for 8-Foot Linear Fluorescent T8 Replacement System Parking Garage

Measure	MMID	Existing Building	
		kWh	kW
T8 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12 1-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	3144	263	0.0301
T8 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12 1-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	3145	322	0.0368
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12 2-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	3146	303	0.0346
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12 2-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	3147	412	0.047
T8 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 1-Lamp, 8-Foot, BF > 1.00, Parking Garage	3148	473	0.0541
T8 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 1-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	3149	631	0.0721
T8 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 1-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	3150	690	0.0788
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 2-Lamp, 8-Foot, BF > 1.00, Parking Garage	3151	756	0.0863
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 2-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	3152	1,083	0.1236
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 2-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	3153	1,191	0.136
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO 2-Lamp, 8-Foot, BF > 1.00, Parking Garage	3154	2,271	0.2593
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO 2-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	3155	2,598	0.2966
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO 2-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	3156	2,707	0.309

Lifecycle Deemed Savings for 8-Foot Linear Fluorescent T8 Replacement System Parking Garage

Measure	MMID	Existing Building (kWh)
T8 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12 1-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	3144	3,945
T8 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12 1-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	3145	4,830
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12 2-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	3146	4,545
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12 2-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	3147	6,180
T8 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 1-Lamp, 8-Foot, BF > 1.00, Parking Garage	3148	7,095
T8 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 1-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	3149	9,465
T8 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 1-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	3150	10,350
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 2-Lamp, 8-Foot, BF > 1.00, Parking Garage	3151	11,340
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 2-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	3152	16,245
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 2-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	3153	17,865
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO 2-Lamp, 8-Foot, BF > 1.00, Parking Garage	3154	34,065
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO 2-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	3155	38,970
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO 2-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	3156	40,605

Measure Costs for 8-Foot Linear Fluorescent T8 Replacement System Parking Garage[2]

Measure	MMID	Existing Building Cost
T8 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12 1-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	3144	$41.00
T8 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12 1-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	3145	$41.00
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12 2-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	3146	$66.00
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12 2-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	3147	$66.00

Measure	MMID	Existing Building Cost
T8 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 1-Lamp, 8-Foot, BF > 1.00, Parking Garage	3148	$41.00
T8 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 1-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	3149	$41.00
T8 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 1-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	3150	$41.00
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 2-Lamp, 8-Foot, BF > 1.00, Parking Garage	3151	$66.00
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 2-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	3152	$66.00
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 2-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	3153	$66.00
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO 2-Lamp, 8-Foot, BF > 1.00, Parking Garage	3154	$66.00
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO 2-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	3155	$66.00
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO 2-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	3156	$66.00

Sources

1. California Energy Commission and California Public Utilities Commission. Database for Energy Efficient Resources (DEER) 2008. http://www.energy.ca.gov/deer/
2. Michigan Master Measure Database. 2011 baselines. Updated May 26, 2011.
3. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Commercial Applications. March 22, 2010.
4. ACES. *Deemed Savings Desk Review*. November 3, 2010.

Revision History

Version Number	Date	Description of Change
01	12/31/2012	New measure

Linear Fluorescent, 2-Lamp, 4-Foot, RWT8 Replacements, 24 Hours, CALP

	Measure Details
Measure Master ID	Linear Fluorescent, 2-Lamp, 4-Foot, RWT8 Replacements, 24 Hours, CALP, 3195
Measure Unit	Per fixture (lamps and ballast)
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Linear
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	307.00
Peak Demand Reduction (kW)	0.035
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by installation year
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	$34.97[2]

Measure Description

Reduced wattage (RW) 4-foot linear fluorescent lighting fixtures that use low ballast factors are an energy-efficient alternative to standard 40-watt or 34-watt linear T12 fluorescent products commonly found in multifamily buildings. These products can be installed on a one-for-one basis to replace 2-lamp T12 luminaires that are “on” 24 hours per day without sacrificing lighting quality.

Description of Baseline Condition

The baseline equipment for existing buildings is a standard 2-lamp T12 fixture.

Description of Efficient Condition

The efficient equipment is a reduced wattage, 2-lamp, 28-watt T8 with a low ballast factor.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{2L\ 4'\ T12} - kWh_{HP/RW}$

Where:

$kWh_{2L\ 4'\ T12}$ = Annual electricity consumption of 2-lamp T12 luminaire

$kWh_{HP/RW}$ = Annual electricity consumption of a 4-foot, linear fluorescent, high performance or low wattage fixture

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = Wattage / 1,000 * CF

Where:

Wattage = Wattage per fixtures
1,000 = Kilowatt conversion factor
CF = Demand coincidence factor (= 1.0)[3]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE}$ = kWh_{SAVED} * EUL

Where:

EUL = Effective useful life (= 15 years)[1]

Deemed Savings

Annual Deemed Savings for 4-Foot RWT8 Linear Fluorescents

Measure	Existing Building
Low Watt T8 System: 28-Watt, 2-Lamp, 4-Foot Ballast & Lamps ≤ 0.78	307 kWh 0.035 kW

Lifecycle Deemed Savings for 4-Foot RWT8 Linear Fluorescents*

Measure	Installation Year			
	2013	2014	2015	2016 and Beyond
Multifamily Common Area 4-Foot 2-Lamp T12 to T8	2,706.8 kWh 0.0350 kW	2,549.2 kWh 0.0350 kW	2,391.5 kWh 0.0350 kW	2,233.8 kWh 0.0170 kW

* kWh savings for products replacing T12 lamps calculated using the following methodology:

- Installed in 2013: receive three years T12 savings and 12 years EISA compliant T8 baseline savings.
- Installed in 2014: receive two years T12 savings and 13 years EISA compliant T8 baseline savings.
- Installed in 2015: receive one year T12 savings and 14 years EISA compliant T8 baseline savings.
- Installed in 2016: receive no T12 savings and 15 years of EISA compliant T8 baseline savings.

Measure Costs for 4-Foot RWT8 Linear Fluorescents

Measure	Existing Building Cost
Low Watt T8 System: 28-Watt, 2-Lamp, 4-Foot Ballast & Lamps ≤ 0.78	$110.90

Assumptions

Annual operating hours: 8,760. 2-lamp T12 fixtures used to generate baseline usage. For 2-lamp reduced wattage with low ballast factor, 28-watt, T8 lamps were used to calculate the new measure average annual energy savings.

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. Actual cost from 2015-16 program data, 30 applications.
3. Focus on Energy Business Programs Deemed Savings Manual V1.0. Commercial Applications. March 22, 2010.

Revision History

Version Number	Date	Description of Change
01	06/20/2013	New measure

Linear Fluorescent, 2-Lamp, 4-Foot, RWT8 Replacements, 12 Hours, CALP

	Measure Details
Measure Master ID	Linear Fluorescent, 2-Lamp, 4-Foot, RWT8 Replacements, 12 Hours, CALP, 3196
Measure Unit	Per fixture (lamps and ballast)
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Linear
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	153.00
Peak Demand Reduction (kW)	0.0270
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by installation year
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	$9.80[2]

Measure Description

Reduced wattage 4-foot linear fluorescent lighting fixtures that use low ballast factors are an energy-efficient alternative to standard 40-watt or 34-watt linear T12 fluorescent products commonly found in multifamily buildings. These products can be installed on a one-for-one basis to replace 2-lamp T12 luminaires without sacrificing lighting quality.

Description of Baseline Condition

The baseline equipment for existing buildings is a standard 2-lamp T12 fixture.

Description of Efficient Condition

The efficient equipment is a reduced wattage, 2-lamp, 28-watt T8 with a low ballast factor.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{2L\ 4'\ T12} - kWh_{HP/RW}$

Where:

$kWh_{2L\ 4'\ T12}$ = Annual electricity consumption of 2-lamp T12 luminaire

$kWh_{HP/RW}$ = Annual electricity consumption of a 4-foot, linear fluorescent, high performance or low wattage fixture

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = Wattage / 1,000 * CF

Where:

Wattage = Wattage per fixtures
1,000 = Kilowatt conversion factor
CF = Demand coincidence factor (= 0.77)[3]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE}$ = kWh_{SAVED} * EUL

Where:

EUL = Effective useful life (= 15 years)[1]

Deemed Savings

Annual Deemed Savings for 4-Foot RWT8 Linear Fluorescents

Measure	Existing Building
Low Watt T8 System: 28-Watt, 2-Lamp, 4-Foot Ballast & Lamps ≤ 0.78	153 kWh 0.0270 kW

Lifecycle Deemed Savings for 4-Foot RWT8 Linear Fluorescents*

Measure	Installation Year			
	2013	2014	2015	2016 and Beyond
Multifamily Common Area 4-Foot 2-Lamp T12 to T8	1,353.4 kWh 0.0270 kW	1,274.6 kWh 0.0270 kW	1,195.7 kWh 0.0270 kW	1,116.9 kWh 0.0131 kW

* kWh savings for products replacing T12 lamps calculated using the following methodology:

- Installed in 2013: receive three years T12 savings and 12 years EISA compliant T8 baseline savings.
- Installed in 2014: receive two years T12 savings and 13 years EISA compliant T8 baseline savings.
- Installed in 2015: receive one year T12 savings and 14 years EISA compliant T8 baseline savings.
- Installed in 2016: receive no T12 savings and 15 years of EISA compliant T8 baseline savings.

Measure Costs for 4-Foot RWT8 Linear Fluorescents

Measure	Existing Building Cost
Low Watt T8 System: 28-Watt, 2-Lamp, 4-Foot Ballast & Lamps ≤ 0.78	$110.90

Assumptions

The annual operating hours were assumed to be 4,380.

The baseline usage was generated using 2-lamp T12 fixtures.

For 2-lamp reduced wattage with low ballast factor, 28-watt, T8 lamps were used to calculate the new measure average annual energy savings.

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. 2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline. .
3. Focus on Energy Business Programs Deemed Savings Manual V1.0. Commercial Applications. March 22, 2010.

Revision History

Version Number	Date	Description of Change
01	06/20/2013	New measure

Reduced Wattage 8-Foot T8 Lamps Replacing 8-Foot Standard T8 Lamps

	Measure Details
Measure Master ID	Reduced Wattage 8-Foot T8 Lamps Replacing 8-Foot Standard T8 Lamps, 2665
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Linear
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by wattage
Peak Demand Reduction (kW)	Varies by wattage
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by wattage
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	$4.33[4]

Measure Description

Reduced wattage 8-foot standard wattage T8 lamps save energy by reducing the total input wattage of the luminaires where installed. Reduced wattage 8-foot T8 lamps can be installed in place of existing 59-watt 8-foot T8 lamps where the tasks that take place in the space do not require the light level provided by the existing lamps.

Description of Baseline Condition

The baseline equipment is standard 59-watt 8-foot T8 lamps.

Description of Efficient Condition

The efficient equipment is 49-watt, 50-watt, 51-watt, or 54-watt 8-foot T8 lamps.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{59wattT8} - kWh_{RWLamp}$

Where:

$kWh_{59wattT8}$ = Annual electricity consumption of standard 59-watt 8-foot T8 lamp

kWh_{RWLamp} = Annual electricity consumption of reduced wattage 8-foot T8 lamp

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = Wattage / 1,000 * CF

Where:

Wattage = Wattage of installed fixture; (= ballast factor * lamp wattage)

1,000 = Kilowatt conversion factor

CF = Demand coincidence factor (= 0.77)[3]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE}$ = ($kWh_{59wattT8}$ - kWh_{RWLamp}) * EUL

Where:

EUL = Effective useful life (= 15 years)[1]

Assumptions

An average of 25% each of 49-watt, 50-watt, 51-watt, and 54-watt 8-foot T8 lamps was used to generate the new measure wattage.

Sources

1. DEER 2014. http://www.deeresources.com/. Rated ballast life of 70,000 hours. Not rated on bulb life. Capped at 15 years.
2. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
3. *Focus on Energy Business Programs Deemed Savings Manual V1.0*. Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.
4. 2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.

Revision History

Version Number	Date	Description of Change
01	12/2012	Updated savings values

LED, Direct Install, 5.3 Watt Replacing Candelabra Base

	Measure Details
Measure Master ID	LED, Direct Install, 5.3 Watt, Candelabra Base,3733
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	38
Peak Demand Reduction (kW)	0.0049
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	646
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	17[1]
Incremental Cost ($/unit)	$7.49[2]

Measure Description

ENERGY STAR-rated LED replacement candelabra base (E12) lamps save energy by reducing the total input wattage of the luminaire as compared to the same luminaire operating with standard wattage incandescent candelabra base (E12) lamps. This measure provides an energy-efficient alternative to using incandescent candelabra base (E12) lamps in individual units.

Description of Baseline Condition

The baseline is an average of 40-watt and 60-watt incandescent candelabra base (E12) lamps. These decorative shaped lamps are exempt from EISA lumen per watt standards.[3]

Description of Efficient Condition

The efficient equipment is an ENERGY STAR-rated candelabra base (E12) LED lamp at 5.3 watts or less.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) * HOU / 1,000$

Where:

$Watts_{BASE}$ = Power consumption of baseline incandescent fixtures (= 50 watts, see Assumptions)

$Watts_{EE}$ = Power consumption of efficient LED product (= 5.3 watts)[1]

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 840 in unit)[4]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{LED}) / 1,000 * CF$

Where:

CF = Coincidence factor (= 0.11 in unit)[4]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 17 years)[1]

Assumptions

A weighted average of 50% each 40-watt and 60-watt candelabra base (E12) incandescent lamps were used to generate the baseline wattage. Fixture lamp weightings are based on a combination of energy audit experience, direct install experience, and feedback from individuals certified through the National Council on Qualifications for the Lighting Professions and from individuals with lighting sales experience.

Deemed Savings

Average Annual Deemed Savings for In-Unit LED Candelabra Base (E12) Lamp

Measure	MMID	Multifamily	
		kWh	kW
Direct Install 5.3 Watt LED Candelabra Base Lamp Replacing Incandescent	3733	38	0.0049

Average Lifecycle Deemed Savings for In-Unit LED Candelabra Base Lamp

Measure	MMID	Multifamily
Direct Install 5.3 Watt LED Candelabra Base Lamp Replacing Incandescent	3733	646

Sources

1. Average rated life of product (based on Maxlite 5B11DLED27) divided by in unit hours-of-use (~15,000 / 840 = 17.86 years, rounded down to 17 years to account for possible persistence and/or shortened life: http://www.energystar.gov/productfinder/product/certified-light-bulbs/details/2220687)
2. Focus on Energy Program Data. 2015. Implementer contract costs as of October 30, 2015. ($4.25 material + $3.24 labor = $7.49).
3. Energy Independence and Securities Act (EISA) of 2007. *Lighting Facts Summary*. Available online: http://www.lightingfacts.com/Library/Content/EISA
4. Cadmus. *Field Study Research: Residential Lighting.* October 18, 2013. Conducted regarding CFL and incandescent bulbs.

Revision History

Version Number	Date	Description of Change
01	10/13/2015	New measure

LED, Direct Install, 6 Watt Replacing G25 Lamp

	Measure Details
Measure Master ID	LED, Direct Install, 6 Watt, G25 Lamp, 3734
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	37
Peak Demand Reduction (kW)	0.0048
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	740
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Incremental Cost	$7.74[2]

Measure Description

ENERGY STAR-rated LED replacement globe lamps save energy by reducing the total input wattage of the luminaire compared to the same luminaire operating with standard wattage incandescent globe lamps. This measure provides an energy-efficient alternative to using incandescent globe lamps in individual units.

Description of Baseline Condition

The baseline is an average of 40-watt and 60-watt incandescent globe lamps. G-shaped lamps are exempt from EISA lumen per watt standards.[3]

Description of Efficient Condition

The efficient equipment is an ENERGY STAR-rated G25 LED lamp at 6-watts or less.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) * HOU / 1,000$

Where:

$Watts_{BASE}$ = Power consumption of baseline incandescent fixtures (= 50 watts; see the Assumptions section)

$Watts_{EE}$ = Power consumption of efficient LED product (= 6 watts)[1]

HOU = Hours-of-use (= 840 in unit)[4]
1,000 = Kilowatt conversion factor

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{LED}) / 1,000 * CF$

Where:

CF = Coincidence factor (= 0.11 in unit)[4]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 20 years)[1]

Assumptions

A weighted average of 50% each 40-watt and 60-watt globe incandescent lamps was used to generate the baseline wattage. Fixture lamp weightings are based on a combination of energy audit experience, direct install experience, and feedback from Lighting Certified individuals through the National Council on Qualifications for the Lighting Professions and individuals with lighting sales experience.

Deemed Savings

Average Annual Deemed Savings for In Unit LED G25 Lamp

Measure	MMID	Multifamily	
		kWh	kW
Direct Install 6-Watt LED Lamp Replacing Incandescent G25 Lamp	3734	37	0.0048

Average Lifecycle Deemed Savings for In Unit LED G25 Lamp

Measure	MMID	Multifamily
Direct Install 6-Watt LED Lamp Replacing Incandescent G25 Lamp	3734	740

Sources

1. Average rated life of product (based on Maxlite 6G25DLED27) divided by in unit hours of use (~25,000 / 840 = 29.76 years). This EUL is over 20 years; under agreement with the PSC, Cadmus, the Administrator, and Implementers set LED EULs above 20 years at 20 years..
2. Based on actual implementer contract costs as of October10/ 30, 20/15. ($4.50 material + $3.24 labor = $7.74).
3. The Energy Independence and Securities Act (EISA) of 2007 Lighting Facts Summary: http://www.lightingfacts.com/Library/Content/EISA
4. Cadmus. Field Study Research: Residential Lighting. October 18, 2013. Conducted regarding CFL and incandescent bulbs.

Revision History

Version Number	Date	Description of Change
01	10/13/2015	New measure

LED, Direct Install, 8 Watt Replacing BR30 Lamp

	Measure Details
Measure Master ID	LED, Direct Install, 8 Watt, BR30 Lamp, 3732
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	48
Peak Demand Reduction (kW)	0.0063
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	960
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Incremental Cost ($/unit)	$8.49[2]

Measure Description

ENERGY STAR-rated LED replacement BR30 lamps save energy by reducing the total input wattage of the luminaire as compared to the same luminaire operating with standard wattage incandescent BR30 lamps. This measure provides an energy-efficient alternative to using incandescent BR30 lamps in several applications.

Description of Baseline Condition

The baseline is 65-watt incandescent BR30 reflector lamps, which are the most common reflector lamps installed in residential recessed can applications. BR30 shaped lamps are exempt from EISA lumen per watt standards.[3]

Description of Efficient Condition

The efficient equipment is an ENERGY STAR-rated BR30 LED lamp at 8 watts or less.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) * HOU / 1,000$

Where:

$Watts_{BASE}$ = Power consumption of baseline incandescent fixtures (= 65 watts)

$Watts_{EE}$ = Power consumption of efficient LED product (= 8 watts)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 840 in unit)[4]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{LED}) / 1{,}000 * CF$

Where:

CF = Coincidence factor (= 0.11 in unit)[4]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 20 years)[1]

Deemed Savings

Average Annual Deemed Savings for In Unit LED BR30 Lamp

Measure	MMID	Multifamily	
		kWh	kW
Direct Install 8 Watt LED Lamp Replacing BR30 Incandescent	3732	48	0.0063

Average Lifecycle Deemed Savings for In Unit LED BR30 Lamp

Measure	MMID	Multifamily
Direct Install 8 Watt LED Lamp Replacing BR30 Incandescent	3732	960

Sources

1. Average rated life of product (based on Maxlite HC8BR30DLED27-RB4) divided by in unit hours-of-use (~25,000 / 840 = 29.76 years, rounded down to 25 years to account for possible persistence and/or shortened life). This EUL is over 20 years; under agreement with the PSC, Cadmus, the Administrator, and Implementers, LED EULs above 20 years are set at 20 years.
2. Focus on Energy Program Data. 2015. Implementer contract costs as of October 30, 2015. ($5.25 material + $3.24 labor = $8.49).
3. Energy Independence and Securities Act (EISA) of 2007. "Lighting Facts Summary." Available online: http://www.lightingfacts.com/Library/Content/EISA
4. Cadmus. *Field Study Research: Residential Lighting*. October 18, 2013. Conducted regarding CFL and incandescent bulbs.

Revision History

Version Number	Date	Description of Change
01	10/13/2015	New measure

LED, Direct Install, 9.5 Watt

	Measure Details
Measure Master ID	LED, Direct Install, 9.5 Watt, 3279
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	42
Peak Demand Reduction (kW)	0.0031
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	840
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1] (in unit only)
Incremental Cost ($/unit)	$7.81[4]

Measure Description

ENERGY STAR-rated LED replacement lamps save energy by reducing the total input wattage of the luminaire as compared to the same luminaire operating with standard wattage incandescent lamps. This measure provides an energy-efficient alternative to using incandescent lamps in several applications.

Description of Baseline Condition

An average of 16.67% each of EISA compliant standard 53-watt incandescent, 60-watt incandescent and halogen, 65-watt incandescent, 70-watt halogen, 72-watt halogen, and 80-watt halogen lamps were used to generate the baseline usage. Existing lamps above 80 watts will be replaced by CFL lamps and are not part of this measure.

Description of Efficient Condition

The efficient condition is an ENERGY STAR-rated, 9.5-watt LED lamp.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = [(Watts_{INCAN} – Watts_{LED}) / 1,000] * HOU$

Where:

$Watts_{INCAN}$ = Electricity consumption of standard incandescent lamp (= 53 watts, 60 watts, 65 watts, 70 watts, 72 watts, or 80 watts)

$Watts_{LED}$ = Electricity consumption of ENERGY STAR-rated LED lamp with a lumen output rating (= 9.5 watts)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 734)[2]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = [(Watts_{INCAN} – Watts_{LED}) / 1{,}000] * CF$

Where:

CF = Coincidence factor (= 0.055)[3]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[1]

Sources

1. Cadmus review of manufacturers measure life; capped at 20 years.
2. Cadmus. *Focus on Energy Evaluated Deemed Savings Changes: 2014 Final Report*. November 6, 2014. Available online: https://focusonenergy.com/sites/default/files/FoE_Deemed_WriteUp%20CY14%20Final.pdf
3. ACES. *Default Deemed Savings Review Final Report.* Table 4-1 MF housing (in unit). June 24, 2008. Available online: http://www.coned.com/documents/Con%20Edison%20Callable%20Load%20Study_Final%20Report_5-15-08.pdf (CF of 65% to 83% is within range of similar programs).
4. Average of MMIDs 3346-3347. Online research, March 2016. Average cost of "8 Watt LED Lamp, 40 Watt equivalent" and "12 Watt LED Lamp, 60 Watt equivalent." Available online: www.1000bulbs.com/category/60-watt-equal-led-light-bulbs/ and www.1000bulbs.com/category/40-watt-equal-led-light-bulbs/

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

LED, Omnidirectional, Retail Store Markdown

	Measure Details
Measure Master ID	LED, Omnidirectional, Retail Store Markdown: 310-749 Lumens, 3553 750-1,049 Lumens, 3554 1,050-1,489 Lumens, 3555 1,490-2,600 Lumens, 3556
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Residential- single family, Residential- multifamily
Annual Energy Savings (kWh)	Varies by light output
Peak Demand Reduction (kW)	Varies by light output
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by light output
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	Varies by measure, see Appendix D[3]

Measure Description

This measure is installing an ENERGY STAR-certified omnidirectional LED bulb that is purchased through a retail outlet to replace an incandescent or halogen bulb. The assumptions were based on a time-of-sale purchase for installation in a residential location.

Description of Baseline Condition

The baseline equipment is a general service incandescent light bulb (standard or EISA compliant halogen). The wattage of the baseline bulb is determined by the lumens equivalence method.

Description of Efficient Condition

The efficient equipment is an ENERGY STAR-certified omnidirectional LED bulb. The actual wattage of the installed bulb will be used to evaluate savings.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1{,}000 * HOU$

Where:

$Watts_{BASE}$ = Power consumption of baseline measure (= varies by lumen bin; see table below)

$Watts_{EE}$ = Power consumption of efficient measure (= varies by lumen bin; see table below)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 1,011)[1]

Power Consumption of Baseline and Efficient Measures by Lumen Bin

Lumen Bin	Mean Wattage of Omnidirectional LED Bulbs[2]	EISA Compliant Baseline Wattages[4]
310-749	6.94	29
750-1,049	10.57	43
1,050-1,489	12.93	53
1,490-2,600	17.27	72

Summer Coincident Peak Savings Algorithm

$kW_{SAVED}= (Watts_{BASE}- Watts_{EE})/1{,}000 * CF$

Where:

CF = Coincidence factor (= 0.1189)[2]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 20 years)[1]

Deemed Savings

The deemed savings were calculated using the mean wattage of the omnidirectional bulbs in the approved ENERGY STAR Qualified Product List, available December 5, 2014. The mean wattage values are shown in the table below.

Mean Savings Values by Lumen Bin

Lumens Bin	MMID	Annual Energy Savings (kWh)	Lifecycle Energy Savings (kWh)	Coincident Peak Demand Reduction (kW)
310-749	3553	22	335	0.0026
750-1,049	3554	33	492	0.0039
1,050-1,489	3555	41	608	0.0048
1,490-2,600	3556	55	830	0.0065

Sources

1. Cadmus review of manufacturers measure life.
2. ENERGY STAR. *Qualified Products List*. December 5, 2014. Mean wattage of omnidirectional LEDs falling within the specified lumens bin.
3. Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.
4. Cadmus. Research based on EISA 2007 backstop legislation. https://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/eisa_2007.pdf

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

LED, Direct Install, 13.5 Watt

	Measure Details
Measure Master ID	LED, Direct Install, 13.5 Watt, 3385, 3439
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	39
Peak Demand Reduction (kW)	0.0035
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	780
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Incremental Cost ($/unit)	$5.85[3]

Measure Description

This measure is the Program Implementer or a subcontractor of the Program Implementer installing a 13.5-watt ENERGY STAR-qualified screw-in LED in place of an incandescent screw-in bulb. The incremental cost of the LED compared to the incandescent light bulb is the full installed cost. Savings are based on a direct installation, not a time-of-sale purchase.

Description of Baseline Condition

The baseline equipment is a 43-watt or 60-watt incandescent light bulb. Energy savings are evaluated using a baseline of 43 watts.

Description of Efficient Condition

This measure applies to standard screw-based 13.5-watt LED lamps.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1{,}000 * HOU$

Where:

$Watts_{BASE}$ = Baseline wattage (= 60)

$Watts_{EE}$ = Efficient wattage (= 13.5)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 829)[2]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1{,}000 * CF$

Where:

CF = Coincidence factor (= 0.075)[2]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 20 years)[1]

Sources

1. Cadmus review of manufacturers' measure life.
2. Cadmus. Focus on Energy Evaluated Deemed Savings Changes. November 6, 2013.
3. Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

LED Fixture, Exterior, CALP

	Measure Details
Measure Master ID	LED Fixture, Exterior, 12 Hours, CALP, 3735
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	184
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	2,024
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	11[1]
Incremental Cost ($/unit)	$12.46[2]

Measure Description

Hardwired LED incentives apply only to complete new fixtures, and only for the replacement of incandescent fixtures. LEDs provide the same or better light output than incandescent lamps while using significantly less energy.

Description of Baseline Condition

The baseline condition is a one-lamp, 72 watt, 65 watt, 43 watt, or 29 watt incandescent fixture; a two-lamp, 43 watt or 29watt incandescent fixture; or a three-lamp, 29 watt incandescent fixture on a switch, photocell, or timer that is used for 12 hours per day.

Description of Efficient Condition

The efficient condition is complete replacement of incandescent fixtures.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{INCANDESCENT} - Watts_{LED}) /1{,}000 * HOU * CNTRL$

Where:

$Watts_{INCANDESCENT}$ = Weighted average annual electricity consumption of incandescent fixture (=63.7 watts)

$Watts_{LED}$ = Weighted average annual electricity consumption of ENERGY STAR® or DLC-listed LED fixtures, filtered to respective EISA lumen equivalents (=20.93 watts)[4]

1,000 = Kilowatt conversion factor

HOU = Run time of exterior fixtures based on an annual average of 12 hours per day from NOAA data.[3] This includes times when photocells turn on prior to exact sunset and turn off after exact sunrise, accounting for diminished outdoor lighting as well as time clock scheduled lighting (= 4,380 hours).

CNTRL = Controls factor allowing for a more conservative estimate of savings. Based on project experience, less than 10% of exterior fixtures on the market have additional controls to operate at conditions other than dusk to dawn (= 0.90)

Summer Coincident Peak Savings Algorithm

There are no peak savings for this measure due to the operation of fixtures during off-peak hours.

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 11 years)[1]

Assumptions

Incandescent weighted average estimates were reviewed by staff with National Council on Qualifications for the Lighting Professions (NCQLP), LC (Lighting Certified) credentials, and were based on feedback from MESP program managers, energy advisors and direct install staff. Lamp wattages were adjusted to meet EISA legislation as listed in the table below.

Baseline Incandescent Weighted Average Assumptions

Lamp Wattage	100W (72W)	65W	(2) 60W (43W)	60W (43W)	(3) 40W (29W)	(2) 40W (29W)	40W (29W)
Weighted Average	5%	25%	25%	25%	5%	10%	5%

Sources

1. Cadmus review of manufacturers' measure life.
2. Online Research, March 2016. Material cost is average sales price of "Led Downlight." Available online: https://www.1000bulbs.com/category/led-downlights/
3. U.S. Department of Commerce | National Oceanic & Atmospheric Administration | NOAA Research - NOAA Solar Calculator http://www.esrl.noaa.gov/gmd/grad/solcalc/
4. Designlights Consortium™ qualified product list data, October 7, 2015. ENERGY STAR® qualified product list data, October 13, 2015.

Revision History

Version Number	Date	Description of Change
01	10/21/2015	Initial measure entry

LED, Standard Bulb, 10 Watt

	Measure Details
Measure Master ID	LED, Direct Install, 10 Watt, 3488, 3567 LED, Pack-Based, 10 Watt, 3861
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	27 (MMID 3488 and 3567), 25 (MMID 3861)
Peak Demand Reduction (kW)	0.0025 (MMID 3488 and 3567), 0.0023 (MMID 3861)
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	540 (MMID 3488 and 3567), 500 (MMID 3861)
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Incremental Cost	$5.90[3]

Measure Description

This measure is installing a 10-watt ENERGY STAR-qualified screw-in LED in place of an incandescent screw-in bulb. Direct install measure savings are based on the assumption that the Program Implementer or their subcontractor performs the installation. Pack-based measure savings are based on the assumption that the lamp was provided as part of a package, so an installation rate less than 100% is applied.

Description of Baseline Condition

The baseline equipment is a 43-watt halogen or 60-watt incandescent light bulb. The baseline of 43 watts was used to calculate savings for both cases.

Description of Efficient Condition

The efficient equipment is standard screw-based 10-watt LED lamps, either installed by the Program Implementer or their subcontractor (direct install), or provided as part of an energy efficiency package (pack-based).

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} - Watts_{EE})/1{,}000 * HOU * ISR$

Where:

$Watts_{BASE}$ = Baseline wattage (= 43)

$Watts_{EE}$ = Efficient wattage (= 10)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 829)

ISR = In-service rate (= 100% for direct install; = 92% for pack-based)[2]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1{,}000 * CF * ISR$

Where:

CF = Coincidence factor (= 0.075)[1]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 20 years)[1]

Deemed Savings

Single Family Annual Savings

$Watts_{EE}$	MMID	Annual kWh_{SAVED}	kW_{SAVED}	Lifecycle kWh_{SAVED}
10	Direct Install, 3488, 3567	27	0.0025	540
10	Pack-Based, 3861	25	0.0023	500

Sources

1. Cadmus review of manufacturers measure life; capped at 20 years.
2. Cadmus. *Ameren Missouri Efficient Products Impact and Process Evaluation: Program Year 2014.* May 15, 2015. Installation rate for LEDs in single-family kits, p. 39. Available online: https://www.efis.psc.mo.gov/mpsc/commoncomponents/view_itemno_details.asp?caseno=EO-2012-0142&attach_id=2015027784.
3. Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®. Weighted Average of 29 to 43 Watt LEDs.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

LED, Recessed Downlight, ENERGY STAR

	Measure Details
Measure Master ID	LED, Recessed Downlight, Replacing CFL, ENERGY STAR: Common Area, 3464 In Unit, 3463 LED, Recessed Downlight, Replacing Incandescent, ENERGY STAR: Common Area, 3462 In Unit, 3461
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by measure and location
Peak Demand Reduction (kW)	Varies by measure and location
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by measure and location
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	11[1]
Incremental Cost ($/unit)	$10.75[6]

Measure Description

This measure is for replacing incandescent or CFL downlights with qualified LED fixtures.

Description of Baseline Condition

The baseline is an incandescent (65 watt) or CFL (16 watt) downlight.[3]

Description of Efficient Condition

The efficient condition is replacing a complete luminaire unit. The downlight (12 watt)[3] must be ENERGY STAR rated and replace the trim, reflector, lens, heat sink, driver, and light source.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1,000 * HOU$

Where:

$Watts_{BASE}$ = Power consumption of baseline measure (= 65 watts if incandescent; = 16 watts if CFL)[3]

$Watts_{EE}$ = Power consumption of efficient LED downlight (= 12 watts)[3]

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 5,950 for multifamily common areas;[4] = 829 for in-residence lighting)[2]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1,000 * CF$

Where:

CF = Coincidence factor (=0.77 for multifamily common areas;[5] = 0.11 for in-residence lighting)[2]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[1]

Deemed Savings

Baseline Technology	Area Type	MMID	$Watts_{BASE}$	$Watts_{EE}$	kWh_{SAVED}	kW_{SAVED}	$kWh_{LIFECYCLE}$
Incandescent	In Unit	3461	65	12	50	0.006	754
CFL		3463	16	12	4	0.000	57
Incandescent	Common Area	3462	65	12	315	0.041	4730
CFL		3464	16	12	24	0.003	357

Assumptions

Incremental cost assumed to be the same as MMID 2458.

Sources

1. Cadmus review of manufacturers' measure life.
2. Cadmus. Field Study Research: Residential Lighting. October 18, 2013. (Report based on using CFL bulbs to replace incandescent bulbs. LEDs will initially be treated the same as CFLs, pending further research)
3. Mid-Atlantic TRM Version 3. March 2013.
4. ACES. *Focus on Energy Deemed Savings Desk Review*. Multifamily Applications for Common Areas. November 3, 2010.
5. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.
6. Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®. Average across wattage based Focus on Energy "LED Downlight" measures.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

LED, Reflector, 12 Watt, Retail Store Markdown

	Measure Details
Measure Master ID	LED, Reflector, 12 Watt, Retail Store Markdown, 3557
Measure Unit	Per reflector
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Residential- upstream
Annual Energy Savings (kWh)	54
Peak Demand Reduction (kW)	0.0063
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	1,080
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Incremental Cost ($/unit)	$5.85[4]

Measure Description

This measure is installing an ENERGY STAR-certified LED reflector or LED recessed downlight that is purchased through a retail outlet to replace an incandescent bulb. The savings are based on a time-of-sale purchase for installation in a residential location.

Description of Baseline Condition

The baseline is an incandescent 65-watt reflector or downlight. Reflectors are exempt from EISA legislation.[3]

Description of Efficient Condition

The efficient equipment is a standard screw-based 12-watt ENERGY STAR-certified LED reflector or downlight.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1{,}000 * HOU$

Where:

$Watts_{BASE}$ = Power consumption of baseline measure (= 65 watts)

$Watts_{EE}$ = Power consumption of efficient measure (= 12 watts)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 1,011)[2]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1{,}000 * CF$

Where:

CF = Coincidence factor (= 0.1189)[2]

Lifecycle Energy-Savings Algorithm

$KWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 20 years) [1]

Assumptions

A 65-watt baseline is used based on 2014 Focus on Energy Residential Lighting CFL data revealing that 65-watt replacements represented 96% of reflector sales. The table below shows total 2014 reflector sales by baseline wattage.

Total 2014 Reflector Sales by Baseline Wattage

Baseline Wattage	Total Reflector Units Sold in 2014	Percentage of Total Reflector Sales
50	6,433	1%
65	71,5395	96%
75	2,137	0%
100	19,503	3%
Total	**743,468**	**100%**

Sources

1. Cadmus review of manufacturers measure life; capped at 20 years.
2. Cadmus. *Focus on Energy Evaluated Deemed Savings Changes.* November 14, 2014.
3. EISA 2007 legislation. https://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/eisa_2007.pdf
4. Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

LED Fixture, Interior, Above 12 Hours to 24 Hours, CALP

	Measure Details
Measure Master ID	LED Fixture, Interior, 12 Hours, CALP, 3603 LED Fixture, Interior, 24 Hours, CALP, 3604
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	Varies by measure
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	Varies by measure
Incremental Cost ($/unit)	$12.46[2]

Measure Description

This measures is installing hardwired LEDs to complete new fixtures. Incentives are only provided for replacing incandescent fixtures. LEDs provide the same or better light output than incandescent lamps while using significantly less energy.

Description of Baseline Condition

The baseline condition is a 1-lamp 72-watt, 65-watt, 43-watt, or 29-watt; a 2-lamp 43-watt or 29-watt; or a 3-lamp 29-watt incandescent fixture on a switch, photocell, or timer that is used for 12 or more hours per day up to 24 hours a day.

Description of Efficient Condition

LED incentives apply only to complete, new, hardwired fixtures that are ENERGY STAR or DLC qualified and meet the EISA lumen equivalency of their incandescent baselines. Incentives are only for replacing incandescent fixtures.

The contractor and/or Program Implementer verifies the hours-of-use during assessments and/or pre-installs. Typically, lights in the common areas are on for 24 hours, especially those in interior spaces and corridors, and are on for 12 to 16 hours on timers or photocells in the entries and/or lobbies with windows.

The effective useful life of this measure is based on the average rated hours for qualifying products, divided by 12 hours and 24 hours, then rounded.

Annual Energy-Savings Algorithm

$KWh_{SAVED} = (Watts_{INCANDESCENT} - Watts_{LED}) / 1{,}000 * HOU$

Where:

$Watts_{INCANDESCENT}$ = Power consumption of baseline measure (= 63.7 watts; see table below)[3]

Baseline Wattage

Baseline Bulb	Wattage	Weighting	Contribution to Baseline (watts)
1L EISA 100w incand	72	5%	3.60
1L 65w BR30 incand	65	25%	16.25
2L EISA 60w incand	86	25%	21.50
1L EISA 60w incand	43	25%	10.75
3L EISA 40w incand	87	5%	4.35
2L EISA 40w incand	58	10%	5.80
1L EISA 40w incand	29	5%	1.45
Total		**100%**	**63.70**

$Watts_{LED}$ = Power consumption of efficient measure (= 20.93 watts; see table below)[4]

Efficient Wattage

Bulb	Wattage	Weighting	Contribution to Efficient (watts)
LED (1,490-2,600 lumens) replacing 1L EISA 100w incand	32.14	5%	1.6000
LED (600-750 lumens) replacing 1L 65w BR30 incand	13.03	25%	3.
LED (750-1,049 lumens) replacing 2L EISA 60w incand	31.18	25%	7.7950
LED (750-1,049 lumens) replacing 1L EISA 60w incand	15.59	25%	3.8975
LED (310-749 lumens) replacing 3L EISA 40w incand	32.81	5%	1.6405
LED (310-749 lumens) replacing 2L EISA 40w incand	21.88	10%	2.1880
LED (310-749 lumens) replacing 1L EISA 40w incand	10.94	5%	0.5470
Total		**100%**	**20.9325**

1,000 = Kilowatt conversion factor

HOU = Average annual hours-of-use (= 4,380 for 12-hour use; = 8,760 for 24-hour use)

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{INCANDESCENT} - Watts_{LED}) / 1{,}000 * CF$

Where:

CF = Coincidence factor (= 0.0 to 1.0 for 24-hour use)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = (= 6 years for 12 hour fixtures; = 13 years for 24 hour fixtures)[1]

Deemed Savings

Annual Savings

Measure	MMID	Multifamily	
		kWh	kW
LED Fixture, Interior, 12 Hours, CALP	3603	187	0.0000
LED Fixture, Interior, 24 Hours, CALP	3604	375	0.0428

Lifecycle Savings

Measure	MMID	Multifamily (kWh)
LED Fixture, Interior, 12 Hours, CALP	3603	2,431
LED Fixture, Interior, 24 Hours, CALP	3604	2,250

Assumptions

Lamp weightings were developed through previous CALP workpapers and based on typical lamp wattages in common area light fixtures such as downlights, wall sconces, and flush/ceiling mounts, using typical lamping configuration data from manufacturers. This information was gathered from previous 12-hour and 24-hour use CFL fixture installations, field assessments in 2014, and data on currently available qualifying fixtures.

Sources

1. ENERGY STAR. "ENERGY STAR Certified Light Bulbs." Accessed January 30, 2015. https://www.energystar.gov/productfinder/product/certified-light-bulbs/results. Filtered EUL per respective incandescent lumen equivalency and indoor application type, rounded to whole number. EULs based on average rated hours for qualifying products, divided by 12-hours and 24-hours usage.
2. Online Research, March 2016. Material cost is average sales price of "Led Downlight." Available online: https://www.1000bulbs.com/category/led-downlights/
3. EISA equivalent wattages for common incandescent lamps.
4. Average wattage of equivalent qualifying ENERGY STAR and DLC-listed LED fixtures as of January 30, 2015.

Revision History

Version Number	Date	Description of Change
01	01/30/2015	New measure
02	03/30/2015	Revised and combined 12 hour and 24 hour workpapers

LED, ENERGY STAR, Replacing Incandescent ≤ 40 Watts

	Measure Details
Measure Master ID	LED, ENERGY STAR, Replacing Incandescent ≤ 40 Watts: In Unit, 3161 Common Area, 3162
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	In Unit= 20; Common Area = 7[1]
Incremental Cost ($/unit)	$6.05[2]

Measure Description

ENERGY STAR-rated LED replacement lamps save energy by reducing the total input wattage of the luminaire compared to using standard wattage incandescent lamps. This measure is an energy-efficient alternative to incandescent lamps in several applications.

Description of Baseline Condition

The baseline measure is standard 25-watt and 40-watt incandescent lamps.

Description of Efficient Condition

The efficient equipment is an ENERGY STAR-rated LED that appears on the “ENERGY STAR® SSL Qualified Light Bulbs” list and is 5 watts to 9 watts.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{INCANDESCENT} - kWh_{LED}$

Where:

$KWh_{INCANDESCENT}$ = Annual electricity consumption of standard 25-watt or 40-watt incandescent lamp

KWh_{LED} = Annual electricity consumption of reduced wattage ENERGY STAR-rated lamp of equivalent lumen output to ≤ 40 watt incandescent

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = Wattage / 1,000 * CF$

Where:

Wattage = Wattage of fixture

1,000 = Kilowatt conversion factor

CF = Demand coincidence factor (= 0.082 for in-unit; = 0.775 for common area)[4]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 20 years in unit; = 7 years common area)[1]

Deemed Savings

Average Annual Deemed Savings for LED Replacing Incandescent Lamp ≤ 40 Watts

Measure	MMID	Existing Building	New Construction
LED Replacing Incandescent Lamp ≤ 40 Watts, In Unit	3161	23.0 kWh 0.0022 kW	23.0 kWh 0.0022 kW
LED Replacing Incandescent Lamp ≤ 40 Watts, Common Area	3162	160.0 kWh 0.0207 kW	160.0 kWh 0.0207 kW

Average Lifecycle Deemed Savings for LED Replacing Incandescent Lamp ≤ 40 Watts

Measure	MMID	Existing Building	New Construction
LED Replacing Incandescent Lamp ≤ 40 Watts, In Unit	3161	667 kWh	667 kWh
LED Replacing Incandescent Lamp ≤ 40 Watts, Common Area	3162	640 kWh	640 kWh

Assumptions

Common Area (MMID 3162):

- Annual operating hours: 5,949.5
- Assumes 40-watt and 25-watt incandescent lamps in calculation of baseline usage
- Assumes average ENERGY STAR-rated LED (5.64 watts) for ≤ 40 watt replacement products

In Unit (MMID 3161):

- Annual operating hours: 839.5
- Assumes 40-watt and 25-watt incandescent lamps in calculation of baseline usage
- Assumes average ENERGY STAR-rated LED (5.64 watts) for ≤ 40 watt replacement products

Sources

1. Cadmus review of manufacturers' measure life; in unit capped at 20 years.
2. Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.
3. ACES. Deemed Savings Desk Review. November 3, 2010.
4. ACES. Default Deemed Savings Review Final Report. June 24, 2008.
5. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.

Revision History

Version Number	Date	Description of Change
01	12/27/2012	New measure

LED, ENERGY STAR, Replacing Incandescent > 40 Watts

	Measure Details
Measure Master ID	LED, ENERGY STAR, Replacing Incandescent > 40 Watts: In Unit, 3159 Common Area, 3160
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	Varies by measure
Incremental Cost ($/unit)	$9.40[2]

Measure Description

ENERGY STAR-rated LED replacement lamps save energy by reducing the total input wattage of the luminaire as compared to the same luminaire operating with standard wattage incandescent lamps. This measure provides an energy-efficient alternative to incandescent lamps in several applications.

Description of Baseline Condition

The baseline measure is standard 60-watt, 65-watt, 75-watt, 90-watt, 100-watt, and 120-watt incandescent lamps.

Description of Efficient Condition

The efficient measure is an ENERGY STAR-rated LED.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{LED} - kWh_{INCANDESCENT}$

Where:

KWh_{LED} = Annual electricity consumption of ENERGY STAR-rated LED with a lumen output rating equivalent to a > 40-watt incandescent

$KWh_{INCANDESCENT}$ = Annual electricity consumption of standard 60-watt, 65-watt, 75-watt, 90-watt, 100-watt, or 120-watt incandescent lamp

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = Wattage / 1{,}000 * CF$

Where:

Wattage = Unit wattage

1,000 = Kilowatt conversion factor

CF = Demand coincidence factor (= 0.77 common area; = 0.0825 in-unit)[4]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 7 years in unit; = 20 years common area)[1]

Deemed Savings

Average Annual Deemed Savings for LED Lamp Replacing Incandescent Lamp > 40 Watts

Measure	MMID	Existing Building	New Construction
LED Replacing Incandescent Lamp > 40 Watts, In Unit	3159	58.0 kWh 0.0057 kW	43.0 kWh 0.0042 kW
LED Replacing Incandescent Lamp > 40 Watts, Common Area	3160	414.0 kWh 0.0536 kW	305.0 kWh 0.0395 kW

Average Lifecycle Deemed Savings for LED Lamp Replacing Incandescent Lamp > 40 Watts

Measure	MMID	Existing Building	New Construction
LED Replacing Incandescent Lamp > 40 Watts, In Unit	3159	2,378 kWh	1,763 kWh
LED Replacing Incandescent Lamp > 40 Watts, Common Area	3160	2,070 kWh	1,525 kWh

Assumptions

Existing Building/Common Area: Assumes 5,949.5 annual operating hours

- An average of 16.67% each of 60-watt, 65-watt, 75-watt, 90-watt, 100-watt, and 120-watt incandescent lamps was used to generate baseline usage
- An average of 33% each of 11.68-watt, 16.70-watt, and 17.81-watt ENERGY STAR-rated LEDs was used to generate new measure usage

Existing Building/In Unit: Assumes 839.5 annual operating hours

- An average of 16.67% each of 60-watt, 65-watt, 75-watt, 90-watt, 100-watt, and 120-watt incandescent lamps was used to generate baseline usage
- An average of 33% each of 11.68-watt, 16.70-watt, and 17.81-watt ENERGY STAR-rated LEDs was used to generate new measure usage

New Construction/Common Area: Assumes 5,939.5 annual operating hours

- An average of 16.67% each of 53-watt incandescent, 60-watt incandescent and halogen, 65-watt incandescent, 70-watt halogen, 72-watt halogen, and 80-watt halogen lamps was used to generate the baseline usage
- An average of 33% each of 11.68-watt, 16.70-watt, and 17.81-watt ENERGY STAR-rated LEDs was used to generate new measure usage

New Construction / In Unit: Assumes 839.5 annual operating hours

- An average of 16.67% each of 53-watt incandescent, 60-watt incandescent and halogen, 65-watt incandescent, 70-watt halogen, 72-watt halogen, and 80-watt halogen lamps was used to generate the baseline usage
- An average of 33% each 11.68-watt, 16.70-watt, and 17.81-watt ENERGY STAR-rated LEDs was used to generate new measure usage

Sources

1. Cadmus review of manufacturers measure life; capped at 20 years.
2. Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.
3. ACES*. Deemed Savings Desk Review.* November 3, 2010.
4. *Focus on Energy Business Programs Deemed Savings Manual V1.0*. Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.
5. ACES. *Default Deemed Savings Review Final Report*. June 24, 2008.

Revision History

Version Number	Date	Description of Change
01	12/26/2012	New measure

In Unit LED Downlight Fixtures ≤ 18 Watts

	Measure Details
Measure Master ID	LED Fixture, Downlight, ≤ 18 Watts, In Unit, 3748
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	43
Peak Demand Reduction (kW)	0.0042
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	2,150
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Incremental Cost ($/unit)	$80.13[2]

Measure Description

LED downlight fixtures can replace existing incandescent fixtures without sacrificing performance, and they save energy because they consume less wattage than the incandescent products they replace.

Description of Baseline Condition

The baseline condition is is a 60-watt to 100-watt incandescent fixture with EISA equivalent lamp wattages of 50 watts to 72 watts.

Description of Efficient Condition

The efficient equipment is an ENERGY STAR-rated downlight fixture that consumes ≤ 18 watts.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) * HOU / 1,000$

Where:

$Watts_{BASE}$ = Power consumption of baseline incandescent fixtures (= 64 watts). A weighted average of 20% each for 53-watt, 60-watt, 65 -watt, 70-watt, and 72-watt incandescent luminaires was used to generate the baseline wattage (see Assumptions)

$Watts_{EE}$ = Power consumption of efficient LED products (= 13 watts)[3]

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 840 in unit)[4]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{LED}) / 1,000 * CF$

Where:

CF = Coincidence factor (= 0.11 in unit)[5]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 20 years)[1]

Deemed Savings

Average Annual Deemed Savings for In-Unit LED Downlights ≤ 18 Watts

Measure	MMID	Multifamily	
		kWh	kW
In-Unit LED Downlights ≤ 18 Watts Replacing 60-100 Watt Incandescent	3748	43	0.0056

Average Lifecycle Deemed Savings for In Unit LED Downlights ≤ 18 Watts

Measure	MMID	Multifamily
In-Unit LED Downlights ≤ 18 Watts Replacing 60-100 Watt Incandescent	3748	860

Assumptions

Lamp weightings are based on a combination of energy audit experience, direct install experience, and feedback from Lighting Certified (LC) individuals through the National Council on Qualifications for the Lighting Professions and from individuals with lighting sales experience.

Sources

1. ENERGY STAR product list. October 13, 2015. Average rated life divided by in-unit hours-of-use (~41,952 / 840 = 49.9 years). Under agreement with the PSC, Cadmus, the Administrator, and Implementers, and per the 2015 EUL review, LED EULs above 20 years are set at 20 years.
2. Incremental cost based on historical project data for similar measure 2984: LED Fixture, Downlights, Accent Lights and Monopoint, ≤ 18 Watts, Common Area.
3. ENERGY STAR product list. from October 13, 2015. Average measured wattage taken from listed products in the Downlight Recessed, Downlight Solid State Retrofit and Downlight Surface Mount fixture types, filtered by wattage limits.
4. Cadmus. Field Study Research of Residential Lighting. October 18, 2013. Results published in the 2014 Focus on Energy Deemed Savings Report: https://focusonenergy.com/sites/default/files/FoE_Deemed_WriteUp%20CY14%20Final.pdf
5. Cadmus. Field Study Research: Residential Lighting. October 25, 2013. Results published in the 2014 Focus on Energy Deemed Savings Report: https://focusonenergy.com/sites/default/files/FoE_Deemed_WriteUp%20CY14%20Final.pdf

Revision History

Version Number	Date	Description of Change
01	10/13/2015	New measure

ENERGY STAR Fluorescent Porch Fixtures

	Measure Details
Measure Master ID	ENERGY STAR Fluorescent Porch Fixtures, 3513
Measure Unit	Per luminaire
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Compact(CFL)
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	54
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	381
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	7[1]
Incremental Cost ($/unit)	$32.00[3]

Measure Description

This measure is an exterior wall or ceiling-mounted ENERGY STAR-certified fluorescent fixture installed in a porch space that was purchased through a retail outlet, either to replace or in lieu of an incandescent fixture. The savings are based on a time-of-sale purchase, for installation in a residential location. This measure is not eligible for peak demand reduction because operation is primarily during off-peak hours.

Description of Baseline Condition

The baseline equipment is an incandescent lamp or luminaire (EISA compliant halogen) fixture. The baseline wattage is determined using the lumens equivalence method in conjunction with the lumen output of the efficient bulb.

Description of Efficient Condition

The efficient measure is an exterior wall or ceiling-mounted ENERGY STAR-certified fluorescent fixture installed in a porch location.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1,000 * HOU$

Where:

$Watts_{BASE}$ = Baseline wattage (= varies by lumen bin; see table below for values)

$Watts_{EE}$ = Efficient wattage (= varies by lumen bin; see table below for values)

1,000 = Kilowatt conversion factor

HOU = Annual hours-of-use (= 1,460)[2]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1,000 * CF$

Where:

CF = Summer coincidence factor (= 0; for this measure, operation will primarily occur during off-peak hours)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 7 years)[1]

Deemed Savings

Deemed Savings by Lumens Bin

Lumen Bin[4]	$Watts_{BASE}$[4]	$Watts_{EE}$[5]	Annual kWh_{SAVED}	$kW_{SAVED, SUMMER PEAK}$	$kWh_{LIEFTIME}$
750-1049	43	13	44	0.0000	308
1050-1489	53	18	51	0.0000	357
1490-2600	72	25	69	0.0000	483
Overall Average	**56**	**19**	**54**	**0.0000**	**381**

Assumptions

A straight baseline lamp average was used to calculate savings, which was deemed appropriate based on a combination of feedback from energy audit experience, Lighting Certified individuals through the National Council on Qualifications for the Lighting Professions, and individuals with lighting sales experience.

Sources

1. ENERGY STAR® Products List. April 15, 2016. Filtered by fluorescent technology and porch fixture type (10,000 / 1,490 = 6.7 years, rounded to 7 years).
2. California Energy Commission. *Impact Analysis: 2005 Update to the California Energy Efficiency Standards for Residential and Nonresidential Buildings.* Table 5 – Annual Hours of Operation for Residential Lighting (average of hours-of-use figures presented for Outdoor – Front Porch and Outdoor – Back Porch, Garage Porch). June 20, 2003. Available online: http://www.regie-energie.qc.ca/audiences/3526-04/DocumentsAudi3526/ASTROLab_3526_Engag-ImpactAnalysis_20mai04.pdf.
3. . *https://www.energystar.gov/products/lighting_fans/light_bulbs*
4. "Energy Independence and Security Act (EISA) of 2007 Efficiency Standards for Light Bulbs." General service incandescent lumen ranges. Last updated 2016. http://www.lightingfacts.com/Library/Content/EISA
5. *ENERGY STAR® average input power pulled from pProducts Llist*. Filtered by fluorescent technology, porch fixture type and lumen bined as of April 15, 2016, filtered by fluorescent technology, Porch fixture type and lumen bin.

Revision History

Version Number	Date	Description of Change
01	10/31/2014	New measure

ENERGY STAR LED Porch Fixtures

	Measure Details
Measure Master ID	ENERGY STAR LED Porch Fixtures, 3157
Measure Unit	LED Porch Luminaire
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	77.0 Existing Building; 58.0 New Construction
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	1,155 Existing Building; 870 New Construction
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Incremental Cost ($/unit)	$10.65[2]

Measure Description

ENERGY STAR-qualified LED porch lights are verified to meet both performance and efficiency thresholds, which ensures that an LED product’s performance is similar to other time-tested technologies used for the same applications and meets ENERGY STAR efficiency criteria.

Description of Baseline Condition

The baseline condition is standard, screw-based incandescent lamps/luminaires.

Description of Efficient Condition

The efficient equipment is an ENERGY STAR-rated LED porch light.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{STANDARD} - kWh_{ES}$

Where:

$kWh_{STANDARD}$ = Annual electricity consumption of standard incandescent porch luminaire

kWh_{ES} = Annual electricity consumption of ENERGY STAR-rated LED porch luminaire

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} / HOURS * CF$

Where:

HOURS = Average annual run hours (= 1,131.5)[3]

CF = Demand coincidence factor (= 0.082)[3]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 20 years)[1]

Deemed Savings

Average Annual Deemed Savings for ENERGY STAR-Rated LED Porch Fixtures

Measure	Existing Building	New Construction
ENERGY STAR-Rated LED Porch Fixtures	77 kWh	58 kWh

Average Lifecycle Deemed Savings for ENERGY STAR-Rated LED Porch Fixtures

Measure	Existing Building	New Construction
ENERGY STAR-Rated LED Porch Fixtures	1,155 kWh	870 kWh

Assumptions

It was assumed the annual operating hours are 1,131.5.[3]

For existing buildings, an average of 33% 60 watt, 33% 75 watt, and 33% 100-watt A-19 halogen and incandescent lamps that meet EISA 2007 as of January 1, 2013 were used to generate the baseline usage.

For new construction, an average of 33% 53 watt, 33% 60 watt, and 33% 72-watt lamps were used to generate the baseline usage.

Sources

1. Cadmus review of manufacturers measure life; capped at 20 years.
2. Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.
3. ACES. *Default Deemed Savings Review Final Report*. June 24, 2008.

Revision History

Version Number	Date	Description of Change
01	12/26/2012	New measure

Parking Garage 4-Foot HPT8 and RWT8 Linear Fluorescent Replacements

	Measure Details
Measure Master ID	T8 1-Lamp 4-Foot, Parking Garage: HPT8, CEE, BF ≤ 0.78, 3163 28 Watt, CEE, BF > 0.78, 3164 28 Watt, CEE, BF ≤ 0.78, 3165 25 Watt, CEE, BF > 0.78, 3166 25 Watt, CEE, BF ≤ 0.78, 3167 T8 2-Lamp 4-Foot, Parking Garage: HPT8, CEE, BF ≤ 0.78, 3168 28 Watt, CEE, BF > 0.78, 3169 28 Watt, CEE, BF ≤ 0.78, 3170 25 Watt, CEE, BF > 0.78, 3171 25 Watt, CEE, BF ≤ 0.78, 3172 T8 3-Lamp 4-Foot, Parking Garage: HPT8, CEE, BF ≤ 0.78, 3173 28 Watt, CEE, BF > 0.78, 3174 28 Watt, CEE, BF ≤ 0.78, 3175 25 Watt, CEE, BF > 0.78, 3176 25 Watt, CEE, BF ≤ 0.78, 3177 T8 4-Lamp 4-Foot, Parking Garage: HPT8, CEE, BF ≤ 0.78, 3178 28 Watt, CEE, BF > 0.78, 3179 28 Watt, CEE, BF ≤ 0.78, 3180 25 Watt, CEE, BF > 0.78, 3181 25 Watt, CEE, BF ≤ 0.78, 3182
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Lighting
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	Varies by measure
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[5]
Incremental Cost ($/unit)	Varies by measure, see Appendix D

Measure Description

High performance and reduced wattage 4-foot linear fluorescent lighting fixtures that use low ballast factors, high wattage lamps, or reduced wattage lamps are an energy-efficient alternative to standard 32-watt linear fluorescent products commonly found in parking garages within multifamily buildings. These products can be installed on a one- for-one basis to replace 1-, 2-, 3-, or 4- lamp T12 or T8 luminaires without sacrificing lighting quality.

Description of Baseline Condition

The baseline condition for existing building parking garages is based on a weighted average of 40% standard T12 fixtures and 60% standard T8 fixtures. The baseline condition for new construction parking garages is based on 100% standard T8 fixtures.

