focus on energy℠

Partnering with Wisconsin utilities

Wisconsin Focus on Energy
TECHNICAL REFERENCE MANUAL

August 15, 2014

Public Service Commission of Wisconsin
610 North Whitney Way
Madison, WI 53707

The Cadmus Group, Inc.

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Executive Summary

Under its existing contract with the Public Service Commission of Wisconsin (the PSC) to evaluate the Focus on Energy programs for the calendar years 2011-2014, the Evaluation Team[1]—in coordination with the Program Administrator, the Program Implementers, and the PSC staff—compiled this Technical Reference Manual (TRM). The information contained in this document summarizes the consensus calculations of the electric and gas energy savings, and the electric demand reductions, achieved from the installation of energy efficiency and renewable energy technologies supported by Focus on Energy programs. The TRM is publicly available online at http://www.focusonenergy.com/about/evaluation-reports.

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

- Deemed Savings – specific per unit savings (or demand reduction) values that have been accepted by the Program Administrator, Program Implementer, the Evaluator and the PSC as reliable. These values are accepted because the measures, and the uses for the measures, are consistent, and sound research supports the savings achieved.
- Savings Algorithms – equations for calculating savings (or demand reductions) based upon project and measure specific details. The TRM also 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 the programs' tracking database (SPECTRUM). This document will be revised annually to account for any changes to the programs and/or technologies.

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 desk 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 expected differences between jurisdictions due to factors such as climate zones, building codes, and market penetrations.

Update Process

Annual updates to this TRM will be published in July of each year to reflect the savings calculations that will be effective for the following calendar year. The present edition presents deemed savings and inputs effective for CY 2015, and will not in all cases reflect the savings and inputs that will remain in

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[1] The Evaluation Team consists of Cadmus, Nexant, St. Norbert College Strategic Research Institute, and TecMarket Works.

place for the rest of 2014. <u>Any changes from 2014 calculations take effect in SPECTRUM, the Focus on Energy database, on January 1, 2015.</u>

Annual updates ensure the TRM remains relevant and useful by:

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

Publishing these updates in July further allows the Program Administrator and Program Implementers to use the TRM to inform advance program planning conducted for the upcoming year. All content updates are integrated in to the original document and changes will be indicated in the Revision History table included for each measure entry.

Two processes are in place to prepare updates to the TRM and ensure those updates are timely, comprehensive, and accurate.

1. Focus on Energy Program Implementers may propose adding new measures or changing the definition of existing measures at any time during the year, by preparing a draft 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. Key criteria for assessing whether workpapers meet this standard include:
    - A clear definition of the measure;
    - A clear description of how the measure saves energy;
    - 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
    - Citation of all data used to valid sources.

    The initial workpaper may be revised to ensure all criteria are met and 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 write-up is approved. Similarly, existing measures are deactivated as soon as they are no longer offered. As a result, the TRM does not serve as a comprehensive list of active measures or savings calculations at every point during the year.

    To incorporate updates in a timely manner, an TRM update is published each January that adds measures approved within the second half of the calendar year, and eliminates any measures that will no longer be used. The January update is limited to additions and deletions and does not incorporate any changes to continuing measures.

2. Updates to savings calculations for existing measures (as well as any more recent measure additions and deletions) are only made during the annual TRM revision released in July. As part of the annual impact evaluation process, 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 June 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 review the proposed updates in June to achieve consensus on final revisions to be published in the TRM.

Navigating the TRM

Focus on Energy savings are calculated, and incentives are paid, by measure. Measures are defined as a specific product, technology, or service offered by one or more Focus on Energy programs, for which definable energy 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 which offer the same type of lighting product in different sizes or wattages.

The TRM is divided into two sections, one for measures in the Residential portfolio and one for measures in the Nonresidential portfolio. Measures in both portfolios are classified in the portfolio where they are most commonly used. For example, while a business may install CFLs in certain parts of its facilities, CFLs are classified within the residential section because most of the CFLs incented through Focus on Energy are purchased for use in homes.

Within each section, measures are sorted by functional groups and categories. These are used for planning purposes, to categorize savings outcomes in evaluation reports, and to classify measures in SPECTRUM. Most of these functional groups and categories are based on technology, including a lighting group with categories addressing CFLs, LEDs, and other specific lighting technologies. Some groups also cover key end uses for technologies, such as laundry or food service.

Measure Detail Structure

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

1. An introductory **Measure Detail Table** summarizes all of the measure characteristics including the formal name of the measure, the programs it is used for, and any information necessary to

include the measure in SPECTRUM. The table also summarizes overall savings for the measure and, where relevant, includes a link to spreadsheets or other supporting files that describe the savings calculation methodology.

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]

i. Residential single-family homes;
ii. Residential multifamily dwellings (such as apartment buildings and condominiums);
iii. Commercial facilities;
iv. Industrial facilities;
v. Agricultural facilities; and
vi. 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 when there is reason to assume that the measure is used differently by different 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 energy savings.

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:

i. *<u>Prescriptive</u>* 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, furnaces, and appliances.

ii. *<u>Custom</u>* measures have savings that vary by project. This is applied to more complex, multifaceted measures whose energy-use factors are likely to be different for each project, such as changes to industrial processes. TRM entries for custom measures do not identify specific savings, but instead specify the calculation formula and inputs that should be used.

iii. *<u>Hybrid</u>* measures, like custom measures, have savings that 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.

2. 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 it is assumed the customer would

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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 residential Upstream sector based on the program design.

purchase in absence of the 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. The difference between the baseline and efficient conditions is how the measure achieves energy savings.

3. Formulas are provided to specify the energy savings or demand savings calculation. The **Annual Energy-Savings Algorithm** identifies how to calculate 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 (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 life of the measure. In addition to describing the algorithms used, all three sections specify the value of variables used in the calculation. These inputs may include assumptions about usage behavior or other variables 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.
4. Savings calculated through those formulas are often reported in the **Measure Detail Table**. However, in some cases—such as calculations for multiple related measures—there are too many separate savings calculations to efficiently include in the Measure Detail Table. In those cases, a **Deemed Savings Table** is provided following the formula sections to describe all completed savings calculations.
5. All factual statements and figures made throughout the measure write-up 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.
6. The **Revision History Table** lists all the revision dates for that TRM entry and briefly describes the changes. In addition to documenting all changes, the table shows any measure versions from before the first edition of the TRM was released in July 2014.

Acknowledgements

This is the first edition of the Wisconsin Focus on Energy TRM. Many individuals and companies have made valuable contributions to compiling and validating the TRM, as well as to preparing the measure write-ups and savings calculations that preceded the formal document. Special thanks go to:

- Vanessa Frambes, Casey Ritz, Charlie Bicknell, Steve Cofer, and Dave Korn from Cadmus
- Sharon Myers, Ann Grodnik-Nagle, Tamara Sondgeroth, Catalina Lamadrid and Margaret Sims from CB&I, the Focus on Energy Program Administrator.

- Program Implementers include:
    - Applied Proactive Technologies- Seth Craigo-Snell,
    - CLEAResult – Bobbi Fey, Kara Wolfe, Karl Hilker and Andrew Burch
    - Conservation Resources Group – Carter Dedolph
    - Franklin Energy – Frank Falter, Zach Obert and Tony Haas
    - JACO – Rich Marshall
    - Leidos – Amy Wanek
    - Staples Energy and GDS – Nathan Baer, Karlee Patzlsberger and Marc Bergum
- Carol Stemrich and Andrew Kell from the PSC of Wisconsin.

Nonresidential Measures—Targeted Markets

The Targeted Markets Portfolio delivers energy efficiency and renewable energy programs to Wisconsin's nonresidential utility customers. Customers 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 Targeted Markets portfolio for calendar year 2014 includes six programs that were designed to meet the needs of different types of nonresidential customers.

Three programs were designed to 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 energy-saving measures, such as CFLs and exit signs, and offering incentives for the installation of additional energy-saving measures.
2. The **Large Energy Users Program** serves customers with high energy use, such as large industrial customers and large commercial and government facilities, providing implementation support and incentives designed to meet each user's specific energy needs.
3. The **Business Incentive Program** offers product-based and custom incentives for medium-sized facilities, such as commercial spaces and school buildings.

In addition, the **Chains & Franchise Program** offers incentives and support specifically designed for customers who have five or more facilities in the State of Wisconsin, such as retail businesses and restaurants.

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, and provides incentives to customers who incorporate those recommendations into their new construction.

Finally, the **Renewable Energy Competitive Incentive Program** offers incentives for the installation of a renewable energy process through a competitive Request for Proposal.

Energy Efficient or Energy Free Livestock Waterer

	Measure Details
Measure Master ID	Energy Efficient or Energy Free Livestock Waterer, 2660, 3018
Measure Unit	Watering Unit
Measure Type	Prescriptive
Program(s)	Business Incentives, Large Energy Users
Sector(s)	Agricultural
Annual Energy Savings (kWh)	Varies by measure, see annual deemed savings table below
Peak Demand Reduction (kW)	0 (winter use only)
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by measure, see lifecycle energy savings table below
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	10[1]
Important Comments	

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. These waterers 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 an energy-free.

Annual Energy-Savings Algorithm

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

Where:

$Watts_{BASE}$ = Power consumption of baseline measure equipment (1,100 W for retrofit and 500 W for new installation)

$Watts_{EE}$ = Power consumption of efficient measure equipment (2500 W for energy-efficient retrofit and 0 W for energy-free installation)

HOU = 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. This is consistent with TMY3 Bin Data.