For 1-lamp, 2-lamp, 3-lamp, and 4-lamp fixture in existing and new construction, the average annual energy use/savings baseline is based on 20% high performance with low ballast factor fixtures, 20% reducted wattage with normal ballast factor 28-watt fixtures, 20% reducted wattage with normal ballast factor 25-watt fixtures, 20% reducted wattage with low ballast factor 28-watt fixtures, and 20% reducted wattage with low ballast factor 25-watt T8 lamps.

Description of Efficient Condition

The efficient condition is high performance T8 fixtures with a low ballast factor, or reduced wattage 25-watt and 28-watt T8s with normal and low ballast factors.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{1\text{-}4L\ 4'\ T8} - kWh_{HP/RW}$

Where:

$kWh_{1\text{-}4L\ 4'\ T8}$ = Annual electricity consumption of a 1 to 4 lamp T8 luminaire

$kWh_{HP/RW}$ = Annual electricity consumption of a 4-foot linear fluorescent high performance or low wattage linear fluorescent fixture

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = Wattage / 1,000 * CF$

Where:

Wattage = Wattage of installed fixture

1,000 = Kilowatt conversion factor

CF = Coincidence factor (= 1.0)[3]

Lifecycle Energy-Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[1]

Deemed Savings

Annual Deemed Savings for Parking Garage 4-Foot HPT8 and RWT8 Linear Fluorescents

Measure	MMID	Existing Building		New Construction	
		kWh	kW	kWh	kW
T8 1-Lamp 4-Foot, HPT8, CEE, BF ≤ 0.78, Parking Garage	3163	112	0.0128	53	0.0060
T8 1-Lamp 4-Foot, 28-Watt, CEE, BF > 0.78, Parking Garage	3164	112	0.0128	53	0.0060
T8 1-Lamp 4-Foot, 28-Watt, CEE, BF ≤ 0.78, Parking Garage	3165	138	0.0158	79	0.0090
T8 1-Lamp 4-Foot, 25-Watt, CEE, BF > 0.78, Parking Garage	3166	138	0.0158	79	0.0090
T8 1-Lamp 4-Foot, 25-Watt, CEE, BF ≤ 0.78, Parking Garage	3167	147	0.0168	88	0.0100
T8 2-Lamp 4-Foot, HPT8, CEE, BF ≤ 0.78, Parking Garage	3168	172	0.0196	88	0.0100
T8 2-Lamp 4-Foot, 28-Watt, CEE, BF > 0.78, Parking Garage	3169	163	0.0186	79	0.0090
T8 2-Lamp 4-Foot, 28-Watt, CEE, BF ≤ 0.78, Parking Garage	3170	215	0.0246	131	0.0150
T8 2-Lamp 4-Foot, 25-Watt, CEE, BF > 0.78, Parking Garage	3171	207	0.0236	123	0.0140
T8 2-Lamp 4-Foot, 25-Watt, CEE, BF ≤ 0.78, Parking Garage	3172	259	0.0296	175	0.0200
T8 3-Lamp 4-Foot, HPT8, CEE, BF ≤ 0.78, Parking Garage	3173	277	0.0316	123	0.0140
T8 3-Lamp 4-Foot, 28-Watt, CEE, BF > 0.78, Parking Garage	3174	268	0.0306	114	0.0130
T8 3-Lamp 4-Foot, 28-Watt, CEE, BF ≤ 0.78, Parking Garage	3175	347	0.0396	193	0.0220
T8 3-Lamp 4-Foot, 25-Watt, CEE, BF > 0.78, Parking Garage	3176	338	0.0386	184	0.0210
T8 3-Lamp 4-Foot, 25-Watt, CEE, BF ≤ 0.78, Parking Garage	3177	408	0.0466	254	0.0290
T8 4-Lamp 4-Foot, HPT8, CEE, BF ≤ 0.78, Parking Garage	3178	261	0.0298	149	0.0170
T8 4-Lamp 4-Foot, 28-Watt, CEE, BF > 0.78, Parking Garage	3179	270	0.0308	158	0.0180
T8 4-Lamp 4-Foot, 28-Watt, CEE, BF ≤ 0.78, Parking Garage	3180	366	0.0418	254	0.0290
T8 4-Lamp 4-Foot, 25-Watt, CEE, BF > 0.78, Parking Garage	3181	340	0.0388	228	0.0260
T8 4-Lamp 4-Foot, 25-Watt, CEE, BF ≤ 0.78, Parking Garage	3182	436	0.0498	324	0.0370

Lifecycle Deemed Savings for Parking Garage 4-Foot HPT8 and RWT8 Linear Fluorescents

Measure	MMID	Existing Building (kWh)	New Construction (kW)
T8 1-Lamp 4-Foot, HPT8, CEE, BF ≤ 0.78, Parking Garage	3163	1,680	795
T8 1-Lamp 4-Foot, 28-Watt, CEE, BF > 0.78, Parking Garage	3164	1,680	795
T8 1-Lamp 4-Foot, 28-Watt, CEE, BF ≤ 0.78, Parking Garage	3165	2,070	1,185

Measure	MMID	Existing Building (kWh)	New Construction (kW)
T8 1-Lamp 4-Foot, 25-Watt, CEE, BF > 0.78, Parking Garage	3166	2,070	1,185
T8 1-Lamp 4-Foot, 25-Watt, CEE, BF ≤ 0.78, Parking Garage	3167	2,205	1,320
T8 2-Lamp 4-Foot, HPT8, CEE, BF ≤ 0.78, Parking Garage	3168	2,580	1,320
T8 2-Lamp 4-Foot, 28-Watt, CEE, BF > 0.78, Parking Garage	3169	2,445	1,185
T8 2-Lamp 4-Foot, 28-Watt, CEE, BF ≤ 0.78, Parking Garage	3170	3,225	1,965
T8 2-Lamp 4-Foot, 25-Watt, CEE, BF > 0.78, Parking Garage	3171	3,105	1,845
T8 2-Lamp 4-Foot, 25-Watt, CEE, BF ≤ 0.78, Parking Garage	3172	3,885	2,625
T8 3-Lamp 4-Foot, HPT8, CEE, BF ≤ 0.78, Parking Garage	3173	4,155	1,845
T8 3-Lamp 4-Foot, 28-Watt, CEE, BF > 0.78, Parking Garage	3174	4,020	1,710
T8 3-Lamp 4-Foot, 28-Watt, CEE, BF ≤ 0.78, Parking Garage	3175	5,205	2,895
T8 3-Lamp 4-Foot, 25-Watt, CEE, BF > 0.78, Parking Garage	3176	5,070	2,760
T8 3-Lamp 4-Foot, 25-Watt, CEE, BF ≤ 0.78, Parking Garage	3177	6,120	3,810
T8 4-Lamp 4-Foot, HPT8, CEE, BF ≤ 0.78, Parking Garage	3178	3,915	2,235
T8 4-Lamp 4-Foot, 28-Watt, CEE, BF > 0.78, Parking Garage	3179	4,050	2,370
T8 4-Lamp 4-Foot, 28-Watt, CEE, BF ≤ 0.78, Parking Garage	3180	5,490	3,810
T8 4-Lamp 4-Foot, 25-Watt, CEE, BF > 0.78, Parking Garage	3181	5,100	3,420
T8 4-Lamp 4-Foot, 25-Watt, CEE, BF ≤ 0.78, Parking Garage	3182	6,540	4,860

Assumptions

Measure Costs for Parking Garage 4-Foot HPT8 and RWT8 Linear Fluorescents[2,5]

Measure	MMID	Existing Building Cost	New Construction Incremental Cost
T8 1-Lamp 4-Foot, HPT8, CEE, BF ≤ 0.78, Parking Garage	3163	$38.00	$6.19
T8 1-Lamp 4-Foot, 28-Watt, CEE, BF > 0.78, Parking Garage	3164	$37.00	$6.19
T8 1-Lamp 4-Foot, 28-Watt, CEE, BF ≤ 0.78, Parking Garage	3165	$37.00	$6.19
T8 1-Lamp 4-Foot, 25-Watt, CEE, BF > 0.78, Parking Garage	3166	$37.00	$6.19
T8 1-Lamp 4-Foot, 25-Watt, CEE, BF ≤ 0.78, Parking Garage	3167	$37.00	$6.19
T8 2-Lamp 4-Foot, HPT8, CEE, BF ≤ 0.78, Parking Garage	3168	$41.00	$8.19
T8 2-Lamp 4-Foot, 28-Watt, CEE, BF > 0.78, Parking Garage	3169	$39.00	$8.19
T8 2-Lamp 4-Foot, 28-Watt, CEE, BF ≤ 0.78, Parking Garage	3170	$39.00	$8.19
T8 2-Lamp 4-Foot, 25-Watt, CEE, BF > 0.78, Parking Garage	3171	$39.00	$8.19
T8 2-Lamp 4-Foot, 25-Watt, CEE, BF ≤ 0.78, Parking Garage	3172	$39.00	$8.19
T8 3-Lamp 4-Foot, HPT8, CEE, BF ≤ 0.78, Parking Garage	3173	$62.00	$10.19
T8 3-Lamp 4-Foot, 28-Watt, CEE, BF > 0.78, Parking Garage	3174	$58.00	$10.19

Measure	MMID	Existing Building Cost	New Construction Incremental Cost
T8 3-Lamp 4-Foot, 28-Watt, CEE, BF ≤ 0.78, Parking Garage	3175	$58.00	$10.19
T8 3-Lamp 4-Foot, 25-Watt, CEE, BF > 0.78, Parking Garage	3176	$58.00	$10.19
T8 3-Lamp 4-Foot, 25-Watt, CEE, BF ≤ 0.78, Parking Garage	3177	$58.00	$10.19
T8 4-Lamp 4-Foot, HPT8, CEE, BF ≤ 0.78, Parking Garage	3178	$66.00	$12.19
T8 4-Lamp 4-Foot, 28-Watt, CEE, BF > 0.78, Parking Garage	3179	$60.00	$12.19
T8 4-Lamp 4-Foot, 28-Watt, CEE, BF ≤ 0.78, Parking Garage	3180	$60.00	$12.19
T8 4-Lamp 4-Foot, 25-Watt, CEE, BF > 0.78, Parking Garage	3181	$60.00	$12.19
T8 4-Lamp 4-Foot, 25-Watt, CEE, BF ≤ 0.78, Parking Garage	3182	$60.00	$12.19

Sources

1. Focus on Energy Evaluation Business Programs: Measure Life Study Final Report. August 25, 2009.
2. Michigan Master Measure Database. May 26, 2011.
3. *Focus on Energy Business Programs Deemed Savings Manual V1.0*. Commercial Applications. March 22, 2010.
4. *Focus on Energy ACES Deemed Savings Desk Review.* Multifamily applications for common areas. November 3, 2010.
5. California Energy Commission and California Public Utilities Commission. *Database for Energy Efficient Resources.* 2008. http://www.energy.ca.gov/deer/

Revision History

Version Number	Date	Description of Change
01	01/2016	New measure

Motors and Drives

ECM, Furnace or Air Handler

	Measure Details
Measure Master ID	ECM, Furnace, New or Replacement, 2989
Measure Unit	Per motor
Measure Type	Prescriptive
Measure Group	Motors and Drives
Measure Category	Motor
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	415
Peak Demand Reduction (kW)	0.0792
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	7,470
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	18[1]
Incremental Cost ($/unit)	$97.00[3]

Measure Description

Conventional natural gas furnaces and air handlers contain a PSC blower motor to deliver the treated air to the home. This motor can be replaced with a brushless DC motor, commonly called an ECM, for electrical savings.

Description of Baseline Condition

The baseline is a furnace or air handler with a PSC motor.

Description of Efficient Condition

The efficient condition is an ECM motor replacing a PSC motor in a furnace or air handler.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = \Delta kWh_{COOL} + \Delta kWh_{HEAT} + \Delta kWh_{CIRC}$

$kWh_{COOL} = Tons * EFLH_{COOL} * 12\ kBTU/ton * (1/SEER_{BASE} – 1/SEER_{ECM}) * \%\ AC$

$kWh_{HEAT} = HOURS_{HEAT} * \Delta kW_{HEAT}$

kWh_{CIRC}= $HOURS_{CIRC}$ * ΔkW_{CIRC}

Where:

Tons = Air conditioner capacity in tons (= 2.425)[2]

$EFLH_{COOL}$ = Equivalent full-load cooling hours (= varies by city; see table below)[2]

Equivalent Full-Load Cooling Hours by Location

Location	$EFLH_{COOL}$	Weighting by Participant
Green Bay	344	22%
Lacrosse	323	3%
Madison	395	18%
Milwaukee	457	48%
Wisconsin Average	380	9%
Overall	**410**	

$SEER_{BASE}$ = Baseline SEER (= 12)[2]

$SEER_{ECM}$ = Efficient condition SEER (= 13)[2]

% AC = Amount of furnaces with AC (= 92.5%)[2]

$HOURS_{HEAT}$ = Hours of heating operation (= 1,158)[2]

ΔkW_{HEAT} = Energy savings in heating (= 0.116 kW)[2]

$HOURS_{CIRC}$ = Hours of fan-only operation (= 1,020)[2]

ΔkW_{CIRC} = Energy savings in fan-only (= 0.207 kW)[2]

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = Tons * 12kBtu/ton * (1/EER_{BASE} – 1/EER_{ECM}) * CF * %AC

Where:

EER_{BASE} = Baseline EER (= 10.5)[2]

EER_{ECM} = Efficient condition EER (= 11)[2]

CF = Coincidence factor (= 68%)[2]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE}$ = kWh_{SAVED} * EUL

Where:

EUL = Effective useful life (= 18 years)[1]

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. Focus on Energy, Deemed Savings Report. November 14, 2014.
3. Illinois Statewide Technical Reference Manual for Energy Efficiency, Version 5.0, Volume 3 (2015). Page 89. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_5/Final/IL-TRM_Effective_060116_v5.0_Vol_3_Res_021116_Final.pdf

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

Air Source Heat Pump, ≥ 16 SEER

	Measure Details
Measure Master ID	Air Source Heat Pump, ≥ 16 SEER, 2992
Measure Unit	Per heat pump
Measure Type	Prescriptive
Measure Group	HVAC
Measure Category	Other
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	933
Peak Demand Reduction (kW)	0.2823
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	16,794
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	18[1]
Incremental Cost ($/unit)	$849.40[2]

Measure Description

A residential-sized air-source heat pump has an input capacity of ≤ 65,000 Btu/hour. The deemed measure algorithms and associated savings for the air-source heat pump were derived from the use of the Illinois Statewide Technical Reference Manual – Section 5.3.1 Air Source Heat Pumps.[2]

Description of Baseline Condition

The baseline measure is a federal standard baseline air-source heat pump of SEER 13 and HSPF 7.7.[2]

Description of Efficient Condition

The efficient measure is a residential-sized air-source heat pump of SEER 16 and HSPF 8.4.[2]

Annual Energy-Savings Algorithm

$$kWh_{SAVED} = ((EFLH_{COOL} * CAP * (1/SEER_{BASE} – 1/SEER_{EE}))/ 1,000) + ((EFLH_{HEAT} * CAP * (1 / HPSF_{BASE} – 1 / HSPF_{EE})) / 1,000)$$

Where:

$EFLH_{COOL}$ = Equivalent full-load cooling hours (= 321)

CAP = Capacity (= 37,000 Btu/hour)

$SEER_{BASE}$ = Baseline seasonal energy efficiency ratio (= 13)

$SEER_{EE}$ = Efficient measure seasonal energy efficiency ratio (= 16)

1,000 = Kilowatt conversion factor

$EFLH_{HEAT}$ = Equivalent full-load heating hours (= 1,909)[3]

$HSPF_{BASE}$ = Baseline heating seasonal performance factor (= 7.7)

$HSPF_{EE}$ = Efficient measure heating seasonal performance factor (= 8.4)

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (CAP * (1/ EER_{BASE} – 1 / EER_{EE})) / 1{,}000 * CF$

Where:

EER_{BASE} = Baseline energy efficiency ratio (= 11.2)[2]

EER_{EE} = Efficient energy efficiency ratio (= 12.8)[2]

CF = Coincidence factor (= 0.68)[4]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (=18 years)[1]

Assumptions

Measure characteristics assume an all-electric heated and cooled home.

The capacity of residential heat pumps is assumed to be 3.1 tons for equipment installed in the Wisconsin market, based on analysis of 75 air-source heat pumps installed between 2013 and 2015 through the Focus on Energy Residential Prescriptive Program. At 12,000 Btu/hour per ton, the assumed average capacity is 37,200 Btu/hr.

Supporting inputs for heating load hours in several Wisconsin cities are shown in the table below.

Equivalent Full-Load Heating Hours by Location

Location	$EFLH_{HEAT}$[3]
Green Bay	1,852
La Crosse	1,966
Madison	1,934
Milwaukee	1,883
Wisconsin Average	**1,909**

Incremental cost is based on the Illinois TRM reported IMC of $411/ton, multiplied by an installed capacity of 3.1 tons.

Cooling hours are based on the cooling hours for an air conditioner in the Deemed Savings Report[4] adjusted for the larger capacity system (410 hours at 2.425 tons is equivalent to 284 hours at 3.5 tons).

Sources

1. 2007 GDS study for New England working group: http://www.iar.unicamp.br/lab/luz/ld/Arquitetural/interiores/ilumina%E7%E3o%20industrial/measure_life_GDS.pdf
2. Illinois Statewide Technical Reference Manual for Energy Efficiency, Version 5.0, Volume 3 (2015). Page 59. $274.00 per ton for a time-of-sale 16 SEER ASHP. The Program assumes a value of 3.1 tons (37,000 MBh), as such $274.00 per ton produces an IMC of $849.40. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_5/Final/IL-TRM_Effective_060116_v5.0_Vol_3_Res_021116_Final.pdf
3. Several Cadmus metering studies reveal that the ENERGY STAR calculator EFLH are over-estimated by 25%. The EFLHHEAT were adjusted by population-weighted HDD and TMY-3 values.
4. Focus on Energy, Deemed Savings Report. November 14, 2014.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry
02	01/2015	Updated EFLH

Other

Multifamily Benchmarking Incentive

	Measure Details
Measure Master ID	Multifamily Benchmarking Incentive, 2746
Measure Unit	Per application
Measure Type	Custom
Measure Group	Other
Measure Category	Other
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by project
Peak Demand Reduction (kW)	Varies by project
Annual Therm Savings (Therms)	Varies by project
Lifecycle Energy Savings (kWh)	Varies by project
Lifecycle Therm Savings (Therms)	Varies by project
Water Savings (gal/yr)	0
Effective Useful Life (years)	Varies by project
Incremental Cost ($/unit)	$0.00 (no cost in addition to initial project cost)

Measure Description

This measure is benchmark tracking incentives, which are progressive, require 12 months of pre-project utility usage, 12 months of post-project completion usage for tracking participation, and are awarded for projects that exceed projected energy savings. The incentive amount is based on the levels of energy savings and peak demand reduction. Owners may sign up for benchmarking at Tier 1 and Tier 2 incentive levels when submitting a custom application, but Tier 3 benchmarking is mandatory to validate these savings because the most savings and financial risk is associated with Tier 3:

- Tier 1 Benchmarking (initial project savings < 15%): $0.40/therm, $0.03/kWh, and $50/peak kW
- Tier 2 Benchmarking (initial project savings > 15%): $0.63/therm, $0.04/kWh, and $75/peak kW
- Tier 3 Benchmarking (initial project savings > 20%): $0.75/therm, $0.05/kWh, and $100/peak kW

This incentive is provided one time and is not available for multiple years of benchmarking. Original project savings estimates tend to be conservative for calculations and assumptions. To verify that the savings are accurate and conservative, benchmarking can include accounting for any shortfalls in the estimates and tracking the accuracy of the calculations.

By offering benchmarking for all tier levels, customers are validated and rewarded for any savings difference between expected and actual. This accounts for any conservative calculation tendencies and rewards savings from measures that could not be offered as prescriptive or custom.

Description of Baseline Condition

The baseline condition varies based on the building use of electricity and/or natural gas as calculated in the original analysis for the measures installed. This baseline is the actual utility usage, minus the calculated savings for the original efficiency project. A dual baseline may be used to calculate lifecycle savings for equipment that is nearing the end of its useful life or is impacted by EISA lighting phase-outs.

Description of Efficient Condition

The efficient condition varies based on equipment installed and equipment performance once installed in reducing electric and/ or natural gas use beyond the original analysis for the measures indicated. All active kWh- and therm-saving program measures are eligible for benchmarking.

Annual Energy-Savings Algorithm

$Therm_{SAVED}$ = Benchmark Therm Savings - Initial Project Savings Estimates

kWh_{SAVED} = Benchmark kWh Savings - Initial Project Savings Estimates

kW_{SAVED} = Benchmark kW Savings - Initial Project Savings Estimates

Therm Savings

$Therm_{SAVED}$ = Annual $Therm_{PRE}$ - Annual $Therm_{POST}$

Annual $Therm_{PRE}$ = Sum $Therms_{PRE}$ calculation for all 12 months (Jan + Feb + Mar +…+ Dec)

$Therm_{PRE}$ = (Total Building Monthly Consumption - Building Baseline Monthly Consumption) / (Actual Monthly HDDs) * (Average Historical Monthly HDDs + Building Baseline Monthly Consumption)

Annual $Therm_{POST}$ = Sum $Therms_{POST}$ calculation for all 12 months (Jan + Feb + Mar +…+ Dec)

$Therm_{POST}$ = (Total Building Monthly Consumption - Building Baseline Monthly Consumption) / Actual Monthly HDDs * Average Historical Monthly HDDs + Building Baseline Monthly Consumption

Where:

Annual $Therm_{PRE}$ = Total yearly weather-normalized therm consumption before efficiency upgrades

Annual $Therm_{POST}$ = Total yearly weather-normalized therm consumption after efficiency upgrades

$Therm_{PRE}$ = Total monthly weather-normalized therm consumption before efficiency upgrades

Total Building Monthly Consumption = Therm consumption from utility history

Building Baseline Monthly Consumption = Minimum therm consumption of June, July, or August

Actual Monthly HDDs = Heating degree days from nearest weather station for actual utility month[1]

Average Historical Monthly HDDs = From NOAA 30 year average data[2]

$Therm_{POST}$ = Total monthly weather-normalized therm consumption after efficiency upgrades

kWh Savings

kWh_{SAVED} = Annual kWh_{PRE} - Annual kWh_{POST}

Annual kWh_{PRE} = Sum kWh_{PRE} calculation for all 12 months (Jan + Feb + Mar +…+ Dec)

kWh_{PRE} = (Total Building Monthly Consumption - Building Baseline Monthly Consumption) / Actual Monthly CDDs * Average Historical Monthly CDDs + Building Baseline Monthly Consumption

Annual kWh_{POST} = Sum kWh_{POST} calculation for all 12 months (Jan + Feb + Mar +…+ Dec)

kWh_{POST} = (Total Building Monthly Consumption - Building Baseline Monthly Consumption) / Actual Monthly CDDs * Average Historical Monthly CDDs + Building Baseline Monthly Consumption

Where:

Annual kWh_{PRE} = Total yearly weather-normalized kWh consumption before efficiency upgrades

Annual kWh_{POST} = Total yearly weather-normalized kWh consumption after efficiency upgrades

kWh_{PRE} = Total monthly weather-normalized kWh consumption before efficiency upgrades

Total Building Monthly Consumption = kWh consumption from utility history

Building Baseline Monthly Consumption = Minimum kWh consumption of all 12 months

Actual Monthly CDDs = Cooling degree days from nearest weather station for actual utility month[1]

Average Historical Monthly CDDs = From NOAA 30 year average data[2]

kWh_{POST} = Total monthly weather-normalized kWh consumption after efficiency upgrades

kW Savings

kW_{SAVED} = Annual kW_{PRE} - Annual kW_{POST}

Where:

Annual kW_{PRE} = Highest kW usage from 12 month utility history before efficiency upgrades

Annual kW_{POST} = Highest kW usage from 12 month utility history after efficiency upgrades

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = Annual kW_{PRE} - Annual kW_{POST}

Where:

Annual kW_{PRE} = Highest kW usage from 12 month utility history before efficiency upgrades

Annual kW_{POST} = Highest kW usage from 12 month utility history after efficiency upgrades

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = EUL * kWh_{SAVED}$

$Therm_{LIFECYCLE} = EUL * Therm_{SAVED}$

Where:

EUL = Weighted effective useful life of the original measures

Lifecycle savings account for the impacts of EISA for affected lighting technologies. A dual baseline lifecycle savings will be used for equipment that is nearing the end of its useful life.

Dual Baseline EUL Example: Boiler EUL deemed at 20 years

- Existing boiler being replaced is 13 years and has an efficiency of 70%.
- New boiler has an efficiency of 92.5%.
- A code baseline boiler has an efficiency of 80%.
- $Therm_{SAVED}$ = Existing (70%) vs. New (92.5%) = 10,000 therms
- $Therm_{SAVED}$ = Code (80%) vs. New (92.5%) = 4,500 therms
- $Therm_{LIFECYCLE} = (4,500 * 13) + (10,000 * 7) = 128,500$ therms

Deemed Savings

The annual and lifecycle savings are calculated on a per-project basis from weather-normalized data.

Lifecycle savings are based on the original measure life or the weighted average of multiple measures.

Assumptions

Projects are only rewarded benchmarking incentives if they exceed initial savings estimates.

If additional efficiency measures or building alterations occur during any part of the benchmarking and data collection time period, that additional energy use or savings will be added or subtracted from the total consumption before weather normalization.

Benchmarking utility data will be collected for the 12 months closest to the project start and 12 months closest to project completion, but will not include the implementation and construction months.

If a customer enrolls in the benchmarking and provide the utility data needed to quantify project savings as well as additional savings after one year, the program claims the additional electricity or natural gas and rewards the customer at a discounted incentive rate of 50%. The building was benchmarked prior to work beginning, an application was submitted for the initial project, and it is possible to know when to start the utility tracking for post install benchmarking.

The minimum energy consumptions for calculating baseline monthly consumption is the lowest consumption value for the time period. This lowest value will not consist of any weather-dependent consumption for natural gas during peak summer months, or weather-dependent electric usage during the winter heating season.

Since this is a custom measure, engineers can and will account for other conditions at their discretion; however, most of the measures are weather dependent or run hour dependent and were included in this workpaper. Other adjustments include, but are not limited to, change of occupancy, equipment failures, and implementing other energy efficiency measures beyond the original scope.

Sources

1. State of Wisconsin Department of Administration. “Heating, Cooling and Growing Degree Days.” http://www.doa.state.wi.us/degreedays/
2. National Oceanographic and Atmospheric Administration, National Climatic Data Center. “Heating and Cooling Degree Day Data.” Wisconsin state-level data. http://www.ncdc.noaa.gov/oa/documentlibrary/hcs/hcs.html

Revision History

Version Number	Date	Description of Change
01	11/01/2013	New measure

Renewable Energy

Ground Source Heat Pump, Residential, Natural Gas and Electric Backup

	Measure Details
Measure Master ID	Ground Source Heat Pump: Electric Back-Up, 2820 Natural Gas Back-Up, 2821
Measure Unit	Per heat pump
Measure Type	Prescriptive
Measure Group	Renewable Energy
Measure Category	Geothermal
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	3,999
Peak Demand Reduction (kW)	0.9286
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	71,982
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	18[1]
Incremental Cost ($/unit)	Actual Program Data in Current Year[8]

Measure Description

This measure is installing residential-sized geothermal (ground source) heat pump systems in residential applications. Geothermal heat pump systems use the earth as a source of heating and cooling by installing an exterior underground loop that works in combination with an interior heat pump unit. The measure provides sites with a centralized heating and cooling system, similar to that of a standard air-source heat pump.

Description of Baseline Condition

The baseline is a 13 SEER air-source heat pump. For estimating therm savings, the calculated results are converted to Btus.

Description of Efficient Condition

A qualifying product must meet a minimum of 15 EER in a closed-loop application, but Focus on Energy will accept program applications for open or closed loop systems. Additionally, the procedures followed to install the equipment must conform to the ACCA Standard 5 Quality Installation requirements.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (EFLH_{COOL} * Btu/h_{COOL} * (1/SEER_{BASE} – 1/(EER_{EE} * 1.02)))/1{,}000 + (EFLH_{HEAT} * Btu/h_{HEAT} * (1/HSPF_{BASE} – 1/(COP_{EE} * 3.412))) / 1{,}000$

Where:

$EFLH_{COOL}$ = Equivalent full-load cooling hours (= 410)[2]

Btu/h_{COOL} = Cooling capacity of equipment (= 40,089 Btu/hour)[3]

$SEER_{BASE}$ = Seasonal energy efficiency ratio of baseline equipment (= 13)[4]

EER_{EE} = Energy efficiency ratio of efficient equipment (= 22.43 kBtu/kWh)[3]

1.02 = Factor to determine SEER based on its EER

1,000 = Kilowatt conversion factor

$EFLH_{HEAT}$ = Equivalent full-load heating hours (= 1,890)[2]

Btu/h_{HEAT} = Heating capacity of the equipment (= 30,579 Btu/hour)[3]

$HSPF_{BASE}$ = Heating seasonal performance factor of baseline equipment (= 7.7 kBtu/kWh)[4]

COP_{EE} = Coefficient of performance (= 4.18)[3]

3.412 = Conversion from Watt to Btu

Summer Coincident Peak Savings Algorithm

The summer coincident peak is defined as the period from 1:00 p.m. to 4:00 p.m. during weekdays from June through August. Using the supplied Wisconsin calculator, the demand reduction was calculated with the following algorithms and methodology:

$kW_{SAVED} = (Btu/h_{COOL} * (1/EER_{BASE} – 1/EER_{EE})) / 1{,}000 * CF$

Where:

EER_{BASE} = Energy efficiency ratio of baseline equipment (= 11)[4]

CF = Coincidence factor (= 0.5)[6]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 18 years)[1]

Assumptions

This system life expectancy is generally constrained by the heat pump exchanger and compressor equipment. The actual ground loop installation itself often has a much longer life expectancy.

Supporting inputs for load hours in several Wisconsin cities are shown in the table below.[2]

Equivalent Full-Load Cooling and Heating Hours by City[7]

Location	$EFLH_{COOL}$	$EFLH_{HEAT}$
Green Bay	344	1,852
La Crosse	323	1,966
Madison	395	1,934
Milwaukee	457	1,883
Wisconsin Average	380	1,909
Weighted Average	**410**	**1,890**

Sources

1. 2012 Illinois TRM. http://www.ilsag.info/technical-reference-manual.html .
2. Several Cadmus metering studies reveal that the ENERGY STAR calculator EFLHs are over-estimated by 30% for cooling, and by 25% for heat pump heating hours. The heating and cooling EFLH values used are adjusted by population-weighted CDD and HDD TMY-3 values.
3. Tracking data model look-ups of AHRI certifications.
4. Federal standard.
5. Proposed update to 2011 Pennsylvania TRM.
6. Energy Center of Wisconsin. *Update of Geothermal Analysis*. Pgs. 19-21. August 31, 2009. Available online: http://www.ecw.org/sites/default/files/249-1.pdf.
7. Several Cadmus metering studies reveal that the ENERGY STAR calculator EFLH are over-estimated by 25%. The $EFLH_{HEAT}$ were adjusted by population-weighted HDD and TMY-3 values.
8. Actual Program Data in Current Year

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry
02	01/2015	Updated EFLH

Solar Photovoltaic

	Measure Details
Measure Master ID	Solar PV, 2819
Measure Unit	Per kWDC installed
Measure Type	Hybrid
Measure Group	Renewable Energy
Measure Category	Photovoltaics
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	1,121
Peak Demand Reduction (kW)	0.450
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	28,025
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	25[1]
Incremental Cost ($/unit)	Actual cost to be provided annually[4]

Measure Description

PV systems generate DC electric current through the photovoltaic effect when exposed to light. The DC power in one or more series of PV modules, called strings, is converted to AC power by an inverter. Inverters can either be classified as string inverters, which are centrally located and combine the output of multiple modules or strings of modules, or can be classified as microinverters, which are installed at the module and convert each module's DC output to AC individually.

AC modules are growing in popularity. They provide AC output without the need for external inverters. Once the output of the PV system is converted into AC current compatible with the local utility grid, the system is interconnected to the residence wiring system.

The total system output is affected by the tilt and azimuth of the modules, module temperature, inverter efficiency, and shading factors. Ideal systems are designed to face south, have minimal shading, have a tilt close to the local latitude, and are installed in a safe area. The most common application is fixed-mounted panels on a south-facing rooftop, but other configurations can include ground mounted or pole mounted arrays, and can be in fixed, manual, or automatic sun tracking configurations.

The average installed capacity of residential PV systems in Wisconsin is 4.4 kWDC.[2]

Description of Baseline Condition

The baseline for this measure is having no PV system installed at the home.

Description of Efficient Condition

PV arrays are designed to be installed within 45 degrees of due south in a safe area, and where there is 10% or less shading they can have a tilt between 10-50 degrees of the local latitude. A central inverter is typically installed in a basement or garage. In some cases, microinverters are used for one or two PV modules, which convert DC to AC power.

Annual Energy-Savings Algorithm

The energy savings for residential PV systems can be calculated using PVWatts, a free online tool developed by NREL. This tool uses TMY2 solar radiation data, combined with user-entered capacity, array type, tilt, azimuth, and derate factor, to calculate hourly AC energy output and annual energy output. The table below summarizes the expected savings per kWDC installed by location. Note that these general calculations do not reflect the actual conditions at any site, but are a general representation of typical PV systems installed in Wisconsin.

System Derate Factor = DerateFactor * (1 - ShadeFactor) * (1 - SnowFactor)

Where:

DerateFactor = Amount of power lost in DC to AC conversion (= 0.80)[3]

ShadeFactor = Percentage of time system is shaded (= 10 per program rules)

SnowFactor = Percentage of time system in covered in snow (= 2 for 34° tilt)[3]

Installed Capacity by City

Reference City	Reference ZIP Code	AC kWh/kWDC Installed Capacity
Milwaukee	53220	1,128
Madison	53706	1,130
Green Bay	54302	1,106
Average		**1,121**

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = Peak Period kWh Product / Peak Period Hours

Peak Hours by City

Reference City	Reference ZIP Code	Peak Hours AC kWh (June, July, August)	kW
Milwaukee	53220	87	0.447
Madison	53706	92	0.469
Green Bay	54302	85	0.434
Average		**88**	**0.450**

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 25 years)[1]

Assumptions

Throughout this document, kWDC is used to refer to the nameplate installed capacity of solar at STCs of 25C and 1,000 W/m2 irradiance.

Generation estimates were made in accordance with PV system guidelines[3] or, when available, are Residential Rewards Program-specific data:

- Array azimuth of 183°
- Derate factor of 0.80
- Fixed array (i.e., non-tracking)
- Array tilt of 34°

All results are normalized to installed kWDC capacity and can be scaled to actual installed capacity on a one-to-one basis (e.g., a 2 kW system will produce twice the output and peak demand reduction of a 1 kW system).

Sources

1. National Renewable Energy Laboratory. *System Useful Life*. Available online: http://www.nrel.gov/analysis/tech_footprint.html
2. *Focus on Energy 2012 Evaluation Report: Volume II*. August 28, 2013. Analysis of 2012 Residential Rewards Program data for 79 funded PV systems. https://focusonenergy.com/sites/default/files/FOC_XC_CY%2012%20Report%20Volume%20II%20Final_08-28-2013.pdf
3. Tetra Tech. *State of Wisconsin Public Service Commission Focus on Energy Evaluation: Standard Calculation Recommendations for Renewable Energy Systems.* January 18, 2011. Available online: https://focusonenergy.com/sites/default/files/standardcalculationrecommendationsCY10_evaluationreport.pdf
4. Actual cost to be provided annually

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Appendix A: List of Acronyms

AC	Alternating current
	Air conditioning
AFUE	Annual Fuel Utilization Efficiency
ACH	Air changes per hour
Btu	British thermal units
CDD	Cooling degree day
CEE	Consortium for Energy Efficiency
CFL	Compact fluorescent light bulb
CMH	Ceramic metal halide
COP	Coefficient of performance
DC	Direct current
DDC	Direct digital control
DHW	Domestic hot water
DLC	Design Lights Consortium
DOE	U.S. Department of Energy
EBTU	Express Building Tune Up
ECM	Electronically commutated motor
EER	Energy efficiency ratio
EF	Energy factor
EFLH	Equivalent full-load hours
EISA	Energy Independence and Security Act
EM&V	Evaluation, measurement, and verification
ERV	Energy recovery ventilator
ETL	Intertek's ETL Mark
EUL	Effective useful life
FSTC	Food Service Technology Center
HDD	Heating degree day
HESCC	High-efficiency sealed combustion condensing
HESCCM	High-efficiency sealed combustion condensing modulating
HID	High-intensity discharge
HO	High output
HOU	Hours-of-use
HP	High performance
HSPF	Heating Season Performance Factor
IECC	International Energy Conservation Code
IPLV	Integrated part load volume
ISR	In-service rate

kWDC	Direct current kilowatts
LED	Light-emitting diode
NAIMA	North American Insulation Manufacturers Association
NPS	Nominal Pipe Size
NREL	National Renewable Energy Laboratory
NRTL	Nationally Recognized Testing Laboratory
OAT	Outside Air Temperature
PIR	Passive infrared
PSC	Public Service Commission of Wisconsin
	Permanent split capacitor
PSMH	Pulse-start metal halide
PTAC	Packaged terminal air conditioner
PTHP	Packaged terminal heat pump
PV	Photovoltaic
QPL	Qualified Product List
RCA	Refrigerant charge and airflow
RFP	Request for proposals
RH	Relative humidity
RTU	Rooftop unit
RW	Reduced wattage
SAM	System Advisor Model
SEER	Seasonal energy efficiency ratio
SP	Shaded pole
STC	Standard test conditions
SWH	Solar water heating
TE	Thermal efficiency
TMY	Typical meteorological year
TRC	Total Resource Cost
TRM	Technical Reference Manual
UL	Underwriters Laboratories
VAV	Variable air volume
VFD	Variable frequency drive
VHO	Very high output
VSD	Variable speed drive

Appendix B: Common Variables

Hours-of-Use

Compressed Air

HOU = Average annual run hours (= 5,083)[3]

Commercial/Industrial Lighting

Commercial/Industrial Lighting HOU by Sector

Sector	HOU
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239

Source: State of Wisconsin Public Service Commission. *Business Programs Deemed Savings Manual V1.0*. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.

Multifamily Lighting (Daily HOU for In-Unit Room estimates)

HOU = Average annual run hours (= 5,950 for multifamily common areas)[4]

Multifamily Lighting Hours-of-Use by Room Type

Room Type	HOU
Bathroom	2.26
Bedroom	1.32
Dining	2.34
Kitchen	2.92
Living Room	2.67
Other (Hall and Office)	0.51

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[3] United States Department of Energy Office of Energy Efficiency & Renewable Energy. *United States Industrial Electric Motor Systems Market Opportunities Assessment*. Pg 42. December 2002.

[4] ACES. *Focus on Energy Deemed Savings Desk Review: Multifamily Applications for Common Areas.* November 3, 2010.

Single Family Residential Lighting (Daily HOU)

Single Family Lighting Hours-of-Use by Room Type

Room Type	HOU
Bathroom	1.00
Bedroom	1.62
Dining	3.18
Kitchen	0.65
Living Room	2.17
Other	0.66
Average Daily Use	2.77

Source: Cadmus. *Focus on Energy Residential Single Family Lighting Hours of Use and Peak Coincidence Factor Findings Memo*. July 2, 2014.

Retail Lighting

Because retail lighting incentives are covered through retail price markdowns at the store level, the program does not collect participant-specific data for where purchased bulbs will be installed. General figures are calculated using the following weighting assumptions:

- Single Family Weighting, 74.7%[5]
- Multifamily Weighting, 25.3%[6]
- Single Family HOU, 2.27 hours per day[7]
- Multifamily HOU, 2.01 hours per day[8]
- Residential Weighting 93%[9]
- Commercial Weighting 7%[10]
- Residential HOU Average, 2.20

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[5] U.S. Census Bureau. Percentage of Wisconsin housing stock that is single family. 2013 Estimates.

[6] U.S. Census Bureau. Percentage of Wisconsin housing stock that is multifamily. 2013 Estimates.

[7] Cadmus. Single family light logger study, 2013.

[8] Cadmus. Multifamily light logger study. 2013.

[9] Cadmus. In-store intercept surveys. 2012.

[10] Ibid.

- Commercial HOU Average, 10.2[11]
- Single Family Coincidence Factor 7.5%[12]
- Multifamily Coincidence Factor 5.5%[13]
- Residential, Averaged, Coincidence Factor 6.99%
- Commercial Coincidence Factor 77%[14]

Average annual HOU based on weighting metrics outlined above = 1,011

Coincidence factor based on weighting metrics outline above = 0.1189

Coincidence Factors

Commercial/Industrial/Multifamily Lighting Coincidence Factors

Sector	CF
Commercial*	0.77
Industrial	0.77
Schools & Government	0.64
Agriculture	0.67
Multifamily Common Area	0.77
In-Residence**	0.055

* *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.
** Cadmus. Field Study: Residential Lighting. October 18, 2013. (Report based on using CFL bulbs to replace incandescent bulbs. Since LEDs will initially be treated the same as CFLs, those values were used.)

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[11] *Wisconsin Business Deemed Savings*. 2010.

[12] U.S. Census Bureau. Percentage of Wisconsin housing stock that is single family. 2013 Estimates.

[13] U.S. Census Bureau. Percentage of Wisconsin housing stock that is multifamily. 2013 Estimates.

[14] Focus on Energy Business Programs Deemed Savings Manual V1.0. Lighting in Commercial Applications. March 22, 2010.

Multifamily Residential Lighting Coincidence Factors*

Exposure Type	Percentage of Lamps	Coincidence Factor	Lower 90% CI	Upper 90% CI
Exposed	41%	2.08%	1.26%	2.90%
Non-Exposed	59%	7.82%	7.58%	8.07%
Overall	**100%**	**5.47%**	**5.11%**	**5.84%**

* Cadmus. *Focus on Energy Residential Multifamily Lighting Hours of Use and Peak Coincidence Factor Findings Memo*. June 30, 2014.

Single Family Residential Lighting*

Room Type	Wisconsin CFL Distribution	Mean Peak CF	Average Time On During Peak (minutes)
Bathroom	15.4%	10.8%	19.5
Bedroom	17.8%	6.8%	12.2
Kitchen	10.0%	8.8%	15.9
Living Room/Family Room	19.9%	10.0%	18.0
Other	36.9%	4.7%	8.5
Weighted Mean CF		**7.5%**	**13.5**

* Cadmus. *Focus on Energy Residential Single Family Lighting Hours of Use and Peak Coincidence Factor Findings Memo*. July 2, 2014.

Phased-In EISA 2007 Standards

Phase-in of these standards occurred in savings calculations as new requirements became effective. From 2015 forward, all baselines have been adjusted to meet these standards.

EISA Requirements and Effective Dates by Lumen Output

Lumen Output	Typical Wattage: Current Incandescent Technology	EISA Requirements		
		Maximum Wattage	Minimum Lifecycle (hours)	Effective Date
1,490-2,600	100	72	1,000	1/1/2012
1,050-1,489	75	53	1,000	1/1/2013
750-1,049	60	43	1,000	1/1/2014
310-749	40	29	1,000	1/1/2014

Equivalent Full-Load Hours

Residential Natural Gas Measures

EFLH = 1,759 hours[15]

Residential Heat Pumps and Split HVAC

Equivalent Full-Load Hours for Air Sealing, Air-Source Heat Pumps, Ground-Source Heat Pumps, and Split A/C System.

Location	$EFLH_{COOL}$	$EFLH_{HEAT}$
Green Bay	344	1,852
La Crosse	323	1,966
Madison	395	1,934
Milwaukee	457	1,883
Wisconsin Average	**380**	**1,909**

* Full load hours calculated using an average from Illinois Statewide Technical Reference Manual, applied to Wisconsin CDDs.

Flow Rates

Faucet Aerators

$GPM_{EXISTING}$ = Baseline flow rate (= 2.2 GPM)[16]

Low-Flow Showerheads

$GPM_{EXISTING}$ = Baseline flow rate (= 2.5 GPM)[17]

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[15] 800 therms consumed by 90% AFUE furnaces (i.e., 720 therms output) for all residential natural gas measures estimate from: Pigg and Nevius. *Electricity Use by New Furnaces.* 2000. Available online: http://www.ecw.org/sites/d3efault/files/230-1.pdf. Using average furnace size of 72,000 Btu (from 2012 SPECTRUM database of 13,000 furnaces), 1,000 full-load heating hours are estimated.

[16] Federal minimum at 80 psi.

[17] Federal minimum at 80 psi.

Temperature (Water)

Water Heaters, Faucet Aerators, and Low-Flow Showerheads

T_{WH} = Water heater temperature setpoint (= 125°F)[18]

$T_{ENTERING}$ = Temperature of water entering water heater (= 52.3°F)[19]

Faucet Aerators (Kitchen)

$T_{POINT\ OF\ USE}$ = Temperature of water at point of use (= 91°F)[20]

Faucet Aerators (Bathroom)

$T_{POINT\ OF\ USE}$ = Temperature of water at point of use (= 86°F)[18]

Low-Flow Showerheads

$T_{POINT\ OF\ USE}$ = Temperature of water at point of use (= 101°F)[18]

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[18] The water heater set point is assumed to be 125°F, as Wisconsin building code 704.06 requires landlords to set water heaters to 125°F: https://docs.legis.wisconsin.gov/statutes/statutes/704/06. Water heater setpoints typically range between 120°F and 140°F because temperatures below 120°F are susceptible to Legionella bacteria (which lead to Legionnaires Disease) and heaters set to temperatures above 140°F can quickly scald users: http://www.nrel.gov/docs/fy12osti/55074.pdf. Most TRMs assume water heater set points of 120°F, 125°F, or 130°F, though most of these are unsourced engineering assumptions. (Residential water heater setpoints include: Connecticut 2012 TRM PSD: 130°F for natural gas DWH and 125°F for tank wrap, HPWH, and temperature reduction; Mid- Atlantic TRM v3.0: 130°F for tank wrap and pipe insulation; Illinois TRM v2.0: 125°F for pipe insulation, natural gas water heater, HPWH, and tank wrap and 120°F for temperature reduction; and Indiana TRM v1.0: 130°F for pipe insulation.)

[19] U.S. Department of Energy. *Domestic Hot Water Scheduler.* Average water main temperature of all locations measured in Wisconsin by scheduler, weighted by city populations.

[20] Calculated from TMY3 weather files of the seven Wisconsin locations using *ASHRAE Estimation of Degree-Days: Fundamentals*, Chapter 14. Statewide weighted values calculated using 2010 US Census data for Wisconsin.

Outside Air Temperature Bin Analysis

Bin Analysis

Bin	Max of Bin	Midpoint	GREEN BAY	LA CROSSE	MADISON	MILWAUKEE	MINOCQUA	RICE LAKE	WAUSAU	Average Hours for WI	Note
95 to 100	100	97.5	0	2	0	3	0	0	0	1	
90 to 95	95	92.5	22	51	25	18	22	4	29	24	
85 to 90	90	87.5	62	121	86	59	36	22	91	68	
80 to 85	85	82.5	275	355	339	225	222	213	335	281	
75 to 80	80	77.5	398	445	486	400	397	398	532	437	
70 to 75	75	72.5	445	489	447	497	413	508	420	460	
65 to 70	70	67.5	675	762	723	692	555	693	666	681	
60 to 65	65	62.5	871	746	770	936	852	810	699	812	
55 to 60	60	57.5	647	583	605	545	680	673	502	605	
50 to 55	55	52.5	420	510	470	547	557	541	423	495	Boiler enabled
45 to 50	50	47.5	527	549	618	603	515	557	586	565	Boiler enabled
40 to 45	45	42.5	579	597	510	723	554	477	718	594	Boiler enabled
35 to 40	40	37.5	777	826	905	883	589	632	619	747	Boiler enabled
30 to 35	35	32.5	820	719	741	720	669	675	792	734	Boiler enabled
25 to 29	30	27.5	507	425	396	423	424	366	539	440	Boiler enabled
20 to 25	25	22.5	579	457	439	531	506	365	551	490	Boiler enabled
15 to 20	20	17.5	443	319	353	390	478	420	406	401	Boiler enabled
10 to 15	15	12.5	265	227	212	228	475	367	252	289	Boiler enabled
5 to 10	10	7.5	157	174	117	97	315	296	247	200	Boiler enabled
0 to 5	5	2.5	111	144	152	116	203	286	138	164	Boiler enabled
-5 to 0	0	-2.5	81	106	157	61	136	182	115	120	Boiler enabled
-10 to -5	-5	-7.5	83	109	105	57	90	177	84	101	Boiler enabled
-15 to -10	-10	-12.5	9	23	70	6	40	69	16	33	Boiler enabled
-20 to -15	-15	-17.5	7	9	21	0	24	24	0	12	Boiler enabled
-25 to -20	-20	-22.5	0	6	9	0	8	5	0	4	Boiler enabled
-30 to -25	-25	-27.5	0	6	4	0	0	0	0	1	Boiler enabled
-35 to -30	-30	-32.5	0	0	0	0	0	0	0	0	Boiler enabled
			5365	5206	5279	5385	5583	5439	5486	5392	Boiler enabled total

Heating and Cooling Degree Days

Heating and Cooling Degree Days for Residential Applications*

Location	HDD	CDD
Milwaukee	7,276	548
Green Bay	7,725	516
Wausau	7,805	654
Madison	7,599	630
La Crosse	7,397	729
Minocqua	8,616	423
Rice Lake	8,552	438
Statewide Weighted	**7,616**	**565**

* Cadmus. *Michigan Water Meter Study.* 2012.

Appendix C: Effective Useful Life Table

The EUL figures listed in the table below were reviewed and updated in CY 2015 and will continue to be updated every odd-numbered year.

Prescriptive Measures by Measure Master ID

MMID	Measure Name	EUL (years)
566	PC Network Energy Management System	2
1981	Natural Gas Furnace with ECM, 95%+ AFUE (Existing)	23 (Residential-single family) 18 (Nonresidential)
1983	Hot Water Boiler, 95%+ AFUE	20
1986	Condensing Water Heater, Natural Gas, 90%+	15 (Residential-single family) 18 (Nonresidential) 12 (Residential-multifamily)
1988	Water Heater, Indirect	15
1989	Water Heater, Electric, EF of 0.93 or greater	15 (Residential and Nonresidential)
2117	CFL, Non PI Direct Install, 14 Watt	6
2118	CFL, Non PI Direct Install, 19 Watt	6
2119	CFL, Non PI Direct Install, 23 Watt	6
2120	Faucet Aerator, Non PI Direct Install, 1.5 gpm, Kitchen, Natural Gas	20
2121	Faucet Aerator, Non PI Direct Install, 1.0 gpm, Bathroom, Natural Gas	20
2123	Showerhead, Non PI Direct Install, 1.5 gpm, Natural Gas	10
2126	Faucet Aerator, Non PI Direct Install, 1.5 gpm, Kitchen, Electric	10
2127	Faucet Aerator, Non PI Direct Install, 1.0 gpm, Bathroom, Electric	10
2129	Showerhead, Non PI Direct Install, 1.5 gpm, Electric	10
2132	CFL, Direct Install, 9 Watt	6 (Residential)
2133	CFL, Direct Install, 14 Watt	6 (Residential) 5 (Nonresidential)
2134	CFL, Direct Install, 19 Watt	7 (Residential) 5 (Nonresidential)
2135	CFL, Direct Install, 23 Watt	6
2136	Faucet Aerators, Direct Install, 1.5 gpm, Kitchen, Natural Gas	10
2137	Faucet Aerator, Direct Install, 1.0 gpm, Bathroom, Natural Gas	10
2139	Showerhead, Direct Install, 1.5 gpm, Natural Gas	10
2140	Showerhead, Direct Install, 1.75 gpm, Natural Gas	10

MMID	Measure Name	EUL (years)
2141	DHW Temperature Turn Down, Direct Install, Natural Gas	15
2145	Showerhead, Direct Install, 1.5 gpm, Electric	10
2146	Showerhead, Direct Install, 1.75 gpm, Electric	10
2147	DHW Temperature Turn Down, Direct Install, Electric	15
2150	Cooler Miser, Direct Install	9
2151	Faucet Aerator, Direct Install, .5 gpm, Bathroom, Electric	10
2155	Faucet Aerator, Direct Install, 1.5 gpm, Kitchen, Electric	10
2156	Faucet Aerator, Direct Install, 1.5 gpm, Kitchen, Natural Gas	10
2158	Pre-Rinse Sprayer, Direct Install, 1.28 gpm, Electric	5
2159	Pre-Rinse Sprayer, Direct Install, 1.28 gpm, Natural Gas	5
2192	A/C Split System ≤ 65 MBh, SEER 15	15
2193	A/C Split System ≤ 65 MBh, SEER 16 or greater	15
2194	A/C Split System, ≤ 65 MBh, SEER 14	15
2197	Anti-sweat Heater Controls, Freezer Case, Low-heat Door	12
2198	Anti-sweat Heater Controls, Freezer Case, No-heat Door	12
2199	Anti-sweat Heater Controls, Freezer Case, Standard Door	12
2200	Anti-sweat Heater Controls, Refrigerated Case, Low-heat or No-heat Door	12
2201	Anti-sweat Heater Controls, Refrigerated Case, Standard Door	12
2202	Beverage Cooler Controls, Occupancy Based	5
2203	Boiler Burner, 10:1 High Turn Down	20
2205	Boiler Control, Linkageless	20
2206	Boiler Oxygen Trim Combustion Controls	5
2209	Boiler Plant Retrofit, Mid Efficiency Plant, 1- 5 MMBh	20
2211	Boiler Tune Up	1
2218	Boiler, Hot Water, Modulating, ≥ 90% AFUE, < 300 mbh	20
2221	Boiler, Outside Temperature Reset/Cutout Control	5
2234	Case Door, Freezer, Low Heat	11
2235	Case Door, Freezer, No Heat	11
2236	Case Door, Cooler, No Heat	11
2237	Ceramic Metal Halide (CMH) Fixture, 20-70 Watts	11
2238	Ceramic Metal Halide (CMH) Lamp, ≤ 25 Watts	11
2239	CFL Fixture, ≤ 100 Watts	13
2243	CFL, 31-115 Watts	5
2245	CFL, Cold Cathode, ≤ 32 Watt	4
2246	CFL, Reflector Flood Lamps, ≤ 32 Watts	5 (Residential-multifamily) 12 (Nonresidential)
2254	Compressed Air Condensate Drains, No Loss Drain	20

MMID	Measure Name	EUL (years)
2259	Compressed Air Nozzles, Air Entraining	15
2264	Compressed Air, Cycling Thermal Mass Air Dryers	15
2269	Cooler Evaporator Fan Control	16
2271	Cooler Night Curtains, Open Coolers	5
2276	Delamping, T12 to T8, 4'	10
2277	Delamping, T8 to T8	TBA
2280	Dishwasher, Low Temp, Door Type, ENERGY STAR, ENERGY STAR, Electric	10
2281	Dishwasher, High Temp, Electric Booster, Door Type, ENERGY STAR, Electric	10
2282	Dishwasher, High Temp, Electric Booster, Door Type, ENERGY STAR, Natural Gas	10
2283	Dishwasher, High Temp, Electric Booster, Multi Tank Conveyor, ENERGY STAR, Electric	10
2284	Dishwasher, High Temp, Electric Booster, Multi Tank Conveyor, ENERGY STAR, Natural Gas	10
2285	Dishwasher, High Temp, Electric Booster, Single Tank Conveyor, ENERGY STAR, Electric	10
2286	Dishwasher, High Temp, Electric Booster, Single Tank Conveyor, ENERGY STAR, Natural Gas	10
2287	Dishwasher, High Temp, Electric Booster, Under Counter, ENERGY STAR, Electric	10
2288	Dishwasher, High Temp, Electric Booster, Under Counter, ENERGY STAR, Natural Gas	10
2289	Dishwasher, High Temp, Gas Booster, Door Type, ENERGY STAR, Natural Gas	10
2290	Dishwasher, High Temp, Gas Booster, Multi Tank Conveyor, ENERGY STAR, Natural Gas	10
2291	Dishwasher, High Temp, Gas Booster, Single Tank Conveyor, ENERGY STAR, Natural Gas	10
2292	Dishwasher, High Temp, Gas Heat, Gas Booster, Under Counter, ENERGY STAR, Natural Gas	10
2293	Dishwasher, Low Temp, Door Type, ENERGY STAR, Natural Gas	10
2294	Dishwasher, Low Temp, Multi Tank Conveyor, ENERGY STAR, Electric	10
2295	Dishwasher, Low Temp, Multi Tank Conveyor, ENERGY STAR, Natural Gas	10
2296	Dishwasher, Low Temp, Single Tank Conveyor, ENERGY STAR, Electric	10
2297	Dishwasher, Low Temp, Single Tank Conveyor, ENERGY STAR, Natural Gas	10
2298	Dishwasher, Low Temp, Under Counter, ENERGY STAR, Electric	10
2299	Dishwasher, Low Temp, Under Counter, ENERGY STAR, Natural Gas	10
2300	Dock Door Infiltration Reduction, New Install	10
2301	Dock Door Infiltration Reduction, Replace Existing	10

MMID	Measure Name	EUL (years)
2302	Dock Pit/Ramp External Seal, Added to Existing "Brush" Barrier	10
2303	Dock Pit/Ramp External Seal, No Brush Barrier Present	10
2306	ECM Compressor Fan Motor	15
2307	ECM Condenser/Condensing Unit Fan Motor	16
2308	ECM Evaporator Fan Motor, Walk-in Cooler, < 1/20hp	16
2309	ECM Evaporator Fan Motor, Walk-in Cooler, 1/20hp - 1 hp	16
2310	ECM Evaporator Fan Motor, Walk-in Freezer, < 1/20hp	16
2311	ECM Evaporator Fan Motor, Walk-in Freezer, 1/20hp - 1 hp	16
2312	ECM Motor, Cooler/Freezer Case	16
2316	Fans, High Volume Low Speed (HVLS), 20 ft. dia.	15
2317	Fans, High Volume Low Speed (HVLS), 22 ft. dia.	15
2318	Fans, High Volume Low Speed (HVLS), 24 ft. dia.	13
2321	Freezer, Chest, Glass Door, < 15 cu ft, ENERGY STAR	12
2322	Freezer, Chest, Glass Door, 15-29 cu ft, ENERGY STAR	12
2323	Freezer, Chest, Glass Door, 30-49 cu ft, ENERGY STAR	12
2324	Freezer, Chest, Glass Door, 50+ cu ft, ENERGY STAR	12
2325	Freezer, Chest, Solid Door, < 15 cu ft, ENERGY STAR	12
2326	Freezer, Chest, Solid Door, 15-29 cu ft, ENERGY STAR	12
2327	Freezer, Chest, Solid Door, 30-49 cu ft, ENERGY STAR	12
2328	Freezer, Chest, Solid Door, 50+ cu ft, ENERGY STAR	12
2329	Freezer, Vertical, Glass Door, < 15 cu ft, ENERGY STAR	12
2330	Freezer, Vertical, Glass Door, 15-29 cu ft, ENERGY STAR	12
2331	Freezer, Vertical, Glass Door, 30-49 cu ft, ENERGY STAR	12
2332	Freezer, Vertical, Glass Door, 50+ cu ft,ENERGY STAR	12
2333	Freezer, Vertical, Solid Door, < 15 cu ft, ENERGY STAR	12
2334	Freezer, Vertical, Solid Door, 15-29 cu ft, ENERGY STAR	12
2335	Freezer, Vertical, Solid Door, 30-49 cu ft, ENERGY STAR	12
2336	Freezer, Vertical, Solid Door, 50+ cu ft, ENERGY STAR	12
2337	Fryer, ENERGY STAR, Electric	12
2338	Fryer, ENERGY STAR, Natural Gas	12
2350	Furnace, ECM, 95%+ AFUE, Natural Gas, 109.9 - 120.7 MBh	18
2352	Furnace, ECM, 95%+ AFUE, Natural Gas, 133.0 - 146.1 MBh	18
2354	Furnace, ECM, 95%+ AFUE, Natural Gas, 54.675 - 60.749 MBh	18
2355	Furnace, ECM, 95%+ AFUE, Natural Gas, 60.750 - 67.499 MBh	18
2356	Furnace, ECM, 95%+ AFUE, Natural Gas, 67.5 - 74.9 MBh	18
2357	Furnace, ECM, 95%+ AFUE, Natural Gas, 75.0 - 82.49 MBh	18
2358	Furnace, ECM, 95%+ AFUE, Natural Gas, 82.5 - 90.75 MBh	18
2359	Furnace, ECM, 95%+ AFUE, Natural Gas, 90.76 - 99.82 MBh	18

MMID	Measure Name	EUL (years)
2360	Furnace, ECM, 95%+ AFUE, Natural Gas, 99.83 - 109.8 MBh	18
2362	Glazing, Triple Poly Carbonate, Roof and Walls, Double Pane Replacement	10
2363	Glazing, Triple Poly Carbonate, Roof and Walls, Single Pane Replacement	10
2364	Glazing, Triple Poly Carbonate, Roof, Double Pane Replacement	10
2365	Glazing, Triple Poly Carbonate, Roof, Single Pane Replacement	10
2366	Glazing, Triple Poly Carbonate, Walls, Double Pane Replacement	10
2367	Glazing, Triple Poly Carbonate, Walls, Single Pane Replacement	10
2371	Griddle, ENERGY STAR, Electric	11
2372	Griddle, ENERGY STAR, Natural Gas	11
2373	Guest Room Energy Management Controls, Electric Heat PTAC Systems	10
2422	Infrared Heating Units, High or Low Intensity	15
2429	Insulation, Steam Fitting, Removable, Natural Gas	10
2430	Insulation, Steam Piping, Natural Gas	10
2456	LED, Reach-In Refrigerated Case, Replaces T12 or T8	20
2457	LED, Reach-In Refrigerated Case, Replaces T12 or T8 w/ Occupancy Control	20
2458	LED, Recessed Downlight, ENERGY STAR	15
2471	Occupancy Sensor, Ceiling Mount, ≤ 500 Watts	8
2472	Occupancy Sensor, Ceiling Mount, ≥ 1,001 Watts	8
2473	Occupancy Sensor, Ceiling Mount, 501-1,000 Watts	8
2474	Occupancy Sensor, Fixture Mount, ≤ 200 Watts	8
2475	Occupancy Sensor, Fixture Mount, > 200 Watts	8
2482	Occupancy Sensor, LED Refrigerated Case Lights	10
2483	Occupancy Sensor, Wall Mount, ≤ 200 Watts	8
2484	Occupancy Sensor, Wall Mount, > 200 Watts	8
2485	Oven, Convection, ENERGY STAR, Electric	12
2486	Oven, Convection, ENERGY STAR, Natural Gas	12
2487	Oven, Rack Type, Double Compartment, Focus QPL, Natural Gas	12
2488	Oven, Rack Type, Single Compartment, Focus QPL, Natural Gas	12
2494	Pre-Rinse Sprayer, ≤.65 gpm, Electric	5
2495	Pre-Rinse Sprayer, ≤.65 gpm, Natural Gas	5
2509	Reach In Refrigerated Case w/ Doors replacing Open Multi Deck Case	15
2510	Refrigeration Controls, Floating Head Pressure, ≤ 150 tons	10
2513	Refrigeration Tune-up, Non Self-Contained Cooler	3
2514	Refrigeration Tune-up, Non Self-Contained Freezer	3
2515	Refrigeration Tune-up, Self-contained Cooler	3
2516	Refrigeration Tune-up, Self-contained Freezer	3
2521	Refrigerator, Chest, Glass Door, < 15 cu ft, ENERGY STAR	12
2522	Refrigerator, Chest, Glass Door, 15-29 cu ft, ENERGY STAR	12

MMID	Measure Name	EUL (years)
2523	Refrigerator, Chest, Glass Door, 30-49 cu ft, ENERGY STAR	12
2524	Refrigerator, Chest, Glass Door, 50+ cu ft, ENERGY STAR	12
2525	Refrigerator, Chest, Solid Door, < 15 cu ft, ENERGY STAR	12
2526	Refrigerator, Chest, Solid Door, 15-29 cu ft, ENERGY STAR	12
2527	Refrigerator, Chest, Solid Door, 30-49 cu ft, ENERGY STAR	12
2528	Refrigerator, Chest, Solid Door, 50+ cu ft, ENERGY STAR	12
2529	Refrigerator, Vertical, Glass Door, < 15 cu ft, ENERGY STAR	12
2530	Refrigerator, Vertical, Glass Door, 15-29 cu ft, ENERGY STAR	12
2531	Refrigerator, Vertical, Glass Door, 30-49 cu ft, ENERGY STAR	12
2532	Refrigerator, Vertical, Glass Door, 50+ cu ft, ENERGY STAR	12
2533	Refrigerator, Vertical, Solid Door, < 15 cu ft, ENERGY STAR	12
2534	Refrigerator, Vertical, Solid Door, 15-29 cu ft, ENERGY STAR	12
2535	Refrigerator, Vertical, Solid Door, 30-49 cu ft, ENERGY STAR	12
2536	Refrigerator, Vertical, Solid Door, 50+ cu ft, ENERGY STAR	12
2542	Steam Trap Repair, < 50 psig, Industrial	6
2544	Steam Trap Repair, > 225 psig, Industrial	6
2546	Steam Trap Repair, 126-225 psig, Industrial	6
2548	Steam Trap Repair, 50-125 psig, Industrial	6
2549	Steamer, 3 Pan, ENERGY STAR, Electric	11
2550	Steamer, 4 Pan, ENERGY STAR, Electric	11
2551	Steamer, 5 Pan, ENERGY STAR, Electric	11
2552	Steamer, 5 Pan, ENERGY STAR, Natural Gas	11
2553	Steamer, 6 Pan, ENERGY STAR, Electric	11
2554	Steamer, 6 Pan, ENERGY STAR, Natural Gas	11
2556	T8 1L 4', 25W, CEE, BF ≤ 0.78	15
2557	T8 1L 4', 28W, CEE, BF ≤ 0.78	15
2558	T8 1L 4', 28W, CEE, BF > 0.78	15
2559	T8 1L 4', HPT8, CEE, BF > 0.78	15
2560	T8 1L, 4', 25W, CEE, BF > 0.78	15
2561	T8 1L, 4', HPT8, CEE, BF ≤ 0.78	15
2562	T8 2L 4', 25W, CEE, BF ≤ 0.78	15
2563	T8 2L 4', 25W, CEE, BF > 0.78	15
2564	T8 2L 4', 28W, CEE, BF ≤ 0.78	15
2565	T8 2L 4', 28W, CEE, BF > 0.78	15
2566	T8 2L 4', HPT8, CEE, BF ≤ 0.78	15
2567	T8 2L 4', HPT8, CEE, BF > 0.78	15
2568	T8 2L 4', HPT8, CEE, replacing 8' 1L T12HO	15
2569	T8 2L 4', HPT8, CEE, replacing 8' 2L T12	15

MMID	Measure Name	EUL (years)
2571	T8 3L 4', 25W, CEE, BF ≤ 0.78	15
2572	T8 3L 4', 25W, CEE, BF > 0.78	15
2573	T8 3L 4', 28W, CEE, BF ≤ 0.78	15
2574	T8 3L 4', 28W, CEE, BF > 0.78	15
2575	T8 3L 4', HPT8, CEE, BF ≤ 0.78	15
2576	T8 3L 4', HPT8, CEE, BF > 0.78	15
2577	T8 4L 4', 25W, CEE, BF ≤ 0.78	15
2578	T8 4L 4', 25W, CEE, BF > 0.78	15
2579	T8 4L 4', 28W, CEE, BF ≤ 0.78	15
2580	T8 4L 4', 28W, CEE, BF > 0.78	15
2581	T8 4L 4', HPT8, CEE, BF ≤ 0.78	15
2582	T8 4L 4', HPT8, CEE, BF > 0.78	15
2590	T8, Low Watt Relamp, 25 Watts, 4'	15
2591	T8, Low Watt Relamp, 28 Watts, 4'	15
2596	Thermal Curtain, Double Pane Glass Walls and Ceiling, Overhead Heating	5
2597	Thermal Curtain, Double Pane Glass Walls and Ceiling, Under Bench Heating	5
2598	Thermal Curtain, Double Pane Glass Walls and Poly Film Ceiling, Overhead Heating	5
2599	Thermal Curtain, Double Pane Glass Walls and Poly Film Ceiling, Under Bench Heating	5
2601	Thermal Curtain, Poly Film Walls and Ceiling, Overhead Heating	5
2602	Thermal Curtain, Poly Film Walls and Ceiling, Under Bench Heating	5
2603	Thermal Curtain, Single Pane Glass Walls and Ceiling, Overhead Heating	5
2604	Thermal Curtain, Single Pane Glass Walls and Ceiling, Under Bench Heating	5
2605	Thermal Curtain, Single Pane Glass Walls and Poly Film Ceiling, Overhead Heating	5
2606	Thermal curtain, Single Pane Glass Walls and Poly Film Ceiling, Under Bench Heating	5
2608	Unit Heater, ≥ 90% Thermal Efficiency	15
2611	Vending Machine Controls, Occupancy Based, Cold Beverage Machine	5
2612	Vending Machine Controls, Occupancy Based, Snack Machine	5
2614	Vending Machine Controls, Sales Based, Snack Machine	5
2616	Vending Machine, Cold Beverage, Software Activated, ENERGY STAR	10
2620	Ventilation Controls, Kitchen Hood, Temp only, Adder for MUA, New	10
2621	Ventilation Controls, Kitchen Hood, Temp only, Adder for MUA, Retrofit	10
2622	Ventilation Controls, Kitchen Hood, Temp only, Exhaust Only, New	10
2623	Ventilation Controls, Kitchen Hood, Temp only, Exhaust Only, Retrofit	10
2624	Ventilation Controls, Kitchen Hood, with Optical, Adder for MUA, New	10

MMID	Measure Name	EUL (years)
2625	Ventilation Controls, Kitchen Hood, with Optical, Adder for MUA, Retrofit	10
2626	Ventilation Controls, Kitchen Hood, with Optical, Exhaust Only, New	10
2627	Ventilation Controls, Kitchen Hood, with Optical, Exhaust Only, Retrofit	10
2628	Ventilation Fan, 36" Dia., Ag	16
2629	Ventilation Fan, 42" Dia., Ag	16
2630	Ventilation Fan, 48" Dia., Ag	16
2631	Ventilation Fan, 50" Dia., Ag	16
2632	Ventilation Fan, 51" Dia., Ag	16
2633	Ventilation Fan, 52" Dia., Ag	16
2634	Ventilation Fan, 54" Dia., Ag	16
2635	Ventilation Fan, 55" Dia., Ag	16
2636	Ventilation Fan, 57" Dia., Ag	16
2637	Ventilation Fan, 60" Dia., Ag	16
2638	Ventilation Fan, 72" Dia., Ag	16
2651	Water Heater, ≥ 0.67 EF, Storage, Natural Gas	10
2652	Water Heater, ≥ 0.82 EF, Tankless, Residential, Natural Gas	13
2658	Water Heater, Indirect, 90% AFUE Boiler, Natural Gas	15
2660	Waterer, Livestock, < 250 Watts	10
2665	T8, Reduced Wattage, Relamp 8'	15
2666	Chiller System Tune Up, Air Cooled, ≤ 500 Tons	5
2667	Chiller System Tune Up, Air Cooled, > 500 Tons	5
2668	Chiller System Tune Up, Water Cooled, ≤ 500 Tons	5
2669	Chiller System Tune Up, Water Cooled, > 500 Tons	5
2670	CFL, ≤ 32 Watt	5
2671	Coil Cleaning, Direct Install, Self Contained Unit	4
2677	Hot Food Holding Cabinet, V = 13-28 cu. ft., ENERGY STAR	12
2678	Hot Food Holding Cabinet, V < 13 cu. ft., ENERGY STAR	12
2679	Hot Food Holding Cabinet, V ≥ 28 cu. ft., ENERGY STAR	12
2686	Faucet Aerator, Direct Install, .5 gpm, Public Restroom, Electric	10
2687	Faucet Aerator, Direct Install, .5 gpm, Public Restroom, Natural Gas	10
2688	Faucet Aerator, Direct Install, .5 gpm, Employee Restroom, Electric	10
2689	Faucet Aerator, Direct Install, .5 gpm, Employee Restroom, Natural Gas	10
2699	PTHP, < 8,000 Btuh	15
2700	PTHP, ≥ 13,000 Btuh	15
2701	PTHP, 10,000-12,999 Btuh	15
2702	PTHP, 8,000 – 9,999 Btuh	15
2703	T5 2L Recessed Indirect Fixture, F28, replacing 3 or 4L - T8 or T12	15
2704	T8 2L 4', Recessed Indirect Fixture, HPT8, replacing 3 or 4L - T8 or T12	15

MMID	Measure Name	EUL (years)
2707	T8, Low-Watt Relamp, 54 Watts, 8-Foot	5
2711	Insulation, Project Based, Attic,	35
2712	Insulation, Project Based, Wall,	25
2713	Insulation, Project Based, Foundation,	20
2714	Insulation, Project Based, Sillbox	20
2732	CFL, Direct Install, 13 Watt	6 (Residential-multifamily) 5 (Nonresidential)
2734	Faucet Aerator, Direct Install, 1.5 gpm, Bathroom, Electric	10
2735	Faucet Aerator, Direct Install, 1.5 gpm, Bathroom, Natural Gas	10
2736	LED, Direct Install, Exit Sign, Retrofit	8
2740	CFL, Direct Install, 18 Watt	6
2741	Insulation, Direct Install, 3' Pipe, Electric	10
2742	Insulation, Direct Install, 3' Pipe, Natural Gas	15
2743	Boiler, Hot Water, Modulating, ≥ 90% AFUE,≤ 300 MBH	20
2744	Boiler Tune Up	2
2753	CFL, ≤ 32 Watts, Common Area	2
2754	CFL, ≤ 32 Watt, In Unit	10
2756	Clothes Washer, Common Area, Electric, ENERGY STAR	11
2757	Clothes Washer, Common Area, Natural Gas, ENERGY STAR	11
2764	Furnace, ECM, ≥ 95%+ AfUE, Natural Gas	18
2768	LED, Exit Sign, Retrofit	8 (Residential-multifamily) 16 (Nonresidential)
2772	Steam Trap Repair, < 10 psig, Radiator	6
2797	Occupancy Sensor, With Co-Pay, Wall Mount, ≤ 200 Watts	9
2798	Occupancy Sensor, With Co-Pay, Wall Mount, > 200 Watts	9
2810	Timer, Engine Block Heater	15
2820	Ground Source Heat Pump, Electric Back-up	18
2821	Ground Source Heat Pump, Natural Gas Back-up	18
2825	Water Heater Fuel Switching, Electric to Natural Gas	15
2884	T8 4L Replacing 250-399 W HID	14
2886	T8 8L Replacing 400-999 W HID	14
2887	T8 8L ≤ 500W, Replacing ≥ 1,000 W HID	14
2888	T8 10L ≤ 500W, Replacing ≥ 1,000 W HID	14
2889	T8 (2) 6L≤ 500W, Replacing ≥ 1,000 W HID	14
2890	T5HO 2L Replacing 250-399 W HID	14
2891	T5HO 3L Replacing 250-399 W HID	14

MMID	Measure Name	EUL (years)
2892	T5HO 4L Replacing 400-999 W HID	14
2893	T5HO 6L Replacing 400-999 W HID	14
2894	T5HO 6L ≤ 500W, Replacing ≥ 1,000 W HID	14
2895	T5HO 8L ≤ 500W, Replacing ≥ 1,000 W HID	14
2896	T5HO (2) 4L ≤ 500W, Replacing ≥ 1,000 W HID	14
2897	T5HO (2) 6L ≤ 800W, Replacing ≥ 1,000 W HID	14
2899	Insulation, Above Grade, R-5 or greater	20
2902	Water Heater, Power Vented, EF = .67-.82, Storage, Natural Gas	15
2958	Refrigerator, Recycling and Replacement Referral	8
2971	LED Lamp, Direct Install, Walk-in Cooler or Freezer	6
2979	LED, Exit Sign, Retrofit, Over Program Limit	16
2984	LED Fixture, Downlights, Accent Lights and Monopoint, ≤ 18 Watts, Common Area	11
2989	ECM, Furnace, New or Replacement	18
2990	Furnace And A/C, ECM, 95% + AFUE, ≥ 16 SEER	23
2992	Air Source Heat Pump, ≥ 16 SEER	18
3001	Delamping, 200-399 Watt Fixture	TBA
3002	Delamping, ≥ 400 Watt Fixture	TBA
3003	LED, Replacing Neon Sign	15
3017	Showerheads, Retail Store Markdown	10
3018	Waterer, Livestock, Energy Free	10
3019	Lighting Fixture, Agricultural Daylighting ≤ 155 Watts	15
3020	Lighting Fixture, Agricultural Daylighting 156 - 250 Watts	15
3021	Lighting Fixture, Agricultural Daylighting 251 - 365 Watts	15
3023	T5, Reduced Wattage, Replacing T5 Or T5HO	6
3024	T5HO, Reduced Wattage, Replacing Standard T5 Or T5HO	8
3025	Faucet Aerator, 1.5 gpm, Kitchen, Natural Gas	10
3026	Faucet Aerator, 1.5 gpm, Kitchen, Electric	10
3027	Faucet Aerator, 1.5 gpm, Bathroom, Natural Gas	10
3028	Faucet Aerator, 1.5 gpm, Bathroom, Electric	10
3029	Faucet Aerator, 1.5 gpm, Shower, Natural Gas	10
3030	Faucet Aerator, 1.5 gpm, Shower, Electric	10
3031	CFL, Reduced Wattage, Pin Based, 18 Watt, Replacing CFL	3
3032	CFL, Reduced Wattage, Pin Based, 26 Watt, Replacing CFL	3
3033	CFL, Reduced Wattage, Pin Based, 32 Watt, Replacing CFL	3
3034	CFL, Reduced Wattage, Pin Based, 42 Watt, Replacing CFL	3
3036	HID, Reduced Wattage, Replacing 1,000 Watt HID, Exterior	4
3037	HID, Reduced Wattage, Replacing 400 Watt HID, Exterior	4

MMID	Measure Name	EUL (years)
3038	HID, Reduced Wattage, Replacing 320 Watt HID, Exterior	4
3039	HID, Reduced Wattage, Replacing 250 Watt HID, Exterior	4
3040	HID, Reduced Wattage, Replacing 175 Watt HID, Exterior	4
3041	T5HO, Exterior Reduced Wattage, Replacing 250-399 Watt HID	15
3042	T5HO, Exterior Reduced Wattage, Replacing 400-999 Watt HID	15
3043	T5HO, Exterior < 500 Watts, Replacing ≥ 1,000 Watt HID	15
3056	LED Fixture, Replacing 320 Watt HID, Parking Garage, 24 Hour	8
3065	Ceramic Metal Halide, 575 Watt, Replacing 1,000 Watt HID, High Bay	15
3067	HID, Reduced Wattage, Replacing 1,000 Watt HID, Interior	4
3068	HID, Reduced Wattage, Replacing 175 Watt HID, Interior	4
3069	HID, Reduced Wattage, Replacing 175 Watt HID, Parking Garage	4
3070	HID, Reduced Wattage, Replacing 250 Watt HID, Interior	4
3071	HID, Reduced Wattage, Replacing 250 Watt HID, Parking Garage	4
3072	HID, Reduced Wattage, Replacing 320 Watt HID, Interior	4
3073	HID, Reduced Wattage, Replacing 400 Watt HID, Interior	4
3074	Induction, 750 Watt, Replacing 1,000 Watt HID, High Bay	27
3075	Induction, PSMH/CMH, ≤ 250 Watt, Replacing 320-400 Watt HID, High Bay	15
3076	Induction, PSMH/CMH, ≤ 250 Watt, Replacing 400 Watt HID, High Bay	15
3077	Induction, PSMH/CMH, ≤ 365 Watt, Replacing 400 Watt HID, High Bay	15
3078	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 150-175 Watt HID, Exterior	15
3079	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 150-175 Watt HID, Parking Garage, 24 Hour	15
3080	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 150-175 Watt HID, Parking Garage, Dusk to Dawn	15
3081	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 250 Watt HID, Exterior	15
3082	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 250 Watt HID, Parking Garage, 24 Hour	15
3083	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 250 Watt HID, Parking Garage, Dusk to Dawn	15
3084	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 320 Watt HID, Exterior	15
3085	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 320-400 Watt HID, Exterior	15
3086	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 400 Watt HID, Exterior	15

MMID	Measure Name	EUL (years)
3087	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 70-100 Watt HID, Exterior	15
3088	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 70-100 Watt HID, Parking Garage, 24 Hour	15
3089	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 70-100 Watt HID, Parking Garage, Dusk to Dawn	15
3090	Induction, PSMH/CMH, Replacing 250 Watt HID, High Bay	15
3091	LED Fixture, < 155 Watts, Replacing 250 Watt HID, High Bay	20
3092	LED Fixture, < 250 Watts, Replacing 320-400 Watt HID, High Bay	20
3093	LED Fixture, < 250 Watts, Replacing 400 Watt HID, High Bay	20
3094	LED Fixture, < 365 Watts, Replacing 400 Watt HID, High Bay	20
3095	LED Fixture, < 500 Watts, Replacing 1,000 Watt HID, High Bay	20
3096	LED Fixture, < 800 Watts, Replacing 1,000 Watt HID, High Bay	20
3097	LED Fixture, Bilevel, Stairwell and Passageway	9
3098	LED Fixture, Downlights, Accent Lights and Monopoint, > 18 Watts, Common Area	11
3099	LED Fixture, Replacing 150-175 Watt HID, Exterior	20
3100	LED Fixture, Replacing 150-175 Watt HID, Parking Garage, 24 Hour	8
3101	LED Fixture, Replacing 150-175 Watt HID, Parking Garage, Dusk to Dawn	16
3102	LED Fixture, Replacing 250 Watt HID, Exterior	20
3103	LED Fixture, Replacing 250 Watt HID, Parking Garage, 24 Hour	8
3104	LED Fixture, Replacing 250 Watt HID, Parking Garage, Dusk to Dawn	16
3105	LED Fixture, Replacing 320 Watt HID, Exterior	20
3106	LED Fixture, Replacing 320-400 Watt HID, Exterior	20
3107	LED Fixture, Replacing 400 Watt HID, Exterior	20
3108	LED Fixture, Replacing 70-100 Watt HID, Exterior	20
3109	LED Fixture, Replacing 70-100 Watt HID, Parking Garage, 24 Hour	8
3110	LED Fixture, Replacing 70-100 Watt HID, Parking Garage, Dusk to Dawn	16
3111	LED Troffer, 2x4, Replacing 4' 3-4 Lamp T8 Troffer	16
3112	LED, ≤ 40 Watt, ENERGY STAR, Replacing Incandescent	7
3113	LED, > 40 Watt, ENERGY STAR, Replacing Incandescent	7
3114	LED, Horizontal Case Lighting	20
3117	Linear Fluorescent, Bilevel, Stairwell and Passageway	18 (Residential-multifamily) 8 (Nonresidential)
3118	Oven, Combination, ENERGY STAR, Electric	12
3119	Oven, Combination, ENERGY STAR, Natural Gas	12
3122	T8 2L 4', HPT8 or RWT8, Replacing T12 1L 8', 0.78 < BF < 1.00	15

MMID	Measure Name	EUL (years)
3123	T8 2L 4', HPT8 or RWT8, Replacing T12 1L 8', BF ≤ 0.78	15
3124	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', 0.78 < BF < 1.00	15
3125	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', BF ≤ 0.78	15
3126	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', BF > 1.00	15
3127	T8 4L 4', HPT8 or RWT8, Replacing T12 2L 8', 0.78 < BF < 1.00	15
3128	T8 4L 4', HPT8 or RWT8, Replacing T12 2L 8', BF ≤ 0.78	15
3129	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', 0.78 < BF < 1.00	15
3130	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', BF ≤ 0.78	15
3131	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', BF > 1.00	15
3132	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', 0.78 < BF < 1.00	15
3133	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', BF ≤ 0.78	15
3134	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', BF > 1.00	15
3135	T8, Low Wattage Relamp, 8'	15
3136	Dishwasher, High Temp, Electric Booster, Pots/Pans Type, ENERGY STAR, Electric	10
3137	Dishwasher, High Temp, Electric Booster, Pots/Pans Type, ENERGY STAR, Natural Gas	10
3138	Dishwasher, High Temp, Gas Booster, Pots/Pans Type, ENERGY STAR, Natural Gas	10
3139	Dishwasher, Low Temp, Pots/Pans Type, ENERGY STAR, Electric	10
3140	Dishwasher, Low Temp, Pots/Pans Type, ENERGY STAR, Natural Gas	10
3141	LED, ≤ 8W	7
3144	T8 2L 4', HPT8 or RWT8, Replacing T12 1L 8', 0.78 < BF < 1.00, Parking Garage	15
3145	T8 2L 4', HPT8 or RWT8, Replacing T12 1L 8', BF ≤ 0.78, Parking Garage	15
3146	T8 4L 4', HPT8 or RWT8, Replacing T12 2L 8', 0.78 < BF < 1.00, Parking Garage	15
3147	T8 4L 4', HPT8 or RWT8, Replacing T12 2L 8', BF ≤ 0.78, Parking Garage	15
3148	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', BF > 1.00, Parking Garage	15
3149	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', 0.78 < BF < 1.00, Parking Garage	15
3150	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', BF ≤ 0.78, Parking Garage	15
3151	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', BF > 1.00, Parking Garage	15
3152	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', 0.78 < BF < 1.00, Parking Garage	15
3153	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', BF ≤ 0.78, Parking Garage	15
3154	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', BF > 1.00, Parking Garage	15

MMID	Measure Name	EUL (years)
3155	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', 0.78 < BF < 1.00, Parking Garage	15
3156	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', BF ≤ 0.78, Parking Garage	15
3157	LED, Porch Fixture, ENERGY STAR	20
3158	LED Fixture, Downlights, Accent Lights and Monopoint, ≤ 18 Watts, In Unit	20
3159	LED, ENERGY STAR, Replacing Incandescent > 40W, In Unit	20
3160	LED, ENERGY STAR, Replacing Incandescent > 40W, Common Area	7
3161	LED, ENERGY STAR, Replacing Incandescent ≤ 40W, In Unit	20
3162	LED, ENERGY STAR, Replacing Incandescent ≤ 40W, Common Area	7
3163	T8 1L 4', HPT8, CEE, BF ≤ 0.78, Parking Garage	15
3164	T8 1L 4', 28W, CEE, BF > 0.78, Parking Garage	15
3165	T8 1L 4', 28W, CEE, BF ≤ 0.78, Parking Garage	15
3166	T8 1L 4', 25W, CEE, BF > 0.78, Parking Garage	15
3167	T8 1L 4', 25W, CEE, BF ≤ 0.78, Parking Garage	15
3168	T8 2L 4', HPT8, CEE, BF ≤ 0.78, Parking Garage	15
3169	T8 2L 4', 28W, CEE, BF > 0.78, Parking Garage	15
3170	T8 2L 4', 28W, CEE, BF ≤ 0.78, Parking Garage	15
3171	T8 2L 4', 25W, CEE, BF > 0.78, Parking Garage	15
3172	T8 2L 4', 25W, CEE, BF ≤ 0.78, Parking Garage	15
3173	T8 3L 4', HPT8, CEE, BF ≤ 0.78, Parking Garage	15
3174	T8 3L 4', 28W, CEE, BF > 0.78, Parking Garage	15
3175	T8 3L 4', 28W, CEE, BF ≤ 0.78, Parking Garage	15
3176	T8 3L 4', 25W, CEE, BF > 0.78, Parking Garage	15
3177	T8 3L 4', 25W, CEE, BF ≤ 0.78, Parking Garage	15
3178	T8 4L 4', HPT8, CEE, BF ≤ 0.78, Parking Garage	15
3179	T8 4L 4', 28W, CEE, BF > 0.78, Parking Garage	15
3180	T8 4L 4', 28W, CEE, BF ≤ 0.78, Parking Garage	15
3181	T8 4L 4', 25W, CEE, BF > 0.78, Parking Garage	15
3182	T8 4L 4', 25W, CEE, BF ≤ 0.78, Parking Garage	15
3183	Strip Curtain, Walk-In Freezers and Coolers	4
3184	Delamping, T12 to T8, 8'	10
3195	Linear Fluorescent, 2L 4'RWT8 Replacements, 24 Hours, CALP	15
3196	Linear Fluorescent, 2L 4'RWT8 Replacements, 12 Hours, CALP	15
3197	CFL Fixture, Interior or Exterior, 24 Hours, CALP	13
3198	CFL Fixture, Interior, 12 Hours, CALP	13
3199	CFL Fixture, Exterior, 12 Hours, CALP	13
3200	LED, Exit Sign, Retrofit, CALP	8
3201	Occupancy Sensor, Wall or Ceiling Mount ≤ 200 Watts, CALP	8

MMID	Measure Name	EUL (years)
3202	Occupancy Sensor, Wall or Ceiling Mount > 200 Watts, CALP	8
3224	Retrocommissioning, Express Building Tune-Up	5
3235	LED, 2x4, Replacing T8 2L	16
3239	LED, 2x2, Replacing T8 2L U-Tube	16
3251	Lighting Controls, Bilevel, Exterior and Parking Garage Fixtures, Dusk to Dawn	8
3252	Lighting Controls, Bilevel, Parking Garage Fixtures, 24 Hour	8
3253	Lighting Controls, Photocell with Internal Timer or Wireless Schedule, Exterior	8
3254	Occupancy Sensor, High Bay Fixtures, Gymnasium	8
3255	Occupancy Sensor, High Bay Fixtures, Industrial	8
3256	Occupancy Sensor, High Bay Fixtures, Retail	8
3257	Occupancy Sensor, High Bay Fixtures, Warehouse	8
3258	Occupancy Sensor, High Bay Fixtures, Public Assembly	8
3259	Occupancy Sensor, High Bay Fixtures, Other	8
3260	Bi Level Controls, High Bay Fixtures, Gymnasium	8
3261	Bi Level Controls, High Bay Fixtures, Industrial	8
3262	Bi Level Controls, High Bay Fixtures, Retail	8
3263	Bi Level Controls, High Bay Fixtures, Warehouse	8
3264	Bi Level Controls, High Bay Fixtures, Public Assembly	8
3265	Bi Level Controls, High Bay Fixtures, Other	8
3273	LED, 8 watts	7
3274	LED, 12 watts	7
3275	Boiler Plant Retrofit, Hybrid Plant, ≥ 1 MMBh	20
3276	Boiler, Hot Water, Condensing, ≥ 90% AFUE, ≥ 300 mbh	20
3277	Boiler, Hot Water, Near Condensing, ≥ 85% AFUE, ≥ 300 mbh \	20
3279	LED, Direct Install, 9.5 Watt	20
3284	Strip Curtain, Walk-In Freezers and Coolers, SBP A La Carte	4
3289	LED Fixture, Replacing 150-175 Watt HID, Exterior, SBP A La Carte	20
3290	LED Fixture, Replacing 320-400 Watt HID, Exterior, SBP A La Carte	20
3291	LED Troffer, 2x4, Replacing 4' 3-4 Lamp T8 Troffer, SBP A La Carte	13
3293	Occupancy Sensor, High Bay Fluorescent Fixtures, Warehouse, SBP A La Carte	8
3294	Occupancy Sensor, High Bay Fluorescent Fixtures, Public Assembly, SBP A La Carte	8
3295	Occupancy Sensor, High Bay Fluorescent Fixtures, Gymnasium, SBP A La Carte	8
3297	Occupancy Sensor, High Bay Fluorescent Fixtures, Industrial, SBP A La Carte	8

MMID	Measure Name	EUL (years)
3298	LED, Reach-In Refrigerated Case, Replaces T12 or T8, SBP A La Carte	16
3299	LED, Reach-In Refrigerated Case, Replaces T12 or T8 w/ Occupancy Control, SBP A La Carte	16
3301	LED Fixture, Replacing 250 Watt HID, Exterior, SBP A La Carte	20
3303	LED Fixture, Replacing 400 Watt HID, Exterior, SBP A La Carte	20
3304	LED Fixture, Replacing 70-100 Watt HID, Exterior, SBP A La Carte	20
3307	T8 2L 4', HPT8 or RWT8, Replacing T12 1L 8', 0.78 < BF < 1.00, SBP A La Carte	15
3309	T8 4L 4', HPT8 or RWT8, Replacing T12 2L 8', 0.78 < BF < 1.00, SBP A La Carte	15
3312	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', 0.78 < BF < 1.00, SBP A La Carte	15
3320	Delamping, T12 to T8, 8', SBP A La Carte	TBA
3323	LED, 2x2, Replacing T12 2L U-Tube, SBP A La Carte	16
3324	LED, 2x2, Replacing T8 2L U-Tube, SBP A La Carte	16
3325	T8, 2’ Lamps, Replacing T12 Single U-Tube, SBP A La Carte	15
3326	T8, 2’ Lamps, Replacing T12 Dual U-Tube, SBP A La Carte	15
3327	T8, 2’ Lamps, Replacing T8 Single U-Tube, SBP A La Carte	15
3328	T8, 2’ Lamps, Replacing T8 Dual U-Tube, SBP A La Carte	15
3329	T8 4L Replacing 250-399 W HID, SBP A La Carte	15
3330	T5HO 2L Replacing 250-399 W HID, SBP A La Carte	15
3331	T8 6L Replacing 400-999 W HID, SBP A La Carte	15
3332	T5HO 4L Replacing 400-999 W HID, SBP A La Carte	15
3333	T8 8L ≤ 500W, Replacing ≥ 1,000 W HID, SBP A La Carte	15
3334	T5HO 6L ≤ 500W, Replacing ≥ 1,000 W HID, SBP A La Carte	15
3335	LED, Horizontal Case Lighting, SBP A La Carte	16
3336	T8 2L 4', recessed Indirect Fixture, HPT8 replacing 3 or 4L - T8 or T12, SBP A La Carte	15
3338	Bi Level Controls, High Bay Fixtures, Industrial, SBP A La Carte	8
3339	Bi Level Controls, High Bay Fixtures, Other, SBP A La Carte	8
3340	Bi Level Controls, High Bay Fixtures, Public Assembly, SBP A La Carte	8
3341	Bi Level Controls, High Bay Fixtures, Retail, SBP A La Carte	8
3342	Bi Level Controls, High Bay Fixtures, Warehouse, SBP A La Carte	8
3343	Lighting Controls, Bilevel, Exterior and Parking Garage Fixtures, Dusk to Dawn, SBP A La Carte	8
3344	Lighting Controls, Bilevel, Parking Garage Fixtures, 24 Hour, SBP A La Carte	8
3345	Lighting Controls, Photocell with Internal Timer or Wireless Schedule, Exterior, SBP A La Carte	8
3347	LED, 12 Watts, SBP Package	7
3348	LED Troffer, 2x4, Replacing 4' 3-4 Lamp T8 Troffer, SBP Package	16

MMID	Measure Name	EUL (years)
3350	Insulation, Direct Install, Pipe, Per Foot, 1" Thickness, Electric, SBP Package	10
3351	Insulation, Direct Install, Pipe, Per Foot, 1" Thickness, Natural Gas, SBP Package	10
3352	LED, 8-12 Watts, SBP Package	7
3353	LED, Replacing Neon Sign, SBP Package	15
3355	Faucet Aerator, Direct Install, 1.5 gpm, Bathroom, Electric, SBP Package	10
3356	Faucet Aerator, Direct Install, 1.5 gpm, Bathroom, Natural Gas, SBP Package	10
3357	Occupancy Sensor, Wall Mount, > 200 Watts, SBP Package	8
3358	Showerhead, Direct Install, 1.75 gpm, Electric, SBP Package	9
3359	Showerhead, Direct Install, 1.75 gpm, Natural Gas, SBP Package	9
3360	LED, Exit Sign, Retrofit, SBP Package	10
3361	Occupancy Sensor, Wall Mount, ≤ 200 Watts, SBP Package	8
3363	LED, ≤ 8W, SBP Package	7
3364	LED, > 12W (Max 20W) Flood Lamp, SBP Package	11
3365	LED, MR16, 8-12W, SBP Package	7
3366	LED, 2x2, Replacing T12 2L U-Tube, SBP Package	16
3367	LED, 2x2, Replacing T8 2L U-Tube, SBP Package	16
3368	Faucet Aerator, Direct Install, .5 gpm Public Restroom, Electric, SBP Package	16
3369	Faucet Aerator, Direct Install, .5 gpm Public Restroom, Natural Gas, SBP Package	7
3370	Faucet Aerator, Direct Install, .5 gpm Employee Restroom, Electric, SBP Package	16
3371	Faucet Aerator, Direct Install, .5 gpm employee Restroom, Natural Gas, SBP Package	16
3372	T8 2L 4', recessed Indirect Fixture, HPT8 replacing 3 or 4L - T8 or T12, SBP Package	16
3385	LED, Non PI Direct Install, 13.5 Watt	20
3387	LED, 1x4, replacing T8 or T12, 2L	16
3391	HPT8, 1x4, replacing T12 or T8, 2L, SBP A La Carte	13
3392	HPT8, 1x4, replacing T12 or T8, 2L, SBP Package	13
3393	LED Fixture,≤ 180 Watts, Replacing 4 lamp T5 or 6 lamp T8, High Bay, DLC Listed	20
3394	LED Fixture, Downlights, ≤ 18 Watts, Replacing 1 lamp pin based CFL Downlight	11
3395	LED Fixture, Downlights, > 18 Watts, Replacing 2 lamp pin based CFL Downlight	11
3396	LED Fixture, Downlights, ≤ 100 Watts, ≥ 4,000 Lumens, Interior	11
3397	LED Fixture, Downlights, ≤ 100 Watts, ≥ 4,000 Lumens, Exterior	11

MMID	Measure Name	EUL (years)
3398	LED Fixture, Downlights, ≥ 6,000 Lumens, Interior	11
3399	LED Fixture, Downlights, ≥ 6,000 Lumens, Exterior	11
3400	LED Fixture, 2x2, Low Output, DLC Listed	16
3401	LED Fixture, 2x2, High Output, DLC Listed	16
3402	LED Lamp, ENERGY STAR, Replacing Incandescent Lamp ≤ 40 Watts, Exterior	7
3403	LED Lamp, ENERGY STAR, Replacing Incandescent Lamp > 40 Watts, Exterior	7
3404	LED Fixture, Downlights, > 18 Watts, Replacing Incandescent Downlight, Exterior	11
3405	LED Fixture, Downlights, ≤ 18 Watts, Replacing Incandescent Downlight, Exterior	11
3406	Daylighting Controls	8
3407	LED Fixture, Replacing 1,000 Watt HID, Exterior	20
3408	PSMH/CMH, Replacing 1,000 Watt HID, Exterior	15
3409	Retrofit Open Refrigerated Cases with Doors	12
3413	CFL, Non PI Direct Install, 13 Watt	8
3414	Ice Machine, CEE Tier 2, Air Cooled, Self Contained, 0-499 lbs/day	10
3415	Ice Machine, CEE Tier 2, Water Cooled, Self Contained, 0-499 lbs/day	10
3416	Ice Machine, CEE Tier 2, Air Cooled, Ice Making Head, 0-499 lbs/day	10
3417	Ice Machine, CEE Tier 2, Air Cooled, Ice Making Head, 500-999 lbs/day	10
3418	Ice Machine, CEE Tier 2, Air Cooled, Ice Making Head, ≥ 1,000 lbs/day	10
3419	Ice Machine, CEE Tier 2, Water Cooled, Ice Making Head, < 500 lbs/day	10
3420	Ice Machine, CEE Tier 2, Water Cooled, Ice Making Head, 500-999 lbs/day	10
3421	Ice Machine, CEE Tier 2, Water Cooled, Ice Making Head, ≥ 1,000 lbs/day	10
3422	Ice Machine, CEE Tier 2, Air Cooled, Remote Condensing, 0-499 lbs/day	10
3423	Ice Machine, CEE Tier 2, Air Cooled, Remote Condensing, 500-999 lbs/day	10
3424	Ice Machine, CEE Tier 2, Air Cooled, Remote Condensing, ≥ 1,000 lbs/day	10
3425	LED, 8ft, Replacing T12 or T8, 1L	16
3426	LED, 8ft, Replacing T12 or T8, 1L, SBP A La Carte	16
3428	LED, 8ft, Replacing T12 or T8, 2L	16
3429	LED, 8ft, Replacing T12 or T8, 2L, SBP A La Carte	16
3439	LED, Non-PI Direct Install, 13.5 Watt, With Co-Pay	20
3440	Natural Gas Furnace with ECM, 97%+ AFUE	23
3461	LED, Recessed Downlight, Replacing Incandescent, ENERGY STAR, In Unit	11
3462	LED, Recessed Downlight, Replacing Incandescent, ENERGY STAR, Common Area	11
3463	LED, Recessed Downlight, Replacing CFL, ENERGY STAR, In Unit	11
3464	LED, Recessed Downlight, Replacing CFL, ENERGY STAR, Common Area	11
3487	CFL, Direct Install, 20 Watt	6

MMID	Measure Name	EUL (years)
3488	LED, Direct Install, 10 Watt	20
3489	DHW Temperature Turn Down, Serving Multiple Dwelling Units, Direct Install, Electric	15
3490	DHW Temperature Turn Down, Serving Multiple Dwelling Units, Direct Install, Natural Gas	15
3491	Furnace with ECM, ≥ 95%+ AFUE, Natural Gas	18
3492	Furnace with ECM, ≥ 90%+ AFUE, Natural Gas	18
3494	Variable Speed ECM Pump, < 100 Watts Max Input, Domestic Hot Water Recirculation	15
3495	Variable Speed ECM Pump, 100 - 500 Watts Max Input, Domestic Hot Water Recirculation	15
3496	Variable Speed ECM Pump, > 500 Watts Max Input, Domestic Hot Water Recirculation	15
3497	Variable Speed ECM Pump, < 100 Watts Max Input, Heating Water Circulation	15
3498	Variable Speed ECM Pump, 100 - 500 Watts Max Input, Heating Water Circulation	15
3499	Variable Speed ECM Pump, > 500 Watts Max Input, Heating Water Circulation	15
3500	Variable Speed ECM Pump, < 100 Watts Max Input, Cooling Water Circulation	15
3501	Variable Speed ECM Pump, 100 - 500 Watts Max Input, Cooling Water Circulation	15
3502	Variable Speed ECM Pump, > 500 Watts Max Input, Cooling Water Circulation	15
3503	Variable Speed ECM Pump, < 100 Watts Max Input, Water Loop Heat Pump Circulation	15
3504	Variable Speed ECM Pump, 100 - 500 Watts Max Input, Water Loop Heat Pump Circulation	15
3505	Variable Speed ECM Pump, > 500 Watts Max Input, Water Loop Heat Pump Circulation	15
3506	Faucet Aerator, 1.0 gpm, Kitchen, Electric	10
3507	Faucet Aerator, 1.0 gpm, Kitchen, Natural Gas	10
3508	Faucet Aerator, 0.5 gpm, Bathroom, Natural Gas	10
3509	Faucet Aerator, 0.5 gpm, Kitchen, Electric	10
3510	Faucet Aerator, 0.5 gpm, Kitchen, Natural Gas	10
3511	LED Replacement of 4’ T8 Lamps w/Integral or External Driver	16
3512	LED Replacement of 4’ T8 Lamps utilizing existing ballast	16

MMID	Measure Name	EUL (years)
3514	Steam Trap Repair, 50-125 psig, General Heating, 3/8" or Larger	6
3515	Steam Trap Repair, 50-125 psig, General Heating, 5/16"	6
3516	Steam Trap Repair, 50-125 psig, General Heating, 7/32" or Smaller	6
3517	Steam Trap Repair, 126-225 psig, General Heating, 1/4"	6
3518	Steam Trap Repair, 126-225 psig, General Heating, 3/8" or Larger	6
3519	Steam Trap Repair, 126-225 psig, General Heating, 5/16"	6
3520	Steam Trap Repair, 126-225 psig, General Heating, 7/32" or Smaller	6
3521	Steam Trap Repair, > 225 psig, General Heating, 1/4"	6
3522	Steam Trap Repair, > 225 psig, General Heating, 3/8" or Larger	6
3523	Steam Trap Repair, > 225 psig, General Heating, 5/16"	6
3524	Steam Trap Repair, > 225 psig, General Heating, 7/32" or Smaller	6
3526	HPT8, 1x4, replacing T12 or T8, 2L, WPS Gold Plus Package	13
3527	T8 2L 4', recessed Indirect Fixture, HPT8 replacing 3 or 4L - T8 or T12, WPS Gold Plus Package	13
3529	T8 2L 4', HPT8 or RWT8, Replacing T12 1L 8', BF ≤ 0.78, WPS Gold Plus Package	15
3530	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', 0.78 < BF < 1.00, WPS Gold Plus Package	15
3531	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', BF ≤ 0.78, WPS Gold Plus Package	15
3532	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', BF > 1.00, WPS Gold Plus Package	15
3533	T8 2L 4', HPT8, CEE, replacing 8' 1L T12HO, WPS Gold Plus Package	15
3534	T8 4L 4', HPT8 or RWT8, Replacing T12 2L 8', 0.78 < BF < 1.00, WPS Gold Plus Package	15
3535	T8 4L 4', HPT8 or RWT8, Replacing T12 2L 8', BF ≤ 0.78, WPS Gold Plus Package	15
3536	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', 0.78 < BF < 1.00, WPS Gold Plus Package	15
3537	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', BF ≤ 0.78, WPS Gold Plus Package	15
3538	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', BF > 1.00, WPS Gold Plus Package	15
3539	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', 0.78 < BF < 1.00, WPS Gold Plus Package	15
3540	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', BF ≤ 0.78, WPS Gold Plus Package	15

MMID	Measure Name	EUL (years)
3541	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', BF > 1.00, WPS Gold Plus Package	15
3542	T8, 2’ Lamps, Replacing T12 Dual U-Tube, WPS Gold Plus Package	6
3543	T8, 2’ Lamps, Replacing T12 Single U-Tube, WPS Gold Plus Package	6
3544	T8, 2’ Lamps, Replacing T8 Dual U-Tube, WPS Gold Plus Package	15
3545	T8, 2’ Lamps, Replacing T8 Single U-Tube, WPS Gold Plus Package	15
3548	CFL, Standard Bulb, 310-749 Lumens, Retail Store Markdown	8
3549	CFL, Standard Bulb, 750-1049 Lumens, Retail Store Markdown	8
3550	CFL, Standard Bulb, 1050-1489 Lumens, Retail Store Markdown	8
3551	CFL, Standard Bulb, 1490-2600 Lumens, Retail Store Markdown	8
3552	CFL, Reflector, 15 watt, Retail Store Markdown	8
3553	LED, Omnidirectional, 310-749 Lumens, Retail Store Markdown	20
3554	LED, Omnidirectional, 750-1049 Lumens, Retail Store Markdown	20
3555	LED, Omnidirectional, 1050-1489 Lumens, Retail Store Markdown	20
3556	LED, Omnidirectional, 1490-2600 Lumens, Retail Store Markdown	20
3557	LED, Reflector, 12 watt, Retail Store Markdown	20
3558	Insulation, Attic, R-19 to R-38	20
3559	Boiler, 95%+ AFUE, With DHW, Natural Gas	20
3560	Occupancy Sensor, Fixture Mount, > 60 Watts	8
3561	Occupancy Sensor, Fixture Mount, ≤ 60 Watts	8
3567	LED, Direct Install, 10 Watt, with Co-pay	20
3570	Insulation and Air Sealing, Attic, R-11 to R-38	20
3571	Showerhead, Handheld, Direct Install, 1.5 gpm, Electric	10
3572	Showerhead, Handheld, Direct Install, 1.5 gpm, Natural Gas	10
3573	Faucet Aerator, Direct Install, 1.5 gpm, Kitchen, Swivel, Electric	10
3574	Faucet Aerator, Direct Install, 1.5 gpm, Kitchen, Swivel, Natural Gas	10
3575	CFL, Direct Install, 9 Watt, Torpedo, Candelabra Base	6
3576	CFL, Direct Install, 14 Watt, Torpedo, Medium Base	6
3577	LED, > 12W	7
3578	LED, > 12W, SBP Package	7
3579	LED, > 16W	7
3580	LED, > 16W, SBP Package	7
3581	T8 LED < 20 Watts, 3L, Replacing 3L or 4L T12/T8	16
3582	T8 LED < 20 Watts, 2L, Replacing 3L or 4L T12/T8	16
3583	Steam Trap Repair, 50-125 psig, General Heating, 1/4"	6
3584	Condensing Water Heater, Natural Gas, 90%+, Claim Only	15
3585	Water Heater, Indirect, Claim Only	15
3586	Water Heater, Electric, EF of 0.93 or greater, Claim Only	15

MMID	Measure Name	EUL (years)
3587	Water Heater, ≥ 0.67 EF, Storage, Natural Gas, Claim Only	10
3588	Water Heater, ≥ 0.82 EF, Tankless, Residential, Natural Gas, Claim Only	13
3596	LED Fixture, Bilevel, Stairwell and Passageway, SBP A La Carte	9
3597	LED Fixture, Bilevel, Stairwell and Passageway, SBP After A La Carte	9
3603	LED Fixture, Interior, 12 Hours, CALP	13
3604	LED Fixture, Interior, 24 Hours, CALP	6
3605	Occupancy Sensor, Fixture Mount, ≤ 200 Watts, CALP	8
3606	Occupancy Sensor, Fixture Mount, > 200 Watts, CALP	8
3607	LED, 4L 4’, < 20W, Replacing 8’ 2L T12 or T8	16
3608	LED, 2L 4', < 20W, Replacing 8’ 1L T12 or T8	16
3609	Smart Thermostat, Existing Natural Gas Boiler	10
3610	Smart Thermostat, Existing Natural Gas Furnace	10
3611	Smart Thermostat, Existing Air Source Heat Pump	10
3612	Smart Thermostat, Installed with 95% AFUE Natural Gas Furnace	10
3613	Smart Thermostat, Installed with 95% AFUE Natural Gas Boiler	10
3614	Smart Thermostat, Installed with Furnace and A/C	10
3615	Smart Thermostat, Installed with Air Source Heat Pump	10
3616	LED, 2L 4', < 20W, Replacing 8’ 1L T12 or T8, SBP A La Carte	16
3617	LED, 4L 4’, < 20W, Replacing 8’ 2L T12 or T8, SBP A La Carte	16
3679	LP Furnace with ECM, 90%+ AFUE (Existing)	23
3778	Boiler, Tier 2, 95%+ AFUE, With DHW, NG	20
3779	Furnace and A/C, Tier 2, ECM, 95% + AFUE, >= 16 SEER	23
3780	Hot Water Boiler, Tier 2, 95%+ AFUE	20
3781	LP Furnace with ECM, 90%+ AFUE (Existing)	23
3782	NG Furnace with ECM, 95%+ AFUE (Existing)	23
3783	NG Furnace, Tier 2, 95%+ AFUE	23
3784	Water Heater, Indirect, Tier 2	15
3785	Insulation, Tier 2, Project Based, Attic	35
3786	Insulation, Tier 2, Project Based, Foundation	20
3787	Insulation, Tier 2, Project Based, Sillbox	20
3788	Insulation, Tier 2, Project Based, Wall	25
3799	T8 2L 4', HPT8, CEE, BF ≤ 0.78, Agriculture	15
3800	T8 4L 4', HPT8, CEE, BF ≤ 0.78, Agriculture	15
3801	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', 0.78 < BF < 1.00, Agriculture	15
3802	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', BF > 1.00, Agriculture	15
3803	T8 4L 4', HPT8 or RWT8, Replacing T12 2L 8', 0.78 < BF < 1.00, Agriculture	15
3804	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', 0.78 < BF < 1.00, Agriculture	15
3805	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', BF > 1.00, Agriculture	15

MMID	Measure Name	EUL (years)
3806	LED Fixture, <155 Watts, Replacing 250 Watt HID, High Bay, Agriculture	20
3807	LED Fixture, <250 Watts, Replacing 400 Watt HID, High Bay, Agriculture	20
3808	LED Fixture, <365 Watts, Replacing 400 Watt HID, High Bay, Agriculture	20
3809	LED Fixture,≤180 Watts, Replacing 4 lamp T5 or 6 lamp T8, High Bay, DLC Listed, Agriculture	20
3810	LED Fixture, <250 Watts, Replacing 320-400 Watt HID, High Bay, Agriculture	20
3811	T8 4L Replacing 250-399 W HID, Agriculture	14
3812	T8 6L Replacing 400-999 W HID, Agriculture	14
3813	T5HO 4L Replacing 400-999 W HID, Agriculture	14
3814	T5HO 6L Replacing 400-999 W HID, Agriculture	14
3815	Induction, PSMH/CMH, Replacing 250 Watt HID, High Bay, Agriculture	15
3816	Induction, PSMH/CMH, ≤250 Watt, Replacing 320-400 Watt HID, High Bay, Agriculture	15
3817	Induction, PSMH/CMH, ≤250 Watt, Replacing 400 Watt HID, High Bay, Agriculture	15
3818	Induction, PSMH/CMH, ≤365 Watt, Replacing 400 Watt HID, High Bay, Agriculture	15
3819	LED Fixture, Downlights, ≤18 Watts, Agriculture	11
3820	LED Fixture, Downlights, > 18 Watts, Agriculture	11
3821	LED, > 40 Watt, ENERGY STAR, Replacing Incandescent, Agriculture	7
3822	LED Replacement of 4’ T8 Lamps w/Integral or External Driver, Agriculture	16
3823	LED Replacement of 4’ T8 Lamps utilizing existing ballast, Agriculture	16
3824	LED Fixture, Replacing 150-175 Watt HID, Exterior, Agriculture	20
3825	LED Fixture, Replacing 250 Watt HID, Exterior, Agriculture	20
3826	LED Fixture, Replacing 320-400 Watt HID, Exterior, Agriculture	20
3827	LED Fixture, Replacing 400 Watt HID, Exterior, Agriculture	20
3828	LED Fixture, Replacing 70-100 Watt HID, Exterior, Agriculture	20
3829	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 150-175 Watt HID, Exterior, Agriculture	15
3830	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 250 Watt HID, Exterior, Agriculture	15
3831	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 320-400 Watt HID, Exterior, Agriculture	15
3832	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 400 Watt HID, Exterior, Agriculture	15
3833	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 70-100 Watt HID, Exterior, Agriculture	15

MMID	Measure Name	EUL (years)
3834	Lighting Controls, Photocell with Internal Timer or Wireless Schedule, Exterior, Agriculture	8

Hybrid and Custom Measures by Measure Master ID

MMID	Measure Name	EUL (years)
212	Coarse Bubble Aeration	20
223	Blower Purge Dryer	15
224	Cycling Air Dryer	15
232	Laundry Heat Recovery	15
246	Overhead Door Seals	20
279	Air-Conditioning Economizer, Automatic	10
281	Air Rotation or Air Turnover Units to Minimize Stratification	15
284	Exhaust Air Heat Recovery System	15
285	Ventilation Filtration vs Make Up Air System	15
287	Mechanical Vent Dampers	15
289	Desiccant Dehumidifier	15
296	Chiller Optimization Controls	10
299	Replace Constant Volume HVAC with VAV	15
309	Air Filtration for Exhaust Air System	15
312	Refrigeration Waste Heat Recovery	15
315	Cooler Economizer	16
371	Combustion Management System on Boiler	15
525	Variable Displacement Compressor	15
548	Compressed Air Nozzles	15
2191	A/C Coil Cleaning, Ultraviolet	20
2196	Air Compressor, Variable Speed Drive, Constant Speed Replacement	15
2204	Boiler Burner, Not Otherwise Specified	20
2207	Boiler Oxygen Trim Controls	10
2210	Boiler System, Automatic Chemical Feed Component	15
2213	Boiler, Combustion Management System	15
2215	Boiler, Flue Gas Heat Recovery	15
2220	Boiler, Not Otherwise Specified	20
2228	Building Envelope, Glazing Retrofit	20
2229	Building Envelope, Not Otherwise Specified	25
2230	Building Envelope, Reduce Air Infiltration	20
2232	Building Envelope, Window Replacement	20
2233	Burners, Recuperative	10

MMID	Measure Name	EUL (years)
2247	Chiller System, Not Otherwise Specified	20
2248	Chiller System, Water Free Cooling Controls and Equipment	10
2249	Chiller, High Efficiency, Air Cooled, Replacement	20
2250	Chiller, High Efficiency, Water Cooled < 150 Tons, Replacement	20
2251	Chiller, High Efficiency, Water Cooled ≥ 300 Tons, Replacement	20
2252	Chiller, High Efficiency, Water Cooled 150-299 Tons, Replacement	20
2255	Compressed Air Controller, Pressure/Flow Controller	15
2256	Compressed Air Heat Recovery, Non-space Heating	15
2257	Compressed Air Heat Recovery, Space Heating	15
2258	Compressed Air Mist Eliminators	5 (New construction) 3 (Retrofit)
2260	Compressed Air System Isolation	15
2261	Compressed Air System Leak Survey and Repair, Year 1	2
2262	Compressed Air System Leak Survey and Repair, Year 2	2
2263	Compressed Air System Leak Survey and Repair, Year 3	2
2265	Compressed Air, Not Otherwise Specified	15
2266	Compressed Air, Process Load Reduction	15
2267	Compressor, Duct in Outside Air	10
2268	Cooler Curtain	5
2270	Cooler Night Covers	5
2274	Daylighting Controls, Automatic	8
2275	Delamping, Not Otherwise Specified	TBA
2278	Demand Limiting Controls	15
2279	Destratification	15
2304	Domestic Hot Water, Not Otherwise Specified	13
2305	Drycooler, Computer Room Air Conditioner Economizer	10
2313	ECM Motor, Not Otherwise Specified	15
2314	Energy Recovery Ventilator	15
2319	Fans, High Volume Low Speed (HVLS), Not Otherwise Specified	15
2320	Food Service, Not Otherwise Specified	15
2361	Furnace, Stack, Melting	15
2368	Grain Dryer, Energy Efficient	20
2600	Thermal Curtain, Not Otherwise Specified	5
2374	Guest Room Energy Management Controls, Not Otherwise Specified	8
2377	Heat Recovery, Compressor Heat Used For Space Heating	15
2378	Heat Recovery, Compressor Heat Used To Pre-heat DHW	15
2379	Heat Recovery, Not Otherwise Specified	15
2381	HVAC Controls, Air Side Economizer, Free Cooling	10