1,000 = Kilowatt conversion factor

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= 0)

Lifecycle Energy-Savings Algorithm

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

Where:

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

Assumptions

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

Deemed Savings

Average Annual Deemed Savings

Type	kWh
Energy Efficient Livestock Waterer	2,584
Energy Free Retrofit Livestock Waterer	3,344
Energy Free New Construction Livestock Waterer	1,520

Lifecycle Energy Savings

Type	kWh
Energy Efficient Livestock Waterer	25,840
Energy Free Retrofit Livestock Waterer	33,440
Energy Free New Construction Livestock Waterer	15,200

Peak Demand Deemed Savings

Type	kWh
All Livestock Waterers	0

Sources

1. Wisconsin PSC EUL database, 2013.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	01/01/2013	Transition to New Template

Agricultural Circulation Fan

	Measure Details
Measure Master ID	Agricultural Circulation Fan, 2253
Measure Unit	Per Fan
Measure Type	Hybrid
Program(s)	Business Incentives, Large Energy Users
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[3]
Important Comments	

Measure Description

Agricultural 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. SPECTRUM averages the parameters for three 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 incentives, 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

$$kWh_{SAVED} = (CFM_{EE} / VER_{EE} – CFM_{Base} / VER_{Base}) * HOU$$

Where:

CFM_{EE} = New efficient unit flow @ 0.10 SP (CFM)

VER_{EE} = New efficient unit ventilating efficiency ratio (CFM/watt) @ 0.10 SP

CFM_{Base} = Baseline unit flow @ 0.10 SP (CFM)

VER_{Base} = Baseline unit ventilating efficiency ratio (CFM/watt) @ 0.10 SP

HOU = Annual hours of operation (= 2,935 hours)[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

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

Where:

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

Sources

1. Deemed savings from Illinois Technical Reference Manual Version 2.0 dated 6/7/2013, referencing Illinois Act On Energy Commercial TRM No. 2010-4 dated 5/31/2011. Uses mid-size fan parameters (36-47" diameter) to represent average installed condition.
2. Deemed savings from Illinois Technical Reference Manual Version 2.0 dated 6/7/2013, referencing Illinois Act On Energy Commercial TRM No. 2010-4 dated 5/31/2011.
3. Wisconsin PSC EUL database, 2013.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	01/05/2012	Original
02	Franklin Energy Services	04/01/2013	Updates by PI

Boiler Plant Retrofit, Hybrid Plant, 1-5 MMBh

	Measure Details
Measure Master ID	Boiler Plant Retrofit, Hybrid Plant, 1-5 MMBh, 2208
Measure Unit	Per 100 MBh
Measure Type	Prescriptive
Program(s)	Business Incentives, Large Energy Users
Sector(s)	Industrial, Commercial, Schools and Government
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	4,618
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	92,363
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Important Comments	

Measure Description

High efficiency sealed combustion, condensing, and modulating (HESCCM) boilers operate by taking advantage of condensing in an effort to decrease energy consumption. Condensing boilers are designed to capture latent heat by condensing water vapor in the exhaust stream. For a boiler to properly condense, 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.

Mid-efficiency boilers use forced draft or induced draft power burners, instead of atmospheric draft, to push or pull gases through the firebox and heat exchanger. Because these boilers have relatively high efficiencies and relatively low flue gas temperatures, they are often constructed with stainless steel or other corrosion-resistant materials to tolerate condensation in the boiler.

This measure applies to the entire boiler plant. The summation of the capacity for all heating equipment must fall between 1,000 MBh and 5,000 MBh. This measure combines high- and mid-efficiency boilers in a boiler plant to take advantage of both condensing boilers (when return water temperatures are low enough for condensing) and mid-efficiency boilers (when return water temperatures do not allow for condensing). The upgraded plant must have at least 50% high-efficiency boilers.

Description of Baseline Condition

The baseline is for multiple 300-1,000 MBh boilers with a thermal efficiency of 80%, according to the 2010 Deemed Savings Manual.[2]

Description of Efficient Condition

The efficient condition is for the entire boiler plant to have capacity for all heating equipment that falls within the range of 1,000 MBh to 5,000 MBh. This measure combines the high-and mid-efficiency boilers in a boiler plant to take advantage of both condensing boilers and mid-efficiency boilers. The upgraded plant must have at least 50% high-efficiency boilers with the following requirements:

- High-efficiency boilers must have thermal efficiency (TE) ≥ 90%
- Mid-efficiency boilers must have TE ≥ 85%
- Boiler plant must be between 1,000 and 5,000 MBh
- Boilers must be capable of capacity modulation
- Boilers must be used for space heating (HVAC), not for industrial purposes or domestic water heating
- Redundant or back-up boilers do not qualify

Annual Energy-Savings Algorithm

$\text{Therms}_{\text{SAVED}} = (C_q * \text{BOF} * \text{HDD} * 24 / \Delta T) * (TE_q / TE_b - 1) / 100$

Where:

C_q = Input capacity of qualifying unit in MBh, from application

BOF = Boiler oversize factor (= 77%)

HDD = Heating degree days (= 7,616, see table below)

24 = Conversion factor, hours per day

ΔT = Design temperature difference (= 80°F)

TE_b = Thermal efficiency of baseline unit (= 80%)

TE_q = Thermal efficiency of qualifying unit, from application

100 = Conversion factor from MBtus to therms

Location	HDD[3]
Milwaukee	7,276
Green Bay	7,725
Wausau	7,805
Madison	7,599
La Cross	7,397
Minocqua	8,616
Rice Lake	8,552
Statewide Weighted	**7,616**

Lifecycle Energy-Savings Algorithm

$\text{Therms}_{\text{LIFETIME}} = \text{Therms}_{\text{SAVED}} * \text{EUL}$

Where:

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

Assumptions

Equipment efficiency used for the deemed savings assumed as 87% TE and equipment size 3,000 MBh.

Sources

1. Wisconsin PSC EUL database, 2013.
2. PA Consulting Group Inc., Public Service Commission of Wisconsin, *Focus on Energy Evaluation, Business Programs: Deemed Savings Manual*, Final Report: March 22, 2010.
3. 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.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	03/19/2012	Original
02	Franklin Energy Services	04/01/2013	Updates by the PI

Boiler Plant Retrofit, Mid-Efficiency Plant, 1-5 MMBh

	Measure Details
Measure Master ID	Boiler Plant Retrofit, Mid-Efficiency Plant, 1-5 MMBh, 2209
Measure Unit	Per 100 MBh
Measure Type	Prescriptive
Program(s)	Business Incentives, Large Energy Users
Sector(s)	Industrial, Commercial, Schools and Government
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	110
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	2,200
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Important Comments	

Measure Description

Mid-efficiency boilers use forced draft or induced draft power burners, instead of atmospheric draft, to push or pull gases through the firebox and heat exchanger. Because these boilers have relatively high efficiencies and relatively low flue gas temperatures, they are often constructed with stainless steel or other corrosion-resistant materials to tolerate condensation in the boiler. This measure is for the entire boiler plant: the capacity for all heating equipment must fall within 1,000 MBh and 5,000 MBh.

Description of Baseline Condition

The deemed savings baseline is for boilers that have 80% TE, according to the 2010 Deemed Savings Manual.[2]

Description of Efficient Condition

The upgraded plant must meet the following requirements:

- Mid-efficiency boilers must have a TE ≥ 85%
- Boiler plant must be between 1,000 MBh and 5,000 MBh
- Boilers must be capable of capacity modulation
- Boiler must be used for space heating (HVAC), not for industrial purposes or domestic water heating
- Redundant or back-up boilers do not qualify

Annual Energy-Savings Algorithm

The following equation is based on the Focus on Energy Business Incentive Program deemed savings for boilers that have TE ≥ 85%.

$$\text{Therms}_{\text{SAVED}} = (C_q * \text{BOF} * \text{HDD} * 24 / \Delta T) * (\text{TE}_q / \text{TE}_b - 1) / 100$$

Where:

C_q = Input capacity of qualifying unit in MBh, from application

BOF = Boiler oversize factor (= 77%)

HDD = Heating degree days (= 7,616, see table below)

24 = Conversion factor, hours per day

ΔT = Design temperature difference (= 80°F)

TE_b = Thermal efficiency of baseline unit (= 80%)

TE_q = Thermal efficiency of qualifying unit, from application

100 = Conversion factor from MBtus to therms

Location	HDD[3]
Milwaukee	7,276
Green Bay	7,725
Wausau	7,805
Madison	7,599
La Cross	7,397
Minocqua	8,616
Rice Lake	8,552
Statewide Weighted	**7,616**

Lifecycle Energy-Savings Algorithm

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

Where:

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

Assumptions

Equipment efficiency used for the deemed savings assumed as 85% TE.

Sources

1. Wisconsin PSC EUL database, 2013.
2. PA Consulting Group Inc., Public Service Commission of Wisconsin, *Focus on Energy Evaluation, Business Programs: Deemed Savings Manual*, Final Report: March 22, 2010.
3. 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.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	03/15/2012	Original
02	Franklin Energy Services	04/01/2013	Updates by the PI

Steam Fittings and Pipe Insulation

	Measure Details
Measure Master ID	Steam Fittings and Pipe Insulation, 2430, 2429
Measure Unit	Per linear foot (pipe insulation) Per fitting (fitting insulation)
Measure Type	Prescriptive
Program(s)	Business Incentive, Large Energy Users
Sector(s)	Industrial, Commercial, Agricultural, Schools and 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]
Important Comments	

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 to ensure proper steam pressure and temperatures where needed. This measure is only for steam pipes in unconditioned spaces. Unconditioned basements and crawlspaces that are insulated from the conditioned space of the building qualify.

Description of Baseline Condition

The baseline measure is for existing, non-insulated steam pipe or fittings that are part of an HVAC steam distribution system.

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 the replacement of existing pipe insulation but only for the insulation of 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. Thickness of insulation must meet 2009 IECC standards, 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 of 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

$Therms_{SAVED\_PIPE}$ = PipeInsul_Save * LF

$Therms_{SAVED\_FITTING}$ = FittingInsul_Save * NF

Where:

PipeInsul_Save = Annual energy savings through insulating per linear foot pipe (therms/linear foot/yr), see table below

LF = Total pipe liner feet

FittingInsul_Save = Annual energy savings through insulating per fitting (therms/fitting/yr), see table below

NF = Number of fittings

Measure	Natural Gas Savings
Steam Pipe Insulation	11.38 therms/linear foot/yr
Steam Fitting Insulation	40.44 therms/fitting/yr

Savings were calculated using the assumptions listed below and 3E Plus v4.0 software, distributed by NAIMA.[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 gas savings in therms.

Lifecycle Energy-Savings Algorithm

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

Where:

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

Assumptions

Pipe will be kept hot for 4,000 hours per year.

The average nominal pipe size is 2 inches outside diameter.

Boiler system efficiency is 80%.

A fitting is equivalent to approximately 3.55 feet of 2 inch pipe.