MMID	Measure Name	EUL (years)
2382	HVAC Controls, Scheduling/Setpoint Optimization	5
2383	HVAC Energy Management System	15
2385	HVAC, Low Temp System w/ Condensing Boilers	20
2386	HVAC, Not Otherwise Specified	15
2387	HVAC, Variable Refrigerant Flow/Volume Systems	15
2420	Induction Lighting, Not Otherwise Specified	15
2421	Industrial Oven or Furnace, Not Otherwise Specified	15
2423	Insulation, Attic, Not Otherwise Specified	25
2425	Insulation, Boiler Plumbing	15
2426	Insulation, Ceiling	25
2428	Insulation, Roof	25
2431	Insulation, Wall, Not Otherwise Specified	25
2432	Insulation, Water Heater, Not Otherwise Specified	6
2435	IT Systems, Cold Aisle Containment	5
2436	IT Systems, Not Otherwise Specified	5
2438	IT Systems, Server Consolidation	5
2440	IT Systems, Server Virtualization, Not Otherwise Specified	5
2441	IT Systems, Uninterruptible Power Supply	20
2443	Laundry Equipment - Not Otherwise Specified	15
2444	Laundry, Not Otherwise Specified	15
2454	LED, Loading Dock Fixture	12
2455	LED, Not Otherwise Specified	18
2459	LED, Traffic Lights	6
2461	Lighting Controls, Not Otherwise Specified	8
2462	Lighting Layout Reconfiguration	10
2463	Lighting, Not Otherwise Specified	12
2464	Mechanical Sub-Cooling	10
2470	Motor, Not Otherwise Specified	15
2489	Overhead Door Retrofit	20
2490	Plastics Equipment, Radiant Heater Band Retrofit	15
3796	Refrigeration System Tune-up, Agriculture	10
3386	Grain Dryer, Energy Efficient, Hybrid	20
2493	Pool, Not Otherwise Specified	15
2496	Pressure Screen Rotor	15
2497	Process Heat Recovery, Condensing Heat Exchanger	15
2498	Process Heat Recovery, Not Otherwise Specified	15
2499	Process, Not Otherwise Specified	15
2504	Pumping and Piping System Efficiency Improvement	15

MMID	Measure Name	EUL (years)
2505	Pumping, Shift To Off-peak	15
2507	Kiln Lumber Drying	5
2508	Radiant Tube Inserts, Not Otherwise Specified	5
2511	Refrigeration Economizer, Ambient Subcooling	15
2517	Refrigeration, Central Parallel Rack System Replacing Individual Units	10
2518	Refrigeration, Defrost Controls	10
2519	Refrigeration, Liquid Pressure Amplifiers	5
2520	Refrigeration, Not Otherwise Specified	16
2537	Regenerative Thermal Oxidizer (RTO)	12
2538	Repulper Rotor	15
2539	Rooftop Unit	15
2543	Steam Trap Repair, > 225 psig, General Heating	6
2545	Steam Trap Repair, 126-225 psig, General Heating	6
2547	Steam Trap Repair, 50-125 psig, General Heating	6
2589	T8, CEE, Not Otherwise Specified	15
409	Greenhouse Perimeter Insulation	15
598	Greenhouse Climate Controls	10
2253	Circulation Fan, High Efficiency, Ag	15
2272	Dairy Refrigeration, Scroll Compressors, Ag	15
2369	Greenhouse Roof Vents	10
2370	Greenhouse Thermal blanket	10
2376	Heat Recovery Tank, No Heating Element, Ag, Electric or Natural Gas	15
2433	Irrigation Measure, Not Otherwise Specified	15
2434	Irrigation Pressure Reduction, Nozzle Installation & Motor Downsizing	15
2468	Milk Pasteurization System, Ag, Electric	15
2469	Milk Pasteurization System, Ag, Natural Gas	15
2607	Ultraviolet, Not Otherwise Specified	20
2609	Unit Heater, Not Otherwise Specified	15
2610	Variable Speed Drive, Chilled Water Pump or Cooling Tower Condensing Pump	15
2619	Ventilation Controls, Kitchen Exhaust Hood	10
2491	Plate Heat Exchanger and Well Water Pre-Cooler	15
2640	VFD, Boiler Draft Fan	15
2641	VFD, Cooling Tower Fan	15
2492	Plate Heat Exchanger, Milk Pipeline, VFD On Milk Vacuum Pump, Ag	15
2643	VFD, HVAC Fan	15
2644	VFD, HVAC Heating Pump	15
2639	VFD, Ag Second Use Water System	15
2646	VFD, Pool Pump Motor	15

MMID	Measure Name	EUL (years)
2647	VFD, Process Fan	15
2648	VFD, Process Pump	15
2650	Waste Water Treatment, Not Otherwise Specified	20
2654	Water Heater, > 90% TE, Condensing, Residential	15
2655	Water Heater, Dual Thermostat, Ag, Natural Gas	15
2656	Water Heater, Fuel Switching, Electric to Natural Gas	15
2657	Water Heater, Fuel Switching, Electric to Natural Gas, Ag	15
2659	Water Heater, Not Otherwise Specified	13
2645	VFD, Not Otherwise Specified	15
2662	Weather Stripping Around Doors, Replacement	20
2663	Welder, Replace w/ High Efficiency Unit	13
2664	Well and Pump Installation	15
2676	High Intensity Discharge Lighting, Not Otherwise Specified	12
2680	HVAC Controls, Not Otherwise Specified	15
2690	Insulation, Attic	25
2710	Air Sealing, Project Based	20
2722	Ventilation Controls, Demand Controlled Ventilation	10
2723	Evaporative Condensers Replace Air-Cooled Condensers	10
2724	Ventilation Controls, Exhaust/Supply For Paint/Spray Booth	10
2726	VFD, Chilled Water Distribution Pump	15
2727	Aeration, Not Otherwise Specified	20
2745	Air Sealing	20
2747	Boiler, ≥ 90% AFUE, Natural Gas	20
2748	Boiler, 85-90% AFUE, Natural Gas	20
2755	Chiller, High Efficiency, Water Cooled, Replacement	20
2760	DHW Plant Replacement	15
2773	Windows, ENERGY STAR	20
2774	Insulation, DHW Plumbing	15
2775	Ventilation Controls	5
2808	T8 6L or T5HO 4L Replacing 400-999 W HID	15
2661	Waterer, Livestock, Not Otherwise Specified, Ag	10
2848	Compressed Air Process Load Shifting	20
2853	Ventilation Controls, Demand Control Ventilation For Air Handling Units	10
2911	Solar Thermal, Not Otherwise Specified	20
2912	Ground Source Heat Pump, Not Otherwise Specified	15
2916	Boiler, Not Otherwise Specified	20
2917	Chiller System, Not Otherwise Specified	20
2918	Compressed Air System, Not Otherwise Specified	15

MMID	Measure Name	EUL (years)
2919	Domestic Hot Water, Not Otherwise Specified	13
2920	Heat Recovery, Not Otherwise Specified	15
2921	HVAC Controls, Not Otherwise Specified	15
2922	HVAC, Not Otherwise Specified	15
2923	IT Systems, Not Otherwise Specified	5
2924	Lighting Controls, Not Otherwise Specified	8
2925	Motors, Not Otherwise Specified	15
2926	Pool, Not Otherwise Specified	5
2927	Process, Not Otherwise Specified	15
2928	Refrigeration, Not Otherwise Specified	15
2933	Roof Top Upgrade, DCV & Economizer, ≤ 7.5 Tons	10
2934	Roof Top Upgrade, DCV, ≤ 7.5 Tons	10
2935	Roof Top Upgrade, DCV, > 7.5 Tons	10
2936	Roof Top Upgrade, Economizer, ≤ 7.5 Tons	10
2937	Roof Top Upgrade, Thermostat & DCV, ≤ 7.5 Tons	10
2938	Roof Top Upgrade, Thermostat & Economizer, ≤ 7.5 Tons	10
2939	Roof Top Upgrade, Thermostat and DCV, > .5 Tons	10
2940	Roof Top Upgrade, Thermostat, ≤ 7.5 Tons	15
2941	Roof Top Upgrade, Thermostat, > 7.5 Tons	15
2942	Roof Top Upgrade, Thermostat, DCV, & Economizer, ≤ 7.5 Tons	10
2824	VFD, Ag Primary Use Water System	15
2960	T8 or T5HO ≤ 155W, Replacing 250-399W HID, Not Otherwise Specified	15
2961	T8 or T5HO ≤ 250W, Replacing 400-999W HID, Not Otherwise Specified	15
2962	T8 or T5HO 251-365W, Replacing 400-999W HID, Not Otherwise Specified	15
2963	T8 or T5HO ≤ 500W, Replacing ≥ 1,000W HID, Not Otherwise Specified	15
2964	T8 or T5HO ≤ 800W, Replacing 1,000W HID, Not Otherwise Specified	15
3016	Ventilation Controls, Parking Lot	5
3022	A/C Split or Packaged System, High Efficiency	15
3045	Water Heater, High Usage, ≥ 90% TE, Natural Gas	10
3046	Water Heater, High Usage, ≥ 0.82 EF, Tankless, Natural Gas	15
3047	Water Heater, High Usage, ≥ 2 EF, Heat Pump Storage, Electric	15
3059	A/C Coil Cleaning, < 10 tons	3
3060	A/C Coil Cleaning, > 20 tons	3
3061	A/C Coil Cleaning, 10-20 tons	3
3062	A/C Refrigerant Charge Correction, < 10 tons	10
3063	A/C Refrigerant Charge Correction, > 20 tons	10
3064	A/C Refrigerant Charge Correction, 10-20 tons	10

MMID	Measure Name	EUL (years)
3066	Economizer, RTU Optimization	10
3120	Programmable Thermostat, RTU Optimization Advanced	5
3121	Programmable Thermostat, RTU Optimization Standard	5
3244	Process Exhaust Filtration	15
3266	Demand Control Ventilation, RTU Optimization	15
3280	VFD, Constant Torque	15
3493	Parking Garage Ventilation Controls with Heating	5
3598	Compressed Air System Leak Survey and Repair, Year 4 and Beyond	2
3835	VFD, Process Pump, Agriculture	15
3836	VFD, Constant Torque, Agriculture	15

Appendix D: Incremental Costs

MMID	Measure Name	Source	Incremental Cost
566	PC Network Energy Management System	2012 Historical Project Data, Small Business Program; 166 projects average cost = $36.97.	$36.97
598	Greenhouse Climate Controls, Hybrid	Historical Project Data, 2016. Agriculture, Schools and Government Program; 4 Projects, 01/2016 to 06/2016. Average Cost is $0.11 per square foot.	$0.11/sq ft
1981	Gas Furnace with ECM, 95+ AFUE (Existing)	2013, Program Implementer CLEAResult surveyed 40 Trade Allies at length concerning cost points at various AFUE increments, both with and without staging and with or without ECMs. CLEAResult took the average reported cost for a 92% furnace with no staging and no ECM and subtracted that amount from the average reported cost for a 95% multi-stage with ECM.	$345.93
1983	Hot Water Boiler, 95%+ AFUE	2013, Program Implementer CLEAResult surveyed 40 Trade Allies and took the average reported cost for an 82% boiler and subtracted that amount from the average reported cost for a 95% boiler.	$3,105.00
1986	Water Heater, Condensing	Illinois Technical Reference Manual, Commercial and Industrial. 2015. Page 87. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_5/Final/IL-TRM_Effective_060116_v5.0_Vol_2_C_and_I_021116_Final.pdf	$440.00
1987	Tankless Water Heater, EF 0.82+	California Energy Commission and California Public Utilities Commission. Database for Energy Efficient Resources (DEER) 2008. Also, RSMeans. Facilities Construction Cost Data. 2011. Available online: http://www.deeresources.com/index.php/ex-ante-database	$454.09
1988	Water Heater, Indirect	New York Statewide Residential Gas High Efficiency Heating Equipment Programs: Evaluation of 2009-2011 Programs. Average of mean and median costs using both approaches, in Table 1-4. Available online: http://www.coned.com/energyefficiency/PDF/EEPS%20CY1%20NY%20HEHE%20Evaluation%20Report%20FINAL%20APPROVED%202014-08-21.pdf	$988.50
1989	Water Heater, Electric, EF 0.93 or greater	California Energy Commission and California Public Utilities Commission. Database for Energy Efficient Resources (DEER) 2008. Also, RSMeans. Facilities Construction Cost Data. 2011. Available online: http://www.deeresources.com/index.php/ex-ante-database	$25.16

MMID	Measure Name	Source	Incremental Cost
2120	Faucet Aerator, Non PI Direct Install, 1.5 gpm, Kitchen, NG	DEER 2015. California Database for Energy Efficient Resources. $6.70 labor + $2.80 materials = $9.50. Available online: http://www.deeresources.com/index.php/ex-ante-database	$9.50
2121	Faucet Aerator, Non PI Direct Install, 1.0 gpm, Bathroom, NG	DEER 2015. California Database for Energy Efficient Resources, $6.70 labor + $6.54 materials = $13.24. Available online: http://www.deeresources.com/index.php/ex-ante-database	$13.24
2123	Low-flow Showerhead, 1.5 gpm, Gas MF	$5.00 = WESCO Distribution Pricing ($3.11) + Labor ($1.89)	$5.00
2126	Faucet Aerator, Non PI Direct Install, 1.5 gpm, Kitchen, Electric	DEER 2015. California Database for Energy Efficient Resources, $6.70 labor + $2.80 materials = $9.50. Available online: http://www.deeresources.com/index.php/ex-ante-database	$9.50
2127	Faucet Aerator, Non PI Direct Install, 1.0 gpm, Bathroom, Electric	DEER 2015. California Database for Energy Efficient Resources, $6.70 labor + $6.54 materials = $13.24. Available online: http://www.deeresources.com/index.php/ex-ante-database	$13.24
2129	Low-flow Showerhead, 1.5 gpm, Electric	$5.00 = WESCO Distribution Pricing ($3.11) + Labor ($1.89)	$5.00
2132	CFL, Direct Install, 9 Watt	Light bulb sales data obtained by Cadmus for California- 2010 through 2012. Note that the CFL average lamp costs include incented lamps.	$1.03
2133	CFL, Direct Install, 14 Watt	Evaluator research for ENERGY STAR®, March 2016. Average costs from online research including Lowes, Home Deport, and 1000bulbs.com.	$1.84
2134	CFL, Direct Install, 19 Watt	Light bulb sales data obtained by Cadmus for California- 2010 through 2012. Note that the CFL average lamp costs include incented lamps.	$0.38
2135	CFL, Direct Install 23W	Evaluator research for ENERGY STAR®, March 2016. Average costs from online research including Lowes, Home Deport, and 1000bulbs.com.	$2.58
2136	Faucet Aerators, Direct Install, 1.5 gpm, Kitchen, NG	DEER 2015. California Database for Energy Efficient Resources, $6.70 labor + $2.80 materials = $9.50. Available online: http://www.deeresources.com/index.php/ex-ante-database	$9.50
2137	Faucet Aerator, Direct Install, 1.0 gpm, Bathroom, NG	DEER 2015. California Database for Energy Efficient Resources, $6.70 labor + $6.54 materials = $13.24. Available online: http://www.deeresources.com/index.php/ex-ante-database	$13.24

MMID	Measure Name	Source	Incremental Cost
2139	Low-flow Showerhead, 1.5 gpm, Gas	$5.00 = WESCO Distribution Pricing ($3.11) + Labor ($1.89)	$5.00
2140	WATER SAVING SHOWER HEADS, DIRECT INSTALL, NG	$5.00 = WESCO Distribution Pricing ($3.11) + Labor ($1.89)	$5.00
2141	DHW Temperature Turn Down, Direct Install, NG	N/A	$0.00
2145	Low-flow Showerhead, 1.5 gpm, Electric MF	$5.00 = WESCO Distribution Pricing ($3.11) + Labor ($1.89)	$5.00
2146	WATER SAVING SHOWER HEADS, DIRECT INSTALL, ELEC	$5.00 = WESCO Distribution Pricing ($3.11) + Labor ($1.89)	$5.00
2147	DHW Temperature Turn Down, Electric	N/A	$0.00
2150	Cololer Miser-Direct Install	Online Research, 2016, CoolerMiser model CM150. Available online: http://www.vendingmiserstore.com/product/energymiser-coolermiser-master-unit-cm150	$169.00
2155	Low Flow Faucet Aerators, Direct Install, Electric, Kitchen	DEER 2015. California Database for Energy Efficient Resources, $6.70 labor + $2.80 materials = $9.50. Available online: http://www.deeresources.com/index.php/ex-ante-database	$9.50
2156	Low Flow Faucet Aerators, Direct Install, Natural Gas, Kitchen	DEER 2015. California Database for Energy Efficient Resources, $6.70 labor + $2.80 materials = $9.50. Available online: http://www.deeresources.com/index.php/ex-ante-database	$9.50
2158	Pre-rinse Spray Valve, Electric MF	Price data for Niagara Conservation branded Power Rinser Pre-Rinse Spray Valve, Niagara N2180. Available online: www.conservationmart.com/p-301-niagara-128-gpm-prerinse-kitchen-spray-n2180.aspx	$37.50
2159	Pre-rinse Spray Valve, Gas MF	Price data for Niagara Conservation branded Power Rinser Pre-Rinse Spray Valve, Niagara N2180. Available online: www.conservationmart.com/p-301-niagara-128-gpm-prerinse-kitchen-spray-n2180.aspx	$37.50
2192	A/C Split System < 65 MBh SEER 15	DEER 2015. California Database for Energy Efficient Resources, $184.25 per ton. Average tonnage verified 2.42 tons per 2013-	$445.89

MMID	Measure Name	Source	Incremental Cost
		2016 Multifamily Program Data, 16 projects. Available online: http://www.deeresources.com/index.php/ex-ante-database	
2193	A/C Split System < 65 MBh SEER 16 or greater	DEER 2015. California Database for Energy Efficient Resources, $276.38 per ton. Average tonnage verified 1.57 tons per 2013-2016 Multifamily Program Data, 20 projects. Available online: http://www.deeresources.com/index.php/ex-ante-database	$433.92
2194	A/C Split System < 65 MBh SEER 14	DEER 2015. California Database for Energy Efficient Resources, $92.13 per ton. Average tonnage verified 2.76 tons per 2013-2016 Multifamily Program Data, 8 projects. Available online: http://www.deeresources.com/index.php/ex-ante-database	$254.28
2196	VSD Air Compressor, Hybrid	Illinois Technical Reference Manual. 2013. Page 141. $127 per hp. 2016 program data has an average compressor of 60 hp; 360 projects. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$7,620.00
2197	Anti-sweat heater controls, on freezer case with low-heat door	San Diego Gas & Electric. Work Paper WPSDGENRRN0009. Anti-Sweat Heat (ASH) Controls. Revision# 0. Cost per linear foot = $34.00; Cost calculated per door assuming 2.5 ft. door average.	$85.00
2198	Anti-sweat heater controls, on freezer case with no-heat door	San Diego Gas & Electric. Work Paper WPSDGENRRN0009. Anti-Sweat Heat (ASH) Controls. Revision# 0. Cost per linear foot = $34.00; Cost calculated per door assuming 2.5 ft. door average.	$85.00
2199	Anti-sweat heater controls, on freezer case with standard door	San Diego Gas & Electric. Work Paper WPSDGENRRN0009. Anti-Sweat Heat (ASH) Controls. Revision# 0. Cost per linear foot = $34.00; Cost calculated per door assuming 2.5 ft. door average.	$85.00
2200	Anti-sweat heater controls, on refrigerated case with low-heat or no-heat doors	San Diego Gas & Electric. Work Paper WPSDGENRRN0009. Anti-Sweat Heat (ASH) Controls. Revision# 0. Cost per linear foot = $34.00; Cost calculated per door assuming 2.5 ft. door average.	$85.00
2201	Anti-sweat heater controls, on refrigerated case with standard door	San Diego Gas & Electric. Work Paper WPSDGENRRN0009. Anti-Sweat Heat (ASH) Controls. Revision# 0. Cost per linear foot = $34.00; Cost calculated per door assuming 2.5 ft. door average.	$85.00

MMID	Measure Name	Source	Incremental Cost
2203	High Turn Down Burner - NEW	Actual Program Data, 2013-2014. 10 Projects, Average is $94.52 per bhp.	$94.52/bhp
2205	Linkageless Boiler Control, per hp	Actual Program Data, 2013-2014. 6 Projects, Average is $75.55 per bhp.	$75.55/bhp
2206	Boiler oxygen trim controls, per hp	Actual Program Data, 2013-2014. 6 Projects, Average is $36.50 per bhp.	$36.50/bhp
2209	Boiler Plant 1M - 5M, Mid Efficiency - NEW	2012 Historical Project Data. 16.43 per MBh average cost.	$16.43/MBh
2211	Boiler Tune-up - service buy down	Illinois Technical Reference Manual. 2013. Page 160. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$0.83/MBh per tune-up
2217	Boiler, hot water, high efficiency modulating, for space heating (AFUE >= 90%)	Similar to MMID 2218. Historical Focus on Energy project data, Nonresidential Sector, 2013. 136 boilers on 100 projects, average total cost is $50.25/MBH	$50.25/MBH
2218	Boiler, Hot Water, Modulating, >=90% AFUE, < 300 mbh	Historical Focus on Energy project data, Nonresidential Sector, 2013. 136 boilers on 100 projects, average total cost is $50.25 per MBh	$50.25/MBh
2221	Boiler Control - Outside Air Reset/Cutout	Illinois Technical Reference Manual. 2013. Page 187. Boiler outside air reset/cutout controls cost is $612.00 per set of controls. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$612.00
2234	Case door, freezer, low heat	Price sheets for Styleline Classic II Plus and Hybridoor freezers, and Anthony 401, 101, and Infinity freezers. Sept 2016.	$548.67
2235	Case door, freezer, no heat	Price sheets for Styleline Classic II Plus freezer, and Anthony ELM, ELM 2, and 401 freezers. Sept 2016.	$121.00
2236	Case door, refrigerated, no heat	Price sheets for Styleline Classic II Plus cooler, and Anthony ELM, ELM 2, 101, 101 No Heat, 401, Infinity, Vista C, and Vista B coolers. Sept 2016.	$208.83
2237	Ceramic Metal Halide (CMH) Fixture, 20-70 Watts	Evaluator Online Research, May 2016. From: http://www.warehouse-lighting.com. Baseline cost is $22.44 for single end metal halides. Average cost of 39 Watt Metal halide is $43.42.	$21.00
2238	Ceramic Metal Halide (CMH) Lamp, ≤ 25 Watts	Evaluator Online Research, May 2016. From: http://www.warehouse-lighting.com. Baseline cost is $8.27 for	$61.84

MMID	Measure Name	Source	Incremental Cost
		120 watt incandescents. Average cost of 20-25 Watt metal halide flood is $70.14.	
2239	CFL Fixture, ≤100 Watts	Historical value, from online research	$7.29
2243	CFL High Wattage 31-115 Watts, replacing incandescent	Actual cost from 2015-16 program data. 11 applications, 2014 - 2015.	$87.00
2245	CFL Cold Cathode Screw-In, replacing incandescent	Online Research	$7.16
2246	CFL reflector flood lamps replacing incandescent reflector flood lamps	Online research on 1000bulbs.com comparing 250 watt PAR38 Halogen ($15.00 average) with 50-65 watt CFL ($18.00 average).	$3.00
2249	High Efficiency Chillers - Retrofit, air cooled all sizes	Northeast Energy Efficiency Partnerships. January 2013. Incremental Cost Study Phase Two Final Report: A Report on 12 Energy Efficiency Measure Incremental Costs in Six Northeast and Mid-Atlantic Markets. $300.00 is average cost of Air-Cooled Chiller Incremental Cost/Ton Estimates Baseline EER = 9.60 and Efficient EER= 10.52. Capacity is 50- 400 tons. Available online: http://www.neep.org/incremental-cost-study-phase-2	$300.00/ton
2250	High Efficiency Chillers - Retrofit, water cooled < 150 tons, Hybrid	Northeast Energy Efficiency Partnerships. January 2013. Incremental Cost Study Phase Two Final Report: A Report on 12 Energy Efficiency Measure Incremental Costs in Six Northeast and Mid-Atlantic Markets. $42.00 is cost of 150 Ton Water-Cooled Scroll/Screw Chiller Incremental Cost/Ton. Baseline Efficiency= 0.78 kW per ton and Efficient Condition = 0.68 kW per ton. Available online: http://www.neep.org/incremental-cost-study-phase-2	$42.00/ton
2251	High Efficiency Chillers - Retrofit, water cooled >= 300 tons	Northeast Energy Efficiency Partnerships. January 2013. Incremental Cost Study Phase Two Final Report: A Report on 12 Energy Efficiency Measure Incremental Costs in Six Northeast and Mid-Atlantic Markets. $31.00 is cost of 400 Ton Water-Cooled Scroll/Screw Chiller Incremental Cost/Ton. Baseline Efficiency= 0.78 kW per ton and Efficient Condition = 0.68 kW per ton. Available online: http://www.neep.org/incremental-cost-study-phase-2	$31.00/ton

MMID	Measure Name	Source	Incremental Cost
2252	High Efficiency Chillers - Retrofit, water cooled >= 150 tons and < 300 tons	Northeast Energy Efficiency Partnerships. January 2013. Incremental Cost Study Phase Two Final Report: A Report on 12 Energy Efficiency Measure Incremental Costs in Six Northeast and Mid-Atlantic Markets. $61.00 is cost of 200 Ton Water-Cooled Scroll/Screw Chiller Incremental Cost/Ton. Baseline Efficiency= 0.78 kW per ton and Efficient Condition = 0.68 kW per ton. Available online: http://www.neep.org/incremental-cost-study-phase-2	$61.00/ton
2253	Agricultural Circulation Fan, High Efficiency, Per Inch od Fan Diameter -	Illinois Technical Reference Manual. 2013. Agriculture circulation or exhaust fan incremental cost (all sizes) is $150.00 each. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$150.00
2254	No Loss Air Condensate Drains NEW	Costs in Six Northeast and Mid-Atlantic Markets. $42.00 is cost of 150 Ton Water-Cooled Scroll/Screw Chiller Incremental Cost/Ton. Baseline Efficiency= 0.78 kW per ton and Efficient Condition = 0.68 kW per ton. Available online: http://www.neep.org/incremental-cost-study-phase-2	$42.00/ton
2255	Pressure/Flow Controllers, NEW	71 past projects since 2012, with average cost of $27.15 per hp.	$27.15/hp
2258	Compressed Air Mist Eliminators, NEW	Actual Program Data, 2014-2015. 24 projects, average cost of $21.55 per hp installed.	$21.55/hp
2259	Compressed Air Nozzles, Air Entraining	Focus on Energy Historical Project Data. 2013.	$36.42/nozzle
2261	Compressed Air System Leak Survey and Repair, Hybrid	Historical project data. 3 projects from 2013 - 2014.	$8.15/hp
2262	Compressed Air System Leak Survey and Repair, Year 2	Historical project data. 2 projects from 2013 - 2014.	$6.41/hp
2263	Compressed Air System Leak Survey and Repair, Year 3	Historical project data. 3 projects from 2013 - 2014.	$5.71/hp
2264	Cycled Refrigeration Thermal Mass Air Dryers NEW	Illinois Statewide Technical Reference Manual for Energy Efficiency, Version 5.0, Volume 2. (2016). Page 476. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_5/Final/IL-TRM_Effective_060116_v5.0_Vol_2_C_and_I_021116_Final.pdf	$6.00/CFM

MMID	Measure Name	Source	Incremental Cost
2269	Cooler Evaporator Fan Control	Northeast Energy Efficiency Partnerships. January 2013. Incremental Cost Study Phase Two Final Report: A Report on 12 Energy Efficiency Measure Incremental Costs in Six Northeast and Mid-Atlantic Markets. $31.00 is cost of 400 Ton Water-Cooled Scroll/Screw Chiller Incremental Cost/Ton. Baseline Efficiency= 0.78 kW per ton and Efficient Condition = 0.68 kW per ton. Available online: http://www.neep.org/incremental-cost-study-phase-2	$31.00/ton
2271	Night Curtains for Open Coolers, per linear foot	Focus on Energy Project Data. 2013. 26 projects, average cost is $38.21 per foot.	$38.21/ft
2272	Scroll Compressors for Dairy Refrigeration, Hybrid	2013 Focus on Energy Project Data. 49 Agriculture Emasures, average cost= $6,201.00.	$6,201.00
2276	DELAMPING, DIRECT INSTALL, 4 FOOT LAMP	Actual program cost from 2015-16 program data, where available, 23 applications.	$51.75
2277	Delamping, T8 to T8	Actual program cost from 2015-16 program data, where available, 23 applications.	$11.59
2280	Dishwasher, Low Temp, Door Type, Energy Star, Energy Star, Electric	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 03/2016. Stationary Single Tank Door Cost. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2281	Dishwasher, High Temp, Electric Booster, Door Type, Energy Star, Electric	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 03/2016. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2282	Dishwasher, High Temp, Electric Booster, Door Type, Energy Star, NG	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 03/2016. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2283	Dishwasher, High Temp, Electric Booster, Multi Tank Conveyor, Energy Star, Electric	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 03/2016. Multi Tank Conveyor Cost. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$970.00
2284	Dishwasher, High Temp, Electric	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 03/2016. Multi Tank Conveyor Cost. Available online:	$970.00

MMID	Measure Name	Source	Incremental Cost
	Booster, Multi Tank Conveyor, Energy Star, NG	https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	
2285	Dishwasher, High Temp, Electric Booster, Single Tank Conveyor, Energy Star, Electric	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 01/2016. High temperature single tank converyor type. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$2,050.00
2286	Dishwasher, High Temp, Electric Booster, Single Tank Conveyor, Energy Star, NG	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 01/2016. High temperature single tank conveyor type. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$2,050.00
2287	Dishwasher, High Temp, Electric Booster, Under Counter, Energy Star, Electric	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 03/2016. High temperature single tank conveyor type. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$120.00
2288	Dishwasher, High Temp, Electric Booster, Under Counter, Energy Star, NG	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 03/2016. High temperature single tank conveyor type. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$120.00
2289	Dishwasher, High Temp, Gas Booster, Door Type, Energy Star, NG	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 03/2016. High temperature single tank conveyor type. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$770.00
2290	Dishwasher, High Temp, Gas Booster, Multi Tank Conveyor, Energy Star, NG	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 01/2016. High temperature multi tank conveyor type. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$970.00
2291	Dishwasher, High Temp, Gas Booster, Single Tank Conveyor, Energy Star, NG	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 01/2016. High temperature single tank conveyor type. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$2,050.00

MMID	Measure Name	Source	Incremental Cost
2292	Dishwasher, High Temp, Gas Heat, Gas Booster, Under Counter, Energy Star, NG	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 03/2016. High temperature single tank conveyor type. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$120.00
2293	Dishwasher, Low Temp, Door Type, Energy Star, NG	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 03/2016. High temperature single tank conveyor type. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2294	Dishwasher, Low Temp, Multi Tank Conveyor, Energy Star, Electric	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 01/2016. Multi tank conveyor low temperature type. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$970.00
2295	Dishwasher, Low Temp, Multi Tank Conveyor, Energy Star, NG	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 01/2016. Multi tank conveyor low temperature type. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$970.00
2296	Dishwasher, Low Temp, Single Tank Conveyor, Energy Star, Electric	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 01/2016. High temperature single tank conveyor type. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2297	Dishwasher, Low Temp, Single Tank Conveyor, Energy Star, NG	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 01/2016. High temperature single tank conveyor type. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2298	Dishwasher, Low Temp, Under Counter, Energy Star, Electric	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 03/2016. High temperature single tank conveyor type. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$50.00
2299	Dishwasher, Low Temp, Under Counter, Energy Star, NG	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 03/2016. High temperature single tank conveyor type. Available online:	$50.00

MMID	Measure Name	Source	Incremental Cost
		https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	
2301	Dock Ramp/Pit Seal, Replacement	Implementer online retailer research. Accessed 01/2016. Price per dock ramp/pit seal, Material cost is $1,000.00 and $250.00 is labor, Incremental Cost = $1,250.00. Available online: https://appliedhandling.com/loading-docks/dock-seals-and-shelters/	$1,250.00
2302	Dock Seal, Added to Existing Barrier	Implementer online retailer research, Global Equipment Company, Inc. , Grainger, Northern Tool. Accessed 01/2016. Per dock seal, Material cost is $1,020.41 and $350.00 is labor, Incremental Cost = $1,370.41. http://www.globalindustrial.com/c/material-handling/dock-truck/dock-seals-shelters-roll-up-doors; https://www.grainger.com/category/dock-seals/dock-equipment/material-handling/ecatalog/N-9r6; http://www.northerntool.com/shop/tools/category_material-handling+loading-dock-equipment+dock-seals-shelters	$1,370.41
2303	Dock Seals, New	Implementer online retailer research, Global Equipment Company, Inc. , Grainger, Northern Tool. Accessed 01/2016. Per dock seal, Material cost is $1,020.41 and $350.00 is labor, Incremental Cost = $1,370.41. http://www.globalindustrial.com/c/material-handling/dock-truck/dock-seals-shelters-roll-up-doors; https://www.grainger.com/category/dock-seals/dock-equipment/material-handling/ecatalog/N-9r6; http://www.northerntool.com/shop/tools/category_material-handling+loading-dock-equipment+dock-seals-shelters	$1,370.41
2305	Drycooler, Computer Room Air Conditioner Economizer	Historical Project Data, 2016. Agriculture, Schools and Government Program; 4 Projects, 11/2012 - 2/2014. Average Cost is $9,858.62.	$9,858.62
2306	Compressor Cooler Motor, ECM - NEW	Regional Technical Forum, UES Measures. "Commercial: Grocery - Compressor Head Fan Motor Retrofit to ECM." Measure Workbook 2.2, June 29, 2016. $260.00 for all "Compressor Head Fan Motor Retrofit to ECM" measures. Available online: http://rtf.nwcouncil.org/measures/measure.asp?id=106	$260.00
2307	ECM (electronically commutated) Condenser/	Regional Technical Forum, UES Measures. "Commercial: Grocery - Compressor Head Fan Motor Retrofit to ECM." Measure Workbook 2.2, June 29, 2016. $260.00 for all "Compressor Head	$260.00

MMID	Measure Name	Source	Incremental Cost
	Condensing Unit Fan Motor	Fan Motor Retrofit to ECM" measures. Available online: http://rtf.nwcouncil.org/measures/measure.asp?id=106	
2308	ECM (electronically commutated) evaporator fan motor replacing shaded-pole motor, <1/20 hp, in walk-in cooler	Regional Technical Forum, UES Measures. "Commercial: Grocery - ECMs for Walk-ins." Measure Workbook 2.2, June 29, 2016.$260.00 for all "ECMs for Walk-ins" measures. Available online: http://rtf.nwcouncil.org/measures/measure.asp?id=162	$260.00
2309	ECM (electronically commutated) evaporator fan motor replacing shaded-pole motor, >=1/20 hp, <1hp, in walk-in cooler	Regional Technical Forum, UES Measures. "Commercial: Grocery - ECMs for Walk-ins." Measure Workbook 2.2, June 29, 2016. $260.00 for all "ECMs for Walk-ins" measures. Available online: http://rtf.nwcouncil.org/measures/measure.asp?id=162	$260.00
2310	ECM (electronically commutated) evaporator fan motor replacing shaded-pole motor, <1/20 hp, in walk-in freezer	Regional Technical Forum, UES Measures. "Commercial: Grocery - ECMs for Walk-ins." Measure Workbook 2.2, June 29, 2016. $260.00 for all "ECMs for Walk-ins" measures. Available online: http://rtf.nwcouncil.org/measures/measure.asp?id=162	$260.00
2311	ECM (electronically commutated) evaporator fan motor replacing shaded-pole motor, >=1/20 hp, <1hp, in walk-in freezer	Regional Technical Forum, UES Measures. "Commercial: Grocery - ECMs for Walk-ins." Measure Workbook 2.2, June 29, 2016. $260.00 for all "ECMs for Walk-ins" measures. Available online: http://rtf.nwcouncil.org/measures/measure.asp?id=162	$260.00
2312	ECM (electronically commutated) motor replacing shaded-pole motor in refrig/freezer case	Regional Technical Forum, UES Measures. "Commercial: Grocery - ECMs for Display Cases." Measure Workbook 3.2, June 29, 2016. $84.45 for all "ECMs for Display Cases" measures. Available online: http://rtf.nwcouncil.org/measures/measure.asp?id=107	$84.45
2314	Energy recovery ventilator, Hybrid	Historical Focus on Energy project data, 2012-2013. 86 projects, excluded high cost per CFM that may be for complete AHU replacement, average cost of ERV is $6.14 per CFM.	$6.14/CFM
2316	High Volume Low Speed (HVLS) fans	RSMeans Mechanical Cost Data, 2012, Box Fan [Equipment].	$4,689.88

MMID	Measure Name	Source	Incremental Cost
	replace Box Fans, 20 ft		
2317	High Volume Low Speed (HVLS) fans replace Box Fans, 22 ft	RSMeans Mechanical Cost Data, 2012, Box Fan [Equipment].	$4,689.88
2318	High Volume Low Speed (HVLS) fans replace Box Fans, 24 ft	RSMeans Mechanical Cost Data, 2012, Box Fan [Equipment].	$4,689.88
2321	Freezer, Chest, Glass Door, < 15 cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 01/2016. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2322	Freezer, Chest, Glass Door, 15-29 cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 01/2016. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2323	Freezer, Chest, Glass Door, 30-49 cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 01/2016. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2324	Freezer, Chest, Glass Door, 50+ cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 01/2016. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2325	Freezer, Chest, Solid Door, < 15 cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 01/2016. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2326	Freezer, Chest, Solid Door, 15-29 cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 01/2016. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2327	Freezer, Chest, Solid Door, 30-49 cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 01/2016. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00

MMID	Measure Name	Source	Incremental Cost
2328	Freezer, Chest, Solid Door, 50+ cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 01/2016. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2329	Freezer, Vertical, Glass Door, < 15 cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 01/2016. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2330	Freezer, Vertical, Glass Door, 15-29 cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 01/2016. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2331	Freezer, Vertical, Glass Door, 30-49 cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 01/2016. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2332	Freezer, Vertical, Glass Door, 50+ cu ft,Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 01/2016. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2333	Freezer, Vertical, Solid Door, < 15 cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 01/2016. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2334	Freezer, Vertical, Solid Door, 15-29 cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 01/2016. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2335	Freezer, Vertical, Solid Door, 30-49 cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 01/2016. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2336	Freezer, Vertical, Solid Door, 50+ cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 01/2016. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00

MMID	Measure Name	Source	Incremental Cost
2337	Fryer, Electric, ENERGY STAR	ENERGY STAR® Commercial Kitchen Savings Calculator. Accessed 03/11/2016. Available online: https://www.energystar.gov/products/commercial_food_service_equipment	$1,120.00
2338	Fryer, Gas, ENERGY STAR	Illinois Technical Reference Manual. 2013. Page 89. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf. Gas fryer incremental cost is $1,200.00 per fryer.	$1,200.00
2350	Furnace, with ECM fan motor, for space heating (AFUE >= 95%), 109.9 - 120.7 MBh	NEEP Regional Evaluation, Measurement & Verification Forum, A Report on Costs in Six Northeast & Mid-Atlantic Markets. 2011. Navigant Consulting. Navigant study completed 15 interviews for this measure. Available online: http://www.neep.org/Assets/uploads/files/emv/emv-products/Incremental%20Cost_study_FINAL_REPORT_2011Sep23.pdf	$1,688.71
2352	Furnace, with ECM fan motor, for space heating (AFUE >= 95%), 133.0 - 146.1 MBh	NEEP Regional Evaluation, Measurement & Verification Forum, A Report on Costs in Six Northeast & Mid-Atlantic Markets. 2011. Navigant Consulting. Navigant study completed 15 interviews for this measure. Available online: http://www.neep.org/Assets/uploads/files/emv/emv-products/Incremental%20Cost_study_FINAL_REPORT_2011Sep23.pdf	$1,708.52
2354	Furnace, with ECM fan motor, for space heating (AFUE >= 95%), 54.675 - 60.749 MBh	NEEP Regional Evaluation, Measurement & Verification Forum, A Report on Costs in Six Northeast & Mid-Atlantic Markets. 2011. Navigant Consulting. Navigant study completed 15 interviews for this measure. Available online: http://www.neep.org/Assets/uploads/files/emv/emv-products/Incremental%20Cost_study_FINAL_REPORT_2011Sep23.pdf	$1,629.71
2355	Furnace, with ECM fan motor, for space heating (AFUE >= 95%), 60.750 - 67.499 MBh	NEEP Regional Evaluation, Measurement & Verification Forum, A Report on Costs in Six Northeast & Mid-Atlantic Markets. 2011. Navigant Consulting. Navigant study completed 15 interviews for this measure. Available online: http://www.neep.org/Assets/uploads/files/emv/emv-products/Incremental%20Cost_study_FINAL_REPORT_2011Sep23.pdf	$1,629.71
2356	Furnace, with ECM fan motor, for space heating (AFUE >= 95%), 67.5 - 74.9 MBh	NEEP Regional Evaluation, Measurement & Verification Forum, A Report on Costs in Six Northeast & Mid-Atlantic Markets. 2011. Navigant Consulting. Navigant study completed 15 interviews for this measure. Available online: http://www.neep.org/Assets/uploads/files/emv/emv-products/Incremental%20Cost_study_FINAL_REPORT_2011Sep23.pdf	$1,640.50

MMID	Measure Name	Source	Incremental Cost
2357	Furnace, with ECM fan motor, for space heating (AFUE >= 95%), 75.0 - 82.5 MBh	NEEP Regional Evaluation, Measurement & Verification Forum, A Report on Costs in Six Northeast & Mid-Atlantic Markets. 2011. Navigant Consulting. Navigant study completed 15 interviews for this measure. Available online: http://www.neep.org/Assets/uploads/files/emv/emv-products/Incremental%20Cost_study_FINAL_REPORT_2011Sep23.pdf	$1,650.50
2358	Furnace, with ECM fan motor, for space heating (AFUE >= 95%), 82.5 - 90.75 MBh	NEEP Regional Evaluation, Measurement & Verification Forum, A Report on Costs in Six Northeast & Mid-Atlantic Markets. 2011. Navigant Consulting. Navigant study completed 15 interviews for this measure. Available online: http://www.neep.org/Assets/uploads/files/emv/emv-products/Incremental%20Cost_study_FINAL_REPORT_2011Sep23.pdf	$1,650.50
2359	Furnace, with ECM fan motor, for space heating (AFUE >= 95%), 90.76 - 99.82 MBh	NEEP Regional Evaluation, Measurement & Verification Forum, A Report on Costs in Six Northeast & Mid-Atlantic Markets. 2011. Navigant Consulting. Navigant study completed 15 interviews for this measure. Available online: http://www.neep.org/Assets/uploads/files/emv/emv-products/Incremental%20Cost_study_FINAL_REPORT_2011Sep23.pdf	$1,660.50
2360	Furnace, with ECM fan motor, for space heating (AFUE >= 95%), 99.83 - 109.8 MBh	NEEP Regional Evaluation, Measurement & Verification Forum, A Report on Costs in Six Northeast & Mid-Atlantic Markets. 2011. Navigant Consulting. Navigant study completed 15 interviews for this measure. Available online: http://www.neep.org/Assets/uploads/files/emv/emv-products/Incremental%20Cost_study_FINAL_REPORT_2011Sep23.pdf	$1,670.50
2362	Glazing, Triple Poly Carbonate, Roof and Walls, Double Pane Replacement	Work Paper PGECOAGR102, Greenhouse IR Film. 2008. Available online: https://www.socalgas.com/regulatory/documents/a-08-07-022/amendedWorkpapers/SW-AgB/Greenhouse%20IR%20Film%20PGECOAGR102%20R0.pdf	$0.021/sq ft
2363	Glazing, Triple Poly Carbonate, Roof and Walls, Single Pane Replacement	Work Paper PGECOAGR102, Greenhouse IR Film. 2008. Available online: https://www.socalgas.com/regulatory/documents/a-08-07-022/amendedWorkpapers/SW-AgB/Greenhouse%20IR%20Film%20PGECOAGR102%20R0.pdf	$0.021/sq ft
2364	Glazing, Triple Poly Carbonate, Roof, Double Pane Replacement	Work Paper PGECOAGR102, Greenhouse IR Film. 2008. Available online: https://www.socalgas.com/regulatory/documents/a-08-07-022/amendedWorkpapers/SW-AgB/Greenhouse%20IR%20Film%20PGECOAGR102%20R0.pdf	$0.021/sq ft
2365	Glazing, Triple Poly Carbonate, Roof,	Work Paper PGECOAGR102, Greenhouse IR Film. 2008. Available online: https://www.socalgas.com/regulatory/documents/a-08-	$0.021/sq ft

MMID	Measure Name	Source	Incremental Cost
	Single Pane Replacement	07-022/amendedWorkpapers/SW-AgB/Greenhouse%20IR%20Film%20PGECOAGR102%20R0.pdf	
2366	Glazing, Triple Poly Carbonate, Walls, Double Pane Replacement	Work Paper PGECOAGR102, Greenhouse IR Film. 2008. Available online: https://www.socalgas.com/regulatory/documents/a-08-07-022/amendedWorkpapers/SW-AgB/Greenhouse%20IR%20Film%20PGECOAGR102%20R0.pdf	$0.021/sq ft
2367	Glazing, Triple Poly Carbonate, Walls, Single Pane Replacement	Work Paper PGECOAGR102, Greenhouse IR Film. 2008. Available online: https://www.socalgas.com/regulatory/documents/a-08-07-022/amendedWorkpapers/SW-AgB/Greenhouse%20IR%20Film%20PGECOAGR102%20R0.pdf	$0.021/sq ft
2371	Griddle, Electric, ENERGY STAR	ENERGY STAR® Commercial Kitchen Savings Calculator. Accessed 03/11/2016. Available online: https://www.energystar.gov/products/commercial_food_service_equipment	$0.00
2372	Griddle, Gas, ENERGY STAR	ENERGY STAR® Commercial Kitchen Savings Calculator. Accessed 03/11/2016. Available online: https://www.energystar.gov/products/commercial_food_service_equipment	$360.00
2373	Guest Room Energy Management Controls, Electric Heat PTAC Systems	Illinois Technical Reference Manual. 2013. Page 202. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$260.00/room
2374	Guest Room Energy Management Controls, Not Otherwise Specified	Similar to measure 2373. Illinois Technical Reference Manual. 2013. Page 202. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$260.00/room
2376	Heat Recovery Tank, No Heating Element, Ag, Electric or NG	2013 Historical Project Data. 101 heat recovery tanks on 96 projects, average total cost is $3,674.00.	$3,674.00
2422	Infrared Heating Units, High or Low Intensity - Existing Building,	RSMeans Mechanical Cost Data, 2012. 60MBH/per MBH - Cabinet Unit Heater [Equipment].	$4.35/MBh
2429	Steam Fittings Insulation - NEW	Actual Program Data, 2015-2016. 20 projects with average actual cost of $37.63 per fitting.	$37.63/fitting
2430	Steam Piping Insulation - NEW	Actual Program Data, 2015-2016. 18 projects with average actual cost of $8.40 per foot	$8.40/ft

MMID	Measure Name	Source	Incremental Cost
2434	Irrigation Pressure Reduction, Nozzle Installation	PacifiCorp and Cascade Energy. 2014. Review and Update: Industrial/Agricultural Incentive Table Measures – Utah. Available online: http://www.psc.state.ut.us/utilities/electric/14docs/14035T03/254603Exhibit%20B%205-15-2014.pdf	$6.92/nozzle
2454	LED loading dock light fixture, Hybrid	Material cost gathered via online research, March 2016; average cost of "LED Dock Utility Lights" from: http://loadingdocksupply.com/led_dock_lights	$334.43
2456	LED Reach-In Refrigerated Case Lighting replaces T12 or T8	Regional Technical Forum, UES Measures. "Commercial: Grocery - Display Case LEDs (Reach-in Cases)." Measure Workbook 3.2; November 16, 2015. $22.00 for all "Commercial: Grocery - Display Case LEDs (Reach-in Cases)" measures. Available online: http://rtf.nwcouncil.org/measures/measure.asp?id=104	$22.00
2457	LED Reach-In Refrigerated Case Lighting replaces T12 or T8- with Occupancy Control	Regional Technical Forum, UES Measures. "Commercial: Grocery - Display Case LEDs (Reach-in Cases)." Measure Workbook 3.2; November 16, 2015. $22.00 for all "Commercial: Grocery - Display Case LEDs (Reach-in Cases)" measures. Available Online: http://rtf.nwcouncil.org/measures/measure.asp?id=104. Measure Workbook 3.1; January 4, 2016. Occupancy sensor = $3.00 for all "Commercial: Grocery - Display Case Motion Sensors". Available online: http://rtf.nwcouncil.org/measures/measure.asp?id=106	$25.00
2458	LED Down Lights	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®. Average across wattage based Focus on Energy "LED Downlight" measures.	$10.75
2471	Occupancy Sensors - Ceiling Mount ≤ 500 Watts	WESCO Distribution Pricing, 2013 ($95.00)+ Labor ($25.00) = $120.00	$120.00
2472	Occupancy Sensors - Ceiling Mount >= 1001 Watts	WESCO Distribution Pricing, 2013 ($95.00)+ Labor ($25.00) = $120.00	$120.00
2473	Occupancy Sensors - Ceiling Mount 501-1000 Watts	WESCO Distribution Pricing, 2013 ($95.00)+ Labor ($25.00) = $120.00	$120.00
2474	Occupancy Sensors - Fixture Mount ≤ 200 Watts	WESCO Distribution Pricing ($70.00) + Labor ($25.00) = $95.00	$95.00

MMID	Measure Name	Source	Incremental Cost
2475	Occupancy Sensors - Fixture Mount > 200 Watts	WESCO Distribution Pricing ($70.00) + Labor ($25.00) = $95.00	$95.00
2482	Occupancy Sensors - for LED Refrigerated Case Lights, per door controlled	Regional Technical Forum, UES Measures. "Commercial: Grocery - Display Case LEDs (Open Cases)." Measure Workbook 1.4; January 4, 2016. http://rtf.nwcouncil.org/measures/measure.asp?id=104; and Regional Technical Forum, UES Measures. "Commercial: Grocery - Display Case Motion Sensors." Measure Workbook 3.1; January 4, 2016. http://rtf.nwcouncil.org/measures/measure.asp?id=106 Occupancy sensor = $3.00 for all "Commercial: Grocery - Display Case Motion Sensors" measures and $29.00 is average cost of all "Commercial: Grocery - Display Case LEDs (Open Cases)" measures.	$32.00
2483	Occupancy Sensors - Wall Mount ≤ 200 Watts	WESCO Distribution Pricing, 2013 ($18.75) + Labor ($16.25) = $35.00	$35.00
2484	Occupancy Sensors - Wall Mount >= 201 Watts	WESCO Distribution Pricing, 2013 ($18.75) + Labor ($16.25) = $35.00	$35.00
2485	Oven, Convection, Electric, ENERGY STAR - per cavity	ENERGY STAR® Commercial Kitchen Savings Calculator. Accessed 03/11/2016. All Ovens Incremental Cost = $0.00. Available online: https://www.energystar.gov/products/commercial_food_service_equipment	$0.00
2486	Oven, Convection, Gas, ENERGY STAR - per cavity	ENERGY STAR® Commercial Kitchen Savings Calculator. Accessed 03/11/2016. All Ovens Incremental Cost = $0.00. Available online: https://www.energystar.gov/products/commercial_food_service_equipment	$0.00
2487	Oven, Rack Type, Gas, Double Compartment, High Efficiency	ENERGY STAR® Commercial Kitchen Savings Calculator. Accessed 03/11/2016. All Rack Ovens Incremental Cost = $0.00. Available online: https://www.energystar.gov/products/commercial_food_service_equipment	$0.00
2488	Oven, Rack Type, Gas, Single Compartment, High Efficiency	ENERGY STAR® Commercial Kitchen Savings Calculator. Accessed 03/11/2016. All Rack Ovens Incremental Cost = $0.00. Available online: https://www.energystar.gov/products/commercial_food_service_equipment	$0.00

MMID	Measure Name	Source	Incremental Cost
2490	Plastics equipment, efficient radiant heater band retrofit	Actual Program Data, 2015-2016. 5 projects with average actual cost of $279.63 per kW.	$279.62/kW
2491	Plate Heat Exchanger and Well Water Pre-Cooler	2013 Vermont TRM. Value derived from Efficiency Vermont custom program data 2003-2012. Available online: http://psb.vermont.gov/sites/psb/files/docketsandprojects/electric/majorpendingproceedings/TRM%20User%20Manual%20No.%202015-87C.pdf	$4,595.00
2494	PreRinse Sprayers, 0.65 GPM Ultra Low Flow- Electric NEW	Midwest program data suggests $35.00 incremental cost. An installation cost of $16.74 can be estimated from DEER 2008, assuming cost of installing a showerhead is equivalent to a pre-rinse sprayer. Available online: http://www.deeresources.com/index.php/ex-ante-database	$51.74
2495	PreRinse Sprayers, 0.65 GPM Ultra Low Flow- Gas NEW	Midwest program data suggests $35.00 incremental cost. An installation cost of $16.74 can be estimated from DEER 2008, assuming cost of installing a showerhead is equivalent to a pre-rinse sprayer. Available online: http://www.deeresources.com/index.php/ex-ante-database	$51.74
2496	Pressure Screen Rotor	Historical Project Data, 2016. Large Energy User Program. 7 projects, 4/2011 to 7/2014. Average cost is $200.77 per hp	$200.77/hp
2507	Radiant tube inserts installed in exhaust of radiant tube burners, Hybrid	Actual Program Data, 2015-2016. 6 projects with average actual cost of $368.65 per insert.	368.64/insert
2509	Open Multideck Cases Replaced by Reach-in Cases with Doors-NEW	California Public Utilities Commission. DEER Database for Energy-Efficiency Resources Version 2011 4.01. Cost Values and Summary Documentation.	$574.87
2510	Floating Head Pressure Control-NEW	Based on size and similar design, assume same as compressor. $260 - Regional Technical Forum, UES Measures. "Commercial: Grocery - Compressor Head Fan Motor Retrofit to ECM." Measure Workbook 2.2, June 29, 2016. $260.00 for all "Compressor Head Fan Motor Retrofit to ECM" measures. Available online: http://rtf.nwcouncil.org/measures/measure.asp?id=106	$260.00
2513	Refrigeration Tune-up, Non Self-Contained Cooler	Historical Focus on Energy project data, 2012-2013. 132 projects, average cost of tune-up is $30.00 per ton.	$30.00/ton

MMID	Measure Name	Source	Incremental Cost
2514	Refrigeration Tune-up, Non Self-Contained Freezer	Historical Focus on Energy project data, 2012-2013. 118 project, average cost of tune-up is $36.00 per ton.	$36.00/ton
2515	Refrigeration Tune-up, Self-contained Cooler	Historical Focus on Energy project data, 2012-2013. 69 projects, average cost of tune-up is $230.00 per ton.	$230.00/ton
2516	Refrigeration Tune-up, Self-contained Freezer	Historical Focus on Energy project data, 2012-2013. 50 projects, average cost of tune-up is $245.00 per ton.	$245.00/ton
2521	Refrigerator, Chest, Glass Door, < 15 cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 03/2016. "Commercial refrigerator" incremental cost is $0.00 for all. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2522	Refrigerator, Chest, Glass Door, 15-29 cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 03/2016. "Commercial refrigerator" incremental cost is $0.00 for all. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2523	Refrigerator, Chest, Glass Door, 30-49 cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 03/2016. "Commercial refrigerator" incremental cost is $0.00 for all. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2524	Refrigerator, Chest, Glass Door, 50+ cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 03/2016. "Commercial refrigerator" incremental cost is $0.00 for all. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2525	Refrigerator, Chest, Solid Door, < 15 cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 03/2016. "Commercial refrigerator" incremental cost is $0.00 for all. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2526	Refrigerator, Chest, Solid Door, 15-29 cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 03/2016. "Commercial refrigerator" incremental cost is $0.00 for all. Available online:	$0.00

MMID	Measure Name	Source	Incremental Cost
		https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	
2527	Refrigerator, Chest, Solid Door, 30-49 cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 03/2016. "Commercial refrigerator" incremental cost is $0.00 for all. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2528	Refrigerator, Chest, Solid Door, 50+ cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 03/2016. "Commercial refrigerator" incremental cost is $0.00 for all. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2529	Refrigerator, Vertical, Glass Door, < 15 cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 03/2016. "Commercial refrigerator" incremental cost is $0.00 for all. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2530	Refrigerator, Vertical, Glass Door, 15-29 cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 03/2016. "Commercial refrigerator" incremental cost is $0.00 for all. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2531	Refrigerator, Vertical, Glass Door, 30-49 cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 03/2016. "Commercial refrigerator" incremental cost is $0.00 for all. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2532	Refrigerator, Vertical, Glass Door, 50+ cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 03/2016. "Commercial refrigerator" incremental cost is $0.00 for all. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2533	Refrigerator, Vertical, Solid Door, < 15 cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 03/2016. "Commercial refrigerator" incremental cost is $0.00 for all. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00

MMID	Measure Name	Source	Incremental Cost
2534	Refrigerator, Vertical, Solid Door, 15-29 cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 03/2016. "Commercial refrigerator" incremental cost is $0.00 for all. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2535	Refrigerator, Vertical, Solid Door, 30-49 cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 03/2016. "Commercial refrigerator" incremental cost is $0.00 for all. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2536	Refrigerator, Vertical, Solid Door, 50+ cu ft, Energy Star	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 03/2016. "Commercial refrigerator" incremental cost is $0.00 for all. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$0.00
2538	Repulper Rotor	Historical Project Data, 2016. Large Energy User Program. 3 projects, 1/2014 to 10/2015. Average cost is $343.17 per hp.	$343.17/hp
2542	Repair leaking steam trap, <50 psig steam (Industrial Only)	Average of 3 projects, 2013 - 2014	$276.78
2543	Repair leaking steam trap, >225 psig, General Heating	Pressure-based extrapolation of costs for MMIDs 2547, 2545, and average costs for 3269, 3270, 3271, and 3272.	$1,127.66
2544	Repair leaking steam trap, >225 psig steam (Industrial Only)	Pressure-based extrapolation of costs for MMIDs 2542, 2548, and 2546.	$895.65
2545	Repair leaking steam trap, 126-225 psig, General Heating	Average of 1 projects, 2013	$633.83
2546	Repair leaking steam trap, 126-225 psig steam (Industrial Only)	Average of 3 projects, 2013 - 2014	$600.18
2547	Repair leaking steam trap, 50-125 psig, General Heating	Average of 4 projects, 2013 - 2014	$391.02
2548	Repair leaking steam trap, 50-125 psig	Average of 13 projects, 2013 - 2014. One project with outlier cost excluded.	$194.61

MMID	Measure Name	Source	Incremental Cost
	steam (Industrial Only)		
2549	Steamer, Electric, 3 pan - ENERGY STAR	ENERGY STAR® Commercial Kitchen Savings Calculator. Accessed 03/11/2016. Available online: https://www.energystar.gov/products/commercial_food_service_equipment	$630.00
2550	Steamer, Electric, 4 pan - ENERGY STAR	ENERGY STAR® Commercial Kitchen Savings Calculator. Accessed 03/11/2016. Available online: https://www.energystar.gov/products/commercial_food_service_equipment	$630.00
2551	Steamer, Electric, 5 pan - ENERGY STAR	ENERGY STAR® Commercial Kitchen Savings Calculator. Accessed 03/11/2016. Available online: https://www.energystar.gov/products/commercial_food_service_equipment	$630.00
2552	Steamer, Gas, 5 pan - ENERGY STAR	ENERGY STAR® Commercial Kitchen Savings Calculator. Accessed 03/11/2016. Available online: https://www.energystar.gov/products/commercial_food_service_equipment	$870.00
2553	Steamer, Electric, 6 pan - ENERGY STAR	ENERGY STAR® Commercial Kitchen Savings Calculator. Accessed 03/11/2016. Available online: https://www.energystar.gov/products/commercial_food_service_equipment	$630.00
2554	Steamer, Gas, 6 pan - ENERGY STAR	ENERGY STAR® Commercial Kitchen Savings Calculator. Accessed 03/11/2016. Available online: https://www.energystar.gov/products/commercial_food_service_equipment	$870.00
2556	T8 1L-4 ft Reduced Wattage with CEE Ballast - 25 Watts (Low BF)	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$2.45
2557	T8 1L-4 ft Reduced Wattage with CEE Ballast - 28 Watts (Low BF)	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$2.07
2558	T8 1L 4', 28W, CEE, BF > 0.78	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$2.07
2559	T8 1L-4 ft Hi Lumen Lamp with CEE Ballast	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes CEE ballast as baseline.	$3.85

MMID	Measure Name	Source	Incremental Cost
2560	T8 1L-4 ft Reduced Wattage with CEE Ballast - 25 Watts	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes CEE ballast as baseline.	$2.45
2560	T8 2L-4 ft Reduced Wattage with CEE Ballast - 25 Watts	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$4.90
2561	T8 1L-4 ft Hi Lumen Lamp with CEE Ballast (Low BF)	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$7.70
2562	T8 2L-4 ft Reduced Wattage with CEE Ballast - 25 Watts (Low BF)	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes CEE ballast as baseline.	$4.90
2563	T8 2L 4', 25W, CEE, BF > 0.78	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$4.90
2564	T8 2L-4 ft Reduced Wattage with CEE Ballast - 28 Watts (Low BF)	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$4.13
2565	T8 2L-4 ft Reduced Wattage with CEE Ballast - 28 Watts	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$4.13
2566	T8 2L-4 ft Hi Lumen Lamp with CEE Ballast (Low BF)	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. There is no additional cost for ballasts.	$15.40
2567	T8 2L-4 ft Hi Lumen Lamp with CEE Ballast	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. There is no additional cost for ballasts.	$15.40

MMID	Measure Name	Source	Incremental Cost
2568	T8 2L-4ft High Performance Tandem Replacing T12HO/VHO 2L-8 ft - From Spectrum	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013.	$130.98
2569	T8 2L 4', HPT8, CEE, replacing 8' 2L T12	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013.	$130.98
2571	T8 3L-4 ft Low Watt with CEE Ballast - 25 Watts (Low BF)	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$7.35
2572	T8 3L-4 ft Reduced Wattage with CEE Ballast - 25 Watts	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$7.35
2573	T8 3L-4 ft Reduced Wattage with CEE Ballast - 28 Watts (Low BF)	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$6.20
2574	T8 3L 4', 28W, CEE, BF > 0.78	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$6.20
2575	T8 3L-4 ft Hi Lumen Lamp with CEE Ballast (Low BF)	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes CEE ballast as baseline.	$11.55
2576	T8 3L-4 ft Hi Lumen Lamp with CEE Ballast	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes CEE ballast as baseline.	$11.55
2577	T8 4L-4 ft Low Watt with CEE Ballast - 25 Watts (Low BF)	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$9.80

MMID	Measure Name	Source	Incremental Cost
2578	T8 4L-4 ft Reduced Wattage with CEE Ballast - 25 Watts	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$9.80
2579	T8 4L-4 ft Reduced Wattage with CEE Ballast - 28 Watts (Low BF)	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$8.27
2580	T8 4L 4', 28W, CEE, BF > 0.78	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$8.27
2581	T8 4L-4 ft Hi Lumen Lamp with CEE Ballast (Low BF)	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes CEE ballast as baseline.	$15.40
2582	T8 4L-4 ft Hi Lumen Lamp with CEE Ballast	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes CEE ballast as baseline.	$15.40
2590	T8 Low Watt Relamp - 25 Watts	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$2.45
2591	T8 Low Watt Relamp - 28 Watts	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$2.07
2592	Thermal Curtain, 8mm Double Polycarbonate Walls and Ceiling, Overhead Heating	Work Paper PGECOAGR101 Greenhouse Thermal Curtains. 2008. Available online: https://www.socalgas.com/regulatory/documents/a-08-07-022/amendedWorkpapers/SW-AgB/Greenhouse%20Thermal%20Curtains%20PGECOAGR101%20R0.pdf	$1.50/sq ft
2593	Thermal Curtain, 8mm Double Polycarbonate Walls and Ceiling, Under Bench Heating	Work Paper PGECOAGR101 Greenhouse Thermal Curtains. 2008. Available online: https://www.socalgas.com/regulatory/documents/a-08-07-022/amendedWorkpapers/SW-AgB/Greenhouse%20Thermal%20Curtains%20PGECOAGR101%20R0.pdf	$1.50/sq ft

MMID	Measure Name	Source	Incremental Cost
2594	Thermal Curtain, 8mm Double Polycarbonate Walls and Poly Film Ceiling, Overhead Heating	Work Paper PGECOAGR101 Greenhouse Thermal Curtains. 2008. Available online: https://www.socalgas.com/regulatory/documents/a-08-07-022/amendedWorkpapers/SW-AgB/Greenhouse%20Thermal%20Curtains%20PGECOAGR101%20R0.pdf	$1.50/sq ft
2595	Thermal Curtain, 8mm Double Polycarbonate Walls and Poly Film Ceiling, Under Bench Heating	Work Paper PGECOAGR101 Greenhouse Thermal Curtains. 2008. Available online: https://www.socalgas.com/regulatory/documents/a-08-07-022/amendedWorkpapers/SW-AgB/Greenhouse%20Thermal%20Curtains%20PGECOAGR101%20R0.pdf	$1.50/sq ft
2596	Thermal Curtain, Double Pane Glass Walls and Ceiling, Overhead Heating	Work Paper PGECOAGR101 Greenhouse Thermal Curtains. 2008. Available online: https://www.socalgas.com/regulatory/documents/a-08-07-022/amendedWorkpapers/SW-AgB/Greenhouse%20Thermal%20Curtains%20PGECOAGR101%20R0.pdf	$1.50/sq ft
2597	Thermal Curtain, Double Pane Glass Walls and Ceiling, Under Bench Heating	Work Paper PGECOAGR101 Greenhouse Thermal Curtains. 2008. Available online: https://www.socalgas.com/regulatory/documents/a-08-07-022/amendedWorkpapers/SW-AgB/Greenhouse%20Thermal%20Curtains%20PGECOAGR101%20R0.pdf	$1.50/sq ft
2598	Thermal Curtain, Double Pane Glass Walls and Poly Film Ceiling, Overhead Heating	Work Paper PGECOAGR101 Greenhouse Thermal Curtains. 2008. Available online: https://www.socalgas.com/regulatory/documents/a-08-07-022/amendedWorkpapers/SW-AgB/Greenhouse%20Thermal%20Curtains%20PGECOAGR101%20R0.pdf	$1.50/sq ft
2599	Thermal Curtain, Double Pane Glass Walls and Poly Film Ceiling, Under Bench Heating	Work Paper PGECOAGR101 Greenhouse Thermal Curtains. 2008. Available online: https://www.socalgas.com/regulatory/documents/a-08-07-022/amendedWorkpapers/SW-AgB/Greenhouse%20Thermal%20Curtains%20PGECOAGR101%20R0.pdf	$1.50/sq ft
2601	Thermal Curtain, Poly Film Walls and Ceiling, Overhead Heating	Work Paper PGECOAGR101 Greenhouse Thermal Curtains. 2008. Available online: https://www.socalgas.com/regulatory/documents/a-08-07-022/amendedWorkpapers/SW-AgB/Greenhouse%20Thermal%20Curtains%20PGECOAGR101%20R0.pdf	$1.50/sq ft
2602	Thermal Curtain, Poly Film Walls and Ceiling, Under Bench Heating	Work Paper PGECOAGR101 Greenhouse Thermal Curtains. 2008. Available online: https://www.socalgas.com/regulatory/documents/a-08-07-022/amendedWorkpapers/SW-AgB/Greenhouse%20Thermal%20Curtains%20PGECOAGR101%20R0.pdf	$1.50/sq ft
2603	Thermal Curtain, Single Pane Glass	Work Paper PGECOAGR101 Greenhouse Thermal Curtains. 2008. Available online: https://www.socalgas.com/regulatory/	$1.50/sq ft

MMID	Measure Name	Source	Incremental Cost
	Walls and Ceiling, Overhead Heating	documents/a-08-07-022/amendedWorkpapers/SW-AgB/Greenhouse%20Thermal%20Curtains%20PGECOAGR101%20R0.pdf	
2604	Thermal Curtain, Single Pane Glass Walls and Ceiling, Under Bench Heating	Work Paper PGECOAGR101 Greenhouse Thermal Curtains. 2008. Available online: https://www.socalgas.com/regulatory/documents/a-08-07-022/amendedWorkpapers/SW-AgB/Greenhouse%20Thermal%20Curtains%20PGECOAGR101%20R0.pdf	$1.50/sq ft
2605	Thermal Curtain, Single Pane Glass Walls and Poly Film Ceiling, Overhead Heating	Work Paper PGECOAGR101 Greenhouse Thermal Curtains. 2008. Available online: https://www.socalgas.com/regulatory/documents/a-08-07-022/amendedWorkpapers/SW-AgB/Greenhouse%20Thermal%20Curtains%20PGECOAGR101%20R0.pdf	$1.50/sq ft
2606	Thermal curtain, Single Pane Glass Walls and Poly Film Ceiling, Under Bench Heating	Work Paper PGECOAGR101 Greenhouse Thermal Curtains. 2008. Available online: https://www.socalgas.com/regulatory/documents/a-08-07-022/amendedWorkpapers/SW-AgB/Greenhouse%20Thermal%20Curtains%20PGECOAGR101%20R0.pdf	$1.50/sq ft
2608	Unit Heater, >= 90% thermal efficiency, per input MBh, for retrofit	Actual Program Data, 2015-2016. 49 projects with average actual cost of $18.00 per MBh.	$18.00/MBh
2611	Vending Machine Controls, occupancy based, on cold beverage machine	Online Research, 2016. CoolerMiser model CM150. Available online: http://www.vendingmiserstore.com/product/energymiser-coolermiser-master-unit-cm150	$169.00
2612	Snack Machine - Install VendingMiser Controller	Online Research, 2016. Average cost of snackmiser models. Available online: http://www.vendingmiserstore.com/category/snackmiser	$156.00
2613	Vending Machine Controls, sales based, on cold beverage machine	Online Research, 2016. CoolerMiser Model CM2iQ. Available online: http://www.vendingmiserstore.com/product/energymiser-cooler-miser-internal-unit-model-cm2iq	$49.00
2614	Vending Machine Controls, Sales Based, Snack Machine	Online Research, 2016. VendingMiser Model VM2iQ. Available online: http://www.vendingmiserstore.com/product/energymiser-vending-miser-internal-unit-model-vm150	$104.00
2616	Vending Machine Controller, Direct Install, Cooled Machine	Online Research, 2016. CoolerMiser model CM150. Available online: http://www.vendingmiserstore.com/product/energymiser-coolermiser-master-unit-cm150	$169.00

MMID	Measure Name	Source	Incremental Cost
2620	Kitchen Hood Ventilation Controls, Temperature Only, NEW System, BONUS for controlling MUA fan	Actual Program Data, 2015-2016. 9 projects with average actual cost of $3,844.46.	$3,884.46
2621	Kitchen Hood Ventilation Controls, Temperature Only, Retrofit, BONUS for controlling MUA fan	Actual Program Data, 2015-2016. 1 project with average actual cost of $629.57.	$629.57
2622	Kitchen Hood Ventilation Controls, Temperature Only, NEW System, Exhaust Fan Controlled	Actual Program Data, 2015-2016. 14 projects with average actual cost of $3,101.77.	$3,101.77
2623	Kitchen Hood Ventilation Controls, Temperature Only, Retrofit, Exhaust Fan Controlled	Actual Program Data, 2015-2016. 5 projects with average actual cost of $2,079.04.	$2,079.04
2624	Kitchen Hood Ventilation Controls, Temp and Optical, NEW System, BONUS for controlling MUA fan	Actual Program Data, 2015-2016. 6 projects with average actual cost of $1,780.83.	$1,780.83
2625	Kitchen Hood Ventilation Controls, Temp and Optical, Retrofit, BONUS for controlling MUA fan	Actual Program Data, 2015-2016. 8 projects with average actual cost of $1,373.63.	$1,373.63
2626	Ventilation Controls, Kitchen Hood, with Optical, Exhaust Only, New	Actual Program Data, 2015-2016. 7 projects with average actual cost of $2,872.86.	$2,872.86
2627	Kitchen Hood Ventilation Controls,	Actual Program Data, 2015-2016. 13 projects with average actual cost of $1,966.46.	$1,966.46

MMID	Measure Name	Source	Incremental Cost
	Temp and Optical, Retrofit, Exhaust Fan Controlled		
2628	Agricultural Exhaust Fan, High Efficiency - 36"	Illinois Technical Reference Manual. 2013. Page 68. Agriculture circulation or exhaust fan incremental cost (all sizes) is $150.00 each. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$150.00
2629	Agricultural Exhaust Fan, High Efficiency - 42"	Similar to measure 2253. Illinois Technical Reference Manual. 2013. Page 68. Agriculture circulation or exhaust fan incremental cost (all sizes) is $150.00 each. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$150.00
2630	Agricultural Exhaust Fan, High Efficiency - 48"	Similar to measure 2253. Illinois Technical Reference Manual. 2013. Page 68. Agriculture circulation or exhaust fan incremental cost (all sizes) is $150.00 each. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$150.00
2631	Agricultural Exhaust Fan, High Efficiency - 50"	Similar to measure 2253. Illinois Technical Reference Manual. 2013. Page 68. Agriculture circulation or exhaust fan incremental cost (all sizes) is $150.00 each. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$150.00
2632	Agricultural Exhaust Fan, High Efficiency - 51"	Similar to measure 2253. Illinois Technical Reference Manual. 2013. Page 68. Agriculture circulation or exhaust fan incremental cost (all sizes) is $150.00 each. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$150.00
2633	Agricultural Exhaust Fan, High Efficiency - 52"	Similar to measure 2253. Illinois Technical Reference Manual. 2013. Page 68. Agriculture circulation or exhaust fan incremental cost (all sizes) is $150.00 each. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$150.00

MMID	Measure Name	Source	Incremental Cost
2634	Agricultural Exhaust Fan, High Efficiency - 54"	Historical Focus on Energy project data, 2012-2013. 12 projects, 289 fans; fan average total cost is $1,139.00.	$1,139.00
2635	Agricultural Exhaust Fan, High Efficiency - 55"	Similar to measure 2634. Historical Focus on Energy project data, 2012-2013. 12 projects, 289 fans; fan average total cost is $1,139.00.	$1,139.00
2636	Agricultural Exhaust Fan, High Efficiency - 57"	Historical Focus on Energy project data, 2012-2013. 4 projects, 145 fans; fan average total cost is $1,695.00.	$1,695.00
2637	Agricultural Exhaust Fan, High Efficiency - 60"	Historical Focus on Energy project data, 2012-2013. 3 projects, 141 fans; fan average total cost is $2,010.00.	$2,010.00
2638	Agricultural Exhaust Fan, High Efficiency - 72"	Historical Focus on Energy project data, 2012-2013. 8 projects, 232 fans; fan average total cost is $2,287.00.	$2,287.00
2639	VFD, Ag Second Use Water System	Evaluator and Implementer Consensus on setting cost on a per hp basis, instead of per motor. Cost set at $130.00 per hp, determined as survey value across full size range of motors eligible for this measure. NEEP 2013 Incremental Cost Study used to develop value. (Incremental Cost Study Phase Two Final Report, Navigant Consulting, 2013). Available online: http://www.neep.org/Assets/uploads/files/emv/emv-products/NEEP%20ICS2%20FINAL%20REPORT%202013Feb11-Website.pdf	$130.00/hp
2640	VFD, Boiler Draft Fan	Evaluator and Implementer Consensus on setting cost on a per hp basis, instead of per motor. Cost set at $130.00 per hp, determined as survey value across full size range of motors eligible for this measure. NEEP 2013 Incremental Cost Study used to develop value. (Incremental Cost Study Phase Two Final Report, Navigant Consulting, 2013). Available online: http://www.neep.org/Assets/uploads/files/emv/emv-products/NEEP%20ICS2%20FINAL%20REPORT%202013Feb11-Website.pdf	$130.00/hp
2641	VFD, Cooling Tower Fan	Evaluator and Implementer Consensus on setting cost on a per hp basis, instead of per motor. Cost set at $130.00 per hp, determined as survey value across full size range of motors eligible for this measure. NEEP 2013 Incremental Cost Study used to develop value. (Incremental Cost Study Phase Two Final	$130.00/hp

MMID	Measure Name	Source	Incremental Cost
		Report, Navigant Consulting, 2013). Available online: http://www.neep.org/Assets/uploads/files/emv/emv-products/NEEP%20ICS2%20FINAL%20REPORT%202013Feb11-Website.pdf	
2643	VFD Fan, Hybrid	Evaluator and Implementer Consensus on setting cost on a per hp basis, instead of per motor. Cost set at $130.00 per hp, determined as survey value across full size range of motors eligible for this measure. NEEP 2013 Incremental Cost Study used to develop value (Incremental Cost Study Phase Two Final Report, Navigant Consulting, 2013). Available online: http://www.neep.org/Assets/uploads/files/emv/emv-products/NEEP%20ICS2%20FINAL%20REPORT%202013Feb11-Website.pdf	$130.00/hp
2644	VFD, HVAC Heating Pump	Evaluator and Implementer Consensus on setting cost on a per hp basis, instead of per motor. Cost set at $130.00 per hp, determined as survey value across full size range of motors eligible for this measure. NEEP 2013 Incremental Cost Study used to develop value (Incremental Cost Study Phase Two Final Report, Navigant Consulting, 2013). Available online: http://www.neep.org/Assets/uploads/files/emv/emv-products/NEEP%20ICS2%20FINAL%20REPORT%202013Feb11-Website.pdf	$130.00/hp
2646	VFD, Pool Pump Motor	Evaluator and Implementer Consensus on setting cost on a per hp basis, instead of per motor. Cost set at $130.00 per hp, determined as survey value across full size range of motors eligible for this measure. NEEP 2013 Incremental Cost Study used to develop value (Incremental Cost Study Phase Two Final Report, Navigant Consulting, 2013). Available online: http://www.neep.org/Assets/uploads/files/emv/emv-products/NEEP%20ICS2%20FINAL%20REPORT%202013Feb11-Website.pdf	$130.00/hp
2647	VFD, Process Fan	Evaluator and Implementer Consensus on setting cost on a per hp basis, instead of per motor. Cost set at $130.00 per hp, determined as survey value across full size range of motors eligible for this measure. NEEP 2013 Incremental Cost Study used to develop value (Incremental Cost Study Phase Two Final Report, Navigant Consulting, 2013). Available online: http://www.neep.org/Assets/uploads/files/emv/emv-	$130.00/hp

MMID	Measure Name	Source	Incremental Cost
		products/NEEP%20ICS2%20FINAL%20REPORT%202013Feb11-Website.pdf	
2648	VFD Pump, Hybrid	Evaluator and Implementer Consensus on setting cost on a per hp basis, instead of per motor. Cost set at $130.00 per hp, determined as survey value across full size range of motors eligible for this measure. NEEP 2013 Incremental Cost Study used to develop value (Incremental Cost Study Phase Two Final Report, Navigant Consulting, 2013). Available online: http://www.neep.org/Assets/uploads/files/emv/emv-products/NEEP%20ICS2%20FINAL%20REPORT%202013Feb11-Website.pdf	$130.00/hp
2651	Storage Water Heater EF >0.67	Ohio TRM, 2010. Page 123. Gas storage DHW EF > 0.67 incremental cost is $400.00 per water heater. Available online: http://s3.amazonaws.com/zanran_storage/amppartners.org/ContentPages/2464316647.pdf	$400.00
2652	Water Heater, >= 0.82 EF, Tankless, Residential, NG	Ohio TRM, 2010. Page 123. Tankless DHW EF > 0.82 incremental cost is $605.00 per water heater. Available online: http://s3.amazonaws.com/zanran_storage/amppartners.org/ContentPages/2464316647.pdf	$605.00
2653	DHW - Ag, Hybrid	IL TRM V5.0, C&I. Page 87. 80 gallon tank. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_5/Final/IL-TRM_Effective_060116_v5.0_Vol_2_C_and_I_021116_Final.pdf	$1,050.00
2655	Water Heater, Dual Thermostat, Ag, NG	Historical Project Data, 2014 to 2016. Agriculture, Schools and Government Program; 7 Projects, 01/2014 to 04/2016. Average Cost is $4,980.00 per water heater.	$4,980/water heater
2657	Water Heater, Fuel Switching, Electric to NG, Ag	Historical Project Data, 2014 to 2016. Agriculture, Schools and Government Program; 8 Projects, 12/2012 to 04/2016. Average Cost is $6,766.00 per water heater.	$6,766/water heater
2658	Water Heater, Residential Type - Indirect, with 90% AFUE+ Modulating Hot Water Boiler	NEEP Regional Evaluation, Measurement & Verification Forum, A Report on Costs in Six Northeast & Mid-Atlantic Markets. 2011. Navigant Consulting. Page 71. Mid-sized unit, 93% AFUE 120-26 MBh = $1,215.50	$1,215.50
2660	Waterer, Livestock, <250 Watts	Illinois Technical Reference Manual. 2013. Page 70. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$787.50

MMID	Measure Name	Source	Incremental Cost
2665	T8 Reduced Wattage Relamp 8 ft - 54 Watts	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$4.33
2666	Air Cooled Chiller System Tune Up, Service Buy Down ≤500 Tons	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$35.00/ton
2667	Air Cooled Chiller System Tune Up, Service Buy Down>500 Tones	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$35.00/ton
2668	Chiller Tune-Up	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$35.00/ton
2669	Water Cooled Chiller System Tune Up, Service Buy Down >500 Tons	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$35.00/ton
2670	CFL ≤ 30 Watts, replacing incandescent	Evaluator research for ENERGY STAR®, March 2016. Average costs from online research including Lowes, Home Deport, and 1000bulbs.com.	$2.16
2671	Coil cleaning, self contained unit - New	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$35/ton

MMID	Measure Name	Source	Incremental Cost
2673	Fryer, Large Vat, Electric, High Efficiency	ENERGY STAR® Commercial Kitchen Savings Calculator. Accessed 03/11/2016. Available online: https://www.energystar.gov/products/commercial_food_service_equipment	$1,120.00
2674	Fryer, Large Vat, Gas, High Efficiency	Illinois Technical Reference Manual. 2013. Page 89. Gas fryer incremental cost is $1,200.00 per fryer. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$1,200.00
2677	Hot Food Holding Cabinet - ENERGY STAR, 13 ≤ V < 28 cu ft	ENERGY STAR®, 2016. Savings Calculator For ENERGY STAR® Qualified Appliances. All Hot holding cabinets incremental cost = 0.00. Available online: https://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx	$0.00
2678	Hot Food Holding Cabinet - ENERGY STAR, V < 13 cu ft	ENERGY STAR®, 2016. Savings Calculator For ENERGY STAR® Qualified Appliances. All Hot holding cabinets incremental cost = 0.00. Available online: https://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx	$0.00
2679	Hot Food Holding Cabinet - ENERGY STAR, V ≥ 28 cu ft	ENERGY STAR®, 2016. Savings Calculator For ENERGY STAR® Qualified Appliances. All Hot holding cabinets incremental cost = 0.00. Available online: https://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx	$0.00
2686	Low Flow Faucet Aerators (Public Restroom), Direct Install, Electric	DEER 2015. California Database for Energy Efficient Resources, $6.70 labor + $6.54 materials = $13.24. Available online: http://www.deeresources.com/index.php/ex-ante-database	$13.24
2687	Low Flow Faucet Aerators (Public Restroom), Direct Install, Natural Gas	DEER 2015. California Database for Energy Efficient Resources, $6.70 labor + $6.54 materials = $13.24. Available online: http://www.deeresources.com/index.php/ex-ante-database	$13.24
2688	FAUCET AERATORS, DIRECT INSTALL, ELEC	DEER 2015. California Database for Energy Efficient Resources, $6.70 labor + $6.54 materials = $13.24. Available online: http://www.deeresources.com/index.php/ex-ante-database	$13.24
2689	FAUCET AERATORS, DIRECT INSTALLNG, NG	DEER 2015. California Database for Energy Efficient Resources, $6.70 labor + $6.54 materials = $13.24. Available online: http://www.deeresources.com/index.php/ex-ante-database	$13.24
2691	LED Canopy Fixture - NEW	Material cost developed from online research, March 2015; Average cost of "LED canopy lights." Available online: https://www.1000bulbs.com/search/?q=led+canopy+lights	$264.72

MMID	Measure Name	Source	Incremental Cost
2692	LED Canopy Fixture, Dusk to Dawn	Material cost developed from online research, March 2015; Average cost of "LED canopy lights." Available online: https://www.1000bulbs.com/search/?q=led+canopy+lights	$264.72
2693	LED Pole Mounted - NEW	RSMeans 2015 material and labor cost for "LED floodlights, pole mounted, incl ballast and lamp, excl pole" ; average cost of 11 to 90 watt lamps.	$1,287.33
2694	LED Wall Pack - NEW	Online Research, March 2016. Average cost for "LED Wall Packs" , 40-59 watt. Available online: https://www.1000bulbs.com/category/led-retrofit-wall-packs/	$297.83
2695	LED Wall Pack, Dusk to Dawn	Online Research, March 2016. Average cost for "LED Wall Packs" , 40-59 watt. Available online: https://www.1000bulbs.com/category/led-retrofit-wall-packs/	$297.83
2699	PTHP, <8000 Btuh, ≥12.3 EER, ≥3.2 COP, Retrofit Application	Illinois Technical Reference Manual. 2013. Page 141. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$49.00/unit
2700	PTHP, ≥13000 Btuh, ≥12.3 EER, ≥3.2 COP, Retrofit Application	Illinois Technical Reference Manual. 2013. Page 141. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$105.00/unit
2701	PTHP, 10000-12999 Btuh, ≥12.3 EER, ≥3.2 COP, Retrofit Application	Illinois Technical Reference Manual. 2013. Page 141. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$84.00/unit
2702	PTHP, 8000 - 9999 Btuh, ≥12.3 EER, ≥3.2 COP, Retrofit Application	Illinois Technical Reference Manual. 2013. Page 141. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$63.00/unit
2703	T5 2L - F28T5 Fixture, Recessed Indirect 2x4, replacing 3LT8 or 4LT12	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$185.50
2704	T8 2L - HPT8 Fixture or Retrofit Module, Recessed Direct or Indirect 2x4, replacing 3L or 4L T8 or T12	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$167.17

MMID	Measure Name	Source	Incremental Cost
2705	Ice Machine, CEE Tier 2, Remote Condensing Without Remote Compressor, Air Cooled, Flake, <500 lbs/day	Illinois Technical Reference Manual. 2013. Page 103. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$981.00
2709	Metal Halide, Electronic Ballast, Pulse Start, 320 Watt	Online research, March 2016. From: warehouse-lighting.com. Baseline measure is 400 watt metal halide, average cost is $15.50. Efficient measure average cost is $20.81 of 320 Watt metal halide lamps.	$5.31
2711	Insulation, Project Based, Attic	Illinois Technical Reference Manual. 2013. Page 141. This measure includes air sealing costs. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$2.69/sq ft
2712	Insulation, Sidewall, Foam	2008 Database for Energy-Efficient Resources, Revised DEER Measure Cost Summary. June 2, 2008. (cost for Wall 2x6 R-19 Batts + R-5 Rigid)	$0.94/sq ft
2713	Insulation, Foundation - Interior	Illinois Technical Reference Manual. 2013. Page 141. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$2.93/sq ft
2714	Insulation, Sill Box	Illinois Technical Reference Manual. 2013. Page 141. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$5.97/sq ft
2726	VFD, Chilled Water Distribution Pump	Evaluator and Implementer Consensus on setting cost on a per hp basis, instead of per motor. Cost set at $130.00 per hp, determined as survey value across full size range of motors eligible for this measure. NEEP 2013 Incremental Cost Study used to develop value (Incremental Cost Study Phase Two Final Report, Navigant Consulting, 2013). Available online: http://www.neep.org/Assets/uploads/files/emv/emv-products/NEEP%20ICS2%20FINAL%20REPORT%202013Feb11-Website.pdf	$130.00/hp
2732	CFL, Direct Install 13W	Evaluator research for ENERGY STAR®, March 2016. Average costs from online research including Lowes, Home Deport, and 1000bulbs.com.	$1.43

MMID	Measure Name	Source	Incremental Cost
2734	Faucet Aerator, Direct Install, 1.5 gpm, Bathroom, Electric	DEER 2015. California Database for Energy Efficient Resources, $6.70 labor + $6.54 materials = $13.24. Available online: http://www.deeresources.com/index.php/ex-ante-database	$13.24
2735	Faucet Aerator, Direct Install, 1.5 gpm, Bathroom, NG	DEER 2015. California Database for Energy Efficient Resources, $6.70 labor + $6.54 materials = $13.24. Available online: http://www.deeresources.com/index.php/ex-ante-database	$13.24
2736	LED EXIT SIGN, DIRECT INSTALL	Online Research, March 2016. Average sales price of Led Exit Signs on 1000bulbs.com =$26.43; RSMeans, 2015 labor cost for install of Signs, interior electric exit sign, wall mounted , 6" = $72.00. $26.43 (material cost) + $72.00 (labor cost) = $98.43.	$98.43
2740	CFL, Direct Install, 18 Watt	Evaluator research for ENERGY STAR®, March 2016. Average costs from online research including Lowes, Home Deport, and 1000bulbs.com.	$1.30
2741	Insulation, Direct Install, 3' Pipe, Electric	RS Means Building Construction Cost Data, 2015. Insulation, pipe covering (price copper tube one less than I.P.S), fiberglass with all service jacket, 1" wall, 2" iron pipe size. Material Cost is $1.36 + Labor Cost is $1.86 = Total is $3.22.	$3.22 per ft.
2742	Insulation, Direct Install, 3' Pipe, NG	RS Means Building Construction Cost Data, 2015. Insulation, pipe covering (price copper tube one less than I.P.S), fiberglass with all service jacket, 1" wall, 2" iron pipe size. Material Cost is $1.36 + Labor Cost is $1.86 = Total is $3.22.	$3.22 per ft.
2743	Boiler, Hot Water, Modulating, >=90% AFUE,≤300 MBH	Illinois Technical Reference Manual. 2013. Page 141. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$50.82/MBh
2744	Boiler Tune Up	Illinois Technical Reference Manual. 2013. Page 160. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$0.83/MBh per tune-up
2747	Boiler, ≥ 90% AFUE, NG	Illinois Technical Reference Manual. 2013. Page 141. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$50.82/MBh
2748	Natural Gas Boiler, 85-90% AFUE	Illinois Technical Reference Manual. 2013. Page 141. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$50.82/MBh
2753	CFL - Common Area	Online Research	$2.71

MMID	Measure Name	Source	Incremental Cost
2754	CFL - In Unit	Online Research	$2.71
2756	Clothes Washer, ENERGY STAR Tier 3, Electric	Illinois Technical Reference Manual. 2013. Page 141. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$325.40
2757	Clothes Washer, ENERGY STAR Tier 3, Gas	Illinois Technical Reference Manual. 2013. Page 141. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$325.40
2760	Domestic Hot Water Plant Replacement	Actual Program Data, 2014-2016. Average actual cost of $27.95 per MBh.	$27.95/MBh
2764	Furnace, with ECM fan motor, for space heating (AFUE >= 95%)	NEEP Regional Evaluation, Measurement & Verification Forum, A Report on Costs in Six Northeast & Mid-Atlantic Markets. 2011. Navigant Consulting. Navigant study completed 15 interviews for this measure. Available online: http://www.neep.org/Assets/uploads/files/emv/emv-products/Incremental%20Cost_study_FINAL_REPORT_2011Sep23.pdf	$1,667.84
2767	LED Lamps - Common Area	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$5.85
2768	LED Exit Fixture or Retrofit Kits	Online Research, March 2016. Average sales price of Led Exit Signs on 1000bulbs.com = $26.43; RSMeans, 2015 labor cost for install of Signs, interior electric exit sign, wall mounted , 6" = $72.00. $26.43 (material cost) + $72.00 (labor cost) = $98.43.	$98.43
2769	LED Lamps - In Unit	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$5.85
2772	Steam Trap Radiator Repair or Replace	Average of 5 projects, 2012 - 2014	$50.89
2778	Water Heater, Dual Thermostat, Ag, Electric	Historical Focus on Energy project data, 2013. 33 water heaters on 32 projects, average total cost is $1,468.00 per water heater.	$1,468.00
2784	CFL, Direct Install, 15 Watt	Light bulb sales data obtained by Cadmus for California- 2010 through 2012. Note that the CFL average lamp costs include incented lamps.	$0.37
2785	CFL LAMP, DIRECT INSTALL, 42 WATT >=2,600 LUMENS	Online research on 1000bulbs.com comparing 250 watt PAR38 Halogen ($15.00 average) with 50-65 watt CFL ($18.00 average).	$3.00

MMID	Measure Name	Source	Incremental Cost
2786	CFL, Direct Install, 7 Watt	Light bulb sales data obtained by Cadmus for California- 2010 through 2012. Note that the CFL average lamp costs include incented lamps.	$1.21
2787	CFL LAMP, DIRECT INSTALL, 9 WATT	Light bulb sales data obtained by Cadmus for California- 2010 through 2012. Note that the CFL average lamp costs include incented lamps.	$0.37
2797	Occupancy Sensor, With Co-Pay, Wall Mount, ≤ 200 Watts	WESCO Distribution Pricing ($18.75) + Labor ($16.25) = $35.00	$35.00
2798	Occupancy Sensor, With Co-Pay, Wall Mount, >200 Watts	WESCO Distribution Pricing ($18.75) + Labor ($16.25) = $35.00	$35.00
2808	T8 6L or T5HO 4L Replacing 400-999 W HID	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$163.56
2810	ENGINE BLOCK HEATER TIMER	Implementer research, 2013. Average online cost of Engine Block Heat Timer.	$25.00
2811	CFL, Direct Install, 9 Watt	Light bulb sales data obtained by Cadmus for California- 2010 through 2012. Note that the CFL average lamp costs include incented lamps.	$1.21
2812	CFL LAMP, DIRECT INSTALL, 13 WATT >= 800 LUMENS	Light bulb sales data obtained by Cadmus for California- 2010 through 2012. Note that the CFL average lamp costs include incented lamps.	$0.37
2813	CFL REFLECTOR LAMP, Direct Install, 14 WATT	Light bulb sales data obtained by Cadmus for California- 2010 through 2012. Note that the CFL average lamp costs include incented lamps.	$0.37
2813	CFL REFLECTOR LAMP, Direct Install, 23 WATTS	Light bulb sales data obtained by Cadmus for California- 2010 through 2012. Note that the CFL average lamp costs include incented lamps.	$1.03
2815	CFL LAMP, DIRECT INSTALL, 23 WATT 1,400 TO 1,599 LUMENS	Light bulb sales data obtained by Cadmus for California- 2010 through 2012. Note that the CFL average lamp costs include incented lamps.	$1.03
2816	CFL, Direct Install, 18 Watt	Light bulb sales data obtained by Cadmus for California- 2010 through 2012. Note that the CFL average lamp costs include incented lamps.	$0.38

MMID	Measure Name	Source	Incremental Cost
2824	VFD, Ag Primary Use Water System	Evaluator and Implementer Consensus on setting cost on a per hp basis, instead of per motor. Cost set at $130.00 per hp, determined as survey value across full size range of motors eligible for this measure. NEEP 2013 Incremental Cost Study used to develop value (Incremental Cost Study Phase Two Final Report, Navigant Consulting, 2013). Available online: http://www.neep.org/Assets/uploads/files/emv/emv-products/NEEP%20ICS2%20FINAL%20REPORT%202013Feb11-Website.pdf	$130.00/hp
2825	Water Heater, Electric to Gas Conversion	Historical data (7 projects) shows average cost of $1,647. Vermont 2015 TRM page 398 shows baseline electric DHW cost of $602.00. $1,647.00 - $602.00 = $1,045.00. Available online: http://psb.vermont.gov/sites/psb/files/docketsandprojects/electric/majorpendingproceedings/TRM%20User%20Manual%20No.%202015-87C.pdf	$1,045.00
2826	Rooftop Tune Up - < 7.5 Ton w/ All Options Office, Hybrid	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$35.00/ton
2827	Rooftop Tune Up - < 7.5 Ton w/ DCV Only Office, Hybrid	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$35.00/ton
2828	Rooftop Tune Up - < 7.5 Ton w/ Eco & DCV Office, Hybrid	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$35.00/ton
2829	Rooftop Tune Up - < 7.5 Ton w/ Eco Only Office, Hybrid	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Ver	$35.00/ton

MMID	Measure Name	Source	Incremental Cost
		sion_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	
2830	Rooftop Tune Up - < 7.5 Ton w/ Programmable Thermostat Only Office, Hybrid	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$35.00/ton
2831	Rooftop Tune Up - < 7.5 Ton w/ Programmable Thermostat & DCV Office, Hybrid	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$35.00/ton
2832	Rooftop Tune Up - < 7.5 Ton w/ Programmable Thermostat & Eco Office, Hybrid	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$35.00/ton
2833	Roof Top Upgrade, Thermostat, DCV, & Economizer, ≤7.5 Tons	2015 Exisiting Cost Figure; Program Information 2012-2014.	$1,250.00
2834	Rooftop Tune Up > 7.5 Ton w/ All Options Office, Hybrid	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$35.00/ton
2835	Rooftop Tune Up > 7.5 Ton w/ Programmable Thermostat Office, Hybrid	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$35.00/ton

MMID	Measure Name	Source	Incremental Cost
2836	Rooftop Tune Up > 7.5 Ton w/ DCV Office, Hybrid	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$35.00/ton
2837	Roof Top Upgrade, Thermostat and DCV, >7.5 Tons	2015 Exisiting Cost Figure; Program Information 2012-2014.	$1,250.00
2853	Demand Control Ventillation for AHU or Rooftop - NEW	Historical data (1/1/14 - 8/10/16)	$1.00/CFM
2862	CFL LAMP, DIRECT INSTALL, 18 WATT >= 1100 LUMENS	Light bulb sales data obtained by Cadmus for California- 2010 through 2012. Note that the CFL average lamp costs include incented lamps.	$0.37
2884	T8 4 lamp replacing 250-399W HID	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013.	$129.00
2885	T8 (2) 6 lamp replacing 1000W HID	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013.	$327.12
2886	T8 8 lamp replacing 400-999W HID	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013.	$215.29
2887	T8 8L ≤ 500W, Replacing >=1000 W HID	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$215.29
2888	T8 10L ≤ 500W, Replacing >=1000 W HID	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$273.80
2889	T8 (2) 6L≤ 500W, Replacing >=1000 W HID	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$327.12

MMID	Measure Name	Source	Incremental Cost
2890	T5HO 2 lamp replacing 250-399W HID	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013.	$156.14
2891	T5HO 3L Replacing 250-399 W HID	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$195.49
2892	T5HO 4 lamp replacing 400-900W HID	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013.	$163.16
2893	T5HO 6 lamp replacing 400-999W HID	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013.	$210.22
2894	T5HO 6 lamp <500W replacing 1000W HID	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013.	$210.22
2895	T5HO 8 lamp or (2) T5HO 4 Lamp <500W replacing 1000W HID	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013.	$262.28
2896	T5HO (2) 4L ≤ 500W, Replacing >=1000 W HID	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$327.12
2897	T5HO (2) 6L ≤ 800W, Replacing >=1000 W HID	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$420.44
2902	Water Heater, Power Vented, EF = .67-.82, Storage, NG	Ohio TRM, 2010. Page 123. Tankless DHW EF > 0.82 incremental cost is $605 per water heater. Available online: http://s3.amazonaws.com/zanran_storage/amppartners.org/ContentPages/2464316647.pdf	$400.00
2931	LED Fixture, Canopy	Material cost developed from online research, March 2015; Average cost of "LED canopy lights." Available online: https://www.1000bulbs.com/search/?q=led+canopy+lights	$264.72
2932	LED Fixture, Exterior Pole Mounted	RSMeans 2015 material and labor cost for "LED floodlights, pole mounted, incl ballast and lamp, excl pole" ; average cost of 11 to 90 watt lamps.	$1,287.33

MMID	Measure Name	Source	Incremental Cost
2933	Roof Top Upgrade, DCV & Economizer, ≤7.5 Tons	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$35.00/ton
2934	Roof Top Upgrade, DCV, ≤7.5 Tons	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$35.00/ton
2935	Roof Top Upgrade, DCV, >7.5 Tons	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$35.00/ton
2936	Roof Top Upgrade, Economizer, ≤7.5 Tons	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$35.00/ton
2937	Roof Top Upgrade, Thermostat & DCV, ≤7.5 Tons	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$35.00/ton
2938	Roof Top Upgrade, Thermostat & Economizer, ≤7.5 Tons	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$35.00/ton

MMID	Measure Name	Source	Incremental Cost
2939	Roof Top Upgrade, Thermostat and DCV, >7.5 Tons	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$35.00/ton
2940	Roof Top Upgrade, Thermostat, ≤7.5 Tons	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$35.00/ton
2941	Roof Top Upgrade, Thermostat, >7.5 Tons	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$35.00/ton
2942	Roof Top Upgrade, Thermostat, DCV, & Economizer, ≤7.5 Tons	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$35.00/ton
2959	CFL, Markdown 17 watts or less	Light bulb sales data obtained by Cadmus for California- 2010 through 2012. Note that the CFL average lamp costs include incented lamps.	$0.37
2959	CFL, Markdown 18 to 24 watts	Light bulb sales data obtained by Cadmus for California- 2010 through 2012. Note that the CFL average lamp costs include incented lamps.	$0.38
2960	T8 or T5HO ≤155W, Replacing 250-399W HID, Not Otherwise Specified	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$156.14
2961	T8 or T5HO ≤250W, Replacing 400-999W HID, Not Otherwise Specified	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$163.56

MMID	Measure Name	Source	Incremental Cost
2962	T8 or T5HO 251-365W, Replacing 400-999W HID, Not Otherwise Specified	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$215.29
2963	T8 or T5HO ≤500W, Replacing >=1000W HID, Not Otherwise Specified	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$273.80
2964	T8 or T5HO ≤800W, Replacing 1000W HID, Not Otherwise Specified	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$342.04
2971	LED Lamp, Direct Install, Walk-in Cooler or Freezer	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$5.85
2979	LED, Exit Sign, Retrofit, Over Program Limit	Online Research, March 2016. Average sales price of Led Exit Signs on 1000bulbs.com = $26.43.	$26.43
2984	LED Fixture, Downlights, Accent Lights and Monopoint, ≤18 Watts, Common Area	Online Research, March 2016. Material cost is average sales price of "Led Downlight." Available online: https://www.1000bulbs.com/category/led-downlights/	$12.46
2987	Water Heater, Heat Pump, EF >=2.0, Electric	Historical Focus on Energy project data, 2013. 12 water heaters on 3 projects, average total cost is $2,893.00 per water heater.	$2,893.00
2989	ECM, Furnace, New or Replacement	Illinois Statewide Technical Reference Manual for Energy Efficiency, Version 5.0, Volume 3 (2015). Page 89. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_5/Final/IL-TRM_Effective_060116_v5.0_Vol_3_Res_021116_Final.pdf	$97.00
2990	Furnace And A/C, ECM, 95% + AFUE, >= 16 SEER	Incremental costs based on Fall 2014 review of Residential Prescriptive trade allies. IMCs are different for the two tiers because the measures use different baselines.	$1,451.66
2992	Air Source Heat Pump, >= 16 SEER	Illinois Statewide Technical Reference Manual for Energy Efficiency, Version 5.0, Volume 3 (2015). Page 59. $274.00 per ton for a time-of-sale 16 SEER ASHP. The Program assumes a value of 3.1 tons (37,000 MBh), as such $274.00 per ton	$849.40

MMID	Measure Name	Source	Incremental Cost
		produces an IMC of $849.40. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_5/Final/IL-TRM_Effective_060116_v5.0_Vol_3_Res_021116_Final.pdf	
3001	Delamping, 200-399 Watt Fixture	Mid-Atlantic TRM Version 6.0. Page 323. Assumed labor for larger fixtures is 50% more than for fluorescent lamps. $10.80 * 1.5 = $16.20. Available online: http://www.neep.org/mid-atlantic-technical-reference-manual-v6	$16.20
3002	Delamping, >=400 Watt Fixture	2015 Implementer survey of Trade Ally's installation Cost.	$15.00
3003	LED, Replacing Neon Sign	2015 Implementer survey of Trade Ally's installation Cost.	$55.00
3016	Ventilation Controls, Parking Lot	Actual Program Data, 2014-2016. 2 multifamily projects average actual cost of $607.00.	$607.00
3017	Showerheads, Retail Store Markdown	$5.00 = WESCO Distribution Pricing ($3.11) + Labor ($1.89)	$5.00
3018	Waterer, Livestock, Energy Free	Historical Focus on Energy project data, 2012-2013. 196 waterers on 34 projects, average total cost of non-energy waterer is $741.00.	$741.00
3019	Lighting Fixture, Agricultural Daylighting ≤ 155 Watts	WESCO Distribution Pricing, 2013 + Labor * 10% add for barn install location = $325.87	$325.87
3020	Lighting Fixture, Agricultural Daylighting 156 - 250 Watts	WESCO Distribution Pricing, 2013 + Labor * 10% add for barn install location = $325.87	$325.87
3021	Lighting Fixture, Agricultural Daylighting 251 - 365 Watts	WESCO Distribution Pricing, 2013 + Labor * 10% add for barn install location = $535.04	$535.04
3022	Split System A/C	NEEP. Incremental Cost Study Phase Three Final Report. Average of CEE Tier 2 values ($126.84 and $37.83) from Table 10. Available online: http://www.neep.org/incremental-cost-study-phase-3	$82.34
3023	T5, Reduced Wattage, Replacing T5 Or T5HO	Online research, March 2016. Average cost of "T5 - High Efficiency - Fluorescent" lamps. Available online: https://www.1000bulbs.com/category/f28t5-fluorescent-tubes/	$3.27

MMID	Measure Name	Source	Incremental Cost
3024	T5HO, Reduced Wattage, Replacing Standard T5 Or T5HO	Online research, March 2016. Average cost of "T5 - High Efficiency - Fluorescent" lamps. Available online: https://www.1000bulbs.com/category/f28t5-fluorescent-tubes/	$3.27
3025	Faucet Aerator, Kitchen, Gas	DEER 2015. California Database for Energy Efficient Resources, $2.80 materials. Available online: http://www.deeresources.com/index.php/ex-ante-database	$2.80
3026	Faucet Aerator, Kitchen, Electric	DEER 2015. California Database for Energy Efficient Resources, $2.80 materials. Available online: http://www.deeresources.com/index.php/ex-ante-database	$2.80
3027	Faucet Aerator, Bath, Gas	DEER 2015. California Database for Energy Efficient Resources, $6.70 labor + $6.54 materials = $13.24. Available online: http://www.deeresources.com/index.php/ex-ante-database	$13.24
3028	Faucet Aerator, Bath, Electric	DEER 2015. California Database for Energy Efficient Resources, $6.70 labor + $6.54 materials = $13.24. Available online: http://www.deeresources.com/index.php/ex-ante-database	$13.24
3029	Faucet Aerator, 1.5 gpm, Shower, NG	$5.00 = WESCO Distribution Pricing ($3.11) + Labor ($1.89)	$5.00
3030	Faucet Aerator, 1.5 gpm, Shower, Electric	$5.00 = WESCO Distribution Pricing ($3.11) + Labor ($1.89)	$5.00
3031	CFL, Reduced Wattage, Pin Based, 18 Watt, Replacing CFL	Cost data obtained through various online lighting retailers in October 2015, including 1000bulbs.com, warehouse-lighting.com, alconlighting.com, earthled.com, and toenic.com. Average prices of baseline equipment and qualifying efficient equipment used to obtain estimated incremental cost. Full data is available upon request.	$3.00
3032	CFL, Reduced Wattage, Pin Based, 26 Watt, Replacing CFL	Online research on GU24 26 watt CFL on 1000bulbs.com; prices range from $3.40 -$6.50, compared to $3.18 (from light bulb sales data obtained by Cadmus). Plus $1 labor cost for replacement.	$2.77
3033	CFL, Reduced Wattage, Pin Based, 32 Watt, Replacing CFL	Online research on GU24 26 watt CFL on 1000bulbs.com; prices range from $7 -$11.33, compared to $7 - $13.25 (also on 1000bulbs.com).	$0.00
3034	CFL, Reduced Wattage, Pin Based, 42 Watt, Replacing CFL	Online research on GU24 26 watt CFL on 1000bulbs.com; prices range from $7 -$11.33, compared to $7 - $13.25 (also on 1000bulbs.com).	$0.00

MMID	Measure Name	Source	Incremental Cost
3036	HID, Reduced Wattage, Replacing 1000 Watt HID, Exterior	Online research, March 2016. Average cost of "1000 Watt pulse start HID." Available online: https://www.1000bulbs.com/category/1000-watt-reduced-envelope-metal-halide-lamps/	$19.73
3037	HID, Reduced Wattage, Replacing 400 Watt HID, Exterior	2015 Implementer assessment of measure cost.	$43.54
3038	HID, Reduced Wattage, Replacing 320 Watt HID, Exterior	Online research, March 2016. Average cost of "320 Watt HID." Available online: https://www.1000bulbs.com/category/320-watt-standard-metal-halide-lamps/	$31.47
3039	HID, Reduced Wattage, Replacing 250 Watt HID, Exterior	Online research, March 2016. Average cost of "250 Watt HID." Available online: https://www.1000bulbs.com/category/250-watt-standard-metal-halide-lamps/	$16.01
3040	HID, Reduced Wattage, Replacing 175 Watt HID, Exterior	Online research, March 2016. Average cost of "175 Watt HID." Available online: https://www.1000bulbs.com/category/175-watt-medium-base-metal-halide-lamps/	$17.74
3041	T5HO, Exterior Reduced Wattage, Replacing 250-399 Watt HID	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$156.14
3042	T5HO, Exterior Reduced Wattage, Replacing 400-999 Watt HID	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$163.56
3043	T5HO, Exterior < 500 Watts, Replacing >= 1000 Watt HID	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$273.80
3045	Water Heater, High Usage, >=90% TE, NG	Historical Focus on Energy project data, 2013. 61 water heaters on 35 projects, average total cost is $7,303.00 per water heater.	$7,303.00
3046	Water Heater, High Usage, >= 0.82 EF, Tankless, NG	Ohio TRM, 2010. Page 123. Tankless DHW EF > 0.82 incremental cost is $605.00 per water heater. Available online: http://s3.amazonaws.com/zanran_storage/amppartners.org/ContentPages/2464316647.pdf	$605.00

MMID	Measure Name	Source	Incremental Cost
3047	Water Heater, High Usage, >= 2 EF, Heat Pump Storage, Electric	Historical Focus on Energy project data, 2013. 12 water heaters on 3 projects, average total cost is $2,893.00 per water heater.	$2,893.00
3056	LED Fixture, Replacing 320 Watt HID, Parking Garage, 24 Hour	Online Research, March 2016. Average price of 300-400 Watt equivalent fixture: "250-400-metal-halide-equivalent LED shoebox fixtures" on 1000bulbs.com. Available online: https://www.1000bulbs.com/category/250-400-metal-halide-equivalent/	$348.23
3059	A/C Coil Cleaning, < 10 tons	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$35.00/ton
3060	A/C Coil Cleaning, > 20 tons	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$35.00/ton
3061	A/C Coil Cleaning, 10-20 tons	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$35.00/ton
3062	A/C Refrigerant Charge Correction, < 10 tons	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$35.00/ton
3063	A/C Refrigerant Charge Correction, > 20 tons	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Ver	$35.00/ton

MMID	Measure Name	Source	Incremental Cost
		sion_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	
3064	A/C Refrigerant Charge Correction, 10-20 tons	Illinois Technical Reference Manual. 2013. Page 154. Incremental Cost source listed as: Act on Energy Commercial Technical Reference Manual No. 2010-4. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$35.00/ton
3065	Ceramic Metal Halide, 575 Watt, Replacing 1000 Watt HID, High Bay	Online research, March 2016 and Program Data, 2015. From: warehouse-lighting.com. Baseline measure is pulse start metal halide high bay, average cost is $344.79. Efficient measure average cost is $571.90 from 2015 Focus on Energy Program application data.	$173.11
3066	Economizer, RTU Optimization	RSMeans. Facilities Construction Cost Data. 29th Edition. 2013. Assumed $54.00 per hour labor rate for work performed on air cooling equipment. Estimated 2 hours for completion based on project experience.	$108.00
3067	HID, Reduced Wattage, Replacing 1000 Watt HID, Interior	Online research, March 2016. Average cost of "1000 Watt pulse start HID." Available online: https://www.1000bulbs.com/category/1000-watt-reduced-envelope-metal-halide-lamps/	$19.73
3068	HID, Reduced Wattage, Replacing 175 Watt HID, Interior	Online research, March 2016. Average cost of "175 Watt HID." Available online: https://www.1000bulbs.com/category/175-watt-medium-base-metal-halide-lamps/	$17.74
3069	HID, Reduced Wattage, Replacing 175 Watt HID, Parking Garage	Online research, March 2016. Average cost of "175 Watt HID." Available online: https://www.1000bulbs.com/category/175-watt-medium-base-metal-halide-lamps/	$17.74
3070	HID, Reduced Wattage, Replacing 250 Watt HID, Interior	Online research, March 2016. Average cost of "250 Watt HID." Available online: https://www.1000bulbs.com/category/250-watt-standard-metal-halide-lamps/	$16.01
3071	HID, Reduced Wattage, Replacing 250 Watt HID, Parking Garage	Online research, March 2016. Average cost of "250 Watt HID." Available online: https://www.1000bulbs.com/category/250-watt-standard-metal-halide-lamps/	$16.01
3072	HID, Reduced Wattage, Replacing 320 Watt HID, Interior	Online research, March 2016. Average cost of "320 Watt HID." Available online: https://www.1000bulbs.com/category/320-watt-standard-metal-halide-lamps/	$31.47

MMID	Measure Name	Source	Incremental Cost
3073	HID, Reduced Wattage, Replacing 400 Watt HID, Interior	Online research, March 2016. Average cost of "400 Watt HID." Available online: https://www.1000bulbs.com/category/400-watt-standard-metal-halide-lamps/	$24.00
3074	Induction, 750 Watt, Replacing 1000 Watt HID, High Bay	2015 Implementer assessment of measure cost.	$750.00
3075	Induction, PSMH/CMH, ≤250 Watt, Replacing 320-400 Watt HID, High Bay	2015 Implementer assessment of measure cost.	$290.00
3076	Metal Halide (MH), Electronic Ballast Pulse Start - 250W replacing 400W HID	Online research, March 2016 and Program Data, 2015. From: warehouse-lighting.com. Baseline measure is 16" Aluminum (400 Watt High Bay Light Fixture, High Pressure Sodium (HPS), 120-277v); cost is $181.26. Efficient measure average cost is $341.00 from 2015 Focus on Energy Program application data.	$159.74
3077	Metal Halide (MH), Electronic Ballast Pulse Start - 320W replacing 400W HID	Online research, March 2016 and Program Data, 2015. From: warehouse-lighting.com. Baseline measure is 16" Aluminum (400 Watt High Bay Light Fixture, High Pressure Sodium (HPS), 120-277v); cost is $181.26. Efficient measure average cost is $391.00 from 2015 Focus on Energy Program application data.	$209.74
3078	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 150-175 Watt HID, Exterior	Actual cost from 2015-16 program data, 8 applications.	$284.48
3079	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 150-175 Watt HID, Parking Garage, 24 Hour	Actual cost from 2015-16 program data, 2 applications.	$256.28
3080	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 150-175 Watt HID, Parking Garage, Dusk to Dawn	2015 Implementer assessment of measure cost.	$15.00

MMID	Measure Name	Source	Incremental Cost
3081	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 250 Watt HID, Exterior	Actual cost from 2015-16 program data, 15 applications.	$244.76
3082	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 250 Watt HID, Parking Garage, 24 Hour	Actual cost from 2015-16 program data, 3 applications.	$98.23
3083	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 250 Watt HID, Parking Garage, Dusk to Dawn	Actual cost from 2015-16 program data, 2 applications.	$410.96
3084	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 320 Watt HID, Exterior	2015 Implementer assessment of measure cost.	$340.00
3085	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 320-400 Watt HID, Exterior	2015 Implementer assessment of measure cost.	$290.00
3086	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 400 Watt HID, Exterior	Actual cost form 2015-16 program data, 15 applications.	$316.61
3087	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 70-100 Watt HID, Exterior	2015 Implementer assessment of measure cost.	$50.00

MMID	Measure Name	Source	Incremental Cost
3088	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 70-100 Watt HID, Parking Garage, 24 Hour	Actual cost from 2015-16 program data, 5 applications.	$143.94
3089	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 70-100 Watt HID, Parking Garage, Dusk to Dawn	2015 Implementer assessment of measure cost.	$50.00
3090	Induction, PSMH/CMH, Replacing 250 Watt HID, High Bay	Actual cost from 2015-16 program data, 1 application.	$100.00
3091	LED Fixture, <155 Watts, Replacing 250 Watt HID, High Bay	Online research, March 2016. Average cost of "LED round high bay fixtures" under 155 Watt replacement. Available online: https://www.1000bulbs.com/category/round-high-bays/	$204.99
3092	LED Fixture, <250 Watts, Replacing 320-400 Watt HID, High Bay	Online research, March 2016. Average cost of "LED round high bay fixtures" 155 Watt to 250 Watt replacement. Available online: https://www.1000bulbs.com/category/round-high-bays/	$387.82
3093	LED Fixture, <250 Watts, Replacing 400 Watt HID, High Bay	Online research, March 2016. Average cost of "LED round high bay fixtures" 155 Watt to 250 Watt replacement. Available online: https://www.1000bulbs.com/category/round-high-bays/	$387.82
3094	LED Fixture, <365 Watts, Replacing 400 Watt HID, High Bay	Online research, March 2016. Average cost of "LED round high bay fixtures" over 400 Watt replacement. Available online: https://www.1000bulbs.com/category/round-high-bays/	$398.41
3095	LED Fixture, <500 Watts, Replacing 1000 Watt HID, High Bay	Online research, March 2016. Average cost of "LED round high bay fixtures" over 400 Watt replacement. Available online: https://www.1000bulbs.com/category/round-high-bays/	$398.41
3096	LED Fixture, <800 Watts, Replacing 1000 Watt HID, High Bay	Online research, March 2016. Average cost of "LED round high bay fixtures" over 400 Watt replacement. Available online: https://www.1000bulbs.com/category/round-high-bays/	$398.41
3097	LED Fixture, Bilevel, Stairwell and Passageway	Materials: WESCO Distribution Pricing, 2013 ($70.00) + Labor: RSMEANS, 2013 ($25.00) = $95.00	$95.00