Sources

1. Wisconsin PSC EUL database, 2013.
2. 2008 Database for Energy Efficient Resources, Cost Values and Summary Documentation, Updated June 2, 2008.
3. This program is available through NAIMA at http://www.pipeinsulation.org/

Revision History

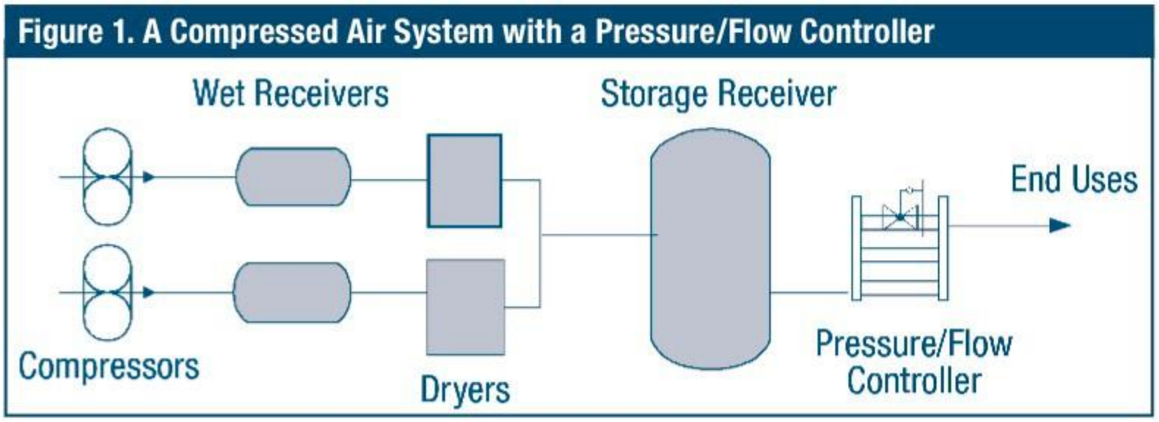
Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	03/20/2012	New Measure

Compressed Air Controller, Pressure/Flow Controller

	Measure Details
Measure Master ID	Compressed Air Controller, Pressure/Flow Controller, 2255
Measure Unit	Compressed Air System
Measure Type	Hybrid
Program(s)	Business Incentives, Large Energy Users
Sector(s)	Industrial, Commercial, Agricultural, Schools and Government
Annual Energy Savings (kWh)	178 per System
Peak Demand Reduction (kW)	0.035 per System
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	2,670 per System
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Important Comments	

Measure Description

One piece of equipment that can greatly increase the control of an air storage system is a pressure/flow controller. 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.



A 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 hp 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 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 efficiency of the system. 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 enhanced product quality when pressure is allowed to fluctuate.

Description of Baseline Condition

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

Description of Efficient Condition

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

Annual Energy-Savings Algorithm

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

Where:

HP = Compressor motor size (hp)
Motor Eff. = Compressor motor efficiency (= 95%)[3]
Load Factor = Average load on compressor motor (= 89%)[3]
HOU = 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 kW/hp / Motor Eff. * Load Factor * % decrease * CF

Where:

CF = Coincidence factor (= 1)

Lifecycle Energy-Savings Algorithm

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

Where:

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

Sources

1. Wisconsin PSC EUL database, 2013.
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.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	03/19/2012	Original
02	Franklin Energy Services	04/01/2013	Updated by the PI

Compressed Air, Cycling Thermal Mass Air Dryers

	Measure Details
Measure Master ID	Compressed Air, Cycling Thermal Mass Air Dryers, 2264
Measure Unit	100 CFM
Measure Type	Hybrid
Program(s)	Business Incentives, Large Energy Users
Sector(s)	Industrial, Commercial, Agricultural, Schools and Goverment
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]
Important Comments	

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

$kWh_{SAVED} = SF * LF * CFM * HOU$

Where:

SF = Savings factor in kW/CFM, see table below[3]

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

CFM = Cubic feet per minute; the rated capacity of air dryer, see table below

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

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= 1)[6]

Lifecycle Energy-Savings Algorithm

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

Where:

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

Assumptions

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

Sources

1. Wisconsin PSC EUL database, 2013.
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. Proposed Standard Savings Estimation Protocol for Ultra-Premium Efficiency Motors, Cascade Energy, 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. Franklin Energy Services, LLC. Personal communications regarding engineering approximation.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	03/19/2012	Original
02	Franklin Energy Services	04/01/2013	Updates by the PI

Compressed Air Heat Recovery, Space Heating

	Measure Details
Measure Master ID	Compressed Air Heat Recovery, Space Heating, 2257
Measure Unit	Horsepower
Measure Type	Hybrid
Program(s)	Business Incentives, Large Energy Users
Sector(s)	Industrial, Commercial, Schools and 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]
Important Comments	

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 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

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

Where:

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

BHP = Compressor motor size, brake horsepower (bhp)

2,545 = Conversion factor Btu to BHP-hour

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

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

100,000 = Conversion from Btus to therms

Lifecycle Energy-Savings Algorithm

$\text{Therm}_{\text{LIFETIME}} = \text{Therms}_{\text{SAVED}} * \text{EUL}$

Where:

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

Sources

1. Wisconsin PSC EUL database, 2013.
2. Bonneville Power Administration. *Compresed 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. Franklin Energy Services, LLC. Personal communications regarding engineering estimate.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	12/28/2012	New Measure

Compressed Air Mist Eliminators

	Measure Details
Measure Master ID	Compressed Air Mist Eliminators, 2258
Measure Unit	Horsepower
Measure Type	Hybrid
Program(s)	Business Incentives, Large Energy Users
Sector(s)	Industrial, Commercial, Agricultural, Schools and Government
Annual Energy Savings (kWh)	71 per HP
Peak Demand Reduction (kW)	0.014 per HP
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	710 per HP
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	10[1]
Important Comments	

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 * HOU * % Savings

% Savings = Total_{PR} * RS

Where:

HP = Compressor motor size (hp)

Motor Eff. = Compressor motor efficiency (= 95%)[2]

Load Factor = Average load on compressor motor (= 89%)[2]

HOU = 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]

0.746 = Conversion factor from HP to kW

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.

Lifecycle Energy-Savings Algorithm

$\text{kWh}_{LIFETIME}$ = kWh_{SAVED} * EUL

Where:

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

Sources

1. Wisconsin PSC EUL database, 2013.
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.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	03/19/2012	Original

Compressed Air Condensate Drains, No Loss Drain

	Measure Details
Measure Master ID	Compressed Air Condensate Drains, No Loss Drain, 2254
Measure Unit	Drain
Measure Type	Prescriptive
Program(s)	Business Incentives, Large Energy Users, Chains and Franchises
Sector(s)	Industrial, Commercial, Agricultural, Schools and 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]
Important Comments	

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 for this 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

$kWh_{SAVED} = SF * HOU$

Where:

SF = Saving Factor in kW/drain (= 0.3)[2]

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

Summer Coincident Peak Savings Algorithm

kW_{saved}= SF * CF

Where:

kW_{saved} = Annual power reduction per drain

CF = Coincidence factor (= 0.80)

Lifecycle Energy-Savings Algorithm

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

Where:

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

Sources

1. Wisconsin PSC EUL database, 2013.
2. TecMarket Works. New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs. October 15, 2010. Pgs 193-194.
3. United States Department of Energy Office of Energy Efficiency & Renewable Energy. *United States Industrial Electric Motor Systems Market Opportunities Assessment*. December 2002. Pg 42.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	03/19/2012	Original
02	Franklin Energy Services	04/01/2013	Updates by the PI

Compressed Air Nozzles, Air Entraining

	Measure Details
Measure Master ID	Compressed Air Nozzles, Air Entraining, 2259
Measure Unit	Nozzle
Measure Type	Prescriptive
Program(s)	Business Incentives, Large Energy Users
Sector(s)	Industrial, Commercial, Schools and 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]
Important Comments	

Measure Description

Engineered nozzles, also known as air entraining nozzles, reduce the amount of compressed air required for cleaning, cooling, and drying, and for blowoff applications. These nozzles use the coanda effect to pull in free air and accomplish tasks for 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 air flow and producing a safer workplace due to the elimination of potential skin contact with high pressure air.

Description of Baseline Condition

The baseline for this savings estimate 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) * HOU

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)

HOU = 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

$kWh_{LIFETIME}$ = 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. Wisconsin PSC EUL database, 2013.
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 (TRM) for Ohio Senate Bill 221 Energy Efficiency and Conservation Program and 09-512-GE-UNC. October 15, 2009.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	04/24/2012	Original
02	Franklin Energy Services	03/15/2013	Updated

Compressed Air System Leak Survey and Repair

	Measure Details
Measure Master ID	Compressed Air System Leak Survey and Repair Year 1, 2261 Compressed Air System Leak Survey and Repair Year 2, 2262 Compressed Air System Leak Survey and Repair Year 3, 2263
Measure Unit	Compressed Air system with leaks over an assumed baseline without
Measure Type	Hybrid
Program(s)	Business Incentives, Large Energy Users, Chains and Franchises
Sector(s)	Agriculture, Commercial, Industrial, Schools and 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)	4[2]
Important Comments	

Measure Description

For the compressed air system survey and repair measure, a Trade Ally analyzes a facility's compressed air system and identifies areas 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 type 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 is a hybrid measure is supported by a calculator tool (excel sheet) and is designed to determine the kWh losses associate with the distribution air system leaks. The required inputs will calculate the estimated system CFM capacity and the associated CFM losses associated with the number of identified leaks. A leak survey will provide the input values for the leak sizes and quantities. The annual energy savings and percent of existing system losses, along with the grant calculations are provided as outputs. The general calculation methodology is below:

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

ΔCFM Loss = #ofLeaks * (CFM / leak)

Where:

OpPressure = Adjustment factor for current operating pressure (table look-up)
ΔCFM Loss = Total CFM lost in whole system
#ofLeaks = Number of leaks at each orifice size
Leak Orifice Size = Size of leak determined from dB reading (table look-up in Assumptions Section[3])
CFM/Leak = CFM of air lost at particular orifice size from dB reading (table look-up)
HOU = Average annual run hours
$/kWh = Unit rate for electricity
10,655 = Cost of 104 CFM compressed air leak @ $0.06/kWh operating 8,760 hours
104 = Total CFM loss from 1/4 inch leak @ 100psig

Adjustment Factor for Operating Pressure (100psig = 1.0)

Pressure (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

Look-Up Table for CFM

Leak Orifice Size (in)	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

Summer Coincident Peak Savings Algorithm

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 4 years)[2]

Assumptions

- Efficiency of Compressor Types:
  - Single-Stage: 3.8 cfm/hp
  - Two-stage: 4.8 cfm/hp
  - Rotary: 5.2 cfm/hp

Decibel (dB) vs. CFM					
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

Sources

1. Focus on Energy Program, 2008-2010 average savings per project
2. Wisconsin PSC EUL database, 2013.
3. Compressed Air Ultrasonic Leak Detection Guide. http://www.plantsupport.com/download/UCAGuide.pdf

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	01/06/2012	Original
02	Franklin Energy Services	04/01/2013	Updates by the PI

Pre-Rinse Sprayer, ≤ 0.65 GPM, Electric or NG

	Measure Details
Measure Master ID	Pre-Rinse Sprayer, ≤ 0.65 GPM, Electric, 2494 Pre-Rinse Sprayer, ≤ 0.65 GPM, Natural Gas, 2495
Measure Unit	Per Unit
Measure Type	Prescriptive
Program(s)	Business Incentives, Large Energy Users, Chains and Franchises
Sector(s)	Agriculture, Commercial and Industrial, Schools and Government, Residential-Multifamily
Annual Energy Savings (kWh)	763
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	26.04
Lifecycle Energy Savings (kWh)	3,815
Lifecycle Therm Savings (Therms)	130.2
Water Savings (gal/yr)	6,290
Effective Useful Life (years)	5[5]

Measure Description

The measure replaces existing higher flow pre-rinse sprayers used in commercial kitchens with low-flow pre-rinse sprayers. Installing these devices is an inexpensive and lasting approach to water conservation. These products save energy by reducing the amount of energy needed to process, move, and heat water. The annual energy savings come from replacing a standard pre-rinse sprayer head (which has an average flow rate of 1.6 GPM) with a low-flow pre-rinse sprayer (which has an average flow rate of 0.65 GPM).