MMID	Measure Name	Source	Incremental Cost
3098	LED Fixture, Downlights, Accent Lights and Monopoint, > 18 Watts, Common Area	Online Research, March 2016. Material cost is average sales price of "Led Downlight." Available online: https://www.1000bulbs.com/category/led-downlights/	$12.46
3099	LED Fixture, Replacing 150-175 Watt HID, Exterior	Actual cost from 2015-16 program data = $311.55. 790 applications, primary participation has been wall packs in BIP, CSF, MESP. Less average price from 1000bulbs.com search for "150-175 Watt HID, Exterior = $70.335. Incremental Cost is $272.17-70.34 =$201.84 . Incremental Cost is $311.55 - $70.335 = $241.22	$241.22
3100	LED Fixture, Replacing 150-175 Watt HID, Parking Garage, 24 Hour	Actual cost from 2015-16 program data = $337.33. 63 applications, primary fixture type is parking garage luminaire. Less average price from 1000bulbs.com search for "150-175 Watt HID, Exterior = $70.335. Incremental Cost is $272.17-70.34 =$201.84 . Incremental Cost is $337.33 - $70.335 = $267.00	$267.00
3101	LED Fixture, Replacing 150-175 Watt HID, Parking Garage, Dusk to Dawn	Actual cost from 2015-16 program data = $337.33. 36 applications, primary fixture type is parking garage luminaire. Less average price from 1000bulbs.com search for "150-175 Watt HID, Exterior = $70.335. Incremental Cost is $272.17-70.34 =$201.84 . Incremental Cost is $337.33 - $70.335 = $267.00	$267.00
3102	LED Fixture, Replacing 250 Watt HID, Exterior	Actual cost from 2015-16 program data = $337.33. 676 applications, primary fixture types are a mix of wall packs and pole mounted. Less average price from 1000bulbs.com search for "150-175 Watt HID, Exterior = $70.335. Incremental Cost is $272.17-70.34 =$201.84 . Incremental Cost is $337.33 - $132.358 = $204.97	$204.97
3103	LED Fixture, Replacing 250 Watt HID, Parking Garage, 24 Hour	Actual cost from 2015-16 program data = $337.33. 13 applications, primary fixture type is parking garage luminaire. Less average price from 1000bulbs.com search for "250 Watt HID, Exterior = $132.36. Incremental Cost is $322.78-$132.36 =$190.42. Incremental Cost is $337.33 - $132.358 = $204.97	$204.97
3104	LED Fixture, Replacing 250 Watt HID, Parking Garage, Dusk to Dawn	Actual cost from 2015-16 program data = $337.33. 24 applications, primary fixture type is parking garage luminaire. Less average price from 1000bulbs.com search for "250 Watt HID, Exterior = $132.36. Incremental Cost is $322.78-$132.36 =$190.42. Incremental Cost is $337.33 - $132.358 = $204.97	$204.97

MMID	Measure Name	Source	Incremental Cost
3105	LED Fixture, Replacing 320 Watt HID, Exterior	Actual cost from 2015-16 program data = $337.33. 60 applications, primary fixture types are a mixture of fuel pump canopy, pole/arm mounted and retrofit kits. Less average price from 1000bulbs.com search for "320 Watt HID, Exterior = $243.06. Incremental Cost is $408-$243.06 =$164.94. Incremental Cost is $337.33 - $243.06 = $94.27	$94.27
3106	LED Fixture, Replacing 320-400 Watt HID, Exterior	Actual cost from 2015-16 program data = $337.33. 283 applications, primary fixture types are a mixture of architectureal floods, pole/arm mounted and wall packs. Less average price from 1000bulbs.com search for "320 Watt HID, Exterior = $243.06. Incremental Cost is $408-$243.06 =$164.94. Incremental Cost is $337.33 - $243.06 = $94.27	$94.27
3107	LED Fixture, Replacing 400 Watt HID, Exterior	Online Research, March 2016. Average price of 250 Watt equivalent fixtures via search: "250-400-metal-halide-equivalent LED shoebox fixtures" on 1000bulbs.com; https://www.1000bulbs.com/category/250-400-metal-halide-equivalent/	$408.00
3108	LED Fixture, Replacing 70-100 Watt HID, Exterior	Actual cost from 2015-16 program data = $242.86. 563 applications, primary fixture types are a mixture of architectureal floods, pole/arm mounted and wall packs. Less average price from 1000bulbs.com search for "70-100 watt HID, Exterior" = $112.14. Incremental Cost is $408-$243.06 =$164.94. Incremental Cost is $242.86 - $112.124 = $130.74	$130.74
3109	LED Fixture, Replacing 70-100 Watt HID, Parking Garage, 24 Hour	Actual cost from 2015-16 program data = $408.17. 44 applications, primary fixture type is parking garage luminaire. Less average price from 1000bulbs.com search for "70-100 watt HID, Exterior" = $112.14. Incremental Cost is $408-$243.06 =$164.94. Incremental Cost is $408.17 - $112.124 = $296.05	$296.05
3110	LED Fixture, Replacing 70-100 Watt HID, Parking Garage, Dusk to Dawn	Actual cost from 2015-16 program data = $240.6. 52 applications, primary fixture type is parking garage luminaire. Less average price from 1000bulbs.com search for "70-100 watt HID, Exterior" = $112.14. Incremental Cost is $408-$243.06 =$164.94. Incremental Cost is $240.6 - $112.124 = $128.48	$128.48
3111	LED Troffer, 2x4, Replacing 4' 3-4 Lamp T8 Troffer	Online Research, March 2016. Average price of "2x4 led troffer fixtures." Actual cost. Available online: www.1000bulbs.com/category/2x4-led-troffer-fixtures/	$168.29

MMID	Measure Name	Source	Incremental Cost
3112	LED, ≤ 40 Watt, ENERGY STAR, Replacing Incandescent	Evaluator Online Cost research from 1000bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$6.05
3113	LED, > 40 Watt, ENERGY STAR, Replacing Incandescent	Evaluator Online Cost research from 1000bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$9.40
3114	LED, Horizontal Case Lighting	Northeast Energy Efficiency Partnerships. Navigant Consulting, Inc. "Incremental Cost Study Phase Three Final Report." May 28, 2014. Available online: http://www.neep.org/file/1084/download?token=NVG0i03k&usg=AFQjCNGXS4vZFo7qPMCZWUIKoZDw2jMxsA&sig2=BeIyTynJm37D7OptXInZiQ&cad=rja	$21.55/ft
3117	Linear Fluorescent, Bilevel, Stairwell and Passageway	Materials: WESCO Distribution Pricing, 2013 ($70.00) + Labor: RSMEANS, 2013 ($25.00) = $95.00	$95.00
3118	Oven, Combination, Energy Star, Electric	ENERGY STAR® Commercial Kitchen Savings Calculator. Accessed 03/11/2016. All Rack Ovens Incremental Cost=$0.00. Available online: https://www.energystar.gov/products/commercial_food_service_equipment	$0.00
3119	Oven, Combination, Energy Star, NG	ENERGY STAR® Commercial Kitchen Savings Calculator. Accessed 03/11/2016. All Rack Ovens Incremental Cost=$0.00. Available online: https://www.energystar.gov/products/commercial_food_service_equipment	$0.00
3120	Programmable Thermostat, RTU Optimization Advanced	Median material cost for preapproved list is $180.00; additional labor is required for programming and running wire from output to economizer, estimated at 2 hours per thermostat at labor rate of $56.48.	$292.00
3121	Programmable Thermostat, RTU Optimization Standard	DEER Measure Cost Summary. Revised June 2, 2008.	$150.00
3122	T8 2L 4', HPT8 or RWT8, Replacing T12 1L 8', 0.78 < BF < 1.00	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$4.90

MMID	Measure Name	Source	Incremental Cost
3123	T8 2L 4', HPT8 or RWT8, Replacing T12 1L 8', BF ≤ 0.78	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$4.90
3124	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', 0.78 < BF < 1.00	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$4.90
3125	T8 2L-4ft High Performance HBF Replacing T12HO 1L-8 ft	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$4.90
3126	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', BF > 1.00	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$4.90
3127	T8 4L-4-4ft High Performance Replacing T12 2L-8 ft	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$9.80
3128	T8 4L 4', HPT8 or RWT8, Replacing T12 2L 8', BF ≤ 0.78	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$9.80
3129	T8 4L-4ft High Performance Replacing T12HO 2L-8 ft -	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$9.80
3130	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', BF ≤ 0.78	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$9.80
3131	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', BF > 1.00	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$9.80
3132	T8 4L-4ft High Performance	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor	$9.80

MMID	Measure Name	Source	Incremental Cost
	Replacing T12HO/VHO 2L-8 ft	duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	
3133	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', BF ≤ 0.78	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$9.80
3134	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', BF > 1.00	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$9.80
3135	Low Watt T8 Lamps	Average of MMID 2590 and MMID 2591. 2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$2.26
3136	Dishwasher, High Temp, Electric Booster, Pots/Pans Type, Energy Star, Electric	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 01/2016. Pot, pan, and utensil high temperature type. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$1,710.00
3137	Dishwasher, High Temp, Electric Booster, Pots/Pans Type, Energy Star, NG	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 01/2016. Pot, pan, and utensil high temperature type. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$1,710.00
3138	Dishwasher, High Temp, Gas Booster, Pots/Pans Type, Energy Star, NG	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 01/2016. Pot, pan, and utensil high temperature type. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$1,710.00
3139	Dishwasher, Low Temp, Pots/Pans Type, Energy Star, Electric	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 01/2016. Pot, pan, and utensil high temperature type, there is no cost in the calculator for low temp pot, pan, and utensil type. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$1,710.00

MMID	Measure Name	Source	Incremental Cost
3140	Dishwasher, Low Temp, Pots/Pans Type, Energy Star, NG	ENERGY STAR® Calculator Commercial Kitchen Equipment. Accessed 01/2016. Pot, pan, and utensil high temperature type, there is no cost in the calculator for low temp pot, pan, and utensil type. Available online: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx	$1,710.00
3141	LED, ≤ 8W	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$6.05
3144	T8 2L 4', HPT8 or RWT8, Replacing T12 1L 8', 0.78 < BF < 1.00, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013.	$4.90
3145	T8 2L 4', HPT8 or RWT8, Replacing T12 1L 8', BF ≤ 0.78, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013.	$4.90
3146	T8 4L 4', HPT8 or RWT8, Replacing T12 2L 8', 0.78 < BF < 1.00, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013.	$9.80
3147	T8 4L 4', HPT8 or RWT8, Replacing T12 2L 8', BF ≤ 0.78, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013.	$9.80
3148	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', BF > 1.00, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013.	$9.80
3149	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', 0.78 < BF < 1.00, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013.	$4.90
3150	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', BF ≤ 0.78, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013.	$4.90

MMID	Measure Name	Source	Incremental Cost
3151	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', BF > 1.00, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013.	$9.80
3152	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', 0.78 < BF < 1.00, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013.	$9.80
3153	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', BF ≤ 0.78, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013.	$9.80
3154	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', BF > 1.00, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013.	$9.80
3155	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', 0.78 < BF < 1.00, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013.	$9.80
3156	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', BF ≤ 0.78, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013.	$9.80
3157	LED, Porch Fixture, Energy Star	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$10.65
3158	LED Fixture, Downlights, Accent Lights and Monopoint, ≤ 18 Watts, In Unit	Online Research, March 2016. Material cost is average sales price of "Led Downlight." Labor cost from RSMeans, 2015; "Interior LED fixtures, downlight recess mounted". $12.46 (material cost) + $44.00 (labor cost)= $56.46. Available online: https://www.1000bulbs.com/category/led-downlights/	$56.46
3159	LED, Energy Star, Replacing Incandescent > 40W, In Unit	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$9.40

MMID	Measure Name	Source	Incremental Cost
3160	LED, Energy Star, Replacing Incandescent > 40W, Common Area	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$9.40
3161	LED, Energy Star, Replacing Incandescent ≤ 40W, In Unit	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$6.05
3162	LED, Energy Star, Replacing Incandescent ≤ 40W, Common Area	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$6.05
3163	T8 1L 4', HPT8, CEE, BF ≤ 0.78, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$2.07
3164	T8 1L 4', 28W, CEE, BF > 0.78, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$2.07
3165	T8 1L 4', 28W, CEE, BF ≤ 0.78, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$2.07
3166	T8 1L 4', 25W, CEE, BF > 0.78, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$2.45
3167	T8 1L 4', 25W, CEE, BF ≤ 0.78, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$2.45
3168	T8 2L 4', HPT8, CEE, BF ≤ 0.78, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$4.06

MMID	Measure Name	Source	Incremental Cost
3169	T8 2L 4', 28W, CEE, BF > 0.78, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$4.13
3170	T8 2L 4', 28W, CEE, BF ≤ 0.78, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$4.13
3171	T8 2L 4', 25W, CEE, BF > 0.78, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$4.90
3172	T8 2L 4', 25W, CEE, BF ≤ 0.78, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$4.90
3173	T8 3L 4', HPT8, CEE, BF ≤ 0.78, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$6.09
3174	T8 3L 4', 28W, CEE, BF > 0.78, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$6.20
3175	T8 3L 4', 28W, CEE, BF ≤ 0.78, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$6.20
3176	T8 3L 4', 25W, CEE, BF > 0.78, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$7.35
3177	T8 3L 4', 25W, CEE, BF ≤ 0.78, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$7.35

MMID	Measure Name	Source	Incremental Cost
3178	T8 4L 4', HPT8, CEE, BF ≤ 0.78, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$8.12
3179	T8 4L 4', 28W, CEE, BF > 0.78, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$8.27
3180	T8 4L 4', 28W, CEE, BF ≤ 0.78, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$8.27
3181	T8 4L 4', 25W, CEE, BF > 0.78, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$9.80
3182	T8 4L 4', 25W, CEE, BF ≤ 0.78, Parking Garage	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$9.80
3183	Strip Curtain, Walk-In Freezers and Coolers	WESCO Distribution Pricing ($45.00) + Labor ($5.00) = $50.00	$50.00
3184	Delamping, Direct Install, 8 Foot Lamp	Mid-Atlantic TRM Version 6.0. Page 323. Available online: http://www.neep.org/mid-atlantic-technical-reference-manual-v6	$10.80
3188	Hot Water Boiler, 95%+ AFUE	Focus on Energy Program, 2013. Program Implementer CLEAResult surveyed 40 Trade Allies and took the average reported cost for an 82% boiler and subtracted that amount from the average reported cost for a 95% boiler.	$3,105.00
3195	Linear Fluorescent, 2L 4’RWT8 Replacements, 24 Hours, CALP	Actual cost from 2015-16 program data, 30 applications.	$34.97
3196	T8 2L-4ft High Performance Tandem Replacing T12 2L-8ft	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$9.80

MMID	Measure Name	Source	Incremental Cost
3197	CFL Fixture, Interior or Exterior, 24 Hours, CALP	Actual cost from 2015-16 program data, 158 applications.	$66.33
3198	CFL Hardwired INTERIOR FIXTURE, DIRECT INSTALL - 28 WATT	CFL, Standard Bulb, 750-1049 Lumen. Evaluator research for ENERGY STAR, March 2016. Average costs from online research including Lowes, Home Deport, and 1000bulbs.com.	$1.62
3199	CFL Hardwired EXTERIOR FIXTURE, DIRECT INSTALL - 18 WATT > 1,100 LUMENS	CFL, Standard Bulb, 750-1049 Lumen. Evaluator research for ENERGY STAR, March 2016. Average costs from online research including Lowes, Home Deport, and 1000bulbs.com.	$1.62
3200	LED, Exit Sign, Retrofit, CALP	Online Research, March 2016. Average sales price of Led Exit Signs on 1000bulbs.com = $26.43; RSMeans, 2015 labor cost for install of Signs, interior electric exit sign, wall mounted , 6" = $72.00. $26.43 (material cost) + $72.00 (labor cost) = $98.43.	$98.43
3201	Occupancy Sensor, Wall or Ceiling Mount ≤200 Watts, CALP	WESCO Distribution Pricing ($18.75) + Labor ($16.25) = $35.00 for Wall Mount. WESCO Distribution Pricing, 2013 + Labor = $120.00 for Ceiling Mount. $77.50 is the average.	$77.50
3202	Occupancy Sensor, Wall or Ceiling Mount >200 Watts, CALP	WESCO Distribution Pricing ($18.75) + Labor ($16.25) = $35.00 for Wall Mount. WESCO Distribution Pricing, 2013 + Labor = $120.00 for Ceiling Mount. $77.50 is the average.	$77.55
3203	CFL Fixture, replacing incandescent fixture	Historical value, from online research	$7.29
3204	CFL Fixtures	Historical value, from online research	$7.29
3205	CFL Fixture, ≤100 Watts, with Copay	Historical value, from online research	$7.29
3223	Coil Brush, Direct Install	No value provided	$0.00
3235	LED, 2x4, Replacing T8 2L	Online Research, March 2016. Average price of "2x4 led troffer fixtures" on 1000bulbs.com; www.1000bulbs.com/category/2x4-led-troffer-fixtures/	$168.29
3239	LED, 2x2, Replacing T8 2L U-Tube	Pricing Data obtained by Implementer through online retailers and contractors, August 2015.	$108.75
3244	Process Exhaust Filtration	Historical Focus on Energy project data, 2013. 8 projects, average total cost of process exhaust filtration is $2.89 per CFM.	$2.89/CFM
3251	Lighting Controls, Bilevel, Exterior and	Materials: WESCO Distribution Pricing, 2013 ($70.00) + Labor: RSMEANS, 2013 ($25.00) = $95.00	$95.00

MMID	Measure Name	Source	Incremental Cost
	Parking Garage Fixtures, Dusk to Dawn		
3252	Lighting Controls, Bilevel, Parking Garage Fixtures, 24 Hour	Materials: WESCO Distribution Pricing, 2013 ($70.00) + Labor: RSMEANS, 2013 ($25.00) = $95.00	$95.00
3253	Lighting Controls, Photocell with Internal Timer or Wireless Schedule, Exterior	Actual cost from 2015-16 program data, 7 applications.	$101.56
3254	Occupancy Sensor, High Bay Fixtures, Gymnasium	WESCO Distribution Pricing, 2013 ($70.00) + Labor ($25.00) = $95.00	$95.00
3255	Occupancy Sensor, High Bay Fixtures, Industrial	WESCO Distribution Pricing ($70.00) + Labor ($25.00) = $95.00	$95.00
3256	Occupancy Sensor, High Bay Fixtures, Retail	WESCO Distribution Pricing ($70.00) + Labor ($25.00) = $95.00	$95.00
3257	Occupancy Sensor, High Bay Fixtures, Warehouse	WESCO Distribution Pricing ($70.00) + Labor ($25.00) = $95.00	$95.00
3258	Occupancy Sensor, High Bay Fixtures, Public Assembly	WESCO Distribution Pricing ($70.00) + Labor ($25.00) = $95.00	$95.00
3259	Occupancy Sensor, High Bay Fixtures, Other	WESCO Distribution Pricing, 2013 ($70.00) + Labor ($25.00) = $95.00	$95.00
3260	Bi Level Controls, High Bay Fixtures, Gymnasium	Materials: WESCO Distribution Pricing, 2013 ($70.00) + Labor: RSMEANS, 2013 ($25.00) = $95.00	$95.00
3261	Bi Level Controls, High Bay Fixtures, Industrial	Materials: WESCO Distribution Pricing, 2013 ($70.00) + Labor: RSMEANS, 2013 ($25.00) = $95.00	$95.00
3262	Bi Level Controls, High Bay Fixtures, Retail	Materials: WESCO Distribution Pricing, 2013 ($70.00) + Labor: RSMEANS, 2013 ($25.00) = $95.00	$95.00

MMID	Measure Name	Source	Incremental Cost
3263	Bi Level Controls, High Bay Fixtures, Warehouse	Materials: WESCO Distribution Pricing, 2013 ($70.00) + Labor: RSMEANS, 2013 ($25.00) = $95.00	$95.00
3264	Bi Level Controls, High Bay Fixtures, Public Assembly	Materials: WESCO Distribution Pricing, 2013 ($70.00) + Labor: RSMEANS, 2013 ($25.00) = $95.00	$95.00
3265	Bi Level Controls, High Bay Fixtures, Other	Materials: WESCO Distribution Pricing, 2013 ($70.00) + Labor: RSMEANS, 2013 ($25.00) = $95.00	$95.00
3266	Demand Control Ventilation, RTU Optimization	Historical data (1/1/14-8/10/16 paid proj) for MMID3266 = $2,796.00 per AHU. This excludes 1 project with $20.00 per AHU and 3 projects > $19,000.00 per AHU.	$2,796.00/ AHU
3269	Steam Trap Repair, < 50 psig, General Heating, 7/32"	Average of 15 projects, 2014	$100.81
3270	Steam Trap Repair, < 50 psig, General Heating, 1/4"	Average of 22 projects, 2014. One project with outlier cost excluded.	$79.84
3271	Steam Trap Repair, < 50 psig, General Heating, 5/16"	Average of 11 projects, 2014	$70.60
3272	Steam Trap Repair, < 50 psig, General Heating, 3/8"	Average of 9 projects, 2014. One project with outlier cost excluded.	$231.67
3273	LED, 8 watts	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$6.05
3274	LED, 12 watts	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$5.85
3275	Boiler Plant Retrofit, Hybrid Plant, >=1 MMBh	Focus on Energy Nonresidential Program Data, 2013. Per historical project data (22 boilers on 13 projects), average hybrid boiler plant total cost is $25.65 per MBh.	$25.65/MBh
3276	Boiler, Hot Water, Condensing, >=90% AFUE, >=300 mbh	Focus on Energy Nonresidential Program Data, 2013. Per historical project data (93 boilers on 52 projects), average >= 90% >= 300 MBh boiler total cost is $25.26 per MBh	$25.65/MBh
3277	Boiler, Hot Water, Near Condensing,	Focus on Energy Nonresidential Program Data, 2013. Per historical project data (14 boilers on 6 projects), average >= 85% >= 300 MBh boiler total cost is $14.72 per MBh.	$14.72/MBh

MMID	Measure Name	Source	Incremental Cost
	>=85% AFUE, >=300 mbh		
3279	LED, Direct Install, 9.5 Watt	Average of MMIDs 3346-3347. Online research, March 2016. Average cost of "8 Watt LED Lamp, 40 Watt equivalent" and "12 Watt LED Lamp, 60 Watt equivalent." Available online: www.1000bulbs.com/category/60-watt-equal-led-light-bulbs/ and www.1000bulbs.com/category/40-watt-equal-led-light-bulbs/	$7.81
3280	VFD, Constant Torque	Evaluator and Implementer Consensus on setting cost on a per hp basis, instead of per motor. Cost set at $130.00 per hp, determined as survey value across full size range of motors eligible for this measure. Constant torque VFD is 15% more than variable torque VFD, 15% added to cost of similar VFD measures: $130.00 per hp x 1.15 = $149.50. Informed by historical Focus on Energy project data, 2012-2013 and NEEP 2013 Incremental Cost Study (Incremental Cost Study Phase Two Final Report, Navigant Consulting, 2013). Available online: http://www.neep.org/Assets/uploads/files/emv/emv-products/NEEP%20ICS2%20FINAL%20REPORT%202013Feb11-Website.pdf	$149.50
3284	Strip Curtain, Walk-In Freezers and Coolers, SBP A La Carte	WESCO Distribution Pricing ($45.00) + Labor ($5.00) = $50.00	$50.00
3286	LED Fixture, <250 Watts, Replacing 320-400 Watt HID, High Bay, SBP A La Carte	Online research, March 2016. Average cost of "LED round high bay fixtures" 155 Watt to 250 Watt replacement. Available online: https://www.1000bulbs.com/category/round-high-bays/	$387.82
3289	LED Fixture, Replacing 150-175 Watt HID, Exterior, SBP A La Carte	Online research, March 2016. Average cost of "LED round high bay fixtures" under 155 Watt replacement. Available online: https://www.1000bulbs.com/category/round-high-bays/	$204.99
3290	LED Fixture, Replacing 320-400 Watt HID, Exterior, SBP A La Carte	Online research, March 2016. Average cost of "LED round high bay fixtures" 155 Watt to 250 Watt replacement. Available https://www.1000bulbs.com/category/round-high-bays/	$387.82
3291	LED Troffer, 2x4, Replacing 4' 3-4 Lamp T8 Troffer, SBP A La Carte	Online Research, March 2016. Average price of "2x4 led troffer fixtures" on 1000bulbs.com; www.1000bulbs.com/category/2x4-led-troffer-fixtures/	$168.29

MMID	Measure Name	Source	Incremental Cost
3293	Occupancy Sensor, High Bay Fluorescent Fixtures, Warehouse, SBP A La Carte	WESCO Distribution Pricing, 2013 ($70.00) + Labor ($25.00) = $95.00	$95.00
3294	Occupancy Sensor, High Bay Fluorescent Fixtures, Public Assembly, SBP A La Carte	WESCO Distribution Pricing, 2013 ($70.00) + Labor ($25.00) = $95.00	$95.00
3295	Occupancy Sensor, High Bay Fluorescent Fixtures, Gymnasium, SBP A La Carte	WESCO Distribution Pricing, 2013 ($70.00) + Labor ($25.00) = $95.00	$95.00
3297	Occupancy Sensor, High Bay Fluorescent Fixtures, Industrial, SBP A La Carte	WESCO Distribution Pricing, 2013 ($70.00) + Labor ($25.00) = $95.00	$95.00
3298	LED, Reach-In Refrigerated Case, Replaces T12 or T8, SBP A La Carte	Regional Technical Forum, UES Measures. "Commercial: Grocery - Display Case LEDs (Reach-in Cases)." Measure Workbook 3.2; November 16, 2015. $22.00 for all "Commercial: Grocery - Display Case LEDs (Reach-in Cases)" measures. Available online: http://rtf.nwcouncil.org/measures/measure.asp?id=104	$22.00
3299	LED, Reach-In Refrigerated Case, Replaces T12 or T8 w/ Occupancy Control, SBP A La Carte	Regional Technical Forum, UES Measures. "Commercial: Grocery - Display Case LEDs (Reach-in Cases)." Measure Workbook 3.2; November 16, 2015. $22.00 for all "Commercial: Grocery - Display Case LEDs (Reach-in Cases)" measures. Available online: http://rtf.nwcouncil.org/measures/measure.asp?id=104. Measure Workbook 3.1; January 4, 2016. Occupancy sensor = $3.00 for all "Commercial: Grocery - Display Case Motion Sensors". Available online: http://rtf.nwcouncil.org/measures/measure.asp?id=106.	$25.00
3301	LED Fixture, Replacing 250 Watt HID, Exterior, SBP A La Carte	Online research, March 2016. Average cost of "LED round high bay fixtures" 155 Watt to 250 Watt replacement. Available online: https://www.1000bulbs.com/category/round-high-bays/	$387.82
3302	LED Fixture, Replacing 320 Watt HID,	Online research, March 2016. Average cost of "LED round high bay fixtures" 155 Watt to 250 Watt replacement. Available online: https://www.1000bulbs.com/category/round-high-bays/	$387.82

MMID	Measure Name	Source	Incremental Cost
	Exterior, SBP A La Carte		
3303	LED Fixture, Replacing 400 Watt HID, Exterior, SBP A La Carte	Online research, March 2016. Average cost of "LED round high bay fixtures" 155 Watt to 250 Watt replacement. Available online: https://www.1000bulbs.com/category/round-high-bays/	$387.82
3304	LED Fixture, Replacing 70-100 Watt HID, Exterior, SBP A La Carte	Online Research, March 2016. Average price of 50-100 Watt equivalent fixtures via search: "50-175-metal-halide-equivalent LED shoebox fixtures" on 1000bulbs.com; https://www.1000bulbs.com/category/50-175-metal-halide-equivalent/	$109.99
3307	T8 2L 4', HPT8 or RWT8, Replacing T12 1L 8', 0.78 < BF < 1.00, SBP A La Carte	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$4.90
3309	T8 4L 4', HPT8 or RWT8, Replacing T12 2L 8', 0.78 < BF < 1.00, SBP A La Carte	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$9.80
3312	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', 0.78 < BF < 1.00, SBP A La Carte	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$4.90
3320	Delamping, T12 to T8, 8', SBP A La Carte	Mid-Atlantic TRM Version 6.0. Page 323. Available online: http://www.neep.org/mid-atlantic-technical-reference-manual-v6	$10.80
3323	LED, 2x2, Replacing T12 2L U-Tube, SBP A La Carte	Pricing Data obtained by Implementer through online retailers and contractors, August 2015.	$108.75
3324	LED, 2x2, Replacing T8 2L U-Tube, SBP A La Carte	Pricing Data obtained by Implementer through online retailers and contractors, August 2015.	$108.75
3325	T8, 2’ Lamps, Replacing T12 Single U-Tube, SBP A La Carte	Online research, March 2016. Average price of "T12 Utube" lamp from: 1000bulbs.com.	$21.49
3326	T8, 2’ Lamps, Replacing T12 Dual U-Tube, SBP A La Carte	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$1.22

MMID	Measure Name	Source	Incremental Cost
3327	T8, 2' Lamps, Replacing T8 Single U-Tube, SBP A La Carte	Online research, March 2016. Average price of "T12 Utube" lamp from: 1000bulbs.com.	$21.49
3328	T8, 2' Lamps, Replacing T8 Dual U-Tube, SBP A La Carte	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$1.22
3329	T8 4L Replacing 250-399 W HID, SBP A La Carte	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$4.90
3330	T5HO 2L Replacing 250-399 W HID, SBP A La Carte	Similar measure 2890. 2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013.	$156.14
3331	T8 6L Replacing 400-999 W HID, SBP A La Carte	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$4.90
3332	T5HO 4L Replacing 400-999 W HID, SBP A La Carte	Similar measure 2892: 2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013.	$163.16
3333	T8 8L ≤ 500W, Replacing >=1000 W HID, SBP A La Carte	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$4.90
3334	T5HO 6L ≤ 500W, Replacing >=1000 W HID, SBP A La Carte	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013.	$210.22
3335	LED, Horizontal Case Lighting, SBP A La Carte	Regional Technical Forum, UES Measures. "Commercial: Grocery - Display Case LEDs (Reach-in Cases)." Measure Workbook 3.2; November 16, 2015. $22.00 for all "Commercial: Grocery - Display Case LEDs (Reach-in Cases)" measures. Available online: http://rtf.nwcouncil.org/measures/measure.asp?id=104	$22.00
3336	T8 2L 4', recessed Indirect Fixture, HPT8	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor	$4.90

MMID	Measure Name	Source	Incremental Cost
	replacing 3 or 4L - T8 or T12, SBP A La Carte	duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	
3343	Lighting Controls, Bilevel, Exterior and Parking Garage Fixtures, Dusk to Dawn, SBP A La Carte	Materials: WESCO Distribution Pricing, 2013 ($70.00) + Labor: RSMEANS, 2013 ($25.00) = $95.00	$95.00
3344	Lighting Controls, Bilevel, Parking Garage Fixtures, 24 Hour, SBP A La Carte	Materials: WESCO Distribution Pricing, 2013 ($70.00) + Labor: RSMEANS, 2013 ($25.00) = $95.00	$95.00
3345	Lighting Controls, Photocell with Internal Timer or Wireless Schedule, Exterior, SBP A La Carte	2015 Implementer assesment of measure cost.	$30.00
3346	LED, 8 Watts, SBP Package	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$6.05
3347	LED, 12 Watts, SBP Package	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$5.85
3348	LED Troffer, 2x4, Replacing 4' 3-4 Lamp T8 Troffer, SBP Package	Online Research, March 2016. Average price of "2x4 led troffer fixtures" on 1000bulbs.com; www.1000bulbs.com/category/2x4-led-troffer-fixtures/	$168.29
3350	Insulation, Direct Install, Pipe, Per Foot, 1" Thickness, Electric, SBP Package	RS Means Building Construction Cost Data, 2015. Insulation, pipe covering (price copper tube one less than I.P.S), fiberglass with all service jacket, 1" wall, 1" iron pipe size. Material Cost is $0.88 + Labor Cost is $1.53 = Total is $2.41	$2.41/ft
3351	Insulation, Direct Install, Pipe, Per Foot, 1" Thickness, NG, SBP Package	RS Means Building Construction Cost Data, 2015. Insulation, pipe covering (price copper tube one less than I.P.S), fiberglass with all service jacket, 1" wall, 1" iron pipe size. Material Cost is $0.88 + Labor Cost is $1.53 = Total is $2.41	$2.41/ft
3352	LED, 8-12 Watts, SBP Package	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®. Weighted Average of 40 to 53 Watt LEDs.	$7.80

MMID	Measure Name	Source	Incremental Cost
3353	LED, Replacing Neon Sign, SBP Package	2015 Implementer survey of Trade Ally's installation Cost.	$55.00
3355	Faucet Aerator, Direct Install, 1.5 gpm, Bathroom, Electric, SBP Package	DEER 2015. California Database for Energy Efficient Resources, $6.70 labor + $6.54 materials = $13.24. Available online: http://www.deeresources.com/index.php/ex-ante-database	$13.24
3356	Faucet Aerator, Direct Install, 1.5 gpm, Bathroom, NG, SBP Package	DEER 2015. California Database for Energy Efficient Resources, $6.70 labor + $6.54 materials = $13.24. Available online: http://www.deeresources.com/index.php/ex-ante-database	$13.24
3357	Occupancy Sensor, Wall Mount, >200 Watts, SBP Package	WESCO Distribution Pricing ($18.75) + Labor ($16.25) = $35.00	$35.00
3358	Showerhead, Direct Install, 1.75 gpm, Electric, SBP Package	$5.00 = WESCO Distribution Pricing ($3.11) + Labor ($1.89)	$5.00
3359	Showerhead, Direct Install, 1.75 gpm, NG, SBP Package	$5.00 = WESCO Distribution Pricing ($3.11) + Labor ($1.89)	$5.00
3360	LED, Exit Sign, Retrofit, SBP Package	Online Research, March 2016. Average sales price of Led Exit Signs on 1000bulbs.com = $26.43.	$26.43
3361	Occupancy Sensor, Wall Mount, ≤200 Watts, SBP Package	WESCO Distribution Pricing ($18.75) + Labor ($16.25) = $35.00	$35.00
3363	LED, ≤ 8W, SBP Package	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$6.05
3364	LED, > 12W (Max 20W) Flood Lamp, SBP Package	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$13.10
3365	LED, MR16, 8-12W, SBP Package	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$11.50
3366	LED, 2x2, Replacing T12 2L U-Tube, SBP Package	Pricing Data obtained by Implementer through online retailers and contractors, August 2015.	$108.75

MMID	Measure Name	Source	Incremental Cost
3367	LED, 2x2, Replacing T8 2L U-Tube, SBP Package	Pricing Data obtained by Implementer through online retailers and contractors, August 2015.	$108.75
3368	Faucet Aerator, Direct Install, .5 gpm Public Restroom, Elec, SBP Package	DEER 2015. California Database for Energy Efficient Resources, $6.70 labor + $6.54 materials = $13.24. Available online: http://www.deeresources.com/index.php/ex-ante-database	$13.24
3369	Faucet Aerator, Direct Install, .5 gpm Public Restroom, NG, SBP Package	DEER 2015. California Database for Energy Efficient Resources, $6.70 labor + $6.54 materials = $13.24. Available online: http://www.deeresources.com/index.php/ex-ante-database	$13.24
3370	Faucet Aerator, Direct Install, .5 gpm Employee Restroom, Elec, SBP Package	DEER 2015. California Database for Energy Efficient Resources, $6.70 labor + $6.54 materials = $13.24. Available online: http://www.deeresources.com/index.php/ex-ante-database	$13.24
3371	Faucet Aerator, Direct Install, .5 gpm employee Restroom, NG, SBP Package	DEER 2015. California Database for Energy Efficient Resources, $6.70 labor + $6.54 materials = $13.24. Available online: http://www.deeresources.com/index.php/ex-ante-database	$13.24
3372	T8 2L 4', recessed Indirect Fixture, HPT8 replacing 3 or 4L - T8 or T12, SBP Package	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$4.90
3385	LED, Non PI Direct Install, 13.5 Watt	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$5.85
3386	Grain Dryer, Energy Efficient, Hybrid	Average of unit pricing values from Mathews Company Grain Dryer Price Book based on suggested base retail prices for their new grain dryer equipment offerings. Print.	$179 per bushel/hr of dryer capacity
3387	LED, 1x4, replacing T8 or T12, 2L	Retailer Cost Data obtained by Implementer through online retailers, August 2015.	$77.00
3391	HPT8, 1x4, replacing T12 or T8, 2L, SBP A La Carte	Online research, March 2016. Average price of "T12 Utube" lamp from: 1000bulbs.com.	$21.49
3392	HPT8, 1x4, replacing T12 or T8, 2L, SBP Package	Online research, March 2016. Average price of "T12 Utube" lamp from: 1000bulbs.com.	$21.49

MMID	Measure Name	Source	Incremental Cost
3393	LED Fixture,≤180 Watts, Replacing 4 lamp T5 or 6 lamp T8, High Bay, DLC Listed	Cost data obtained through various online lighting retailers from July 2016.	$215.69
3394	LED Fixture, Downlights, ≤18 Watts, Replacing 1 lamp pin based CFL Downlight	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$10.80
3395	LED Fixture, Downlights, >18 Watts, Replacing 2 lamp pin based CFL Downlight	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$17.55
3396	LED Fixture, Downlights, ≤100 Watts, > =4000 Lumens, Interior	Online research, May 2016. Average cost of "LED Downlights" over 45 Watt equivalent (4000 + Lumens). Available online: https://www.1000bulbs.com/category/led-downlight-lighting/	$24.73
3397	LED Fixture, Downlights, ≤100 Watts, >=4000 Lumens, Exterior	Online research, May 2016. Average cost of "Exterior LED Downlights" over 45 Watt equivalent (4000 + Lumens). Available online: https://www.1000bulbs.com/category/led-downlight-lighting/	$51.85
3398	LED Fixture, Downlights, >=6000 Lumens, Interior	Online research, May 2016. Average cost of "LED Downlights" over 65 Watt equivalent (6000 + Lumens). Available online: https://www.1000bulbs.com/category/led-downlight-lighting/	$35.67
3399	LED Fixture, Downlights, >=6000 Lumens, Exterior	Online research, May 2016. Average cost of "LED Downlights" over 65 Watt equivalent (6000 + Lumens). Available online: https://www.1000bulbs.com/category/led-downlight-lighting/	$35.92
3400	LED Fixture, 2x2, Low Output, DLC Listed	Pricing Data obtained by Implementer through online retailers and contractors, August 2015.	$108.75
3401	LED Fixture, 2x2, High Output, DLC Listed	Pricing Data obtained by Implementer through online retailers and contractors, August 2015.	$108.75
3402	LED Lamp, Energy Star, Replacing Incandescent Lamp ≤40 Watts, Exterior	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$6.05

MMID	Measure Name	Source	Incremental Cost
3403	LED Lamp, Energy Star, Replacing Incandescent Lamp >40 Watts, Exterior	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®. Weighted Average 60,75, and 100 W LEDs.	$9.40
3404	LED Fixture, Downlights, >18 Watts, Replacing Incandescent Downlight, Exterior	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$12.46
3405	LED Fixture, Downlights, ≤18 Watts, Replacing Incandescent Downlight, Exterior	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$17.55
3406	Daylighting Controls	Actual cost from 2015-16 program data, 21 applications	$0.73
3407	LED Fixture, Replacing 1000 Watt HID, Exterior	Online research, March 2016. Average cost of "LED round high bay fixtures" over 400 Watt replacement. Available online: https://www.1000bulbs.com/category/round-high-bays/	$398.41
3408	PSMH/CMH, Replacing 1000 Watt HID, Exterior	Evaluator Online Research, May 2016. From: Bestlights.com; venturelights.com; and warehouselighting.com and Focus on Energy Program information. Baseline cost is $322.00 for 1000 Watt HID Exterior lamps. Average cost of fixture types found in FoE Invoices from 2015-2016 is $375.00.	$53.00
3409	Retrofit Open Refrigerated Cases with Doors	Historical Focus on Energy project data, 2013. 2 projects, average cost is $126.53 per foot.	$126.53/ft
3413	CFL, Non PI Direct Install, 13 Watt	Light bulb sales data obtained by Cadmus for California- 2010 through 2012. Note that the CFL average lamp costs include incented lamps.	$0.37
3414	Ice Machine, CEE Tier 2, Air Cooled, Self Contained, 0-499 lbs/day	Illinois Technical Reference Manual. 2013. Page 103. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$981.00
3415	Ice Machine, CEE Tier 2, Water Cooled, Self Contained, 0-499 lbs/day	Illinois Technical Reference Manual. 2013. Page 103. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$981.00

MMID	Measure Name	Source	Incremental Cost
3416	Ice Machine, CEE Tier 2, Air Cooled, Ice Making Head, 0-499 lbs/day	Illinois Technical Reference Manual. 2013. Page 103. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$981.00
3417	Ice Machine, CEE Tier 2, Air Cooled, Ice Making Head, 500-999 lbs/day	Illinois Technical Reference Manual. 2013. Page 103. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$981.00
3418	Ice Machine, CEE Tier 2, Air Cooled, Ice Making Head, >=1,000 lbs/day	Illinois Technical Reference Manual. 2013. Page 103. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$981.00
3419	Ice Machine, CEE Tier 2, Water Cooled, Ice Making Head, <500 lbs/day	Illinois Technical Reference Manual. 2013. Page 103. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$981.00
3420	Ice Machine, CEE Tier 2, Water Cooled, Ice Making Head, 500-999 lbs/day	Illinois Technical Reference Manual. 2013. Page 103. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$981.00
3421	Ice Machine, CEE Tier 2, Water Cooled, Ice Making Head, >=1,000 lbs/day	Illinois Technical Reference Manual. 2013. Page 103. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$981.00
3422	Ice Machine, CEE Tier 2, Air Cooled, Remote Condensing, 0-499 lbs/day	Illinois Technical Reference Manual. 2013. Page 103. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$981.00
3423	Ice Machine, CEE Tier 2, Air Cooled, Remote Condensing, 500-999 lbs/day	Illinois Technical Reference Manual. 2013. Page 103. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$981.00
3424	Ice Machine, CEE Tier 2, Air Cooled, Remote Condensing, >=1,000 lbs/day	Illinois Technical Reference Manual. 2013. Page 103. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$981.00

MMID	Measure Name	Source	Incremental Cost
3425	LED, 8ft, Replacing T12 or T8, 1L	Online Research, March 2016. Average cost of "8 foot LED T8 replacement." Available online: https://www.1000bulbs.com/category/led-tubes-retrofit/	$20.49
3426	LED, 8ft, Replacing T12 or T8, 1L, SBP A La Carte	Online Research, March 2016. Average cost of "8 foot LED T8 replacement." Available online: https://www.1000bulbs.com/category/led-tubes-retrofit/	$20.49
3428	LED, 8ft, Replacing T12 or T8, 2L	Online Research, March 2016. Average cost of "8 foot LED T8 replacement." Available online: https://www.1000bulbs.com/category/led-tubes-retrofit/	$40.98
3429	LED, 8ft, Replacing T12 or T8, 2L, SBP A La Carte	Online Research, March 2016. Average cost of "8 foot LED T8 replacement." Available online: https://www.1000bulbs.com/category/led-tubes-retrofit/	$40.98
3439	LED, Non-PI Direct Install, 13.5 Watt, With Co-Pay	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$5.85
3461	LED, Recessed Downlight, Replacing Incandescent, Energy Star, In Unit	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®. Average across wattage based Focus on Energy "LED Downlight" measures.	$10.75
3462	LED, Recessed Downlight, Replacing Incandescent, Energy Star, Common Area	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®. Average across wattage based Focus on Energy "LED Downlight" measures.	$10.75
3463	LED, Recessed Downlight, Replacing CFL, Energy Star, In Unit	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®. Average across wattage based Focus on Energy "LED Downlight" measures.	$10.75
3464	LED, Recessed Downlight, Replacing CFL, Energy Star, Common Area	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®. Average across wattage based Focus on Energy "LED Downlight" measures.	$10.75
3487	CFL, Direct Install, 20 Watt	Historical value	$5.00
3488	LED, Direct Install, 10 Watt	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®. Weighted Average of 29 to 43 Watt LEDs.	$5.90
3489	DHW Temperature Turn Down, Serving	This is a behavioral measure and has no cost.	$0.00

MMID	Measure Name	Source	Incremental Cost
	Multiple Dwelling Units, Direct Install, Electric		
3490	DHW Temperature Turn Down, Serving Multiple Dwelling Units, Direct Install, NG	This is a behavioral measure and has no cost.	$0.00
3491	Furnace with ECM, ≥95%+ AFUE, NG	2015-02-10 Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Furnaces. Difference between North region's 80% and 95% furnaces in Table 8.5.1. Available online: https://www.regulations.gov/document?D=EERE-2014-BT-STD-0031-0027	$723.00
3492	Furnace with ECM, ≥90%+ AFUE, NG	2015-02-10 Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Furnaces. Difference between North region's 80% and 90% furnaces in Table 8.5.1. Available online: https://www.regulations.gov/document?D=EERE-2014-BT-STD-0031-0027	$575.00
3493	Parking Garage Ventilation Controls with Heating	Actual Program Data for MMID 3016, 2014-2016. 2 multifamily projects average actual cost of $607.00.	$607.00
3494	Variable Speed ECM Pump, < 100 Watts Max Input, Domestic Hot Water Recirculation	Pricing research, Nov 2014. PSC and ECM pump motors from Viridian, Stratos, Star, Top, and other brands were examined across taco-hvac.com, wilo-usa.com, and nz.grundfos.com.	$690.79
3495	Variable Speed ECM Pump, 100 - 500 Watts Max Input, Domestic Hot Water Recirculation	Pricing research, Nov 2014. PSC and ECM pump motors from Viridian, Stratos, Star, Top, and other brands were examined across taco-hvac.com, wilo-usa.com, and nz.grundfos.com.	$1,324.75
3496	Variable Speed ECM Pump, > 500 Watts Max Input, Domestic Hot Water Recirculation	Pricing research, Nov 2014. PSC and ECM pump motors from Viridian, Stratos, Star, Top, and other brands were examined across taco-hvac.com, wilo-usa.com, and nz.grundfos.com.	$1,844.58

MMID	Measure Name	Source	Incremental Cost
3497	Variable Speed ECM Pump, < 100 Watts Max Input, Heating Water Circulation	Pricing research, Nov 2014. PSC and ECM pump motors from Viridian, Stratos, Star, Top, and other brands were examined across taco-hvac.com, wilo-usa.com, and nz.grundfos.com.	$690.79
3498	Variable Speed ECM Pump, 100 - 500 Watts Max Input, Heating Water Circulation	Pricing research, Nov 2014. PSC and ECM pump motors from Viridian, Stratos, Star, Top, and other brands were examined across taco-hvac.com, wilo-usa.com, and nz.grundfos.com.	$1,324.75
3499	Variable Speed ECM Pump, > 500 Watts Max Input, Heating Water Circulation	Pricing research, Nov 2014. PSC and ECM pump motors from Viridian, Stratos, Star, Top, and other brands were examined across taco-hvac.com, wilo-usa.com, and nz.grundfos.com.	$1,844.58
3500	Variable Speed ECM Pump, < 100 Watts Max Input, Cooling Water Circulation	Pricing research, Nov 2014. PSC and ECM pump motors from Viridian, Stratos, Star, Top, and other brands were examined across taco-hvac.com, wilo-usa.com, and nz.grundfos.com.	$690.79
3501	Variable Speed ECM Pump, 100 - 500 Watts Max Input, Cooling Water Circulation	Pricing research, Nov 2014. PSC and ECM pump motors from Viridian, Stratos, Star, Top, and other brands were examined across taco-hvac.com, wilo-usa.com, and nz.grundfos.com.	$1,324.75
3502	Variable Speed ECM Pump, > 500 Watts Max Input, Cooling Water Circulation	Pricing research, Nov 2014. PSC and ECM pump motors from Viridian, Stratos, Star, Top, and other brands were examined across taco-hvac.com, wilo-usa.com, and nz.grundfos.com.	$1,844.58
3503	Variable Speed ECM Pump, < 100 Watts Max Input, Water Loop Heat Pump Circulation	Pricing research, Nov 2014. PSC and ECM pump motors from Viridian, Stratos, Star, Top, and other brands were examined across taco-hvac.com, wilo-usa.com, and nz.grundfos.com.	$690.79
3504	Variable Speed ECM Pump, 100 - 500 Watts Max Input, Water Loop Heat Pump Circulation	Pricing research, Nov 2014. PSC and ECM pump motors from Viridian, Stratos, Star, Top, and other brands were examined across taco-hvac.com, wilo-usa.com, and nz.grundfos.com.	$1,324.75

MMID	Measure Name	Source	Incremental Cost
3505	Variable Speed ECM Pump, > 500 Watts Max Input, Water Loop Heat Pump Circulation	Pricing research, Nov 2014. PSC and ECM pump motors from Viridian, Stratos, Star, Top, and other brands were examined across taco-hvac.com, wilo-usa.com, and nz.grundfos.com.	$1,844.58
3506	Faucet Aerator, 1.0 gpm, Kitchen, NG	DEER 2015. California Database for Energy Efficient Resources, $6.70 labor + $6.54 materials = $13.24. Available online: http://www.deeresources.com/index.php/ex-ante-database	$13.24
3507	Faucet Aerator, 1.0 gpm, Kitchen, Electric	DEER 2015. California Database for Energy Efficient Resources, $6.70 labor + $6.54 materials = $13.24. Available online: http://www.deeresources.com/index.php/ex-ante-database	$13.24
3508	Faucet Aerator, 0.5 gpm, Bathroom, NG	DEER 2015. California Database for Energy Efficient Resources, $6.70 labor + $6.54 materials = $13.24. Available online: http://www.deeresources.com/index.php/ex-ante-database	$13.24
3509	Faucet Aerator, 0.5 gpm, Kitchen, Electric	DEER 2015. California Database for Energy Efficient Resources, $6.70 labor + $6.54 materials = $13.24. Available online: http://www.deeresources.com/index.php/ex-ante-database	$13.24
3510	Faucet Aerator, 0.5 gpm, Kitchen, NG	DEER 2015. California Database for Energy Efficient Resources, $6.70 labor + $6.54 materials = $13.24. Available online: http://www.deeresources.com/index.php/ex-ante-database	$13.24
3511	LED Replacement of 4' T8 Lamps w/Integral or External Driver	Online research, Sept 2016. Available online: https://www.energyavenue.com/Sylvania/73107?gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFK-uSa-sFtYYo2HoW5piw9OCxbjku5rFsAlCYHiszo2UaAvPJ8P8HAQ; https://a19led.com/products/cree-ur-series-retrofit-kit-ur2-48-45l-40k-10v-fd?utm_medium=cpc&utm_source=googlepla&variant=16950356097&gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFK6i-wzHiYiyYqQK-8Pkn5xth3-d_JRLhZy3vCUDWo1kaAugw8P8HAQ; http://www.adlsupply.com/ballasts/philips-advance-icn-2p32-n/?gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFK49fTcL_EluiJxnnAgMbLGQvMyjl_LjjXKPLUwd5TkoaAlPi8P8HAQ http://www.lighting-spot.com/ge-232-mv-n.html?fee=24&fep=527&gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFKwQ8BslaEWkUNaQJiYJLq1E2EvCC8qV6AszId7rFH0waAjHg8P8HAQ; https://www.bulbamerica.com/products/osram-sylvania-32w-120v-t8-2-lamp-high-efficiency-electric-ballast?CAWELAID=12	$46.55

MMID	Measure Name	Source	Incremental Cost
		0150920000389459&CAGPSPN=pla&CAAGID=11213624286&CATCI=pla-129513636246&catargetid=120150920000808680&cadevice=c&gclid=Cj0KEQjw57W9BRDM9_a-2v	
3512	LED Replacement of 4' T8 Lamps utilizing existing ballast	Online research, Sept 2016. Available online: http://www.greenledzone.com/t8-led-tube-light-direct-wire-ballast-compatible-p/gl-lod-c08-m1218.htm?gclid=Cj0KEQjwxLC9BRDb1dP8o7Op68IBEiQAwWggQA7zZ34iQp1t8ivOd4GwDDOKE1flh40UVRP3kOWcoToaAh7p8P8HAQ; http://www.shineretrofits.com/james-industry-bt816w4ft-16-watt-4-foot-led-plug-and-play-ballast-compatible-t8-linear-tube-lamp-frosted-aluminum-housing.html?gclid=Cj0KEQjwxLC9BRDb1dP8o7Op68IBEiQAwWggQAYs8tG6hrZ21H2cx1HyxyJIthWTf8X1LY6FTU_i9_AaApAp8P8HAQ; https://www.earthled.com/products/thinklux-led-fluorescent-replacement-tube-4-foot-18-watt-universal-t8-or-t12-ballast-compatible-dimmable?variant=20878204932; https://www.1000bulbs.com/product/7028/TCP-31032841.html?utm_source=SmartFeedGoogleBase&utm_medium=Shopping&utm_term=TCP-31032841&utm_content=800+Series+Phosphors&utm_campaign=SmartFeedGoogleBaseShopping&gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFK3_139urG; https://www.1000bulbs.com/product/90200/USH-3000480.html?utm_source=SmartFeedGoogleBase&utm_medium=Shopping&utm_term=USH-3000480&utm_content=800+Series+Phosphors&utm_campaign=SmartFeedGoogleBaseShopping&gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFK2B1rtXuKJ; http://www.adlsupply.com/fluorescent-t8/sylvania-21781-fo32-841-eco/?gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFK7UbfdMKV6L5tIYN6DNgvVs1fr2zovtgAyLuo8_F6hEaAnRn8P8HAQ	$11.29
3513	ENERGY STAR Fluorescent Porch Fixtures	ENERGY STAR® Products List. Filtered by fluorescent technology, porch fixture type and lumen bin. April 15, 2016.	$32.00
3514	Steam Trap Repair, 50-125 psig, General Heating, 3/8" or Larger	Average of 4 projects for MMID 2547 (Repair leaking steam trap, 50-125 psig), 2013 - 2014	$391.02

MMID	Measure Name	Source	Incremental Cost
3515	Steam Trap Repair, 50-125 psig, General Heating, 5/16"	Average of 4 projects for MMID 2547 (Repair leaking steam trap, 50-125 psig), 2013 - 2014	$391.02
3516	Steam Trap Repair, 50-125 psig, General Heating, 7/32" or Smaller	Average of 4 projects for MMID 2547 (Repair leaking steam trap, 50-125 psig), 2013 - 2014	$391.02
3517	Steam Trap Repair, 126-225 psig, General Heating, 1/4"	Average of 1 project, 2013	$633.83
3518	Steam Trap Repair, 126-225 psig, General Heating, 3/8" or Larger	Average of 1 project, 2013	$633.83
3519	Steam Trap Repair, 126-225 psig, General Heating, 5/16"	Average of 1 project, 2013	$633.83
3520	Steam Trap Repair, 126-225 psig, General Heating, 7/32" or Smaller	Average of 1 project, 2013	$633.83
3521	Steam Trap Repair, >225 psig, General Heating, 1/4"	Pressure-based extrapolation of costs for MMIDs 2547, 2545, and average costs for 3269, 3270, 3271, and 3272.	$1,127.66
3522	Steam Trap Repair, >225 psig, General Heating, 3/8" or Larger	Pressure-based extrapolation of costs for MMIDs 2547, 2545, and average costs for 3269, 3270, 3271, and 3272.	$1,127.66
3523	Steam Trap Repair, >225 psig, General Heating, 5/16"	Pressure-based extrapolation of costs for MMIDs 2547, 2545, and average costs for 3269, 3270, 3271, and 3272.	$1,127.66
3524	Steam Trap Repair, >225 psig, General Heating, 7/32" or Smaller	Pressure-based extrapolation of costs for MMIDs 2547, 2545, and average costs for 3269, 3270, 3271, and 3272.	$1,127.66
3525	LED, Direct Install, 10 Watt, HES	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®. Weighted Average of 29 to 43 Watt LEDs.	$5.90

MMID	Measure Name	Source	Incremental Cost
3548	CFL, Standard Bulb, 310-749 Lumens, Retail Store Markdown	Light bulb sales data obtained by Cadmus for California- 2010 through 2012. Note that the CFL average lamp costs include incented lamps.	$1.21
3549	CFL, Standard Bulb, 750-1049 Lumens, Retail Store Markdown	Evaluator research for ENERGY STAR®, March 2016. Average costs from online research including Lowes, Home Deport, and 1000bulbs.com.	$1.62
3550	CFL, Standard Bulb, 1050-1489 Lumens, Retail Store Markdown	Evaluator research for ENERGY STAR®, March 2016. Average costs from online research including Lowes, Home Deport, and 1000bulbs.com.	$2.74
3551	CFL, Standard Bulb, 1490-2600 Lumens, Retail Store Markdown	Evaluator research for ENERGY STAR®, March 2016. Average costs from online research including Lowes, Home Deport, and 1000bulbs.com.	$1.03
3552	CFL, Reflector, 15 watt, Retail Store Markdown	Evaluator research for ENERGY STAR®, March 2016. Average costs from online research including Lowes, Home Deport, and 1000bulbs.com.	$2.80
3553	LED, Omnidirectional, 310-749 Lumens, Retail Store Markdown	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$4.50
3554	LED, Omnidirectional, 750-1049 Lumens, Retail Store Markdown	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$5.85
3555	LED, Omnidirectional, 1050-1489 Lumens, Retail Store Markdown	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$12.50
3556	LED, Omnidirectional, 1490-2600 Lumens, Retail Store Markdown	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$12.50
3557	LED, Reflector, 12 watt, Retail Store Markdown	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$5.85

MMID	Measure Name	Source	Incremental Cost
3558	Insulation, Attic, R-19 to R-38	Attic Insulation IC of $0.99 per sq ft + NREL National Residential Efficiency Measures Database (for air sealing).	$2,647.71
3559	Boiler, 95%+ AFUE, With DHW, NG	NEEP Regional Evaluation, Measurement & Verification Forum, A Report on Costs in Six Northeast & Mid-Atlantic Markets. 2011. Navigant Consulting. Page A-10. Mid-sized (126 MBh) Residential Combination Heat/Hot Water Incremental Cost 95 CAE = $2,803.00.	$2,803.00
3560	Occupancy Sensor, Fixture Mount, > 60 Watts	Mid-Atlantic Technical Reference Manual Version 5.0, April 2015. Page 302. Available online: http://www.neep.org/sites/default/files/resources/Mid-Atlantic_TRM_V5_FINAL_5-26-2015.pdf	$200.00
3561	Occupancy Sensor, Fixture Mount, ≤ 60 Watts	Mid-Atlantic Technical Reference Manual Version 5.0, April 2015. Page 302. Available online: http://www.neep.org/sites/default/files/resources/Mid-Atlantic_TRM_V5_FINAL_5-26-2015.pdf	$200.00
3567	LED, Direct Install, 10 Watt, with Co-pay	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®. Weighted Average of 29 to 43 Watt LEDs.	$5.90
3570	Insulation and Air Sealing, Attic, R-11 to R-38	Attic Insulation IC of $0.99 per sq ft + NREL National Residential Efficiency Measures Database (for air sealing).	$2,647.71
3571	Showerhead, Handheld, Direct Install, 1.5 gpm, Electric	$5.00 = WESCO Distribution Pricing ($3.11) + Labor ($1.89)	$5.00
3572	Showerhead, Handheld, Direct Install, 1.5 gpm, NG	$5.00 = WESCO Distribution Pricing ($3.11) + Labor ($1.89)	$5.00
3573	Faucet Aerator, Direct Install, 1.5 gpm, Kitchen, Swivel, Electric	DEER 2015. California Database for Energy Efficient Resources, $6.70 labor + $6.54 materials = $13.24. Available online: http://www.deeresources.com/index.php/ex-ante-database	$13.24
3574	Faucet Aerator, Direct Install, 1.5 gpm, Kitchen, Swivel, NG	DEER 2015. California Database for Energy Efficient Resources, $6.70 labor + $6.54 materials = $13.24. Available online: http://www.deeresources.com/index.php/ex-ante-database	$13.24
3575	CFL, Direct Install, 9 Watt, Torpedo, Candelabra base	Evaluator research for ENERGY STAR®, March 2016. Average costs from online research including Lowes, Home Deport, and 1000bulbs.com.	$1.47