Description of Baseline Condition

The federal standard for commercial pre-rinse sprayers is 1.6 GPM or lower; 1.6 GPM is the baseline efficiency level.[3]

Description of Efficient Condition

The efficient condition is replacing a standard pre-rinse sprayer rated at 1.6 GPM or higher with a pre-rinse sprayer rated at 0.65 GPM or less.

Annual Energy-Savings Algorithm

The savings for the measure was calculated internally, using data from an evaluation report for a similar measure from the California Urban Water Conservation Council.[1]

$$\text{Gallons}_{\text{SAVED}} = \{(\mathrm{GPM}_{\mathrm{BASELINE}} * \mathrm{HPD}_{\mathrm{BASELINE}}) - (\mathrm{GPM}_{\mathrm{EE}} * \mathrm{HPD}_{\mathrm{EE}})\} * \mathrm{DPY} * 60$$

$$\text{kWh}_{\text{SAVED}} = \{(\mathrm{GPM}_{\mathrm{BASELINE}} * \mathrm{HPD}_{\mathrm{BASELINE}}) - (\mathrm{GPM}_{\mathrm{EE}} * \mathrm{HPD}_{\mathrm{EE}})\} * \frac{\mathrm{DPY} * 60 * (\mathrm{T}_{\mathrm{OUT}} - \mathrm{T}_{\mathrm{IN}}) * 8.33}{\eta * 3{,}412}$$

$$\text{Therms}_{\text{SAVED}} = \{(\mathrm{GPM}_{\mathrm{BASELINE}} * \mathrm{HPD}_{\mathrm{BASELINE}}) - (\mathrm{GPM}_{\mathrm{EE}} * \mathrm{HPD}_{\mathrm{EE}})\} * \frac{\mathrm{DPY} * 60 * (\mathrm{T}_{\mathrm{OUT}} - \mathrm{T}_{\mathrm{IN}}) * 8.33}{\eta * 100{,}000}$$

Where:

$GPM_{BASELINE}$ = Baseline gallons per minute (= 1.65)[1]

$HPD_{BASELINE}$ = Baseline hours used per day (= 0.44)[1]

GPM_{EE} = Gallons per minute with low-flow pre-rinse sprayer (= 0.65)[1]

HPD_{EE} = Hours used per day with low-flow pre-rinse sprayer (= 0.60)[1]

DPY = Days used per year (= 312)[1]

60 = Number of minutes in an hour

T_{OUT} = End-use water temperature (= 101°F; see assumption below)

T_{IN} = Inlet water temperature (= 52.3°F)[1]

8.33 = Conversion factor, 8.33 density of water in lbs/gal (x) 1.0 specific heat capacity of water in Btu/lb °F, (Btu/gallon/°F)

η = Water heater conversion efficiency (= 98% if electric, = 76% if gas)[4]

Summer Coincident Peak Savings Algorithm

$$kW_{SAVED} = \frac{kWh_{SAVED}}{8{,}760} * CF$$

Where:

8,760 = Number of hours in a year

CF = Coincidence factor (= 0)

Lifecycle Energy-Savings Algorithm

$$kWh_{LIFETIME} = kWh_{SAVED} \times EUL$$

$$Therms_{LIFETIME} = Therms_{SAVED} \times EUL$$

Where:

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

Assumptions

The average end-use water temperature is assumed to be 101°F; this is an equally weighted average of cold (72.3°F), mixed (105.0°F), and hot (125.6°F) water temperatures.

Sources

1. United States Department of Energy. *DHW Scheduler*. Average water main temp. of all locations measured in Wisconsin by scheduler, weighted by city populations.
2. *Title 10, Code of Federal Regulations.* Part 431 - Energy Efficiency Program for Certain Commercial and Industrial Equipment, Subpart O - Commercial Pre-Rinse Spray Valves. January 1, 2010.

3. *2008 Database for Energy Efficient Resources*. Cost Values and Summary Documentation. Updated June 2, 2008.
4. AHRI. RWH research. Most common RE for non-heat pump water heaters: http://www.ahridirectory.org/ahridirectory/pages/rwh/defaultSearch.aspx
5. Wisconsin PSC EUL database, 2013.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	03/19/2012	Original
02	Franklin Energy Services	04/01/2013	Updated by the PI

Dishwasher, ENERGY STAR® Commercial

	Measure Details
Measure Master ID	Dishwasher, ENERGY STAR Commercial, 2280 3137 3138 3140 2761 2285 2291 2296 2281 2286 2292 2297 2282 2287 2293 2298 2283 2288 2294 2299 2284 2289 2295
Measure Unit	Dishwasher
Measure Type	Prescriptive
Program(s)	Business Incentive, Chains & Franchise, Large Energy Users
Sector(s)	Commercial, Schools & Government, Industrial, Agricultural
Annual Energy Savings (kWh)	Varies by configuration
Peak Demand Reduction (kW)	Varies by configuration
Annual Therm Savings (Therms)	Varies by configuration
Lifecycle Energy Savings (kWh)	Varies by configuration
Lifecycle Therm Savings (Therms)	Varies by configuration
Water Savings (gal/yr)	Varies by configuration
Effective Useful Life (years)	10[1]
Important Comments	

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 criteria for idle energy use rates and the volume of water consumed per rack.

Dishwasher measures are for higher temperature and lower temperature machines in door type, multitank conveyer, single-tank conveyor, and under-counter machines. Water heater configurations are for electric water heaters with anelectric 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 found in ENERGY STAR's commercial kitchen equipment calculator;[2] the values are based on the EPA FSTC research on available commercial dishwasher models in 2013.[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

$kWh_{SAVED} = \Delta kWh/yr_{water\ heater} + \Delta kWh/yr_{booster\ heater} + \Delta kWh/yr_{idle}$

$Therms_{SAVED} = \Delta Therms/yr_{water\ heater} + \Delta Therms/yr_{booster\ heater}$

$Gallons_{SAVED} = Gallons/yr_{BASE} – Gallons/yr_{EE}$

Fuel Type	Machine Type	Algorithm
Electric	Water Heater	$\Delta kWh/yr_{water\ heater} = Gallons_{SAVED} * kWh/gallon_{water\ heater}$
	Booster Heater	$\Delta kWh/yr_{booster\ heater} = Gallons_{SAVED} * kWh/gallon_{booster\ heater}$
Gas	Water Heater	$\Delta Therms/yr_{water\ heater} = Gallons_{SAVED} * Therms/gallon_{water\ heater}$
	Booster Heater	$\Delta Therms/yr_{booster\ heater} = Gallons_{SAVED} * Therms/gallon_{booster\ heater}$

Fuel Type	Machine Type	Energy Use
Electric	Water Heater	$kWh/gallon_{water\ heater} = \Delta T_{WH} * C_{water} * \rho_{water} / \eta_{electric} / 3{,}413$
	Booster Heater	$kWh/gallon_{water\ heater} = \Delta T_{BH} * C_{water} * \rho_{water} / \eta_{electric} / 3{,}413$
Gas	Water Heater	$Therms/gallon_{water\ heater} = \Delta T_{WH} * C_{water} * \rho_{water} / \eta_{gas} / 100{,}000$
	Booster Heater	$Therms/gallon_{booster\ heater} = \Delta T_{WH} * C_{water} * \rho_{water} / \eta_{gas} / 100{,}000$

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

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

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

Where:

GPR_{BASE} = Gallons per rack of baseline equipment[2]

GPR_{EE} = Gallons per rack of ENERGY STAR equipment[2]

RD = Number of racks of dishes washed each day[2]

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

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

WT = Washtime (= length of wash cycles in minutes, from table below)

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

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

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

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

100,000 = Conversion factor from Btu to therms

3,413 = Conversion factor from Btu to kWh

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

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

$kW_{BASE\ IDLE}$ = kW consumed by baseline when on but not in a wash cycle (from table below)[2]

$kW_{EE\ IDLE}$ = kW consumed by efficient equipment when on but not in a wash cycle (from table below)[2]

	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

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

Where:

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

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

Lifecycle Energy-Savings Algorithm

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

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

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

Where:

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

Assumptions

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

Deemed Savings

Savings With Electric Water Heater and Booster Heater

	Baseline		ENERGY STAR		Savings	
	Electric (kWh)	Gas (therm)	Electric (kWh)	Gas (therm)	Electric (kWh)	Gas (therm)
Low Temperature						
Under Counter	11,085	0	8,508	0	2,577	0
Stationary Single-Tank Door	39,824	0	23,433	0	16,392	0
Single-Tank Conveyor	42,687	0	28,868	0	13,819	0
Multitank Conveyor	50,656	0	31,567	0	19,090	0
High Temperature (with electric booster heater)						
Under Counter	12,474	0	9,278	0	3,196	0
Stationary Single-Tank Door	40,351	0	28,325	0	12,027	0
Single-Tank Conveyor	46,069	0	36,758	0	9,311	0
Multitank Conveyor	73,321	0	45,538	0	27,784	0
Pot, Pan, and Utensil	21,351	0	17,991	0	3,360	0
High Temperature (with gas booster heater)						
Under Counter	9,502	131	6,933	103	2,569	28
Stationary Single-Tank Door	27,218	578	19,264	399	7,954	179
Single-Tank Conveyor	33,415	557	26,577	448	6,838	109
Multitank Conveyor	52,159	931	33,757	518	18,403	413
Pot, Pan, and Utensil	14,224	314	12,086	260	2,138	54

Savings With Natural Gas Water Heater and Booster Heater

	Baseline		ENERGY STAR		Savings	
	Electric (kWh)	Gas (therm)	Electric (kWh)	Gas (therm)	Electric (kWh)	Gas (therm)
Low Temperature						
Under Counter	2,829	363	2,829	250	0	113
Stationary Single-Tank Door	2,409	1,647	2,409	925	0	721
Single-Tank Conveyor	9,344	1,467	8,760	885	584	582
Multitank Conveyor	10,950	1,747	10,950	907	0	840
High Temperature (with electric booster heater)						
Under Counter	7,272	229	5,174	181	2,098	48
Stationary Single-Tank Door	17,368	1,012	12,468	698	4,900	314

Single-Tank Conveyor	23,925	975	18,941	784	4,984	190
Multitank Conveyor	36,288	1,630	24,921	907	11,367	723
Pot, Pan, and Utensil	8,879	549	7,657	455	1,222	94
High Temperature (with gas booster heater)						
Under Counter	4,300	360	2,829	284	1,471	76
Stationary Single-Tank Door	4,234	1,590	3,407	1,097	827	493
Single-Tank Conveyor	11,271	1,531	8,760	1,232	2,511	299
Multitank Conveyor	15,126	2,561	13,140	1,426	1,986	1,135
Pot, Pan, and Utensil	1,752	863	1,752	715	0	148

Annual Water Savings

	Baseline (Gallons/yr)	ENERGY STAR (Gallons/yr)	Savings (Gallons/yr)
Low Temperature			
Under Counter	47,359	32,576	14,783
Stationary Single-Tank Door	214,620	120,596	94,024
Single-Tank Conveyor	191,260	115,340	75,920
Multitank Conveyor	227,760	118,260	109,500
High Temperature			
Under Counter	29,839	23,543	6,296
Stationary Single-Tank Door	131,838	90,958	40,880
Single-Tank Conveyor	127,020	102,200	24,820
Multitank Conveyor	212,430	118,260	94,170
Pot, Pan, and Utensil	71,540	59,276	12,264

Sources

1. Wisconsin PSC EUL database, 2013.
2. United States Department of Energy. ENERGY STAR Commercial Kitchens Calculator. www.energystar.gov
3. United State Environmental Protection Agency, Food Service Technology Center.
4. AHRI. 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 savings derived using dishwasher load shape.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy	01/01/2013	New Measure
02	Franklin Energy	02/01/2013	Update to Version 2 Specification and Inclusion of Pots & Pans

ENERGY STAR® Commercial Combination Ovens (Gas or Electric)

	Measure Details
Measure Master ID	ENERGY STAR Commercial Combination Ovens (Gas or Electric), 3119 or 3118 respectively
Measure Unit	Per Oven
Measure Type	Prescriptive
Program(s)	Business Incentives, Chains & Franchise, Large Energy Users
Sector(s)	Commercial, Schools & Government, Industrial, Agricultural
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]
Important Comments	

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

Efficient condition is any commercial combination oven that is on the ENERGY STAR Commercial Combination Ovens qualified products list,[1] per the ENERGY STAR V2.0 performance specification for gas and electric combination ovens.[2]

Annual Energy-Savings Algorithms

Electric Combination Oven:

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

$$Wh/day_{EE} = Wh/day_{convection,EE} + Wh/day_{steam,EE} + Wh/day_{preheat,\ EE}$$

$$Wh/day_{convection,EE} = (1\text{-}\%_{steam}) * \{(m * E_{convection}) / \eta_{covection,EE} + [E_{idle\text{-}convection,EE} * (t_{day} - m/PC_{convection,EE} – nP * t_{preheat}/60)]\}$$

$\text{Wh/day}_{\text{steam, EE}} = \%_{\text{steam}} * \{(m * E_{\text{steam}}) / \eta_{\text{steam,EE}} + [E_{\text{idle-steam, EE}} * (t_{\text{day}} - m/PC_{\text{Steam,EE}} - nP * t_{\text{preheat}}/60)]\}$

$\text{Wh/day}_{\text{preheat, EE}} = E_{\text{preheat, EE}} * nP$

$\text{Wh/day}_{\text{BASELINE}} = \text{Wh/day}_{\text{convection,BASELINE}} + \text{Wh/day}_{\text{steam,BASELINE}} + \text{Wh/day}_{\text{preheat,BASELINE}}$

$\text{Wh/day}_{\text{convection, BASELINE}} = (1-\%_{\text{steam}}) *\{(m * E_{\text{convection}}) / \eta_{\text{convection,BASELINE}} + [E_{\text{idle-convection,BASELINE}} * (t_{\text{day}} - m/PC_{\text{Convection,BASELINE}} - nP * t_{\text{preheat}}/60)]\}$

$\text{Wh/day}_{\text{steam, BASELINE}} = \%_{\text{steam}} * \{(m* E_{\text{steam}}) / \eta_{\text{steam,BASELINE}} + [E_{\text{idle-steam, BASELINE}} * (t_{\text{day}} - m/PC_{\text{Steam,BASELINE}} - nP * t_{\text{preheat}}/60)]\}$

$\text{Wh/day}_{\text{preheat, BASELINE}} = E_{\text{preheat,BASELINE}} * nP$

Gas Combination Oven:

$\text{Therms}_{\text{SAVED}} = (\text{Btu/day}_{\text{BASELINE}} - \text{Btu/day}_{\text{EE}}) * DPY / 100{,}000$

$\text{Btu/day}_{\text{EE}} = \text{Wh/day}_{\text{convection,EE}} + \text{Wh/day}_{\text{steam,EE}} + \text{Wh/day}_{\text{preheat,EE}}$

$\text{Btu/day}_{\text{convection, EE}} = (1-\%_{\text{steam}}) * \{(m* E_{\text{convection}}) / \eta_{\text{covection,EE}} + [E_{\text{idle-convection,EE}} * (t_{\text{day}} - m/PC_{\text{convection,EE}} - nP * t_{\text{preheat}}/60)]\}$

$\text{Btu/day}_{\text{steam, EE}} = \%_{\text{steam}} * \{(m * E_{\text{steam}}) / \eta_{\text{steam, EE}} + [E_{\text{idle-steam, EE}} * (t_{\text{day}} - m/PC_{\text{Steam,EE}} - nP * t_{\text{preheat}}/60)]\}$

$\text{Btu/day}_{\text{preheat, EE}} = E_{\text{preheat,EE}} * nP$

$\text{Btu/day}_{\text{BASELINE}} = \text{Btu/day}_{\text{convection,BASELINE}} + \text{Btu/day}_{\text{steam,BASELINE}} + \text{Btu/day}_{\text{preheat,BASELINE}}$

$\text{Btu/day}_{\text{convection, BASELINE}} = (1-\%_{\text{steam}}) * \{(m * E_{\text{convection}}) / \eta_{\text{ convection,BASELINE}} + [E_{\text{idle-convection,BASELINE}} * (t_{\text{day}} - m/PC_{\text{Convection,BASELINE}} - nP * t_{\text{preheat}}/60)]\}$

$\text{Btu/day}_{\text{steam, BASELINE}} = \%_{\text{steam}} * \{(m* E_{\text{steam}}) / \eta_{\text{steam,BASELINE}} + [E_{\text{idle-steam,BASELINE}} * (t_{\text{day}} - m/PC_{\text{Steam,BASELINE}} - nP * t_{\text{preheat}}/60)]\}$

$\text{Btu/day}_{\text{preheat, BASELINE}} = E_{\text{preheat,BASELINE}} * nP$

Where:

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

1,000 = Kilowatt conversion factor

100,000 = Conversion factor from Btu to therms

%steam = Percentage of time in steam mode (= 50%)[3]

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

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

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

η = Cooking energy efficiency, from table below[3]

	Electric		Gas	
	Baseline	EE	Baseline	EE
$\eta_{convection}$	65%	70%	35%	44%
η_{steam}	40%	50%	20%	38%

E_{idle} = ENERGY STAR idle energy rate, from table below[3]

	Electric (W)		Gas (Btu/h)	
	Baseline	EE	Baseline	EE
$E_{idle,\ convection}$	3,750	2,500	20,000	11,000
$E_{idle,steam}$	12,500	6,000	12,500	6,000

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

PC = Production capacity, in lbs/hour, from table below[3]

	Baseline	EE
$PC_{convection}$	100	125
PC_{steam}	150	200

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

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

$E_{preheat}$ = Measured preheat energy; energy used per preheat, from table below[2]

	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 = Summer peak coincidence factor (= 1)

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

Lifecycle Energy-Savings Algorithm

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

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. United States Department of Energy. ENERGY STAR product finder: Commercial Combination Ovens.
2. United States Department of Energy. Version 2.0 ENERGY STAR performance specification for gas and electric combination ovens.
3. Food Service Technology Center. Life-Cycle & Energy Cost Calculator: Combination Ovens. http://www.fishnick.com/saveenergy/tools/calculators/
4. United States Department of Energy. ENERGY STAR Commercial Kitchen Equipment Calculator.
5. United States Department of Energy. ENERGY STAR Commercial Kitchen Equipment Calculator: Oven Calcs Tab.
6. United States Department of Energy. ENERGY STAR Commercial Kitchen Equipment Calculator: Steam Cooker Calcs Tab.
7. Southern California Gas Company. *08-07-022 Applications for Approval of Gas Energy Efficiency Programs and Budgets for Years 2009-2011.* "Food Service Products List Prices 11-07-05" http://www.socalgas.com/regulatory/A0807022.shtml

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	01/31/2013	New Measure

IT Systems, Server Virtualization

	Measure Details
Measure Master ID	IT Systems, Server Virtualization, 2439
Measure Unit	Per Server
Measure Type	Hybrid
Program(s)	Large Energy Users, Business Incentives, Chains and Franchises
Sector(s)	Commercial and Industrial, Schools and Government
Annual Energy Savings (kWh)	8,454 with default assumptions but can be calculated as well
Peak Demand Reduction (kW)	0.965 with default assumptions but can be calculated as well
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	126,810 with default assumptions but can be calculated as well
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Important Comments	

Measure Description

Server virtualization is a way of reducing the number of physical computer servers by running multiple, independent operating systems on a single server. This is achieved through virtualization software that creates and runs multiple virtual machines on a more powerful host server. This technology has a premium cost with licensing, virtualization software, and hardware, and it is being adopted because it lowers energy consumption, improves utilization availability, and saves maintenance costs.