MMID	Measure Name	Source	Incremental Cost
3576	CFL, Direct Install, 14 Watt, Torpedo, Medium base	Evaluator Online Research, March 2016. Average costs from online research at 1000bulbs.com. Available online: https://www.1000bulbs.com/category/decorative-cfl-compact-fluorescents/	$4.14
3577	LED, > 12W, SBP After A La Carte	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$5.85
3578	LED, > 12W, SBP Package	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$5.85
3579	LED, > 16W, SBP After A La Carte	Market research, October 2016. 1000bulbs.com, amazon.com, lowes.com	$9.80
3580	LED, > 16W, SBP Package	Market research, October 2016. 1000bulbs.com, amazon.com, lowes.com	$9.80
3582	T8 LED < 20 Watts, 2L, Replacing 3L or 4L T12/T8, SBP After A La Carte	Program Implementer market research 2014.	$62.00
3583	Steam Trap Repair, 50-125 psig, General Heating, 1/4"	Average of 4 projects for MMID 2547 (Repair leaking steam trap, 50-125 psig), 2013 - 2014	$0.00
3584	Condensing Water Heater, NG, 90%+, Claim Only	Per Ohio TRM dated 8/6/10 (pg 123): condensing storage DHW incremental cost is $685.00 per water heater	$685.00
3585	Water Heater, Indirect, Claim Only	NEEP Regional Evaluation, Measurement & Verification Forum, A Report on Costs in Six Northeast & Mid-Atlantic Markets. 2011. Navigant Consulting. Page 11. Mid-sized (60 MBh and 48 gals) Residential Indirect Water Heater Incremental Cost Results ($ per unit) Non-Regional Specific.	$1,294.00
3586	Water Heater, Electric, EF of 0.93 or greater, Claim Only	California Energy Commission and California Public Utilities Commission. Database for Energy Efficient Resources (DEER) 2008. And RSMeans. Facilities Construction Cost Data. 2011. Available online: http://www.deeresources.com/index.php/ex-ante-database	$25.16
3587	Water Heater, >= 0.67 EF, Storage, NG, Claim Only	Ohio TRM, 2010. Page 123. Gas storage DHW EF > 0.67 incremental cost is $400.00 per water heater. Available online: http://s3.amazonaws.com/zanran_storage/amppartners.org/ContentPages/2464316647.pdf	$400.00

MMID	Measure Name	Source	Incremental Cost
3588	Water Heater, >= 0.82 EF, Tankless, Residential, NG, Claim Only	Ohio TRM, 2010. Page 123. Tankless DHW EF > 0.82 incremental cost is $605.00 per water heater. Available online: http://s3.amazonaws.com/zanran_storage/amppartners.org/ContentPages/2464316647.pdf	$605.00
3596	LED Fixture, Bilevel, Stairwell and Passageway, SBP A La Carte	Materials: WESCO Distribution Pricing, 2013 ($70.00) + Labor: RSMEANS, 2013 ($25.00) = $95.00	$95.00
3597	LED Fixture, Bilevel, Stairwell and Passageway, SBP After A La Carte	Materials: WESCO Distribution Pricing, 2013 ($70.00) + Labor: RSMEANS, 2013 ($25.00) = $95.00	$95.00
3598	Compressed Air System Leak Survey and Repair, Year 4 and Beyond	Average of costs for MMIDs 2261, 2262, and 2263	$6.76/hp
3603	LED Fixture, Interior, 12 Hours, CALP	Online Research, March 2016. Material cost is average sales price of "Led Downlight." Available online: https://www.1000bulbs.com/category/led-downlights/	$12.46
3604	LED Fixture, Interior, 24 Hours, CALP	Online Research, March 2016. Material cost is average sales price of "Led Downlight." Available online: https://www.1000bulbs.com/category/led-downlights/	$12.46
3605	Occupancy Sensor, Fixture Mount, ≤200 Watts, CALP	Similar to MMID 2474. WESCO Distribution Pricing ($70.00) + Labor ($25.00) = $95.00	$115.00
3606	Occupancy Sensor, Fixture Mount, >200 Watts, CALP	Similar to MMID 2475. WESCO Distribution Pricing ($70.00) + Labor ($25.00) = $95.00	$115.00
3607	LED, 4L 4’, <20W, Replacing 8’ 2L T12 or T8, SBP After A La Carte	Pricing was collected from online sources and distributors for lamps, ballasts, drivers, and 8 foot conversion kits. Labor was estimated. Incremental costs were determined between a baseline conversion of 8 foot T12 lamps to T8 lamps with a new ballast and a improved conversion of 8 T12 lamps to T8LED lamps with a new ballast.	$103.00
3608	LED, 2L 4', <20W, Replacing 8’ 1L T12 or T8, SBP After A La Carte	Pricing was collected from online sources and distributors for lamps, ballasts, drivers, and 8 foot conversion kits. Labor was estimated. Incremental costs were determined between a baseline conversion of 8 foot T12 lamps to T8 lamps with a new	$52.00

MMID	Measure Name	Source	Incremental Cost
		ballast and a improved conversion of 8 T12 lamps to T8LED lamps with a new ballast.	
3609	Smart Thermostat, Existing NG Boiler	2015 Retail Research. Average cost of Smart Thermostats available 2015.	$250.00
3610	Smart Thermostat, Existing NG Furnace	2015 Retail Research. Average cost of Smart Thermostats available 2015.	$250.00
3611	Smart Thermostat, Existing Air Source Heat Pump	2015 Retail Research. Average cost of Smart Thermostats available 2015.	$250.00
3612	Smart Thermostat, Installed with 95% AFUE NG Furnace	2015 Retail Research. Average cost of Smart Thermostats available 2015.	$250.00
3613	Smart Thermostat, Installed with 95% AFUE NG Boiler	2015 Retail Research. Average cost of Smart Thermostats available 2015.	$250.00
3614	Smart Thermostat, Installed with Furnace and A/C	2015 Retail Research. Average cost of Smart Thermostats available 2015.	$250.00
3615	Smart Thermostat, Installed with Air Source Heat Pump	2015 Retail Research. Average cost of Smart Thermostats available 2015.	$250.00
3616	LED, 2L 4', <20W, Replacing 8' 1L T12 or T8, SBP A La Carte	Pricing was collected from online sources and distributors for lamps, ballasts, drivers, and 8 foot conversion kits. Labor was estimated. Incremental costs were determined between a baseline conversion of 8 foot T12 lamps to T8 lamps with a new ballast and a improved conversion of 8 T12 lamps to T8LED lamps with a new ballast.	$52.00
3617	LED, 4L 4', <20W, Replacing 8' 2L T12 or T8, SBP A La Carte	Pricing was collected from online sources and distributors for lamps, ballasts, drivers, and 8 foot conversion kits. Labor was estimated. Incremental costs were determined between a baseline conversion of 8 foot T12 lamps to T8 lamps with a new ballast and a improved conversion of 8 T12 lamps to T8LED lamps with a new ballast.	$103.00
3619	Occupancy Sensor, Fixture Mount, ≤ 60 Watts, SBP Package	Similar to MMID 3561. Mid-Atlantic Technical Reference Manual Version 5.0, April 2015. Page 302. Available online: http://www.neep.org/sites/default/files/resources/Mid-Atlantic_TRM_V5_FINAL_5-26-2015.pdf	$200.00

MMID	Measure Name	Source	Incremental Cost
3621	Occupancy Sensor, Fixture Mount, ≤ 60 Watts, SBP After A La Carte	Similar to MMID 3561. Mid-Atlantic Technical Reference Manual Version 5.0, April 2015. Page 302. Available online: http://www.neep.org/sites/default/files/resources/Mid-Atlantic_TRM_V5_FINAL_5-26-2015.pdf	$200.00
3628	LED, ≤ 8W, SBP A La Carte	Similar to MMID 3273. Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$6.05
3629	LED, > 12W, SBP A La Carte	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$5.85
3630	LED, > 16W, SBP A La Carte	Market research, October 2016. 1000bulbs.com, amazon.com, lowes.com	$9.80
3631	LED, 12 Watts, SBP A La Carte	Similar to MMMID 3274. Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$5.85
3632	HVAC Controls, Surgery Occupancy	Historical Program Data- 4 similar projects done under other measure names	$5,500.00
3652	DEET, Savings Period 1	Staff estimate- $2000.00 for energy projects + $10000.00 average staff time in average-sized building	$12,000.00
3653	DEET, Savings Period 2	Staff estimate- $2000.00 for energy projects + $10000.00 average staff time in average-sized building	$12,000.00
3654	DEET, Savings Period 3	Staff estimate- $2000.00 for energy projects + $10000.00 average staff time in average-sized building	$12,000.00
3655	DEET, Savings Period 4	Staff estimate- $2000.00 for energy projects + $10000.00 average staff time in average-sized building	$12,000.00
3656	DEET, Savings Period 5	Staff estimate- $2000.00 for energy projects + $10000.00 average staff time in average-sized building	$12,000.00
3657	DEET, Savings Period 6	Staff estimate- $2000.00 for energy projects + $10000.00 average staff time in average-sized building	$12,000.00
3658	DEET, Savings Persistence	Staff estimate- $2000.00 for energy projects + $10000.00 average staff time in average-sized building	$12,000.00
3659	Chiller Plant Chilled Water Setpoint Adjustment	RSMeans 2013 Facilities Construction Cost Data, 29th Edition	$108.00
3660	Chiller Plant Condenser Water Setpoint Adjustment	RSMeans 2013 Facilities Construction Cost Data, 29th Edition	$108.00

MMID	Measure Name	Source	Incremental Cost
3661	Economizer Optimization	RSMeans. Facilities Construction Cost Data. 29th Edition. 2013. Assumed $54.00 per hour labor rate for work performed on air cooling equipment. Estimated two hours for completion based on project experience.	$108.00
3662	Hot Water Supply Reset	RSMeans 2013 Facilities Construction Cost Data, 29th Edition	$108.00
3663	Outside Air Intake Optimization	RSMeans 2013 Facilities Construction Cost Data, 29th Edition	$212.00
3664	Schedule Optimization, Weekday, Heating, 0-50000sq ft	RSMeans 2013 Facilities Construction Cost Data, 29th Edition	$168.00
3665	Schedule Optimization, Weekday, Cooling, 0-50000sq ft	RSMeans 2013 Facilities Construction Cost Data, 29th Edition	$168.00
3666	Schedule Optimization, Weekend, Heating, 0-50000sq ft	RSMeans 2013 Facilities Construction Cost Data, 29th Edition	$168.00
3667	Schedule Optimization, Weekend, Cooling, 0-50000sq ft	RSMeans 2013 Facilities Construction Cost Data, 29th Edition	$168.00
3668	Schedule Optimization, Weekday, Heating, 50000-100000sq ft	RSMeans 2013 Facilities Construction Cost Data, 29th Edition	$168.00
3669	Schedule Optimization, Weekday, Cooling, 50000-100000sq ft	RSMeans 2013 Facilities Construction Cost Data, 29th Edition	$168.00
3670	Schedule Optimization, Weekend, Heating, 50000-100000sq ft	RSMeans 2013 Facilities Construction Cost Data, 29th Edition	$168.00
3671	Schedule Optimization,	RSMeans 2013 Facilities Construction Cost Data, 29th Edition	$168.00

MMID	Measure Name	Source	Incremental Cost
	Weekend, Cooling, 50000-100000sq ft		
3672	Supply Air Temperature Reset, Heating	RSMeans 2013 Facilities Construction Cost Data, 29th Edition	$96.00
3673	Supply Air Temperature Reset, Cooling	RSMeans 2013 Facilities Construction Cost Data, 29th Edition	$96.00
3674	Temperature Sensor Calibration	RSMeans 2013 Facilities Construction Cost Data, 29th Edition	$108.00
3675	Valve Repair, Chilled Water	RSMeans 2013 Facilities Construction Cost Data, 29th Edition	$112.00
3676	Valve Repair, Hot Water	RSMeans 2013 Facilities Construction Cost Data, 29th Edition	$112.00
3677	VFD Fan Motor Control Restoration	RSMeans 2013 Facilities Construction Cost Data, 29th Edition	$56.00
3678	VFD Pump Control Restoration	RSMeans 2013 Facilities Construction Cost Data, 29th Edition	$56.00
3679	LP Furnace with ECM, 90%+ AFUE (Existing)	2014 Implementer (CLEAResult) survey of Trade Ally Costs.	$432.00
3680	Spring-loaded Garage Door Hinge, 55 Degree Indoor Temperature Setpoint	2015 Vendor Feedback. The average installation cost is based on the average door size of 10 feet wide by 12 feet tall, with six panels and five sets of hinges at $28.00 per set (trade ally feedback /web quote) plus an estimated installation of $200.00 per door.	$228.00
3681	Spring-loaded Garage Door Hinge, 60 Degree Indoor Temperature Setpoint	2015 Vendor Feedback. The average installation cost is based on the average door size of 10 feet wide by 12 feet tall, with six panels and five sets of hinges at $28.00 per set (trade ally feedback /web quote) plus an estimated installation of $200.00 per door.	$228.00
3682	Spring-loaded Garage Door Hinge, 65 Degree Indoor Temperature Setpoint	2015 Vendor Feedback. The average installation cost is based on the average door size of 10 feet wide by 12 feet tall, with six panels and five sets of hinges at $28.00 per set (trade ally feedback /web quote) plus an estimated installation of $200.00 per door.	$228.00
3683	Spring-loaded Garage Door Hinge, 70	2015 Vendor Feedback. The average installation cost is based on the average door size of 10 feet wide by 12 feet tall, with six panels and five sets of hinges at $28.00 per set (trade ally	$228.00

MMID	Measure Name	Source	Incremental Cost
	Degree Indoor Temperature Setpoint	feedback /web quote) plus an estimated installation of $200.00 per door.	
3684	Water Heater, High Usage, ≥90% TE, K-12 School	2015 Michigan Energy Measures Database (MEMD); supplied by Morgan Marketing Partners. Available online: http://www.michigan.gov/mpsc/0,4639,7-159-52495_55129---,00.html	$1,135.00
3685	Insulation, 1/2" and 3/4" Pipe, Hot Water Space Heat, NG	Illinois Technical Reference Manual. 2015. Page 229. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	$9.40
3686	Insulation, 1" and 1 1/4" Pipe, Hot Water Space Heat, NG	Illinois Technical Reference Manual. 2015. Page 229. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	$9.40
3687	Insulation, 1 1/2" and 2" Pipe Hot Water Space Heat, NG	Illinois Technical Reference Manual. 2015. Page 229. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	$9.40
3688	Insulation, 3" and 4" Pipe, Hot Water Space Heat, NG	Illinois Technical Reference Manual. 2015. Page 229. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	$10.53
3689	Insulation, 1/2" and 3/4" Pipe, Hot Water Space Heat, Electric	Illinois Technical Reference Manual. 2015. Page 229. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	$9.40
3690	Insulation, 1" and 1 1/4" Pipe, Hot Water Space Heat, Electric	Illinois Technical Reference Manual. 2015. Page 229. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	$9.40
3691	Insulation, 1 1/2" and 2" Pipe Hot Water Space Heat, Electric	Illinois Technical Reference Manual. 2015. Page 229. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	$9.40
3692	Insulation, 3" and 4" Pipe, Hot Water Space Heat, Electric	Illinois Technical Reference Manual. 2015. Page 229. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	$10.53

MMID	Measure Name	Source	Incremental Cost
3693	Single package vertical HVAC unit, ≥90%+ Thermal Efficiency, ≥10.0 EER Cooling, NG	MESP program manager discussion with vendor of single package vertical units early 2015. Vendor noted an incremental cost of $500.00 to $600.00 to upgrade from a 80% to 90% efficient unit. Used $550.00 as the midpoint of this range.	$550.00
3694	Single package vertical HVAC unit, ≥90%+ Thermal Efficiency, NG	MESP program manager discussion with vendor of single package vertical units early 2015. Vendor noted an incremental cost of $500.00 to $600.00 to upgrade from a 80% to 90% efficient unit. Used $550.00 as the midpoint of this range.	$550.00
3695	Insulation, 1/2" and 3/4" Pipe, Domestic Hot Water, NG	Illinois Technical Reference Manual. 2015. Page 229. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	$7.15
3696	Insulation, 1" and 1 1/4" Pipe, Domestic Hot Water, NG	Illinois Technical Reference Manual. 2015. Page 229. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	$7.15
3697	Insulation, 1 1/2" and 2" Pipe, Domestic Hot Water, NG	Illinois Technical Reference Manual. 2015. Page 229. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	$8.28
3698	Insulation, 3" and 4" Pipe, Domestic Hot Water, NG	Illinois Technical Reference Manual. 2015. Page 229. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	$9.40
3699	Insulation, 1/2" and 3/4" Pipe, Domestic Hot Water, Electric	Illinois Technical Reference Manual. 2015. Page 229. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	$7.15
3700	Insulation, 1" and 1 1/4" Pipe, Domestic Hot Water, Electric	Illinois Technical Reference Manual. 2015. Page 229. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	$7.15
3701	Insulation, 1 1/2" and 2" Pipe, Domestic Hot Water, Electric	Illinois Technical Reference Manual. 2015. Page 229. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	$8.28

MMID	Measure Name	Source	Incremental Cost
3702	Insulation, 3" and 4" Pipe, Domestic Hot Water, Electric	Illinois Technical Reference Manual. 2015. Page 229. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	$9.40
3703	Insulation, Wall, NG heat with Cooling	2008 Database for Energy-Efficient Resources, Revised DEER Measure Cost Summary. June 2, 2008. (cost for Wall 2x6 R-19 Batts + R-5 Rigid)	$0.94/sq ft
3704	Insulation, Wall, NG heat without Cooling	2008 Database for Energy-Efficient Resources, Revised DEER Measure Cost Summary. June 2, 2008. (cost for Wall 2x6 R-19 Batts + R-5 Rigid)	$0.94/sq ft
3705	Insulation, Wall, Electric heat with Cooling	2008 Database for Energy-Efficient Resources, Revised DEER Measure Cost Summary. June 2, 2008. (cost for Wall 2x6 R-19 Batts + R-5 Rigid)	$0.94/sq ft
3706	Insulation, Wall, Electric heat without Cooling	2008 Database for Energy-Efficient Resources, Revised DEER Measure Cost Summary. June 2, 2008. (cost for Wall 2x6 R-19 Batts + R-5 Rigid)	$0.94/sq ft
3707	Insulation, Attic, NG heat with Cooling, Existing Insulation ≤R-11	2008 Database for Energy-Efficient Resources. Revised DEER Measure Cost Summary. June 2, 2008.	$0.94/sq ft
3708	Insulation, Attic, NG heat without Cooling, Existing Insulation ≤R-11	2008 Database for Energy-Efficient Resources. Revised DEER Measure Cost Summary. June 2, 2008.	$0.94/sq ft
3709	Insulation, Attic, NG heat with Cooling, Existing Insulation R-12 to R-19	2008 Database for Energy-Efficient Resources. Revised DEER Measure Cost Summary. June 2, 2008.	$0.94/sq ft
3710	Insulation, Attic, NG heat without Cooling, Existing Insulation R-12 to R-19	2008 Database for Energy-Efficient Resources. Revised DEER Measure Cost Summary. June 2, 2008.	$0.94/sq ft
3711	Insulation, Attic, Electric heat with Cooling, Existing Insulation ≤R-11	2008 Database for Energy-Efficient Resources. Revised DEER Measure Cost Summary. June 2, 2008.	$0.94/sq ft
3712	Insulation, Attic, Electric heat without	2008 Database for Energy-Efficient Resources. Revised DEER Measure Cost Summary. June 2, 2008.	$0.94/sq ft

MMID	Measure Name	Source	Incremental Cost
	Cooling, Existing Insulation ≤R-11		
3713	Insulation, Attic, Electric heat with Cooling, Existing Insulation R-12 to R-19	2008 Database for Energy-Efficient Resources. Revised DEER Measure Cost Summary. June 2, 2008.	$0.94/sq ft
3714	Insulation, Attic, Electric heat without Cooling, Existing Insulation R-12 to R-19	2008 Database for Energy-Efficient Resources. Revised DEER Measure Cost Summary. June 2, 2008.	$0.94/sq ft
3716	ELO, LED ≤ 60 Watts, Replacing 150-175 Watt HID	2012-2013 data gathered from installation contractors from all four geographical quadrants of the Focus on Energy program territory. Of 40 installation parties contacted, 12 completed the questionnaire in time to be included in the dataset. Internet pricing data, accessed in August 2015 from a variety of sources, was used for LED materials, some HID ballasts, controls sockets, and photocell/timer controls. Products that were selected were randomly chosen based on them meeting the measure definitions.	$176.00
3717	ELO, LED ≤ 60 Watts, Replacing 150-175 Watt HID, with Integrated Timer or Wireless Schedule	2012-2013 data gathered from installation contractors from all four geographical quadrants of the Focus on Energy program territory. Of 40 installation parties contacted, 12 completed the questionnaire in time to be included in the dataset. Internet pricing data, accessed in August 2015 from a variety of sources, was used for LED materials, some HID ballasts, controls sockets, and photocell/timer controls. Products that were selected were randomly chosen based on them meeting the measure definitions.	$417.00
3718	ELO, LED ≤ 60 Watts, Replacing 150-175 Watt HID, with Bi-Level Control	2012-2013 data gathered from installation contractors from all four geographical quadrants of the Focus on Energy program territory. Of 40 installation parties contacted, 12 completed the questionnaire in time to be included in the dataset. Internet pricing data, accessed in August 2015 from a variety of sources, was used for LED materials, some HID ballasts, controls sockets, and photocell/timer controls. Products that were selected were	$417.00

MMID	Measure Name	Source	Incremental Cost
		randomly chosen based on them meeting the measure definitions.	
3719	ELO, LED 60-125 Watts, Replacing 250 Watt HID	2012-2013 data gathered from installation contractors from all four geographical quadrants of the Focus on Energy program territory. Of 40 installation parties contacted, 12 completed the questionnaire in time to be included in the dataset. Internet pricing data, accessed in August 2015 from a variety of sources, was used for LED materials, some HID ballasts, controls sockets, and photocell/timer controls. Products that were selected were randomly chosen based on them meeting the measure definitions.	$643.00
3720	ELO, LED 60-125 Watts, Replacing 250 Watt HID, with Integrated Timer or Wireless Schedule	2012-2013 data gathered from installation contractors from all four geographical quadrants of the Focus on Energy program territory. Of 40 installation parties contacted, 12 completed the questionnaire in time to be included in the dataset. Internet pricing data, accessed in August 2015 from a variety of sources, was used for LED materials, some HID ballasts, controls sockets, and photocell/timer controls. Products that were selected were randomly chosen based on them meeting the measure definitions.	$884.00
3721	ELO, LED 60-125 Watts, Replacing 250 Watt HID, with Bi-Level Control	2012-2013 data gathered from installation contractors from all four geographical quadrants of the Focus on Energy program territory. Of 40 installation parties contacted, 12 completed the questionnaire in time to be included in the dataset. Internet pricing data, accessed in August 2015 from a variety of sources, was used for LED materials, some HID ballasts, controls sockets, and photocell/timer controls. Products that were selected were randomly chosen based on them meeting the measure definitions.	$884.00
3722	ELO, LED 125-200 Watts, Replacing 320 Watt HID	2012-2013 data gathered from installation contractors from all four geographical quadrants of the Focus on Energy program territory. Of 40 installation parties contacted, 12 completed the questionnaire in time to be included in the dataset. Internet pricing data, accessed in August 2015 from a variety of sources, was used for LED materials, some HID ballasts, controls sockets, and photocell/timer controls. Products that were selected were randomly chosen based on them meeting the measure definitions.	$1,126.00

MMID	Measure Name	Source	Incremental Cost
3723	ELO, LED 125-200 Watts, Replacing 320 Watt HID, with Integrated Timer or Wireless Schedule	2012-2013 data gathered from installation contractors from all four geographical quadrants of the Focus on Energy program territory. Of 40 installation parties contacted, 12 completed the questionnaire in time to be included in the dataset. Internet pricing data, accessed in August 2015 from a variety of sources, was used for LED materials, some HID ballasts, controls sockets, and photocell/timer controls. Products that were selected were randomly chosen based on them meeting the measure definitions.	$1,367.00
3724	ELO, LED 125-200 Watts, Replacing 320 Watt HID, with Bi-Level Control	2012-2013 data gathered from installation contractors from all four geographical quadrants of the Focus on Energy program territory. Of 40 installation parties contacted, 12 completed the questionnaire in time to be included in the dataset. Internet pricing data, accessed in August 2015 from a variety of sources, was used for LED materials, some HID ballasts, controls sockets, and photocell/timer controls. Products that were selected were randomly chosen based on them meeting the measure definitions.	$1,367.00
3725	ELO, LED 125-200 Watts, Replacing 400 Watt HID	2012-2013 data gathered from installation contractors from all four geographical quadrants of the Focus on Energy program territory. Of 40 installation parties contacted, 12 completed the questionnaire in time to be included in the dataset. Internet pricing data, accessed in August 2015 from a variety of sources, was used for LED materials, some HID ballasts, controls sockets, and photocell/timer controls. Products that were selected were randomly chosen based on them meeting the measure definitions.	$1,126.00
3726	ELO, LED 125-200 Watts, Replacing 400 Watt HID, with Integrated Timer or Wireless Schedule	2012-2013 data gathered from installation contractors from all four geographical quadrants of the Focus on Energy program territory. Of 40 installation parties contacted, 12 completed the questionnaire in time to be included in the dataset. Internet pricing data, accessed in August 2015 from a variety of sources, was used for LED materials, some HID ballasts, controls sockets, and photocell/timer controls. Products that were selected were randomly chosen based on them meeting the measure definitions.	$1,367.00
3727	ELO, LED 125-200 Watts, Replacing 400	2012-2013 data gathered from installation contractors from all four geographical quadrants of the Focus on Energy program	$1,367.00

MMID	Measure Name	Source	Incremental Cost
	Watt HID, with Bi-Level Control	territory. Of 40 installation parties contacted, 12 completed the questionnaire in time to be included in the dataset. Internet pricing data, accessed in August 2015 from a variety of sources, was used for LED materials, some HID ballasts, controls sockets, and photocell/timer controls. Products that were selected were randomly chosen based on them meeting the measure definitions.	
3728	ELO, LED 200-650 Watts, Replacing 1000 Watt HID	2012-2013 data gathered from installation contractors from all four geographical quadrants of the Focus on Energy program territory. Of 40 installation parties contacted, 12 completed the questionnaire in time to be included in the dataset. Internet pricing data, accessed in August 2015 from a variety of sources, was used for LED materials, some HID ballasts, controls sockets, and photocell/timer controls. Products that were selected were randomly chosen based on them meeting the measure definitions.	$1,130.00
3729	ELO, LED 200-650 Watts, Replacing 1000 Watt HID, with Integrated Timer or Wireless Schedule	2012-2013 data gathered from installation contractors from all four geographical quadrants of the Focus on Energy program territory. Of 40 installation parties contacted, 12 completed the questionnaire in time to be included in the dataset. Internet pricing data, accessed in August 2015 from a variety of sources, was used for LED materials, some HID ballasts, controls sockets, and photocell/timer controls. Products that were selected were randomly chosen based on them meeting the measure definitions.	$1,371.00
3730	ELO, LED 200-650 Watts, Replacing 1000 Watt HID, with Bi-Level Control	2012-2013 data gathered from installation contractors from all four geographical quadrants of the Focus on Energy program territory. Of 40 installation parties contacted, 12 completed the questionnaire in time to be included in the dataset. Internet pricing data, accessed in August 2015 from a variety of sources, was used for LED materials, some HID ballasts, controls sockets, and photocell/timer controls. Products that were selected were randomly chosen based on them meeting the measure definitions.	$1,371.00
3731	CFL, Direct Install, 14.2, Watt BR30	Evaluator Online Research, March 2016. Average costs from online research at 1000bulbs.com. Available online: https://www.1000bulbs.com/search/?q=BR30+cfl	$3.35

MMID	Measure Name	Source	Incremental Cost
3732	LED, Direct Install, 8 Watt, BR30	Focus on Energy Program Data. 2015. Implementer contract costs as of October 30, 2015. ($5.25 material + $3.24 labor = $8.49).	$8.49
3733	LED, Direct Install, 5.3 Watt, Candelabra Base	Focus on Energy Program Data. 2015. Implementer contract costs as of October 30, 2015. ($4.25 material + $3.24 labor = $7.49).	$7.49
3734	LED, Direct Install, 6 Watt, G25 Lamp	Based on actual implementer contract costs as of October10/ 30, 20/15. ($4.50 material + $3.24 labor = $7.74).	$7.74
3735	LED Fixture, Exterior, 12 Hours, CALP	Online Research, March 2016. Material cost is average sales price of "Led Downlight." Available online: https://www.1000bulbs.com/category/led-downlights/	$12.46
3736	LED Fixture, Track/Mono/Accent, ≤ 18 Watts	Online Research, March 2016. Material cost is average sales price of "Led Downlight." Available online: https://www.1000bulbs.com/category/led-downlights/	$12.46
3737	LED Fixture, Track/Mono/Accent, > 18 Watts	Online Research, March 2016. Material cost is average sales price of "Led Downlight." Available online: https://www.1000bulbs.com/category/led-downlights/	$12.46
3738	LED Fixture, Linear Ambient, Replacing 1 or 2 T5 lamp(s) in Cross Section	Implementer Retail Pricing Review October 2015.	$27.50
3739	LED Fixture, Linear Ambient, Replacing 3 or 4 T5 lamps in Cross Section	Implementer Retail Pricing Review October 2015.	$27.50
3740	LED Fixture, Linear Ambient, Replacing 1 or 2 T8/T12 lamp(s) in Cross Section	Cost data obtained through various online lighting retailers in October 2015, including 1000bulbs.com, warehouse-lighting.com, alconlighting.com, earthled.com, and toenic.com. Average prices of baseline equipment and qualifying efficient equipment used to obtain estimated incremental cost. Full data is available upon request.	$34.25
3741	LED Fixture, Linear Ambient, Replacing 3 or 4 T8/12 lamps in Cross Section	Cost data obtained through various online lighting retailers in October 2015, including 1000bulbs.com, warehouse-lighting.com, alconlighting.com, earthled.com, and toenic.com. Average prices of baseline equipment and qualifying efficient equipment used to obtain estimated incremental cost. Full data is available upon request.	$34.25

MMID	Measure Name	Source	Incremental Cost
3742	LED Lamp, Energy Star, Replacing ≥ 23 Watt CFL	Cost data obtained through various online lighting retailers in October 2015, including 1000bulbs.com, warehouse-lighting.com, alconlighting.com, earthled.com, and toenic.com. Average prices of baseline equipment and qualifying efficient equipment used to obtain estimated incremental cost. Full data is available upon request.	$11.00
3743	LED Lamp, Energy Star, Replacing ≥ 23 Watt CFL, Common Area	Cost data obtained through various online lighting retailers in October 2015, including 1000bulbs.com, warehouse-lighting.com, alconlighting.com, earthled.com, and toenic.com. Average prices of baseline equipment and qualifying efficient equipment used to obtain estimated incremental cost. Full data is available upon request.	$11.00
3744	LED Lamp, Energy Star, Replacing ≥ 23 Watt CFL, In Unit	Cost data obtained through various online lighting retailers in October 2015, including 1000bulbs.com, warehouse-lighting.com, alconlighting.com, earthled.com, and toenic.com. Average prices of baseline equipment and qualifying efficient equipment used to obtain estimated incremental cost. Full data is available upon request.	$11.00
3745	LED Lamp, Energy Star, Replacing < 23 Watt CFL	Cost data obtained through various online lighting retailers in October 2015, including 1000bulbs.com, warehouse-lighting.com, alconlighting.com, earthled.com, and toenic.com. Average prices of baseline equipment and qualifying efficient equipment used to obtain estimated incremental cost. Full data is available upon request.	$3.00
3746	LED Lamp, Energy Star, Replacing < 23 Watt CFL, Common Area	Cost data obtained through various online lighting retailers in October 2015, including 1000bulbs.com, warehouse-lighting.com, alconlighting.com, earthled.com, and toenic.com. Average prices of baseline equipment and qualifying efficient equipment used to obtain estimated incremental cost. Full data is available upon request.	$3.00
3747	LED Lamp, Energy Star, Replacing < 23 Watt CFL, In Unit	Cost data obtained through various online lighting retailers in October 2015, including 1000bulbs.com, warehouse-lighting.com, alconlighting.com, earthled.com, and toenic.com. Average prices of baseline equipment and qualifying efficient equipment used to obtain estimated incremental cost. Full data is available upon request.	$3.00

MMID	Measure Name	Source	Incremental Cost
3748	LED Fixture, Downlight, ≤ 18 Watts, In Unit	Incremental cost based on historical project data for similar measure 2984: LED Fixture, Downlights, Accent Lights and Monopoint, ≤ 18 Watts, Common Area.	$80.13
3749	LED Fixture, Downlight, > 18 Watts	Online Research, March 2016. Material cost is average sales price of "Led Downlight." Available online: https://www.1000bulbs.com/category/led-downlights/.	$12.46
3750	LED Fixture, Downlight, ≤ 18 Watts	Incremental cost based on historical project data for similar measure 2984: LED Fixture, Downlights, Accent Lights and Monopoint, ≤ 18 Watts, Common Area.	$80.13
3751	Insulation, 1/2" and 3/4" Pipe, Steam Space Heat, NG	Illinois Technical Reference Manual. 2015. Page 229. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	$11.65
3752	Insulation, 1" and 1 1/4" Pipe, Steam Space Heat, NG	Illinois Technical Reference Manual. 2015. Page 229. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	$11.65
3753	Insulation, 1 1/2" and 2" Pipe, Steam Space Heat, NG	Illinois Technical Reference Manual. 2015. Page 229. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	$11.65
3754	Insulation, 3" and 4" Pipe, Steam Space Heat, NG	Illinois Technical Reference Manual. 2015. Page 229. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	$11.65
3755	Insulation, 1/2" and 3/4" Pipe, Steam Space Heat, Electric	Illinois Technical Reference Manual. 2015. Page 229. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	$11.65
3756	Insulation, 1" and 1 1/4" Pipe, Steam Space Heat, Electric	Illinois Technical Reference Manual. 2015. Page 229. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	$11.65
3757	Insulation, 1 1/2" and 2" Pipe, Steam Space Heat, Electric	Illinois Technical Reference Manual. 2015. Page 229. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	$11.65

MMID	Measure Name	Source	Incremental Cost
3758	Insulation, 3" and 4" Pipe, Steam Space Heat, Electric	Illinois Technical Reference Manual. 2015. Page 229. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	$11.65
3759	LED Replacement of 4' T8 Lamps, Direct Wire	Online research, Sept 2016. Available online: http://www.greenledzone.com/t8-led-tube-light-direct-wire-ballast-compatible-p/gl-lod-c08-m1218.htm?gclid=Cj0KEQjwxLC9BRDb1dP8o7Op68IBEiQAwWggQA7zZ34iQp1t8ivOd4GwDDOKE1flh40UVRP3kOWcoToaAh7p8P8HAQ; http://greenlightdepot.com/collections/led-tube-lights/products/4ft-18w-led-linear-versa-tube-ul-dlc?variant=3706824772&gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFK5S0WZ_BBNcC7Y5DA7At4cO2rcAGaAl2RyJQZVbZE4MaAtJc8P8HAQ; https://www.1000bulbs.com/product/153506/PLT-10018.html?utm_source=SmartFeedGoogleBase&utm_medium=Shopping&utm_term=PLT-10018&utm_content=LED+Lighting+Specials&utm_campaign=SmartFeedGoogleBaseShopping&gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFKzDoix0ocMbl; https://www.1000bulbs.com/product/7028/TCP-31032841.html?utm_source=SmartFeedGoogleBase&utm_medium=Shopping&utm_term=TCP-31032841&utm_content=800+Series+Phosphors&utm_campaign=SmartFeedGoogleBaseShopping&gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFK3_139urG; https://www.1000bulbs.com/product/90200/USH-3000480.html?utm_source=SmartFeedGoogleBase&utm_medium=Shopping&utm_term=USH-3000480&utm_content=800+Series+Phosphors&utm_campaign=SmartFeedGoogleBaseShopping&gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFK2B1rtXuKJ; http://www.adlsupply.com/fluorescent-t8/sylvania-21781-fo32-841-eco/?gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFK7UbfdMKV6L5tIYN6DNgvVs1fr2zovtgAyLuo8_F6hEaAnRn8P8HAQ	$6.62
3760	LED Troffer, 1x4, Replacing 4' 1-2 Lamp T8 Troffer	Cost data obtained through various online retailers, pulled August 2015.	$77.00
3761	A/C Split or Packaged System, High Efficiency, Multifamily	Based on a review of TRM incremental cost assumptions from Vermont (Vermont Technical Reference Manual. August 2013. and California Municipal Utilities (CMUA Savings	$100.00

MMID	Measure Name	Source	Incremental Cost
		Estimation Technical Reference Manual). 2014. Available online: http://www.greenmountainpower.com/upload/photos/371TRM_User_Manual_No_2013-82-5-protected.pdf; http://cmua.org/energy-efficiency-technical-reference-manual	
3762	Energy Star LED Commercial Threshold Fixture, < 20 Watts, SBP After A La Carte	Pricing from web-based stores, June 16, 2015. Incandescent and LED pricing from www.lightingdirect.com and www.homedepot.com was averaged, then an installation cost of $10.00 ($30.00 per hr. at 20 minutes) was added to both the baseline and efficient conditions. The incremental cost is the difference between baseline and proposed total cost.	$50.00
3763	Energy Star Fluorescent Commercial Threshold Fixture, < 30 Watts , SBP After A La Carte	Pricing from web based stores. Incandescent and fluorescent pricing from www.lightingdirect.com and www.homedepot.com was averaged, then an installation cost of $10.00 ($30.00 per hr. at 20 minutes) was added to both the baseline and efficient conditions. The incremental cost is the difference between baseline and proposed total cost. Detailed information contained in Implementer sheet “EnergyStarPorch Certified-2015-03-20”.	$20.00
3764	T8 LED < 20 Watts, 1L, Replacing 2L or 3L T12/T8, SBP Package	Fluorescent and LED pricing pulled from multiple online sources, then averaged for both baseline and efficient conditions. Incremental cost is the difference between baseline and proposed total cost. Internal Implementer Spreadsheet, ‘Pricing’ tab in Excel calculation Four-foot Linear LED replacing 4-foot T8 fluor 2to1 calculation_GDS_SBP_03_19_15.	$33.74
3765	T8 LED < 20 Watts, 1L, Replacing 2L or 3L T12/T8, SBP A La Carte	Fluorescent and LED pricing pulled from multiple online sources, then averaged for both baseline and efficient conditions. Incremental cost is the difference between baseline and proposed total cost. Internal Implementer Spreadsheet, ‘Pricing’ tab in Excel calculation Four-foot Linear LED replacing 4-foot T8 fluor 2to1 calculation_GDS_SBP_03_19_15.	$33.74
3766	T8 LED < 20 Watts, 1L, Replacing 2L or 3L T12/T8, SBP After A La Carte	Fluorescent and LED pricing pulled from multiple online sources, then averaged for both baseline and efficient conditions. Incremental cost is the difference between baseline and proposed total cost. Internal Implementer Spreadsheet, ‘Pricing’ tab in Excel calculation Four-foot Linear LED replacing 4-foot T8 fluor 2to1 calculation_GDS_SBP_03_19_15.	$33.74
3767	Circulation Fan, HS/HE, 36"-47", Ag	Illinois Technical Reference Manual. 2015. Page 62. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_	$150.00

MMID	Measure Name	Source	Incremental Cost
		Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	
3768	Circulation Fan, HS/HE, 48"-52", Ag	Illinois Technical Reference Manual. 2015. Page 62. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	$150.00
3769	Circulation Fan, HS/HE, ≥ 53", Ag	Illinois Technical Reference Manual. 2015. Page 62. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	$150.00
3770	Ventilation Fan, HS/HE, 24"-35", Ag	Illinois Technical Reference Manual. 2015. Page 62. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	$150.00
3771	Ventilation Fan, HS/HE, 36"-47", Ag	Illinois Technical Reference Manual. 2015. Page 62. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	$150.00
3772	Ventilation Fan, HS/HE, 48"-52", Ag	Illinois Technical Reference Manual. 2015. Page 62. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	$150.00
3773	Ventilation Fan, HS/HE, ≥ 53", Ag	Illinois Technical Reference Manual. 2015. Page 62. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf	$150.00
3774	Refrigeration Heat Recovery Unit No Heating Element, Ag, Natural Gas	Wisconsin Focus on Energy. Project data from April 2012 to October 2015 (101 RHR units on 96 projects), average total cost.	$3,674.00
3775	Refrigeration Heat Recovery Unit No Heating Element, Ag, Electric	Wisconsin Focus on Energy. Project data from April 2012 to October 2015 (101 RHR units on 96 projects), average total cost.	$3,674.00
3776	VFD, Variable Torque, Irrigation Well Pump	NEEP 2013 Incremental Cost Study: Incremental Cost Study Phase Two Final Report, Navigant Consulting, 2013. Available online: http://www.neep.org/Assets/uploads/files/emv/emv-	$130.00

MMID	Measure Name	Source	Incremental Cost
		products/NEEP%20ICS2%20FINAL%20REPORT%202013Feb11-Website.pdf	
3777	VFD, High Speed Ventilation/Circulation Fan, Ag	NEEP 2013 Incremental Cost Study: Incremental Cost Study Phase Two Final Report, Navigant Consulting, 2013. Available online: http://www.neep.org/Assets/uploads/files/emv/emv-products/NEEP%20ICS2%20FINAL%20REPORT%202013Feb11-Website.pdf	$130.00
3778	Boiler, Tier 2, 95%+ AFUE, With DHW, NG	NEEP Regional Evaluation, Measurement & Verification Forum, A Report on Costs in Six Northeast & Mid-Atlantic Markets. 2011. Navigant Consulting. Page A-10. Mid-sized (126 MBh) Residential Combination Heat/Hot Water Incremental Cost 95 CAE = $2,803.00.	$2,803.00
3779	Furnace and A/C, Tier 2, ECM, 95% + AFUE, >= 16 SEER	Incremental costs based on Fall 2014 review of Residential Prescriptive trade allies. IMCs are different for the two tiers because the measures use different baselines.	$2,238.73
3780	Hot Water Boiler, Tier 2, 95%+ AFUE	2013, Program Implementer CLEAResult surveyed 40 Trade Allies and took the average reported cost for an 82% boiler and subtracted that amount from the average reported cost for a 95% boiler.	$3,105.00
3781	LP Furnace with ECM, Tier 2, 90%+ AFUE (Existing)	Implementer Trade Ally Survey, CLEAResult, 2014. Documented in Wisconsin Public Service Commission. Incremental Cost Database. December 2014.	$432.00
3782	NG Furnace with ECM, Tier 2, 95%+ AFUE (Existing)	Implementer Trade Ally Survey, CLEAResult, 2014. Documented in Wisconsin Public Service Commission. Incremental Cost Database. December 2014.	$1,565.00
3783	NG Furnace, Tier 2, 95%+ AFUE	Implementer Trade Ally Survey, CLEAResult, 2014. Documented in Wisconsin Public Service Commission. Incremental Cost Database. December 2014.	$1,194.00
3784	Water Heater, Indirect, Tier 2	New York Statewide Residential Gas High Efficiency Heating Equipment Programs: Evaluation of 2009-2011 Programs. Average of mean and median costs using both approaches, in Table 1-4. Available online: http://www.coned.com/energyefficiency/PDF/EEPS%20CY1%20NY%20HEHE%20Evaluation%20Report%20FINAL%20APPROVED%202014-08-21.pdf	$988.50
3785	Insulation, Tier 2, Project Based, Attic	Illinois Technical Reference Manual. 2013. Page 141. This measure includes air sealing costs. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Ver	$2.69/sq ft

MMID	Measure Name	Source	Incremental Cost
		sion_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	
3786	Insulation, Tier 2, Project Based, Foundation	Illinois Technical Reference Manual. 2013. Page 141. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf	$2.93/sq ft
3787	Insulation, Tier 2, Project Based, Sillbox	Illinois Technical Reference Manual. 2013. Page 141. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf.	$5.97/sq ft
3788	Insulation, Tier 2, Project Based, Wall	2008 Database for Energy-Efficient Resources, Revised DEER Measure Cost Summary. June 2, 2008. (cost for Wall 2x6 R-19 Batts + R-5 Rigid)	$0.94/sq ft
3796	Refrigeration System Tune-up, Agriculture	Historical Data (54 projects), average of May 2013 – July 2015 approved application kWh savings. Refer to the 'Dairy Refrigeration System Tune Up Support Doc'.	$260.86
3797	VFD, Dairy Milk Pump, Agriculture	Vermont Technical Reference Manual. Page 24. August 2013. Available online: http://www.greenmountainpower.com/upload/photos/371TRM_User_Manual_No_2013-82-5-protected.pdf	$3,004.00
3798	VFD, Dairy Vacuum Pump, Agriculture	Vermont Technical Reference Manual. Page 22. March 16, 2015. (VFD milk pump cost = $4,014.00 based on Vermont project data from 2003-2012). Available online: http://psb.vermont.gov/sites/psb/files/docketsandprojects/electric/majorpendingproceedings/TRM%20User%20Manual%20No.%202015-87C.pdf	$4,014.00
3799	T8 2L 4', HPT8, CEE, BF ≤ 0.78, Agriculture	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. There is no additional cost for ballasts.	$15.40
3800	T8 4L 4', HPT8, CEE, BF ≤ 0.78, Agriculture	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes CEE ballast as baseline.	$15.40
3801	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', 0.78 < BF < 1.00, Agriculture	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$4.90
3802	T8 2L 4', HPT8 or RWT8, Replacing	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor	$4.90

MMID	Measure Name	Source	Incremental Cost
	T12HO 1L 8', BF > 1.00, Agriculture	duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	
3803	T8 4L 4', HPT8 or RWT8, Replacing T12 2L 8', 0.78 < BF < 1.00, Agriculture	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$9.80
3804	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', 0.78 < BF < 1.00, Agriculture	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$9.80
3805	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', BF > 1.00, Agriculture	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013. Assumes T8 and CEE ballast as baseline.	$9.80
3806	LED Fixture, <155 Watts, Replacing 250 Watt HID, High Bay, Agriculture	Online research, March 2016. Average cost of "LED round high bay fixtures" under 155 Watt replacement. Available online: https://www.1000bulbs.com/category/round-high-bays/	$204.99
3807	LED Fixture, <250 Watts, Replacing 400 Watt HID, High Bay, Agriculture	Online research, March 2016. Average cost of "LED round high bay fixtures" 155 Watt to 250 Watt replacement. Available online: https://www.1000bulbs.com/category/round-high-bays/	$387.82
3808	LED Fixture, <365 Watts, Replacing 400 Watt HID, High Bay, Agriculture	Online research, March 2016. Average cost of "LED round high bay fixtures" over 400 Watt replacement. Available online: https://www.1000bulbs.com/category/round-high-bays/	$398.41
3809	LED Fixture,≤180 Watts, Replacing 4 lamp T5 or 6 lamp T8, High Bay, DLC Listed, Agriculture	Cost data obtained through various online lighting retailers from July 2016.	$215.69
3810	LED Fixture, <250 Watts, Replacing 320-400 Watt HID, High Bay, Agriculture	Online research, March 2016. Average cost of "LED round high bay fixtures" 155 Watt to 250 Watt replacement. Available online: https://www.1000bulbs.com/category/round-high-bays/	$387.82
3811	T8 4L Replacing 250-399 W HID, Agriculture	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013.	$129.00

MMID	Measure Name	Source	Incremental Cost
3812	T8 6L Replacing 400-999 W HID, Agriculture	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013.	$327.12
3813	T5HO 4L Replacing 400-999 W HID, Agriculture	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013.	$163.16
3814	T5HO 6L Replacing 400-999 W HID, Agriculture	2014 Focus on Energy Program Data; verified with average price of lamps on 1000bulbs.com (2014). Evaluator estimate for labor duration, labor cost from RSMeans, 2013.	$210.22
3815	Induction, PSMH/CMH, Replacing 250 Watt HID, High Bay	Actual cost from 2015-16 program data, 1 application.	$100.00
3816	Induction, PSMH/CMH, ≤250 Watt, Replacing 320-400 Watt HID, High Bay, Agriculture	2015 Implementer assessment of measure cost.	$290.00
3817	Induction, PSMH/CMH, ≤250 Watt, Replacing 400 Watt HID, High Bay, Agriculture	Online research, March 2016 and Program Data, 2015. From: warehouse-lighting.com. Baseline measure is 16" Aluminum (400 Watt High Bay Light Fixture, High Pressure Sodium (HPS), 120-277v); cost is $181.26. Efficient measure average cost is $341.00 from 2015 Focus on Energy Program application data.	$159.74
3818	Induction, PSMH/CMH, ≤365 Watt, Replacing 400 Watt HID, High Bay, Agriculture	Online research, March 2016 and Program Data, 2015. From: warehouse-lighting.com. Baseline measure is 16" Aluminum (400 Watt High Bay Light Fixture, High Pressure Sodium (HPS), 120-277v); cost is $181.26. Efficient measure average cost is $391.00 from 2015 Focus on Energy Program application data.	$209.74
3819	LED Fixture, Downlights, ≤18 Watts, Agriculture	Incremental cost based on historical project data for similar measure 2984: LED Fixture, Downlights, Accent Lights and Monopoint, ≤ 18 Watts, Common Area.	$80.13
3820	LED Fixture, Downlights, > 18 Watts, Agriculture	Online Research, March 2016. Material cost is average sales price of "Led Downlight." Available online: https://www.1000bulbs.com/category/led-downlights/	$12.46
3821	LED, > 40 Watt, ENERGY STAR, Replacing	Evaluator Online Cost research from 1000bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®.	$9.40

MMID	Measure Name	Source	Incremental Cost
	Incandescent, Agriculture		
3822	LED Replacement of 4’ T8 Lamps w/Integral or External Driver, Agriculture	Online research, Sept 2016. Available online: https://www.energyavenue.com/Sylvania/73107?gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFK-uSa-sFtYYo2HoW5piw9OCxbjku5rFsAlCYHiszo2UaAvPJ8P8HAQ; https://a19led.com/products/cree-ur-series-retrofit-kit-ur2-48-45l-40k-10v-fd?utm_medium=cpc&utm_source=googlepla&variant=16950356097&gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFK6i-wzHiYiyYqQK-8Pkn5xth3-d_JRLhZy3vCUDWo1kaAugw8P8HAQ; http://www.adlsupply.com/ballasts/philips-advance-icn-2p32-n/?gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFK49fTcL_EIuiJxnnAgMbLGQvMyjl_LjjXKPLUwd5TkoaAlPi8P8HAQ; http://www.lighting-spot.com/ge-232-mv-n.html?fee=24&fep=527&gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFKwQ8BslaEWkUNaQJiYJLq1E2EvCC8qV6AszId7rFH0waAjHg8P8HAQ; https://www.bulbamerica.com/products/osram-sylvania-32w-120v-t8-2-lamp-high-efficiency-electric-ballast?CAWELAID=120150920000389459&CAGPSPN=pla&CAAGID=11213624286&CATCI=pla-129513636246&catargetid=120150920000808680&cadevice=c&gclid=Cj0KEQjw57W9BRDM9_a-2v	$46.55
3823	LED Replacement of 4’ T8 Lamps utilizing existing ballast, Agriculture	Online research, Sept 2016. Available online: http://www.greenledzone.com/t8-led-tube-light-direct-wire-ballast-compatible-p/gl-lod-c08-m1218.htm?gclid=Cj0KEQjwxLC9BRDb1dP8o7Op68IBEiQAwWggQA7zZ34iQp1t8ivOd4GwDDOKE1flh40UVRP3kOWcoToaAh7p8P8HAQ; http://www.shineretrofits.com/james-industry-bt816w4ft-16-watt-4-foot-led-plug-and-play-ballast-compatible-t8-linear-tube-lamp-frosted-aluminum-housing.html?gclid=Cj0KEQjwxLC9BRDb1dP8o7Op68IBEiQAwWggQAYs8tG6hrZ21H2cx1HyxyJIthWTf8X1LY6FTU_i9_AaApAp8P8HAQ; https://www.earthled.com/products/thinklux-led-fluorescent-replacement-tube-4-foot-18-watt-universal-t8-or-t12-ballast-compatible-dimmable?variant=20878204932; https://www.1000bulbs.com/product/7028/TCP-31032841.html?utm_source=SmartFeedGoogleBase&utm_medium=Shopping&utm_term=TCP-31032841&utm_content=	$11.29

MMID	Measure Name	Source	Incremental Cost
		800+Series+Phosphors&utm_campaign=SmartFeedGoogleBaseShopping&gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFK3_139urG; https://www.1000bulbs.com/product/90200/USH-3000480.html?utm_source=SmartFeedGoogleBase&utm_medium=Shopping&utm_term=USH-3000480&utm_content=800+Series+Phosphors&utm_campaign=SmartFeedGoogleBaseShopping&gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFK2B1rtXuKJ; http://www.adlsupply.com/fluorescent-t8/sylvania-21781-fo32-841-eco/?gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFK7UbfdMKV6L5tIYN6DNgvVs1fr2zovtgAyLuo8_F6hEaAnRn8P8HAQ	
3824	LED Fixture, Replacing 150-175 Watt HID, Exterior, Agriculture	Actual cost from 2015-16 program data = $311.55. 790 applications, primary participation has been wall packs in BIP, CSF, MESP. Less average price from 1000bulbs.com search for "150-175 Watt HID, Exterior = $70.335. Incremental Cost is $272.17-70.34 =$201.84 . Incremental Cost is $311.55 - $70.335 = $241.22	$241.22
3825	LED Fixture, Replacing 250 Watt HID, Exterior, Agriculture	Actual cost from 2015-16 program data = $337.33. 676 applications, primary fixture types are a mix of wall packs and pole mounted. Less average price from 1000bulbs.com search for "150-175 Watt HID, Exterior = $70.335. Incremental Cost is $272.17-70.34 =$201.84 . Incremental Cost is $337.33 - $132.358 = $204.97	$204.97
3826	LED Fixture, Replacing 320-400 Watt HID, Exterior, Agriculture	Actual cost from 2015-16 program data = $337.33. 283 applications, primary fixture types are a mixture of architectureal floods, pole/arm mounted and wall packs. Less average price from 1000bulbs.com search for "320 Watt HID, Exterior = $243.06. Incremental Cost is $408-$243.06 =$164.94. Incremental Cost is $337.33 - $243.06 = $94.27	$94.27
3827	LED Fixture, Replacing 400 Watt HID, Exterior, Agriculture	Online Research, March 2016. Average price of 250 Watt equivalent fixtures via search: "250-400-metal-halide-equivalent LED shoebox fixtures" on 1000bulbs.com; https://www.1000bulbs.com/category/250-400-metal-halide-equivalent/	$408.00
3828	LED Fixture, Replacing 70-100 Watt HID, Exterior, Agriculture	Actual cost from 2015-16 program data = $242.86. 563 applications, primary fixture types are a mixture of architectureal floods, pole/arm mounted and wall packs. Less average price from 1000bulbs.com search for "70-100 watt HID,	$130.74

MMID	Measure Name	Source	Incremental Cost
		Exterior" = $112.14. Incremental Cost is $408-$243.06 =$164.94. Incremental Cost is $242.86 - $112.124 = $130.74	
3829	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 150-175 Watt HID, Exterior, Agriculture	Actual cost from 2015-16 program data, 8 applications.	$284.48
3830	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 250 Watt HID, Exterior, Agriculture	Actual cost from 2015-16 program data, 15 applications.	$244.76
3831	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 320-400 Watt HID, Exterior, Agriculture	2015 Implementer assessment of measure cost.	$290.00
3832	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 400 Watt HID, Exterior, Agriculture	Actual cost form 2015-16 program data, 15 applications.	$316.61
3833	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 70-100 Watt HID, Exterior, Agriculture	2015 Implementer assessment of measure cost.	$50.00
3834	Lighting Controls, Photocell with Internal Timer or Wireless Schedule, Exterior, Agriculture	Actual cost from 2015-16 program data, 7 applications.	$101.56

MMID	Measure Name	Source	Incremental Cost
3835	VFD, Process Pump, Agriculture	Evaluator and Implementer Consensus on setting cost on a per hp basis, instead of per motor. Cost set at $130.00 per hp, determined as survey value across full size range of motors eligible for this measure. NEEP 2013 Incremental Cost Study used to develop value (Incremental Cost Study Phase Two Final Report, Navigant Consulting, 2013). Available online: http://www.neep.org/Assets/uploads/files/emv/emv-products/NEEP%20ICS2%20FINAL%20REPORT%202013Feb11-Website.pdf	$130.00/hp
3836	VFD, Constant Torque, Agriculture	Evaluator and Implementer Consensus on setting cost on a per hp basis, instead of per motor. Cost set at $130.00 per hp, determined as survey value across full size range of motors eligible for this measure. Constant torque VFD is 15% more than variable torque VFD, 15% added to cost of similar VFD measures: $130.00 per hp x 1.15 = $149.50. Informed by historical Focus on Energy project data, 2012-2013 and NEEP 2013 Incremental Cost Study (Incremental Cost Study Phase Two Final Report, Navigant Consulting, 2013). Available online: http://www.neep.org/Assets/uploads/files/emv/emv-products/NEEP%20ICS2%20FINAL%20REPORT%202013Feb11-Website.pdf	$149.50
3837	LED Lamp, Energy Star, Replacing ≥ 23 Watt CFL, Agriculture	Cost data obtained through various online lighting retailers in October 2015, including 1000bulbs.com, warehouse-lighting.com, alconlighting.com, earthled.com, and toenic.com. Average prices of baseline equipment and qualifying efficient equipment used to obtain estimated incremental cost. Full data is available upon request.	$11.00
3838	LED Lamp, Energy Star, Replacing < 23 Watt CFL, Agriculture	Cost data obtained through various online lighting retailers in October 2015, including 1000bulbs.com, warehouse-lighting.com, alconlighting.com, earthled.com, and toenic.com. Average prices of baseline equipment and qualifying efficient equipment used to obtain estimated incremental cost. Full data is available upon request.	$3.00
3839	LED Replacement of 4’ T8 Lamps, Direct Wire, Agriculture	Online research, Sept 2016. Available online: http://www.greenledzone.com/t8-led-tube-light-direct-wire-ballast-compatible-p/gl-lod-c08-m1218.htm?gclid=Cj0KEQjwxLC9BRDb1dP8o7Op68IBEiQAwWggQA7zZ34iQp1t8ivOd4GwDDOKE1flh40UVRP3kOWcoToaAh7p8P8HAQ; http://greenlight	$6.62

MMID	Measure Name	Source	Incremental Cost
		depot.com/collections/led-tube-lights/products/4ft-18w-led-linear-versa-tube-ul-dlc?variant=3706824772&gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFK5S0WZ_BBNcC7Y5DA7At4cO2rcAGaAl2RyJQZVbZE4MaAtJc8P8HAQ; https://www.1000bulbs.com/product/153506/PLT-10018.html?utm_source=SmartFeedGoogleBase&utm_medium=Shopping&utm_term=PLT-10018&utm_content=LED+Lighting+Specials&utm_campaign=SmartFeedGoogleBaseShopping&gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFKzDoix0ocMbl; https://www.1000bulbs.com/product/7028/TCP-31032841.html?utm_source=SmartFeedGoogleBase&utm_medium=Shopping&utm_term=TCP-31032841&utm_content=800+Series+Phosphors&utm_campaign=SmartFeedGoogleBaseShopping&gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFK3_139urG; https://www.1000bulbs.com/product/90200/USH-3000480.html?utm_source=SmartFeedGoogleBase&utm_medium=Shopping&utm_term=USH-3000480&utm_content=800+Series+Phosphors&utm_campaign=SmartFeedGoogleBaseShopping&gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFK2B1rtXuKJ; http://www.adlsupply.com/fluorescent-t8/sylvania-21781-fo32-841-eco/?gclid=Cj0KEQjw57W9BRDM9_a-2vWJ68EBEiQAwPNFK7UbfdMKV6L5tIYN6DNgvVs1fr2zovtgAyLuo8_F6hEaAnRn8P8HAQ	
3842	Air Sealing, Tier 2, Project Based	Implementer findings	$0.00
3859	CFL, 13 Watt, Pack-based	Light bulb sales data obtained by Cadmus for California- 2010 through 2012. Note that the CFL average lamp costs include incented lamps.	$0.37
3860	CFL, 23 Watt, Pack-based	Light bulb sales data obtained by Cadmus for California- 2010 through 2012. Note that the CFL average lamp costs include incented lamps.	$1.03
3861	LED, 10 Watt, Pack-based	Evaluator Online Cost research from 1000 bulbs.com, Lowes, and HomeDepot. Research conducted March 2016 for ENERGY STAR®. Weighted Average of 29 to 43 Watt LEDs.	$5.90
3862	Faucet Aerator, Kitchen, 1.5 GPM, Pack-based	DEER 2015. California Database for Energy Efficient Resources, $6.70 labor + $2.80 materials = $9.50. Available online: http://www.deeresources.com/index.php/ex-ante-database.	$9.50