Server virtualization can result in significant savings by reducing the number of physical servers, which in turn reduces the load on the electrical system and cooling system. Applications for server virtualization can include any business operating more than one server, but it is more common in businesses operating multiple servers.

Description of Baseline Condition

The baseline is calculated for each server using existing conditions (assuming no virtualization) and savings are based on virtualization. Servers and supporting systems operate 8,760 hours per year.

Description of Efficient Condition

The incentive is only for x86 servers that are transferred onto a virtual host server. A minimum of eight x86 servers are required for a server virtualization project. The following information must be recorded for each old server that is recycled and for each new virtual host server:

- Brand
- Model number
- Idle and full load power requirements
- Average utilization (loading)

Annual Energy-Savings Algorithm

$$\mathrm{kWh}_{\mathrm{SAVED\ Per\ VH}} = (\mathrm{kWh}_{\mathrm{BV}} - \mathrm{kWh}_{\mathrm{AV}})/\mathrm{m}$$

$$\mathrm{kWh}_{\mathrm{BV}} = 8{,}760/1{,}000 * \sum_{1}^{\mathrm{n}} (\mathrm{W}_{\mathrm{rs,idle}} + \mathrm{U}_{\mathrm{rs}} * (\mathrm{W}_{\mathrm{rs,full\ load}} - \mathrm{W}_{\mathrm{rs,idle}})$$

$$\mathrm{kWh}_{\mathrm{AV}} = 8{,}760/1{,}000 * \sum_{1}^{\mathrm{m}} (\mathrm{W}_{\mathrm{vh,idle}} + \mathrm{U}_{\mathrm{vh}} * (\mathrm{W}_{\mathrm{vh,full\ load}} - \mathrm{W}_{\mathrm{vh,idle}})$$

Where:

$\mathrm{kWh}_{\mathrm{BV}}$ = Energy use before virtualization

rs = servers to be retired, numbered 1 to n

8,760 = Hours per year

1,000 = Number of watts in a kW

$\mathrm{W}_{\mathrm{rs,idle}}$ = Power use in watts of a server to be retired in idle

U_{rs} = Utilization of server to be retired

$\mathrm{W}_{\mathrm{rs,\ full\ load}}$ = Power use in watts of a server to be retired at full load

$\mathrm{kWh}_{\mathrm{AV}}$ = Energy use after virtualization

vh = Virtual host servers, numbered 1 to m

$\mathrm{W}_{\mathrm{vh,\ idle}}$ = Power use in watts of a virtual host server in idle

$\mathrm{W}_{\mathrm{vh,\ full\ load}}$ = Power use in watts of virtual host server at full load

U_{vh} = Virtual host server utilization

$\mathrm{kWh}_{\mathrm{SAVED\ Per\ VH}}$ = Savings from virtualization per virtual host server

Power usage information can be found in server equipment specifications and CPU utilitization can be used as a proxy for server utilization rates. If this information is unavailable, the following default assumptions can be used in the equation above when actual data is missing:

$\mathrm{W}_{\mathrm{rs,idle}}$ = 138[2]

$\mathrm{W}_{\mathrm{rs,\ full\ load}}$ = 198

U_{rs} = 9%[3]

$\mathrm{W}_{\mathrm{vh,\ idle}}$ = 164

$\mathrm{W}_{\mathrm{vh,\ full\ load}}$ = 235

U_{vh} = 50%[4]

m = 1 virtual host server

n = 8 retired servers (minimum number required)

Using the default assumptions yields the energy savings per virtual host server installed as:

$$\mathrm{kWh}_{\mathrm{SAVED\ Per\ VH}} = \frac{8{,}760}{1{,}000} * \big(8 * (138 + 0.09 * 198) - 1\,(164 + 0.50 * 235)\big) = \ 8{,}454\ \mathrm{kWh}$$

Summer Coincident Peak Savings Algorithm

Using the default assumptions and annual savings of 8,454 kWh shown above, yields the summer coincidence peak savings per virtual host server installed as:

$kW_{SAVED} = kWh_{SAVED\ Per\ VH}\ /HOU * CF = 0.965\ kW$

Where:

$kW_{SAVED\ Per\ VH}$ = Power saved by virtualization = 8,454 kWh

HOU = Average annual run hours (= 8,760)

CF = Coincidence factor (= 1)

Lifecycle Energy-Savings Algorithm

Using the default assumptions and annual savings of 8,454 kWh shown above, yields the lifecycle energy savings per virtual host server installed as:

$kWh_{LIFETIME\ SAVING\ Per\ VH} = kWh_{SAVED\ Per\ VH} * EUL$

Where:

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

Sources

1. Wisconsin PSC EUL database, 2013.
2. Wattages are based on average power use in idle server dataset submitted by manufacturers to develop latest ENERGY STAR server specification. Performed by Cadmus. October 16, 2013.
3. Glanz, James. *Power, Pollution and the Internet.* The New York Times. September 22, 2012. (Article cited two sources that estimated the average server utilization rate to be 6 to 12%.) www.nytimes.com/2012/09/23/technology/data-centers-waste-vast-amounts-of-energy-belying-industry-image.html?pagewanted=all
4. VMWare. *Using Virtualization to Improve Data Center Efficiency*, Green Grid White Paper. Editor: Richard Talaber. 2009. http://www.thegreengrid.org/Global/Content/white-papers/Using-Virtualization-to-Improve-Data-Center-Efficiency

Revision History

Version Number	Authored by	Date	Description of Change

Energy Recovery Ventilator

	Measure Details
Measure Master ID	Energy Recovery Ventilator, 2314
Measure Unit	CFM
Measure Type	Hybrid
Program(s)	Business Incentives, Large Energy Users
Sector(s)	Commercial, Industrial, Schools & Government
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]
Important Comments	

Measure Description

This measure is the installation of an 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 heating occurring in the winter. In addition, the following specifications must be met:

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

Annual Energy-Savings Algorithm

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

When in cooling, the following equations were used to determine savings for each temperature interval:[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 following equations were used to determine savings for each temperature interval:

$$Therms_{SAVED} = \Sigma\ (\Delta Therms_{temp\text{-}interval})$$

$$\Delta Therms_{temp\text{-}interval} = ((1.08 * V_{supply} * \eta_{HX\text{-}Winter} * (T_{heated\ space} - T_{outside}) / 100{,}000) / \eta_{Heating}) * t_{temp\text{-}interval}$$

Where:

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

$1/\ \rho_{air}$ = Specific air of air (= 0.075 lb/cubic foot)

60 = Conversion factor from hours to minutes

V_{Supply} = Volume of supply air (= actual or default value of 7,200 CFM)

$\eta_{HX\text{-}Summer}$ = Efficiency of summer heat exchanger (= actual or default value of 74%)

H_{out} = Enthalpy of outside air in Btu/lb, 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 the cooling system (= 1.20 kW/ton)

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 ft-lb/min

5.202 = Conversion factor from inches of water to lb/square foot

$\eta_{fanmech}$ = Fan mechanical efficiency (= actual of default value of 65%)

$\eta_{fanmotor}$ = Fan motor efficiency (= actual or default value of 89.5% for 5 HP fan motor)

0.746 = Conversion factor from HP to kW

1.08 = Conversion factor from minutes to hours and lb of water to cubic feet

$\eta_{HX\text{-}Winter}$ = Efficiency of summer heat exchanger (= actual or 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 the heating system (= 85%)

Summer Coincident Peak Savings Algorithm

$kW_{saved} = kWh_{SAVED} / HOU_{cooling}$

Where:

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

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

Lifecycle Energy-Savings Algorithm

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

Where:

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

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, 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]

	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
	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

Deemed Savings

	Annual Energy Savings	Peak Demand Savings	Lifecycle Energy Savings
Yearlong	72 kWh	-	1,080 kWh
	13,576 Therms	-	203,640 Therms
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 gas savings, whereas the electric energy use increases due to the kWh consumed by the fan. However, the overall Btu savings is net positive.

Sources

1. PA Consulting Group Inc. and Public Service Commission of Wisconsin. *Focus on Energy Evaluation, Business Programs: Deemed Savings Manual*. Final Report. March 22, 2010.
2. Focus on Energy Program, Energy Recovery Ventilator Calculation.
3. Wisconsin PSC EUL database, 2013.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	01/06/2012	Original
02	Franklin Energy Services	04/01/2013	Updates by the PI

RTU Optimization - Economizer

	Measure Details
Measure Master ID	RTU Optimization – Economizer, 3066
Measure Unit	Per Ton
Measure Type	Hybrid
Program(s)	Business Incentives, Chains & Franchises, Large Energy Users
Sector(s)	Commercial, Industrial, Agricultural, Schools & Government
Annual Energy Savings (kWh)	See table below (per ton)
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	See table below (per ton)
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	10[4] yrs

Measure Description

A majority of commercial spaces are heated and cooled by packaged rooftop units. This measure is the installation of 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 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, the estimated average balance point of the buildings addressed.

$$kWh_{SAVED} = kWh/year_{baseline} – kWh/year_{economizer}$$

$$kWh/year_{economizer} = \Sigma(kW_{hour\text{-}interval\text{-}economizer} * 1 \text{ hour})$$

$$kWh/year_{baseline} = \Sigma(kW_{hour\text{-}interval\text{-}baseline} * 1 \text{ hour})$$

$$kW_{our\text{-}interval\text{-}economizer} = CAP * R_{CAP} * (12 / EER) * Econ_{Operating}$$

$$kW_{hour\text{-}interval\text{-}baseline} = CAP * R_{CAP} * (12 / EER)$$

Where:

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

R_{CAP} = The cooling load at which the air conditioning compressor is operating, as a percentage/fraction 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 values used for deemed savings values = 9.675)[2]

$Econ_{Operating}$ = Binary variable (1 or 0) that indicates whether or not the economizer is in operation; economizer operates when the outside air temperature (dry-bulb) is between 55°F and 65°F, inclusive

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

Summer Coincident Peak Savings Algorithm

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

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 10 years)[4]

Assumptions

- 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 during the savings analysis.
- The fraction of the full capacity that the air conditioning compressor is operating at 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 for each installation, including some extra capacity for cooling beyond 95°F.

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

Deemed Savings

The deemed savings were calculated as shown in the table below.