MMID	Measure Name	Source	Incremental Cost
3863	Faucet Aerator, Bathroom, 1.0 GPM, Pack-based	DEER 2015. California Database for Energy Efficient Resources, \$6.70 labor + \$6.54 materials = \$13.24. Available online: http://www.deeresources.com/index.php/ex-ante-database	\$13.24
3864	Showerhead, 1.5 GPM, Pack-based	\$5.00 = WESCO Distribution Pricing (\$3.11) + Labor (\$1.89)	\$5.00
3868	Natural Gas Furnace with ECM: 96% + AFUE	Wisconsin Public Service Commission. Incremental Cost Database. December 2014	\$1,071.47
3870	Natural Gas Furnace with ECM: Tier 2, 96% + AFUE	Wisconsin Public Service Commission. Incremental Cost Database. December 2014	\$2,007.50
3871	Natural Gas Furnace with ECM: Tier 2, 97% + AFUE	Wisconsin Public Service Commission. Incremental Cost Database. December 2014	\$2,450.00
3869	Natural Gas Furnace with ECM: 98% + AFUE	Wisconsin Public Service Commission. Incremental Cost Database. December 2014	\$2,522.54
3872	Natural Gas Furnace with ECM: Tier 2, 98% + AFUE	Wisconsin Public Service Commission. Incremental Cost Database. December 2014	\$2,892.50

Appendix E: Measure Lookup by MMID

MMID	Measure Name	Page #
1981	Natural Gas Furnace with ECM, 95%+ AFUE (Existing)	122
1983	Hot Water Boiler, 95%+ AFUE	491
1986	Condensing Water Heater, Natural Gas, 90%+	550
1988	Water Heater, Indirect, 95% or greater	557
1989	Water Heater, Electric, EF ≥ 0.93	557
2120	Faucet Aerator, Direct Install, 1.5 GPM, Kitchen, Natural Gas	522
2121	Faucet Aerator, Direct Install, 1.0 GPM, Bathroom, Residential, Natural Gas	522
2123	Showerhead, Direct Install, 1.5 GPM, Natural Gas	523
2126	Faucet Aerator, Direct Install, 1.5 GPM, Kitchen, Electric	522
2127	Faucet Aerator, Direct Install, 1.0 GPM, Bathroom, Residential, Electric	522
2129	Showerhead, Direct Install, 1.5 GPM, Electric	523
2132	CFL, Standard Bulb, 9 Watts	601
2133	CFL, Standard Bulb, 14 Watts	601
2134	CFL, Standard Bulb, 19 Watts	601
2135	CFL, Standard Bulb, 23 Watts	601
2136	Faucet Aerator, Direct Install, 1.5 GPM, Kitchen, Natural Gas	522
2137	Faucet Aerator, Direct Install, 1.0 GPM, Bathroom, Residential, Natural Gas	522
2141	DHW Temperature Turn Down, Direct Install, Natural Gas	532
2143	Faucet Aerator, 1.0 GPM, Bathroom, Electric	529
2147	DHW Temperature Turn Down, Direct Install, Electric	532
2192	A/C Split System, ≤ 65 MBh, SEER 15	579
2193	A/C Split System, ≤ 65 MBh, SEER 16+	579
2194	A/C Split System, ≤ 65 MBh, SEER 14	579
2221	Boiler Control, Outside Air Temperature Reset/Cutout Control	496
2238	Ceramic Metal Halide Lamp, ≤ 25 Watts	255
2246	CFL Reflector Lamps	595
2253	Circulation Fan, High Efficiency, Ag	25
2254	Compressed Air Condensate Drains, No Loss Drain	54
2255	Compressed Air Controller, Pressure/Flow Controller	37
2257	Compressed Air Heat Recovery, Space Heating	43
2258	Compressed Air Mist Eliminators	45
2259	Compressed Air Nozzles, Air Entraining	48
2261	Compressed Air System Leak Survey and Repair, Year 1	50
2262	Compressed Air System Leak Survey and Repair, Year 2	50
2263	Compressed Air System Leak Survey and Repair, Year 3	50
2264	Compressed Air, Cycling Thermal Mass Air Dryers	40

MMID	Measure Name	Page #
2276	Delamping, T12 to T8, 4-Foot	319
2277	Delamping, T8 to T8	319
2280	Dishwasher, Low Temp, Door Type, ENERGY STAR, Electric	63
2281	Dishwasher, High Temp, Electric Booster, Door Type, ENERGY STAR, Electric	63
2282	Dishwasher, High Temp, , Electric Booster, Door Type, ENERGY STAR, Natural Gas	63
2283	Dishwasher, High Temp, Electric Booster, Multi Tank Conveyor, ENERGY STAR, Electric	63
2284	Dishwasher, High Temp, Electric Booster, Multi Tank Conveyor, ENERGY STAR, Natural Gas	63
2285	Dishwasher, High Temp, Electric Booster, Single Tank Conveyor, ENERGY STAR, Electric	63
2286	Dishwasher, High Temp, Electric Booster, Single Tank Conveyor, ENERGY STAR, Natural Gas	63
2287	Dishwasher, High Temp, Electric Booster, Under Counter, ENERGY STAR, Electric	63
2288	Dishwasher, High Temp, Electric Booster, Under Counter, ENERGY STAR, Natural Gas	63
2289	Dishwasher, High Temp, Natural Gas Booster, Door Type, ENERGY STAR, Natural Gas	63
2290	Dishwasher, High Temp, Natural Gas Booster, Multi Tank Conveyor, ENERGY STAR, Natural Gas	63
2291	Dishwasher, High Temp, Natural Gas Booster, Single Tank Conveyor, ENERGY STAR, Natural Gas	63
2292	Dishwasher, High Temp, Natural Gas Heat, Natural Gas Booster, Under Counter, ENERGY STAR, Natural Gas	63
2293	Dishwasher, Low Temp, Door Type, ENERGY STAR, Natural Gas	63
2294	Dishwasher, Low Temp, Multi Tank Conveyor, ENERGY STAR, Electric	63
2295	Dishwasher, Low Temp, Multi Tank Conveyor, ENERGY STAR, Natural Gas	63
2296	Dishwasher, Low Temp, Single Tank Conveyor, ENERGY STAR, Electric	63
2297	Dishwasher, Low Temp, Single Tank Conveyor, ENERGY STAR, Natural Gas	63
2298	Dishwasher, Low Temp, Under Counter, ENERGY STAR, Electric	63
2299	Dishwasher, Low Temp, Under Counter, ENERGY STAR, Natural Gas	63
2306	ECM Compressor Fan Motor	466
2314	Energy Recovery Ventilator	113
2316	High Volume, Low Speed Fan, 20-foot diameter	118
2317	High Volume, Low Speed Fan, 22-foot diameter	118
2318	High Volume, Low Speed Fan, 24 foot diameter	118
2321	Commercial Freezer, Chest, Glass Door, < 15 cu ft, ENERGY STAR	95
2322	Commercial Freezer, Chest, Glass Door, 15-29 cu ft, ENERGY STAR	95
2323	Commercial Freezer, Chest, Glass Door, 30-49 cu ft, ENERGY STAR	95
2324	Commercial Freezer, Chest, Glass Door, 50+ cu ft, ENERGY STAR	95
2325	Commercial Freezer, Chest, Solid Door, < 15 cu ft, ENERGY STAR	95
2326	Commercial Freezer, Chest, Solid Door, 15-29 cu ft, ENERGY STAR	95

MMID	Measure Name	Page #
2327	Commercial Freezer, Chest, Solid Door, 30-49 cu ft, ENERGY STAR	95
2328	Commercial Freezer, Chest, Solid Door, 50+ cu ft, ENERGY STAR	95
2329	Commercial Freezer, Vertical, Glass Door, < 15 cu ft, ENERGY STAR	95
2330	Commercial Freezer, Vertical, Glass Door, 15-29 cu ft, ENERGY STAR	95
2331	Commercial Freezer, Vertical, Glass Door, 30-49 cu ft, ENERGY STAR	95
2332	Commercial Freezer, Vertical, Glass Door, 50+ cu ft, ENERGY STAR	95
2333	Commercial Freezer, Vertical, Solid Door, < 15 cu ft, ENERGY STAR	95
2334	Commercial Freezer, Vertical, Solid Door, 15-29 cu ft, ENERGY STAR	95
2335	Commercial Freezer, Vertical, Solid Door, 30-49 cu ft, ENERGY STAR	95
2336	Commercial Freezer, Vertical, Solid Door, 50+ cu ft, ENERGY STAR	95
2429	Insulation, Steam Fitting, Removable, Natural Gas	30
2430	Insulation, Steam Piping, Natural Gas	30
2471	Occupancy Sensor, Ceiling Mount, ≤ 500 Watts	224
2472	Occupancy Sensor, Ceiling Mount, ≥ 1,001 Watts	224
2473	Occupancy Sensor, Ceiling Mount, 501-Watts to 1,000 Watts	224
2474	Occupancy Sensor, ≤ 200 Watts, Fixture Mount	224
2475	Occupancy Sensor, > 200 Watts, Fixture Mount	224
2483	Occupancy Sensor, ≤ 200 Watts, Wall Mount	224
2484	Occupancy Sensor, > 200 Watts, Wall Mount	224
2485	Oven, Convection, ENERGY STAR, Electric	81
2486	Oven, Convection, ENERGY STAR, Natural Gas	84
2487	Oven, Rack Type, ENERGY STAR, Natural Gas, Double Compartment	87
2488	Oven, Rack Type, ENERGY STAR, Natural Gas, Single Compartment	87
2491	Plate Heat Exchanger and Well Water Pre-Cooler	19
2496	Pressure Screen Rotor	455
2509	Reach In Refrigerated Case w/ Doors Replacing Open Multi Deck Case	468
2521	Commercial Refrigerator, Chest, Glass Door, < 15 cu ft, ENERGY STAR	91
2522	Commercial Refrigerator, Chest, Glass Door, 15-29 cu ft, ENERGY STAR	91
2523	Commercial Refrigerator, Chest, Glass Door, 30-49 cu ft, ENERGY STAR	91
2524	Commercial Refrigerator, Chest, Glass Door, 50+ cu ft, ENERGY STAR	91
2525	Commercial Refrigerator, Chest, Solid Door, < 15 cu ft, ENERGY STAR	91
2526	Commercial Refrigerator, Chest, Solid Door, 15-29 cu ft, ENERGY STAR	91
2527	Commercial Refrigerator, Chest, Solid Door, 30-49 cu ft, ENERGY STAR	91
2528	Commercial Refrigerator, Chest, Solid Door, 50+ cu ft, ENERGY STAR	91
2529	Commercial Refrigerator, Vertical, Glass Door, < 15 cu ft, ENERGY STAR	91
2530	Commercial Refrigerator, Vertical, Glass Door, 15-29 cu ft, ENERGY STAR	91
2531	Commercial Refrigerator, Vertical, Glass Door, 30-49 cu ft, ENERGY STAR	91
2532	Commercial Refrigerator, Vertical, Glass Door, 50+ cu ft, ENERGY STAR	91

MMID	Measure Name	Page #
2533	Commercial Refrigerator, Vertical, Solid Door, < 15 cu ft, ENERGY STAR	91
2534	Commercial Refrigerator, Vertical, Solid Door, 15-29 cu ft, ENERGY STAR	91
2535	Commercial Refrigerator, Vertical, Solid Door, 30-49 cu ft, ENERGY STAR	91
2536	Commercial Refrigerator, Vertical, Solid Door, 50+ cu ft, ENERGY STAR	91
2538	Repulper Rotor	458
2643	Variable Frequency Drive, HVAC Fan	127
2644	Variable Frequency Drive, HVAC Heating Pump	127
2647	Variable Frequency Drive, Process Fan	461
2648	Variable Frequency Drive, Process Pump	461
2652	Water Heater, ≥ 0.82 EF, Tankless, Residential, Natural Gas	554
2660	Energy Efficient Livestock Waterer, < 250 Watts	22
2665	Reduced Wattage 8-Foot T8 Lamps Replacing 8-Foot Standard T8 Lamps	621
2666	Chiller System Tune-Up, Air Cooled, ≤ 500 Tons	155
2667	Chiller System Tune-Up, Air Cooled, > 500 Tons	155
2668	Chiller System Tune-Up, Water Cooled, ≤ 500 Tons	155
2669	Chiller System Tune-Up, Water Cooled, > 500 Tons	155
2703	2-Lamp F28T5, HPT8, RWT8 2x4 High-Efficiency Recessed Fixtures	415
2704	T8, 2 Lamp, 4-Foot, Recessed Indirect Fixture, HPT8, Replacing 3 Lamp or 4 Lamp T8 or T12	253
2707	T8, Low-Watt Relamp, 54 Watts, 8-Foot	251
2744	Boiler Tune-Up	499
2745	Air Sealing	505
2746	Multifamily Benchmarking Incentive	679
2747	Natural Gas Boiler, ≥ 90% AFUE	494
2756	Clothes Washer, Common Area, ENERGY STAR, Electric	583
2757	Clothes Washer, Common Area, ENERGY STAR, Natural Gas	583
2760	Domestic Hot Water Plant Replacement	547
2768	LED Exit Signs	371
2810	Engine Block Heater Timer	486
2819	Solar Photovoltaic	688
2820	Ground Source Heat Pump, Electric Back-Up	482
2820	Ground Source Heat Pump, Residential, Electric Back-Up	685
2821	Ground Source Heat Pump, Natural Gas Back-Up	482
2821	Ground Source Heat Pump, Residential, Natural Gas Back-Up	685
2853	Demand Control Ventilation for Air Handling Units	99
2884	High Bay Fluorescent Lighting, T8 4L Replacing 250-399 W HID	418
2886	High Bay Fluorescent Lighting, T8 8L Replacing 400-999 W HID	418
2887	High Bay Fluorescent Lighting, T8 8L ≤ 500 W, Replacing ≥ 1,000 W HID	418

MMID	Measure Name	Page #
2888	High Bay Fluorescent Lighting, T8 10L ≤ 500 W, Replacing ≥ 1,000 W HID	418
2889	High Bay Fluorescent Lighting, T8 (2) 6L ≤ 500 W, Replacing ≥ 1,000 W HID	418
2890	High Bay Fluorescent Lighting, T5HO 2L Replacing 250-399 W HID	418
2891	High Bay Fluorescent Lighting, T5HO 3L Replacing 250-399 W HID	418
2892	High Bay Fluorescent Lighting, T5HO 4L Replacing 400-999 W HID	418
2893	High Bay Fluorescent Lighting, T5HO 6L Replacing 400-999 W HID	418
2894	High Bay Fluorescent Lighting, T5HO 6L ≤ 500 W, Replacing ≥ 1,000 W HID	418
2895	High Bay Fluorescent Lighting, T5HO 8L ≤ 500 W, Replacing ≥ 1,000 W HID	418
2896	High Bay Fluorescent Lighting, T5HO (2) 4L ≤ 500 W, Replacing ≥ 1,000 W HID	418
2897	High Bay Fluorescent Lighting, T5HO (2) 6L ≤ 800 W, Replacing ≥ 1,000 W HID	418
2984	LED Fixture, Downlights, Accent Lights, and Monopoint ≤ 18 Watts, Common Area	379
2989	ECM, Furnace or Air Handler	673
2992	Air Source Heat Pump, ≥ 16 SEER	676
3001	Delamping, 200 - 399 Watt Fixture	323
3002	Delamping, ≥ 400 Watt Fixture	323
3017	Retail Store Markdown, Low-Flow Showerheads	543
3018	Energy Free Livestock Waterer	22
3019	Lighting Fixture, Agricultural Daylighting, ≤ 155 Watts	206
3020	Lighting Fixture, Agricultural Daylighting, 156 - 250 Watts	206
3021	Lighting Fixture, Agricultural Daylighting, 251 - 365 Watts	206
3022	A/C Split or Packaged System, High Efficiency, Business, All Sizes	134
3023	Reduced Wattage Lamps, Replacing Standard T5	248
3024	Reduced Wattage Lamps, Replacing Standard T5HO	248
3025	Faucet Aerator, 1.5 GPM, Kitchen, Natural Gas	529
3026	Faucet Aerator, 1.5 GPM, Kitchen, Electric	529
3027	Faucet Aerator, 1.5 GPM, Bathroom, Natural Gas	529
3028	Faucet Aerator, 1.5 GPM, Bathroom, Electric	529
3029	Faucet Aerator, 1.5 GPM, Shower, Natural Gas	529
3030	Faucet Aerator, 1.5 GPM, Shower, Electric	529
3031	CFL, Reduced Wattage, Pin Based, 18 Watt, Replacing CFL	229
3032	CFL, Reduced Wattage, Pin Based, 26 Watt, Replacing CFL	229
3033	CFL, Reduced Wattage, Pin Based, 32 Watt, Replacing CFL	229
3034	CFL, Reduced Wattage, Pin Based, 42 Watt, Replacing CFL	229
3036	HID, Reduced Wattage, Exterior, Replacing 1,000 Watt HID	335
3037	HID, Reduced Wattage, Exterior, Replacing 400 Watt HID	335
3038	HID, Reduced Wattage, Exterior, Replacing 320 Watt HID	335
3039	HID, Reduced Wattage, Exterior, Replacing 250 Watt HID	335
3040	HID, Reduced Wattage, Exterior, Replacing 175 Watt HID	335

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3045	Water Heater, High Usage, ≥ 90% TE, Natural Gas	56
3046	Water Heater, High Usage, ≥ 0.82 EF, Tankless, Natural Gas	56
3047	Water Heater, High Usage, ≥ 2 EF, Heat Pump Storage, Electric	56
3056	Exterior/Parking LED Fixtures, Replacing 320 Watt HID, Parking Garage	257
3059	Air Conditioning Unit Tune Up - Coil Cleaning, < 10 Tons	143
3060	Air Conditioning Unit Tune Up - Coil Cleaning, > 20 Tons	143
3061	Air Conditioning Unit Tune Up - Coil Cleaning, 10-20 Tons	143
3062	Air Conditioning Unit Tune Up - Refrigerant Charge Correction, < 10 Tons	146
3063	Air Conditioning Unit Tune Up - Refrigerant Charge Correction, > 20 Tons	146
3064	Air Conditioning Unit Tune Up - Refrigerant Charge Correction, 10-20 Tons	146
3066	Economizer, RTU Optimization	110
3067	HID, Reduced Wattage, Interior, Replacing 1,000 Watt HID	335
3068	HID, Reduced Wattage, Interior, Replacing 175 Watt HID	335
3069	HID, Reduced Wattage, Parking Garage, Replacing 175 Watt HID	335
3070	HID, Reduced Wattage, Interior, Replacing 250 Watt HID	335
3071	HID, Reduced Wattage, Parking Garage, Replacing 250 Watt HID	335
3072	HID, Reduced Wattage, Interior, Replacing 320 Watt HID	335
3073	HID, Reduced Wattage, Interior, Replacing 400 Watt HID	335
3074	High Bay – Induction, PSMH, CMH Fixtures, Induction, 750 Watt, Replacing 1,000 Watt HID, High Bay	430
3075	High Bay – Induction, PSMH, CMH Fixtures, ≤ 250 Watt, Replacing 320-400 Watt HID	430
3076	High Bay – Induction, PSMH, CMH Fixtures, ≤ 250 Watt, Replacing 400 Watt HID	430
3077	High Bay – Induction, PSMH, CMH Fixtures, ≤ 365 Watt, Replacing 400 Watt HID	430
3078	Induction, PSMH/CMF or Linear Fluorescent, Exterior, Replacing 150-175 Watt HID	423
3079	Induction, PSMH/CMH, or Linear Fluorescent, Parking Garage, Replacing 150-175 Watt HID, 24 Hour	426
3080	Induction, PSMH/CMH, or Linear Fluorescent, Parking Garage, Replacing 150-175 Watt HID, Dusk to Dawn	426
3081	Induction, PSMH/CMF or Linear Fluorescent, Exterior, Replacing 250 Watt HID	423
3082	Induction, PSMH/CMH, or Linear Fluorescent, Parking Garage, Replacing 250 Watt HID, 24 Hour	426
3083	Induction, PSMH/CMH, or Linear Fluorescent, Parking Garage, Replacing 250 Watt HID, Dusk to Dawn	426
3084	Induction, PSMH/CMF or Linear Fluorescent, Exterior, Replacing 320 -Watt HID	423
3086	Induction, PSMH/CMF or Linear Fluorescent, Exterior, Replacing 400 Watt HID	423
3087	Induction, PSMH/CMF or Linear Fluorescent, Exterior, Replacing 70-100 Watt HID	423
3088	Induction, PSMH/CMH, or Linear Fluorescent, Parking Garage, Replacing 70-100 Watt HID, 24 Hour	426

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3090	High Bay – Induction, PSMH, CMH Fixtures, Replacing 250 Watt HID	430
3091	LED Fixtures, High Bay, < 155 Watts, Replacing 250 Watt HID	360
3092	LED Fixtures, High Bay, < 250 Watts, Replacing 320-400 Watt HID	360
3093	LED Fixtures, High Bay, < 250 Watts, Replacing 400 Watt HID	360
3094	LED Fixtures, High Bay, < 365 Watts, Replacing 400 Watt HID	360
3095	LED Fixtures, High Bay, < 500 Watts, Replacing 1,000 Watt HID	360
3096	LED Fixtures, High Bay, < 800 Watts, Replacing 1,000 Watt HID	360
3097	LED Fixture, Bi-Level, Stairwell and Passageway	315
3099	LED Fixture, Exterior, Replacing 150-175 Watt HID	354
3100	Exterior/Parking LED Fixtures, Replacing 150-175 Watt HID, Parking Garage, 24 Hour	257
3101	Exterior/Parking LED Fixtures, Replacing 150-175 Watt HID, Parking Garage, Dusk to Dawn	257
3102	LED Fixture, Exterior, Replacing 250 Watt HID	354
3103	Exterior/Parking LED Fixtures, Replacing 250 Watt HID, Parking Garage, 24 Hour	257
3104	Exterior/Parking LED Fixtures, Replacing 250 Watt HID, Parking Garage, Dusk to Dawn	257
3105	LED Fixture, Exterior, Replacing 320 Watt HID	354
3106	LED Fixture, Exterior, Replacing 320-400 Watt HID	354
3107	LED Fixture, Exterior, Replacing 400 Watt HID	354
3108	LED Fixture, Exterior, Replacing 70-100 Watt HID	354
3109	Exterior/Parking LED Fixtures, Replacing 70-100 Watt HID, Parking Garage, 24 Hour	257
3110	Exterior/Parking LED Fixtures, Replacing 70-100 Watt HID, Parking Garage, Dusk to Dawn	257
3111	LED Troffer, 2x4, Replacing 4-Foot, 3-4 Lamp T8 Troffer	343
3112	LED Lamp Replacing Incandescent Lamp ≤ 40 Watts	398
3113	LED Lamp Replacing Incandescent Lamp > 40 Watts	401
3114	LED, Horizontal Case Lighting	364
3118	ENERGY STAR Commercial Combination Oven, Electric	76
3119	ENERGY STAR Commercial Combination Oven, Natural Gas	76
3120	Programmable Thermostat, RTU Optimization Advanced	130
3121	Programmable Thermostat, RTU Optimization Standard	130
3122	T8, 2-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12, 1-Lamp, 8-Foot, 0.78 < BF < 1.00	241
3123	T8, 2-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12, 1-Lamp, 8-Foot, BF ≤ 0.78	241
3124	T8, 2-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO, 1-Lamp, 8-Foot, 0.78 < BF < 1.00	241
3125	T8, 2-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO, 1-Lamp, 8-Foot, BF ≤ 0.78	241
3126	T8, 2-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO, 1-Lamp, 8-Foot, BF > 1.00	241

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3127	T8, 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12, 2-Lamp, 8-Foot, 0.78 < BF < 1.00	241
3128	T8, 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12, 2-Lamp, 8-Foot, BF ≤ 0.78	241
3129	T8, 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO, 2-Lamp, 8-Foot, 0.78 < BF < 1.00	241
3130	T8, 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO, 2-Lamp, 8-Foot, BF ≤ 0.78	241
3131	T8, 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO, 2-Lamp, 8-Foot, BF > 1.00	241
3132	T8, 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12VHO, 2-Lamp, 8-Foot, 0.78 < BF < 1.00	241
3133	T8, 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12VHO, 2-Lamp, 8-Foot, BF ≤ 0.78	241
3134	T8, 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12VHO, 2-Lamp, 8-Foot, BF > 1.00	241
3135	T8, Low-Watt Relamp, 8-Foot	251
3137	Dishwasher, High Temp, Electric Booster, Pots/Pans Type, ENERGY STAR, Natural Gas	63
3138	Dishwasher, High Temp, Natural Gas Booster, Pots/Pans Type, ENERGY STAR, Natural Gas	63
3140	Dishwasher, Low Temp, Pots/Pans Type, ENERGY STAR, Natural Gas	63
3144	T8 2-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12 1-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	610
3145	T8 2-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12 1-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	610
3146	T8 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12 2-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	610
3147	T8 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12 2-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	610
3148	T8 2-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO 1-Lamp, 8-Foot, BF > 1.00, Parking Garage	610
3149	T8 2-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO 1-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	610
3150	T8 2-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO 1-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	610
3151	T8 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO 2-Lamp, 8-Foot, BF > 1.00, Parking Garage	610
3152	T8 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO 2-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	610
3153	T8 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO 2-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	610
3154	T8 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12VHO 2-Lamp, 8-Foot, BF > 1.00, Parking Garage	610

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3155	T8 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12VHO 2-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	610
3156	T8 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12VHO 2-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	610
3157	ENERGY STAR LED Porch Fixtures	666
3158	LED Fixture, Downlights, Accent Lights, and Monopoint ≤ 18 Watts, In Unit	379
3159	LED, ENERGY STAR, Replacing Incandescent > 40 Watts, In Unit	656
3160	LED, ENERGY STAR, Replacing Incandescent > 40 Watts, Common Area	656
3161	LED, ENERGY STAR, Replacing Incandescent ≤ 40 Watts, In Unit	653
3162	LED, ENERGY STAR, Replacing Incandescent ≤ 40 Watts, Common Area	653
3163	T8 1-Lamp 4-Foot, Parking Garage, HPT8, CEE, BF ≤ 0.78	668
3164	T8 1-Lamp 4-Foot, Parking Garage, 28 Watt, CEE, BF > 0.78	668
3165	T8 1-Lamp 4-Foot, Parking Garage, 28 Watt, CEE, BF ≤ 0.78	668
3166	T8 1-Lamp 4-Foot, Parking Garage, 25 Watt, CEE, BF > 0.78	668
3167	T8 1-Lamp 4-Foot, Parking Garage, 25 Watt, CEE, BF ≤ 0.78	668
3168	T8 2-Lamp 4-Foot, Parking Garage, HPT8, CEE, BF ≤ 0.78	668
3169	T8 2-Lamp 4-Foot, Parking Garage, 28 Watt, CEE, BF > 0.78	668
3170	T8 2-Lamp 4-Foot, Parking Garage, 28 Watt, CEE, BF ≤ 0.78	668
3171	T8 2-Lamp 4-Foot, Parking Garage, 25 Watt, CEE, BF > 0.78	668
3172	T8 2-Lamp 4-Foot, Parking Garage, 25 Watt, CEE, BF ≤ 0.78	668
3173	T8 3-Lamp 4-Foot, Parking Garage, HPT8, CEE, BF ≤ 0.78	668
3174	T8 3-Lamp 4-Foot, Parking Garage, 28 Watt, CEE, BF > 0.78	668
3175	T8 3-Lamp 4-Foot, Parking Garage, 28 Watt, CEE, BF ≤ 0.78	668
3176	T8 3-Lamp 4-Foot, Parking Garage, 25 Watt, CEE, BF > 0.78	668
3177	T8 3-Lamp 4-Foot, Parking Garage, 25 Watt, CEE, BF ≤ 0.78	668
3178	T8 4-Lamp 4-Foot, Parking Garage, HPT8, CEE, BF ≤ 0.78	668
3179	T8 4-Lamp 4-Foot, Parking Garage, 28 Watt, CEE, BF > 0.78	668
3180	T8 4-Lamp 4-Foot, Parking Garage, 28 Watt, CEE, BF ≤ 0.78	668
3181	T8 4-Lamp 4-Foot, Parking Garage, 25 Watt, CEE, BF > 0.78	668
3182	T8 4-Lamp 4-Foot, Parking Garage, 25 Watt, CEE, BF ≤ 0.78	668
3183	Strip Curtains for Walk-In Freezers and Coolers	476
3184	Delamping, T12 to T8, 8-Foot	319
3195	Linear Fluorescent, 2-Lamp, 4-Foot, RWT8 Replacements, 24 Hours, CALP	615
3196	Linear Fluorescent, 2-Lamp, 4-Foot, RWT8 Replacements, 12 Hours, CALP	618
3197	CFL Fixture, Interior or Exterior, 24 Hours, CALP	593
3198	CFL Fixture, 12 Hours, CALP, Interior	591
3199	CFL Fixture, 12 Hours, CALP, Exterior	591
3201	Occupancy Sensor, ≤ 200 Watts, Wall or Ceiling Mount, CALP	224

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3235	LED Fixture Replacing 2x4 Linear Fluorescent Fixture	289
3239	LED, 2x2, Replacing T8 2 Lamp U-Tube	285
3244	Process Exhaust Filtration	452
3251	Lighting Controls, Bi-Level, Exterior and Parking Garage Fixtures, Dusk to Dawn	315
3252	Lighting Controls, Bi-Level, Parking Garage Fixtures, 24 Hour	315
3254	Occupancy Sensor, High Bay Fixtures, Gymnasium	219
3255	Occupancy Sensor, High Bay Fixtures, Industrial	219
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3258	Occupancy Sensor, High Bay Fixtures, Public Assembly	219
3259	Occupancy Sensor, High Bay Fixtures, Other	219
3260	Bi Level Controls, High Bay Fixtures, Gymnasium	213
3261	Bi Level Controls, High Bay Fixtures, Industrial	213
3262	Bi Level Controls, High Bay Fixtures, Retail	213
3263	Bi Level Controls, High Bay Fixtures, Warehouse	213
3264	Bi Level Controls, High Bay Fixtures, Public Assembly	213
3265	Bi Level Controls, High Bay Fixtures, Other	213
3266	Demand Control Ventilation, RTU Optimization	140
3274	LED, Direct Install, 12 Watts	367
3279	LED, Direct Install, 9.5 Watt	632
3280	Variable Frequency Drive, Constant Torque	461
3284	Strip Curtains for Walk-In Freezers and Coolers, SBP A La Carte	476
3289	LED Fixture, Exterior, Replacing 150-175 Watt HID	354
3291	LED Troffer, 2x4, Replacing 4-Foot, 3-4 Lamp T8 Troffer	343
3301	LED Fixture, Exterior, Replacing 250 Watt HID	354
3303	LED Fixture, Exterior, Replacing 400 Watt HID	354
3304	LED Fixture, Exterior, Replacing 70-100 Watt HID	354
3307	T8, 2-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12, 1-Lamp, 8-Foot, 0.78 < BF < 1.00, SBP A La Carte	241
3309	T8, 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12, 2-Lamp, 8-Foot, 0.78 < BF < 1.00, SBP A La Carte	241
3312	T8, 2-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO, 1-Lamp, 8-Foot, 0.78 < BF < 1.00, SBP A La Carte	241
3312	T8, 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO 1L 8', 0.78 < BF < 1.00, SBP A La Carte	241
3320	Delamping, T12 to T8, 8-Foot	319

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3325	T8 2-Foot Lamps, Replacing Single T12 U-Tube Lamp	326
3326	T8 2-Foot Lamps, Replacing Double T12 U-Tube Lamp	326
3329	High Bay Fluorescent Lighting, T8 4L Replacing 250-399 W HID	418
3330	High Bay Fluorescent Lighting, T5HO 2L Replacing 250-399 W HID	418
3331	High Bay Fluorescent Lighting, T8 6L Replacing 400-999 W HID	418
3332	High Bay Fluorescent Lighting, T5HO 4L Replacing 400-999 W HID	418
3333	High Bay Fluorescent Lighting, T8 8L ≤ 500 W, Replacing ≥ 1,000 W HID	418
3334	High Bay Fluorescent Lighting, T5HO 6L ≤ 500 W, Replacing ≥ 1,000 W HID	418
3335	LED, Horizontal Case Lighting	364
3347	LED, Direct Install, 12 Watts	367
3348	LED Troffer, 2x4, Replacing 4-Foot, 3-4 Lamp T8 Troffer	343
3353	LED Lamp Replacing Neon Sign	407
3357	Occupancy Sensor, > 200 Watts, Wall Mount	224
3361	Occupancy Sensor, ≤ 200 Watts, Wall Mount	224
3366	LED, 2x2, Replacing T12 2 Lamp U-Tube, SBP Package	285
3385	LED, Direct Install, 13.5 Watt	637
3386	Energy Efficient Grain Dryer	12
3387	LED 1-Foot by 4-Foot Replacing 2 Lamp Linear Fluorescent	382
3391	HPT8, 1-Foot by 4-Foot, Replacing T12 or T8, 2 Lamp, SBP A La Carte	236
3392	HPT8, 1-Foot by 4-Foot, Replacing T12 or T8, 2 Lamp, SBP Package	236
3393	LED Fixture, ≤ 180 Watts, Replacing 4 Lamp T5 or 6 Lamp T8, High Bay, DLC Listed	346
3394	LED Fixture, Downlights, ≤ 18 Watts, Replacing 1-Lamp Pin-Based CFL Downlight	260
3395	LED Fixture, Downlights, > 18 Watts, Replacing 2-Lamp Pin-Based CFL Downlight	260
3396	LED Fixture, Downlights, ≤ 100 Watts, ≥ 4000 Lumens, Interior	374
3397	LED Fixture, Downlights, ≤ 100 Watts, ≥ 4000 Lumens, Exterior	374
3398	LED Fixture, Downlights, ≥ 6,000 Lumens, Interior	374
3399	LED Fixture, Downlights, ≥ 6,000 Lumens, Exterior	374
3400	DLC Listed 2x2 LED Fixtures, Low Output	411
3401	DLC Listed 2x2 LED Fixtures, High Output	411
3402	LED Lamp, ENERGY STAR, Exterior, Replacing Incandescent Lamp ≤ 40 Watts	357
3403	LED Lamp, ENERGY STAR, Exterior, Replacing Incandescent Lamp > 40 Watts	357
3404	Exterior LED Downlights Luminaires > 18 Watts	351
3405	LED Fixture, Downlights, ≤ 18 Watts, Replacing Incandescent Downlight, Exterior	349
3406	Daylighting Control	210
3407	LED Fixture, Replacing 1,000 Watt HID, Exterior	282
3408	PSMH/CMH, Replacing 1,000 Watt HID, Exterior	282
3409	Retrofit Open Multi-Deck Cases with Doors	472

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3414	Ice Machine, CEE Tier 2, Air Cooled, Self Contained, 0-499 lbs/day	71
3415	Ice Machine, CEE Tier 2, Water Cooled, Self Contained, 0-499 lbs/day	71
3416	Ice Machine, CEE Tier 2, Air Cooled, Ice Making Head, 0-499 lbs/day	71
3417	Ice Machine, CEE Tier 2, Air Cooled, Ice Making Head, 500-999 lbs/day	71
3418	Ice Machine, CEE Tier 2, Air Cooled, Ice Making Head, ≥ 1,000 lbs/day	71
3419	Ice Machine, CEE Tier 2, Water Cooled, Ice Making Head, < 500 lbs/day	71
3420	Ice Machine, CEE Tier 2, Water Cooled, Ice Making Head, 500-999 lbs/day	71
3421	Ice Machine, CEE Tier 2, Water Cooled, Ice Making Head, ≥ 1,000 lbs/day	71
3422	Ice Machine, CEE Tier 2, Air Cooled, Remote Condensing, 0-499 lbs/day	71
3423	Ice Machine, CEE Tier 2, Air Cooled, Remote Condensing, 500-999 lbs/day	71
3424	Ice Machine, CEE Tier 2, Air Cooled, Remote Condensing, ≥ 1,000 lbs/day	71
3425	LED 8-Foot, Replacing T12 or T8, 1 Lamp	386
3426	LED 8-Foot, Replacing T12 or T8, 1 Lamp	386
3428	LED 8-Foot, Replacing T12 or T8, 2 Lamp	386
3429	LED 8-Foot, Replacing T12 or T8, 2 Lamp	386
3439	LED, Direct Install, 13.5 Watt	637
3440	Natural Gas Furnace with ECM, 97%+ AFUE	122
3461	LED, Recessed Downlight, Replacing Incandescent, ENERGY STAR, In Unit	644
3462	LED, Recessed Downlight, Replacing Incandescent, ENERGY STAR, Common Area	644
3463	LED, Recessed Downlight, Replacing CFL, ENERGY STAR, In Unit	644
3464	LED, Recessed Downlight, Replacing CFL, ENERGY STAR, Common Area	644
3487	CFL, Direct Install, 20 Watt	589
3488	LED, Direct Install, 10 Watt	642
3493	Parking Garage Ventilation Controls	103
3494	Variable Speed ECM Pump, Domestic Hot Water Recirculation, < 100 Watts Max Input	200
3495	Variable Speed ECM Pump, Domestic Hot Water Recirculation, 100 - 500 Watts Max Input	200
3496	Variable Speed ECM Pump, Domestic Hot Water Recirculation, > 500 Watts Max Input	200
3497	Variable Speed ECM Pump, Heating Water Circulation, < 100 Watts Max Input	200
3498	Variable Speed ECM Pump, Heating Water Circulation, 100 - 500 Watts Max Input	200
3499	Variable Speed ECM Pump, Heating Water Circulation, > 500 Watts Max Input	200
3500	Variable Speed ECM Pump, Cooling Water Circulation, < 100 Watts Max Input	200
3501	Variable Speed ECM Pump, Cooling Water Circulation, 100 - 500 Watts Max Input	200
3502	Variable Speed ECM Pump, Cooling Water Circulation, > 500 Watts Max Input	200
3503	Variable Speed ECM Pump, Water Loop Heat Pump Circulation, < 100 Watts Max Input	200

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3504	Variable Speed ECM Pump, Water Loop Heat Pump Circulation, 100 - 500 Watts Max Input	200
3505	Variable Speed ECM Pump, Water Loop Heat Pump Circulation, > 500 Watts Max Input	200
3506	Faucet Aerator, 1.0 GPM, Kitchen, Electric	529
3507	Faucet Aerator, 1.0 GPM, Kitchen, Natural Gas	529
3508	Faucet Aerator, 0.5 GPM, Bathroom, Natural Gas	529
3509	Faucet Aerator, 0.5 GPM, Kitchen, Electric	529
3510	Faucet Aerator, 0.5 GPM, Kitchen, Natural Gas	529
3511	LED Replacement of 4-Foot T8 Lamps with Integral or External Driver	394
3512	LED Replacement of 4-Foot T8 Lamps Using Existing Ballast	390
3513	ENERGY STAR Fluorescent Porch Fixtures	663
3548	CFL, Standard Bulb, Retail Store Markdown, 310-749 Lumens	607
3549	CFL, Standard Bulb, Retail Store Markdown, 750-1,049 Lumens	607
3550	CFL, Standard Bulb, Retail Store Markdown, 1,050-1,489 Lumens	607
3551	CFL, Standard Bulb, Retail Store Markdown, 1,490-2,600 Lumens	607
3552	CFL, Reflector, 15 Watt, Retail Store Markdown	598
3553	LED, Omnidirectional, Retail Store Markdown, 310-749 Lumens	634
3554	LED, Omnidirectional, Retail Store Markdown, 750-1,049 Lumens	634
3555	LED, Omnidirectional, Retail Store Markdown, 1,050-1,489 Lumens	634
3556	LED, Omnidirectional, Retail Store Markdown, 1,490-2,600 Lumens	634
3557	LED, Reflector, 12 Watt, Retail Store Markdown	647
3558	Insulation, Attic, R-19 to R-38	513
3559	Combination Boiler, Natural Gas, AFUE ≤ 0.95	501
3560	Occupancy Sensor, Fixture Mount, > 60 Watts	224
3561	Occupancy Sensor, Fixture Mount, ≤ 60 Watts	224
3567	LED, Direct Install, 10 Watt	642
3570	Insulation and Air Sealing, Attic, R-11 to R-38	513
3577	LED, Direct Install, > 12 Watts	367
3578	LED, Direct Install, > 12 Watts	367
3579	LED, Direct Install, > 16 Watt	367
3580	LED, Direct Install, > 16 Watt	367
3582	LED Tube Retrofit of 4-Foot T12 or T8 Fixtures	404
3584	Condensing Water Heater, Natural Gas, 90%+, Claim Only	550
3585	Water Heater, Indirect, Claim Only	557
3586	Water Heater, Electric, EF ≥ 0.93, Claim Only	557
3588	Water Heater, ≥ 0.82 EF, Tankless, Residential, Natural Gas, Claim Only	554
3596	LED Fixture, Bi-Level, Stairwell and Passageway, SBP A La Carte	315

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3598	Compressed Air System Leak Survey and Repair, Year 4 and Beyond	50
3603	LED Fixture, Interior, 12 Hours, CALP	649
3604	LED Fixture, Interior, 24 Hours, CALP	649
3605	Occupancy Sensor, ≤ 200 Watts, Fixture Mount, CALP	224
3606	Occupancy Sensor, > 200 Watts, Fixture Mount, CALP	224
3609	Smart Thermostat, Existing Natural Gas Boiler	561
3610	Smart Thermostat, Existing Natural Gas Furnace	561
3611	Smart Thermostat, Existing Air Source Heat Pump	561
3612	Smart Thermostat, Installed with 95% AFUE Natural Gas Furnace	568
3613	Smart Thermostat, Installed with 95% AFUE Natural Gas Boiler	568
3614	Smart Thermostat, Installed with Furnace and A/C	568
3615	Smart Thermostat, Installed with Air-Source Heat Pump	568
3616	LED, 4-Foot, 2 Lamp, < 20 Watts, Replacing 8-Foot, 1 Lamp T12 or T8, SBP A La Carte	386
3617	LED, 4-Foot, 4 Lamp, < 20 Watts, Replacing 8-Foot, 2 Lamp T12 or T8, SBP A La Carte	386
3629	LED, Direct Install, > 12 Watts, SBP A La Carte	367
3630	LED, Direct Install, > 16 Watt, SBP A La Carte	367
3631	LED, Direct Install, 12 Watts, SBP A La Carte	367
3632	Surgery Occupancy, HVAC Controls	105
3652	DEET Behavioral Savings, Savings Period 1	448
3653	DEET Behavioral Savings, Savings Period 2	448
3654	DEET Behavioral Savings, Savings Period 3	448
3655	DEET Behavioral Savings, Savings Period 4	448
3656	DEET Behavioral Savings, Savings Period 5	448
3657	DEET Behavioral Savings, Savings Period 6	448
3658	DEET Behavioral Savings, Savings Persistence	448
3659	EBTU Chiller Plant, Chilled Water Setpoint Adjustment	150
3660	EBTU Chiller Plant, Condenser Water Setpoint Adjustment	150
3661	Economizer Optimization	159
3662	Hot Water Supply Reset	163
3663	Outside Air Intake Control Optimization	167
3664	Schedule Optimization, Weekday, Heating, 0-50,000 square feet	174
3665	Schedule Optimization, Weekday, Cooling, 0-50,000 square feet	174
3666	Schedule Optimization, Weekend, Heating, 0-50,000 square feet	174
3667	Schedule Optimization, Weekend, Cooling, 0-50,000 square feet	174
3668	Schedule Optimization, Weekday, Heating, 50,000-100,000 square feet	174
3669	Schedule Optimization, Weekday, Cooling, 50,000-100,000 square feet	174
3670	Schedule Optimization, Weekend, Heating, 50,000-100,000 square feet	174

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3671	Schedule Optimization, Weekend, Cooling, 50,000-100,000 square feet	174
3672	Supply Air Temperature Reset, Heating	179
3673	Supply Air Temperature Reset, Cooling	179
3674	Temperature Sensor Calibration	183
3675	Valve Repair, Chilled Water	188
3676	Valve Repair, Hot Water	188
3677	VFD Fan Motor Control Restoration	192
3678	VFD Pump Control Restoration	196
3679	LP or Oil Furnace with ECM, 90%+ AFUE (Existing)	122
3680	Spring-Loaded Garage Door Hinge, 55 Degree Indoor Temperature Setpoint	33
3681	Spring-Loaded Garage Door Hinge, 60 Degree Indoor Temperature Setpoint	33
3682	Spring-Loaded Garage Door Hinge, 65 Degree Indoor Temperature Setpoint	33
3683	Spring-Loaded Garage Door Hinge, 70 Degree Indoor Temperature Setpoint	33
3684	Water Heater, High Usage, ≥ 90% TE, K-12 School	56
3685	Pipe Insulation, Hot Water Space Heating, 0.5-inch and 0.75-inch Pipe, Natural Gas	537
3686	Pipe Insulation, Hot Water Space Heating, 1-inch and 1.25-inch Pipe, Natural Gas	537
3687	Pipe Insulation, Hot Water Space Heating, 1.5-inch and 2-inch Pipe, Natural Gas	537
3688	Pipe Insulation, Hot Water Space Heating, 3-inch and 4-inch Pipe, Natural Gas	537
3689	Pipe Insulation, Hot Water Space Heating, 0.5-inch and 0.75-inch Pipe, Electric	537
3690	Pipe Insulation, Hot Water Space Heating, 1-inch and 1.25-inch Pipe, Electric	537
3691	Pipe Insulation, Hot Water Space Heating, 1.5-inch and 2-inch Pipe, Electric	537
3692	Pipe Insulation, Hot Water Space Heating, 3-inch and 4-inch Pipe, Electric	537
3693	Single Package Vertical HVAC Unit, ≥ 90%+ Thermal Efficiency, ≥ 10.0 EER Cooling, Natural Gas	575
3694	Single Package Vertical HVAC Unit, ≥ 90%+ Thermal Efficiency, Natural Gas	575
3695	Pipe Insulation, Domestic Hot Water, 0.5-inch and 0.75-inch Pipe, Natural Gas	537
3696	Pipe Insulation, Domestic Hot Water, 1-inch and 1.25-inch Pipe, Natural Gas	537
3697	Pipe Insulation, Domestic Hot Water, 1.5-inch and 2-inch Pipe, Natural Gas	537
3698	Pipe Insulation, Domestic Hot Water, 3-inch and 4-inch Pipe, Natural Gas	537
3699	Pipe Insulation, Domestic Hot Water, 0.5-inch and 0.75-inch Pipe, Electric	537
3700	Pipe Insulation, Domestic Hot Water, 1-inch and 1.25-inch Pipe, Electric	537
3701	Pipe Insulation, Domestic Hot Water, 1.5-inch and 2-inch Pipe, Electric	537
3702	Pipe Insulation, Domestic Hot Water, 3-inch and 4-inch Pipe, Electric	537
3703	Wall Insulation, Natural Gas Heat with Cooling	518
3704	Wall Insulation, Natural Gas Heat without Cooling	518
3705	Wall Insulation, Electric Heat with Cooling	518
3706	Wall Insulation, Electric Heat without Cooling	518
3707	Attic Insulation, Natural Gas Heat with Cooling, Existing Insulation ≤ R-11	509

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3708	Attic Insulation, Natural Gas Heat without Cooling, Existing Insulation ≤ R-11	509
3709	Attic Insulation, Natural Gas Heat with Cooling, Existing Insulation R-12 to R-19	509
3710	Attic Insulation, Natural Gas Heat, without Cooling, Existing Insulation R-12 to R-19	509
3711	Attic Insulation, Electric Heat with Cooling, Existing Insulation ≤ R-11	509
3712	Attic Insulation, Electric Heat without Cooling, Existing Insulation ≤ R-11	509
3713	Attic Insulation, Electric Heat with Cooling, Existing Insulation R-12 to R-19	509
3714	Attic Insulation, Electric Heat without Cooling, Existing Insulation R-12 to R-19	509
3716	Exterior Lighting Optimization, LED, ≤ 60 Watts, Replacing 250 Watt HID	330
3717	Exterior Lighting Optimization, LED, ≤ 60 Watts, Replacing 250 Watt HID, With Integrated Timer or Wireless Schedule	330
3718	Exterior Lighting Optimization, LED, ≤ 60 Watts, Replacing 250 Watt HID, With Bi-Level Control	330
3719	Exterior Lighting Optimization, LED, 60-125 Watts, Replacing 250 Watt HID	330
3720	Exterior Lighting Optimization, LED, 60-125 Watts, Replacing 250 Watt HID, With Integrated Timer or Wireless Schedule	330
3721	Exterior Lighting Optimization, LED, 60-125 Watts, Replacing 250 Watt HID, With Bi-Level Control	330
3722	Exterior Lighting Optimization, LED, 125-200 Watts, Replacing 320 Watt HID	330
3723	Exterior Lighting Optimization, LED, 125-200 Watts, Replacing 320 Watt HID, With Integrated Timer or Wireless Schedule	330
3724	Exterior Lighting Optimization, LED, 125-200 Watts, Replacing 320 Watt HID, With Bi-Level Control	330
3725	Exterior Lighting Optimization, LED, 125-200 Watts, Replacing 400 Watt HID	330
3726	Exterior Lighting Optimization, LED, 125-200 Watts, Replacing 400 Watt HID, With Integrated Timer or Wireless Schedule	330
3727	Exterior Lighting Optimization, LED, 125-200 Watts, Replacing 400 Watt HID, With Bi-Level Control	330
3728	Exterior Lighting Optimization, LED, 200-650 Watts, Replacing 1000 Watt HID	330
3729	Exterior Lighting Optimization, LED, 200-650 Watts, Replacing 1000 Watt HID, With Integrated Timer or Wireless Schedule	330
3730	Exterior Lighting Optimization, LED, 200-650 Watts, Replacing 1000 Watt HID, With Bi-Level Control	330
3731	CFL, Direct Install, 14.2 Watt Replacing BR30	586
3732	LED, Direct Install, 8 Watt Replacing BR30 Lamp	629
3733	LED, Direct Install, 5.3 Watt Replacing Candelabra Base	623
3734	LED, Direct Install, 6 Watt Replacing G25 Lamp	626
3735	LED Fixture, Exterior, 12 Hours, CALP	639
3736	LED Track/Mono/Accent Fixtures ≤ 18 Watts	305

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3737	LED Track/Mono/Accent Fixtures > 18 Watts	308
3738	LED Fixture, Linear Ambient, Replacing 1 or 2 T5 Lamp(s) in Cross Section	293
3739	LED Fixture, Linear Ambient, Replacing 3 or 4 T5 Lamps in Cross Section	293
3740	LED Fixture, Linear Ambient, Replacing 1 or 2 T8/T12 Lamp(s) in Cross Section	297
3741	LED Fixture, Linear Ambient, Replacing 3 or 4 T8/12 Lamps in Cross Section	297
3742	LED Lamp, ENERGY STAR, Replacing ≥ 23 Watt CFL	278
3743	LED Lamp, ENERGY STAR, Replacing ≥ 23 Watt CFL, Common Area	278
3744	LED Lamp, ENERGY STAR, Replacing ≥ 23 Watt CFL, In Unit	278
3745	LED Lamp, ENERGY STAR, Replacing < 23 Watt CFL	274
3746	LED Lamp, ENERGY STAR, Replacing < 23 Watt CFL, Common Area	274
3747	LED Lamp, ENERGY STAR, Replacing < 23 Watt CFL, In Unit	274
3748	LED Fixture, Downlight, ≤ 18 Watts, In Unit	660
3749	LED Downlight Fixtures > 18 Watts	267
3750	LED Downlight Fixtures ≤ 18 Watts	264
3751	Pipe Insulation, Steam Space Heating, 0.5-inch and 0.75-inch Pipe, Natural Gas	537
3752	Pipe Insulation, Steam Space Heating, 1-inch and 1.25-inch Pipe, Natural Gas	537
3753	Pipe Insulation, Steam Space Heating, 1.5-inch and 2-inch Pipe, Natural Gas	537
3754	Pipe Insulation, Steam Space Heating, 3-inch and 4-inch Pipe, Natural Gas	537
3755	Pipe Insulation, Steam Space Heating, 0.5-inch and 0.75-inch Pipe, Electric	537
3756	Pipe Insulation, Steam Space Heating, 1-inch and 1.25-inch Pipe, Electric	537
3757	Pipe Insulation, Steam Space Heating, 1.5-inch and 2-inch Pipe, Electric	537
3758	Pipe Insulation, Steam Space Heating, 3-inch and 4-inch Pipe, Electric	537
3759	LED Replacement of 4-Foot T8 Lamps Direct Wire	301
3760	LED Troffer, 1x4, Replacing 4-Foot 1-2 Lamp T8 Troffer	340
3761	A/C Split or Packaged System, High Efficiency, Multifamily, > 5.4 tons	134
3762	ENERGY STAR LED Commercial Threshold Fixture, < 20 Watts	271
3763	ENERGY STAR Fluorescent Porch Fixture, < 30 Watts	233
3764	T8 LED < 20 Watts, 1 Lamp, Replacing 2 Lamp or3 Lamp T12/T8, SBP Package	311
3765	T8 LED < 20 Watts, 1 Lamp, Replacing 2 Lamp or3 Lamp T12/T8, SBP A La Carte	311
3766	T8 LED < 20 Watts, 1 Lamp, Replacing 2 Lamp or3 Lamp T12/T8, SBP After A La Carte	311
3767	High Speed, High Efficiency Fan, Agriculture, Circulation Fan, 36 inches to 47 inches	6
3768	High Speed, High Efficiency Fan, Agriculture, Circulation Fan, 48 inches to 52 inches	6
3769	High Speed, High Efficiency Fan, Agriculture, Circulation Fan, ≥ 53 inches	6
3770	High Speed, High Efficiency Fan, Agriculture, Ventilation Fan, 24 inches to 35 inches	6
3771	High Speed, High Efficiency Fan, Agriculture, Ventilation Fan, 36 inches to 47 inches	6
3772	High Speed, High Efficiency Fan, Agriculture, Ventilation Fan, 48 inches to 52 inches	6
3773	High Speed, High Efficiency Fan, Agriculture, Ventilation Fan, ≥ 53 inches	6
3774	Heat Recovery Tank, No Heating Element, Natural Gas	2

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3775	Heat Recovery Tank, No Heating Element, Electric	2
3776	Ag, VFD, Field Irrigation Pump	435
3777	Variable Frequency Drive, High Speed Ventilation/Circulation Fan, Ag	127
3778	Combination Boiler, Natural Gas, AFUE ≤ 0.95	501
3780	Hot Water Boiler, 95%+ AFUE	491
3781	LP or Oil Furnace with ECM, Tier 2, 90%+ AFUE (Existing)	122
3782	Natural Gas Furnace with ECM, Tier 2, 95%+ AFUE (Existing)	122
3783	Natural Gas Furnace, Tier 2, 95% AFUE	122
3784	Water Heater, Indirect, 95% or greater	557
3796	Dairy Refrigeration Tune-Up	27
3797	VFD, Diary Milk Pump,Agriculture	439
3798	VFD, Vacuum Pump, Agriculture	443
3801	T8, 2-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO, 1-Lamp, 8-Foot, 0.78 < BF < 1.00	241
3802	T8, 2-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO, 1-Lamp, 8-Foot, BF > 1.00	241
3803	T8, 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12, 2-Lamp, 8-Foot, 0.78 < BF < 1.00	241
3804	T8, 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO, 2-Lamp, 8-Foot, 0.78 < BF < 1.00	241
3805	T8, 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO, 2-Lamp, 8-Foot, BF > 1.00	241
3806	LED Fixtures, High Bay, < 155 Watts, Replacing 250 Watt HID	360
3807	LED Fixtures, High Bay, < 250 Watts, Replacing 400 Watt HID	360
3808	LED Fixtures, High Bay, < 365 Watts, Replacing 400 Watt HID	360
3809	LED Fixture, ≤ 180 Watts, Replacing 4 Lamp T5 or 6 Lamp T8, High Bay, DLC Listed	346
3810	LED Fixtures, High Bay, < 250 Watts, Replacing 320-400 Watt HID	360
3811	High Bay Fluorescent Lighting, T8 4L Replacing 250-399 W HID	418
3812	High Bay Fluorescent Lighting, T8 6L Replacing 400-999 W HID	418
3813	High Bay Fluorescent Lighting, T5HO 4L Replacing 400-999 W HID	418
3814	High Bay Fluorescent Lighting, T5HO 6L Replacing 400-999 W HID	418
3815	High Bay – Induction, PSMH, CMH Fixtures, Replacing 250 Watt HID	430
3816	High Bay – Induction, PSMH, CMH Fixtures, ≤ 250 Watt, Replacing 320-400 Watt HID	430
3817	High Bay – Induction, PSMH, CMH Fixtures, ≤ 250 Watt, Replacing 400 Watt HID	430
3818	High Bay – Induction, PSMH, CMH Fixtures, ≤ 365 Watt, Replacing 400 Watt HID	430
3819	LED Downlight Fixtures ≤ 18 Watts	264
3820	LED Downlight Fixtures > 18 Watts	267
3821	LED Lamp Replacing Incandescent Lamp > 40 Watts	401
3822	LED Replacement of 4-Foot T8 Lamps with Integral or External Driver	394
3823	LED Replacement of 4-Foot T8 Lamps Using Existing Ballast	390
3824	LED Fixture, Exterior, Replacing 150-175 Watt HID	354

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3825	LED Fixture, Exterior, Replacing 250 Watt HID	354
3826	LED Fixture, Exterior, Replacing 320-400 Watt HID	354
3827	LED Fixture, Exterior, Replacing 400 Watt HID	354
3828	LED Fixture, Exterior, Replacing 70-100 Watt HID	354
3829	Induction, PSMH/CMF or Linear Fluorescent, Exterior, Replacing 150-175 Watt HID	423
3830	Induction, PSMH/CMF or Linear Fluorescent, Exterior, Replacing 250 Watt HID	423
3832	Induction, PSMH/CMF or Linear Fluorescent, Exterior, Replacing 400 Watt HID	423
3833	Induction, PSMH/CMF or Linear Fluorescent, Exterior, Replacing 70-100 Watt HID	423
3835	Variable Frequency Drive, Process Pump	461
3836	Variable Frequency Drive, Constant Torque	461
3837	LED Lamp, ENERGY STAR, Replacing ≥ 23 Watt CFL	278
3838	LED Lamp, ENERGY STAR, Replacing < 23 Watt CFL	274
3839	LED Replacement of 4-Foot T8 Lamps Direct Wire	301
3859	CFL, Pack-Based, 13 Watt	604
3860	CFL, Pack-Based, 23 Watts	601
3861	LED, Pack-Based, 10 Watt	642
3862	Faucet Aerator, Pack Based, 1.5 GPM, Kitchen	522
3863	Faucet Aerator, Pack Based, 1.0 GPM, Bathroom, Residential	522
3864	Showerhead, Pack Based, 1.5 GPM	523
3868	Natural Gas Furnace with ECM, 96%+ AFUE	122
3869	Natural Gas Furnace with ECM, 98%+ AFUE	122
3870	Natural Gas Furnace with ECM, Tier 2, 96%+ AFUE	122
3871	Natural Gas Furnace with ECM, Tier 2, 97%+ AFUE	122
3872	Natural Gas Furnace with ECM, Tier 2, 98%+ AFUE	122