WI City	Annual Electric Energy Savings (kWh/yr/ton)	Peak Demand Savings (kW)	Lifecycle Electric Energy Savings (kWh/ton)
Madison	176.51	0	1760.5
Milwaukee	222.04	0	2220.4
Green Bay	229.31	0	2293.1
La Crosse	167.35	0	1673.5
Minocqua	215.00	0	2150.0
Wausau	174.78	0	1747.8
Rice Lake	201.93	0	2019.3

Sources

1. *Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions.* Pg. 47, Dual Enthalpy Economizer. 2013.
2. Straight unweighted average of minimum EER standards for RTUs of cooling capacities greater than 11.25 tons; the International Energy Conservation Code. Table 503.2.3(1). 2009.
3. 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. Wisconsin PSC EUL database, 2013.

Document Revision History

Version Number	Authored by	Date	Description of Change
01	Eric Wall – Franklin Energy Services	3/11/2013	New Measure

High-Efficiency Packaged and Split System Air Conditioning Units

	Measure Details
Measure Master ID	High-Efficiency Packaged and Split System Air Conditioning Units, 3022
Measure Unit	Per Split System Installed
Measure Type	Hybrid
Program(s)	Business Incentives, Chains & Franchise, Large Energy Users
Sector(s)	Commercial, Schools & Government, Industrial, Agricultural
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]
Important Comments	

Measure Description

This measure is the installation of 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.

Description of Baseline Condition

The baseline equipment for new construction or where new equipment is required by code is assumed to be a standard-efficiency packaged or split air conditioner that meets the 2009 IECC energy-efficiency requirements.[4] The rating conditions for the baseline and efficient equipment efficiencies must be equivalent.

Baseline Equipment for New Construction

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

The baseline equipment for existing buildings is assumed to be a standard-efficiency packaged or split air conditioner that meets the 2006 IECC energy-efficiency requirements.[3] The rating conditions for the baseline and efficient equipment efficiencies must be equivalent.

Baseline Equipment for Existing Building

IECC 2009 Table 503.2.3(1)	Minimum Efficiency
Standard AC Unit < 65 kBtu/hour (5.42 tons)	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 < 239 KBtu/hour (11.25 to 20 tons)	9.7 EER
Standard AC Unit ≥ 240 and < 759 kBtu/hour (20 to 63.33 tons)	9.5 EER
Standard AC Unit ≥ 760 kBtu/hour (63.33 tons)	9.2 EER

Description of Efficient Condition

The efficient equipment shall be a high-efficiency packaged air conditioner that exceeds the minimum CEE energy-efficiency requirements.[4]

CEE High Efficiency RTU Efficiencies by Size	Minimum to Qualify
High Eff AC Unit < 65 kBtu/hour (5.42 tons)	15.0 SEER
High Eff AC Unit ≥ 65 and < 135 kBtu/hour (5.42 to 11.25 tons)	11.5 EER
High Eff AC Unit ≥ 135 and < 239 KBtu/hour (11.25 to 20 tons)	11.5 EER
High Eff AC Unit ≥ 240 and < 759 kBtu/hour (20 to 63.33 tons)	10.6 EER
High Eff AC Unit ≥ 760 kBtu/hour (63.33 tons)	9.9 EER

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{BASE} – kWh_{EE}$

Baseline (kWh_{BASE})	
≥ 65 kBtu	kWh_{BASE} = Capacity * RLF * $EFLH_C$ * ($1/EER_{BASE}$) * (1 kW/1,000 W)
< 65 kBtu	kWh_{BASE} = Capacity * RLF * $EFLH_C$ * ($1/SEER_{BASE}$) * (1 kW/1,000 W)
Efficient (kWh_{EE})	
≥ 65 kBtu	kWh_{EE} = Capacity * RLF * $EFLH_C$ * ($1/EER_{EE}$) * (1 kW/1,000 W)
< 65 kBtu	kWh_{EE} = Capacity * RLF * $EFLH_C$ * ($1/SEER_{BASE}$) * (1 kW/1,000 W)

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 of the air conditioning unit (= 0.90)

$EFLH_C$ = Cooling equivalent full load hours (see table below for default values)[5]

EER_{BASE} = Energy efficiency ratio of standard efficiency code baseline unit, in Btu/watt-hour

$SEER_{BASE}$ = Seasonal energy efficiency rating. Factor used on smaller commercial and residential cooling equipment > 65 kBtu. For air conditioning units < 65 kBtu, used SEER instead of EER to calculate kWh_{SAVED}, then converted SEER to EER (11.3/13) to calculate kW saved.

EER_{EE} = Energy efficiency ratio of energy-efficient unit, in Btu/watt-hour

Building Type	$EFLH_C$[5]
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**

Lifecycle Energy-Savings Algorithm

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

Where:

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

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kW_{BASE} – kW_{EE}$

Baseline (kWh_{BASE})	
≥ 65 kBtu	kW_{BASE} = Capacity * (1kW/1,000 W) * CF * (1/EER_{BASE})
< 65 kBtu	kW_{BASE} = Capacity (Btu/hour) * (1 kW/1,000 W) * CF * (1/$SEER_{BASE}$)
Efficient (kWh_{EE})	
≥ 65 kBtu	kW_{EE} = Capacity * (1 kW/1,000 W) * CF * (1/EER_{EE})
< 65 kBtu	kW_{EE} = Capacity * (1 kW/1,000 W) * CF * (1/$SEER_{EE}$)

Where:

CF = Coincidence factor (= 0.8)[6]

Deemed Savings

Capacity (Btu/hour)	SEER/ EER_{BASE}	SEER/ EER_{EE}	kWh_{BASE}	kWh_{EE}	ΔkWh/yr	kW_{BASE}	kW_{EE}	kW_{SAVED}	$kWh_{LIFETIME}$
50,000	10	15	2,695.50	1,797.00	898.50	4.00	2.67	1.33	13,477.50
100,000	10.3	11.5	5,233.98	4,687.83	546.15	7.77	6.96	0.81	8,192.32
187,000	9.7	11.5	10,392.96	8,766.23	1,626.72	15.42	13.01	2.41	24,400.86
517,500	9.5	10.6	29,366.76	26,319.27	3,047.49	43.58	39.06	4.52	45,712.41
800,000	9.2	9.9	46,878.26	43,563.64	3,314.62	69.57	64.65	4.92	49,719.37

Assumptions

- The average (mean) value for all building types was used to determine cooling EFLH.
- 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 those units that are < 65 kBtu/hour (which used 50 kBth/hour) and ≥ 760 kBtu/hour (which used 800 kBtu/hour).

Sources

1. Wisconsin PSC EUL database, 2013.
2. Consortium for Energy Efficiency. *High Efficiency Commercial Air Conditioning and Heat Pump Initiative, Unitary AC Specifications.*
3. International Energy Conservation Code. Table 503.2.3(1). 2006.
4. International Energy Conservation Code. Table 503.2.3(1). 2009.
5. DEER model runs are weather normalized for statewide use by population density.
6. Focus on Energy Business Programs Deemed Savings Manual V1.0. March 22, 2010.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	01/01/2013	New Measure

Air Conditioning Unit Tune Up - Coil Cleaning

	Measure Details
Measure Master ID	Air Conditioning Unit Tune Up - Coil Cleaning, 3059(<10 Tons), 3060 (>20 Tons), 3061 (10-20 Tons)
Measure Unit	Tons of Refrigeration Capacity
Measure Type	Hybrid
Program(s)	Business Incentives, Chains & Franchise, Large Energy Users
Sector(s)	Commercial, Schools & Government, Industrial, Agricultural
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[2]

Measure Description

This measure is coil cleaning and on packaged AC units operating in commercial applications, applicable for commercial and industrial customers, and applies savings from documented tune-ups for package or split system AC equipment.

Description of Baseline Condition

The baseline condition is an AC system that has fouled condenser coils.

Description of Efficient Condition

The efficient equipment is a unitary or split system AC that has had condenser coil cleaning as part of a tune up.

Annual Energy-Savings Algorithm

Air Conditioning Condenser Coil Cleaning (for AC units < 65,000 Btu/hour, use SEER instead of EER to calculate):

$$kWh_{SAVED} = (EFLH_C * CAPY_C / 1{,}000) * (1/[EER*CCF] - 1/EER)$$

$$kWh_{SAVED} = (EFLH_C * CAPY_C / 1{,}000) * (1/[SEER*CCF] - 1/SEER)$$

Where:

$EFLH_C$ = Equivalent full load hours for mechanical cooling

$CAPY_C$ = Unit capacity, in Btu/hour for cooling

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

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

CCF = Condenser coil fouling COP degradation factor for cooling (= 93.2%)

Summer Coincident Peak Savings Algorithm

Air Conditioning Condenser Coil Cleaning (for AC units < 65,000 Btu/hour, convert SEER to EER to calculate, using 11.3/13 as the conversion factor):

$kW_{SAVED} = (CF*CAPY_C / 1,000)*(1/[EER*CCF]-1/EER)$

CF = Coincidence factor

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life years[2]

Assumptions

Calculation Variable Assumptions

Component	Type	Value	Source
$CAPY_C$	Variable	Nameplate	Data Gathering
EER	Variable	Nameplate	Data Gathering
$EFLH_C$	Variable	See Equivalent Full Load Hours by Business Type (table below)	2
CCF	Fixed	93.2%	4
CF	Fixed	90%	5

Equivalent Full Load Hours by Business Type

Building Type	$EFLH_C$[8]
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

Deemed Savings

Condenser Coil Cleaning Annual kWh Savings*

	< 65,000	65,000 - 134,999	135,000 - 239,999	240,000 - 759,999	≥ 760,000
College	69.2	76	80.8	82.6	85.3
Food Sales	59.1	64.9	69	70.5	72.9
Food Service	45.6	50.1	53.3	54.4	56.2
Healthcare	63.4	69.6	74	75.6	78.1
Hotel/Motel	52.3	57.5	61.1	62.4	64.5
Industrial	41	45	47.8	48.9	50.5
Office	45.6	50.1	53.3	54.4	56.2
Other	46.5	51.1	54.3	55.5	57.3
Public Assembly	42.2	46.4	49.3	50.4	52
Public Services (non-food)	42.2	46.4	49.3	50.4	52
Retail	44.8	49.2	52.3	53.4	55.2
School	34.7	38.1	40.5	41.3	42.7
Warehouse	28.3	31	33	33.7	34.8

* Table shows kWh/ton savings (1 Ton = 12,000 Btu/hour)

Condenser Coil Cleaning Lifecycle kWh Savings[1]

	< 65,000	65,000 - 134,999	135,000 - 239,999	240,000 - 759,999	≥ 760,000
College	207.6	228	242.4	247.8	255.9
Food Sales	177.3	194.7	207	211.5	218.7
Food Service	136.8	150.3	159.9	163.2	168.6
Healthcare	190.2	208.8	222	226.8	234.3
Hotel/Motel	156.9	172.5	183.3	187.2	193.5
Industrial	123	135	143.4	146.7	151.5
Office	136.8	150.3	159.9	163.2	168.6
Other	139.5	153.3	162.9	166.5	171.9
Public Assembly	126.6	139.2	147.9	151.2	156
Public Services (non-food)	126.6	139.2	147.9	151.2	156
Retail	134.4	147.6	156.9	160.2	165.6
School	104.1	114.3	121.5	123.9	128.1
Warehouse	84.9	93	99	101.1	104.4

(1) Table shows kWh/ton savings (1 Ton = 12,000 Btu/hour)

Condenser Coil Cleaning Demand kW Savings

	< 65,000	65,000 - 134,999	135,000 - 239,999	240,000 - 759,999	≥ 760,000
Any	0.071	0.078	0.083	0.085	0.088

Sources

1. Regional coincidence factor for cooling demand.
2. Wisconsin PSC EUL database, 2013.
3. DEER model runs weather normalized for statewide use by population density
4. Weighted value for bin charges in table 2 based on SCE program results for C&I buildings with 3,154 units participating. The weighting assumptions will be calibrated annually to reflect Wisconsin findings.
5. Pigg, Scott (Energy Center of Wisconsin). *Central Air Conditioning in Wisconsin*. ECW Report Number 241-1. 2008.
6. DEER *Database for Energy Efficiency Resources.* 2005.
7. Bureau of Labor Statistics. *Databases, Tables & Calculators by Subject: CPI Inflation Calculator*. Available online: http://www.bls.gov/data/inflation_calculator.htm.
8. DEER model runs are weather normalized for statewide use by population density.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	01/01/2013	New Measure

Air Conditioning Unit Tune Up - Refrigerant Charge Correction

	Measure Details
Measure Master ID	Air Conditioning Unit Tune Up - Refrigerant Charge Correction 3062,3063,3064
Measure Unit	Tons of Refrigeration Capacity
Measure Type	Hybrid
Program(s)	Business Incentives, Chains & Franchise, Large Energy Users
Sector(s)	Commercial, Schools & Government, Industrial, Agricultural
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)	Refrigerant charge correction:10[1]

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 package or split system AC equipment.

Description of Baseline Condition

The baseline condition is an AC system has incorrect refrigerant charge.

Description of Efficient Condition

The efficient equipment is a unitary or split system AC that has had refrigerant charge correction as part of a tune up.

Annual Energy-Savings Algorithm

Air Conditioning Charge Correction: (for AC units < 65,000 Btu/hour, use SEER instead of EER to calculate):

$$kWh_{SAVED} = (EFLH_C*CAPY_C/1{,}000)*(1/[EER*RCF]-1/EER)$$

$$kWh_{SAVED} = (EFLH_C*CAPY_C/1{,}000\ )*(1/[SEER*RCF]-1/SEER)$$

Where:

$EFLH_C$ = Equivalent full load hours for mechanical cooling

$CAPY_C$ = Unit capacity, in Btu/hour for cooling

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

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

RCF = Refrigerant charge COP degradation factor for cooling (= 98.3%)

Summer Coincident Peak Savings Algorithm

Air Conditioning Charge Correction (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

Lifecycle Energy-Savings Algorithm

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

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
$EFLH_C$	Variable	See Equivalent Full Load Hours by Business Type (table below)	2
RCF	Variable	98.3%[9]	3
CF	Fixed	90%	5

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%

Equivalent Full Load Hours by Business Type

Building Type	$EFLH_C$[8]
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

Deemed Savings

Refrigerant Charge Correction Annual kWh Savings*

	< 65,000	65,000 - 134,999	135,000 - 239,999	240,000 - 759,999	≥ 760,000
College	18.3	20.4	21.6	22.1	22.8
Food Sales	15.6	17.4	18.5	18.9	19.5
Food Service	12	13.4	14.3	14.6	15.1
Healthcare	16.7	18.7	19.8	20.3	20.9
Hotel/Motel	13.8	15.4	16.4	16.7	17.3
Industrial	10.8	12.1	12.8	13.1	13.5
Office	12	13.4	14.3	14.6	15.1
Other	12.3	13.7	14.5	14.9	15.3
Public Assembly	11.2	12.4	13.2	13.5	13.9
Public Services (non-food)	11.2	12.4	13.2	13.5	13.9
Retail	11.8	13.2	14	14.3	14.8
School	9.1	10.2	10.8	11.1	11.4
Warehouse	7.5	8.3	8.8	9	9.3

* Table shows kWh/ton savings (1 Ton = 12,000 Btu/hour)

Refrigerant Charge Correction Lifecycle kWh Savings*

	< 65,000	65,000 - 134,999	135,000 - 239,999	240,000 - 759,999	≥ 760,000
College	183	204	216	221	228
Food Sales	156	174	185	189	195
Food Service	120	134	143	146	151
Healthcare	167	187	198	203	209
Hotel/Motel	138	154	164	167	173
Industrial	108	121	128	131	135
Office	120	134	143	146	151
Other	123	137	145	149	153
Public Assembly	112	124	132	135	139
Public Services (non-food)	112	124	132	135	139
Retail	118	132	140	143	148
School	91	102	108	111	114
Warehouse	75	83	88	90	93

* Table shows kWh/ton savings (1 Ton = 12,000 Btu/hour)

Refrigerant Charge Correction Demand Savings

	< 65,000	65,000 - 134,999	135,000 - 239,999	240,000 - 759,999	≥ 760,000
Any	0.019	0.021	0.022	0.023	0.023

Sources

1. Regional coincidence factor for cooling demand.
2. DEER, *Database for Energy Efficiency Resources*. EUL Listing. 2008.
3. DEER model runs weather normalized for statewide use by population density
4. Weighted value for bin charges in table 2 based on SCE program results for C&I buildings with 3,154 units participating. The weighting assumptions will be calibrated annually to reflect Wisconsin findings.
5. Pigg, Scott (Energy Center of Wisconsin). *Central Air Conditioning in Wisconsin*. ECW Report Number 241-1. 2008.
6. DEER *Database for Energy Efficiency Resources.* 2005.
7. Bureau of Labor Statistics. *Databases, Tables & Calculators by Subject: CPI Inflation Calculator*. Available online: http://www.bls.gov/data/inflation_calculator.htm.
8. DEER model runs are weather normalized for statewide use by population density.
9. Department of Energy, Weatherization Center. http://www.waptac.org/data/files/website_docs/training/standardized_curricula/curricula_resources/us%20doe_evaluating%20refrigerant%20charge.pdf

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	01/01/2013	New Measure

Bi-Level Controls for Interior, Exterior, and Parking Garages

	Measure Details
Measure Master ID	Bi-level Controls for Interior, 3004, 3097 (LED), 3117 (fluorescent) Bi-level Controls for Exterior, 3115, 3251, 3343 Bi-level Controls for Parking Garages, 3252
Measure Unit	Fixture
Measure Type	Hybrid
Program(s)	Business Incentives, Chains & Franchise, Large Energy Users, Small Business
Sector(s)	Commercial, Schools & Government, Industrial, Agricultural
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]
Important Comments	Excel Calculation: Bi Level Controls for Interior Exterior and Parking Garages Calculation_FES_BIP_CSF_LEU_01.01.13

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 Wattsof the fixture(s) being controlled

1,000 = Kilowatt conversion factor

0.60 = 40% savings potential from bi-level controls

HOU = Average annual run hours, see table below (= 8,760 for parking garages and = 4,380 for exterior)

Sector	Interior HOU[2]
Agriculture	4,698
Commercial	3,730
Industrial	4,745
Schools & Government	3,239

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= 0.0 for parking, exterior, and interior)

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 8 years)[1]

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 kW savings is given to exterior lighting due to exterior lighting (CF = 0).

Deemed Savings

Bi-Level Controls Parking Garage (Hybrid)

Savings per Fixture	All Sectors
kWh Savings	1,135
kW Savings	0.13
Lifetime Savings	9,082

Bi-Level Controls Exterior (Hybrid)

Savings per Fixture	All Sectors
kWh Savings	568
kW Savings	0
Lifetime Savings	4,541

Bi-Level Controls Interior (Hybrid)

Savings per Fixture	Agricultural	Commercial	Industrial	Schools & Government
kWh Savings	609	483	615	420
kW Savings	0.09	0.10	0.10	0.08
Lifetime Savings	4,871	3,867	4,920	3,358

Sources

1. Wisconsin PSC EUL Database, 2013.
2. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin. Focus on Energy Business Programs: Deemed Savings Manual V1.0. Updated March 22, 2010. Table 3.2 Lighting Hours of Use in Commercial Applications.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	12/31/2012	New Measure

Delamping 200-Watt to 399-Watt Light Fixture

Delamping ≥ 400-Watt Light Fixture

	Measure Details
Measure Master ID	Delamping 200-Watt to 399-Watt Light Fixture, 3001, 3321
Measure Unit	Per Fixture
Measure Type	Prescriptive
Program(s)	Small Business
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

	Measure Details
Measure Master ID	Delamping ≥ 400-Watt Light Fixture, 3002, 3322
Measure Unit	Per Fixture
Measure Type	Prescriptive
Program(s)	Small Business
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

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 metal halide 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

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

Where:

$Watts_{BASE}$ = Watts of baseline measure (high wattage light fixture; either 200-watt or 399-watt light fixture = 299 watts, or ≥ 400-watt light fixture = 463 watts)

$Watts_{EE}$ = Watts of efficient measure (= 0)

1,000 = Kilowatt conversion factor

HOU = Average annual run hours, see table below

Sector	HOU[2]
Agriculture	4,698
Commercial	3,730
Industrial	4,745
Schools & Government	3,239

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor, see table below

Sector	CF[3]
Agriculture	0.67
Commercial	0.77
Industrial	0.77
Schools & Government	0.64

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 13 years)[1]

Assumptions

The baseline wattage of the 250-watt metal halide is 295 watts. The baseline wattage of the 400-watt metal halide is 458 watts.[4]

Deemed Savings

Deemed Savings for Delamping 200-Watt to 399-Watt Light Fixtures

	Agriculture	Commercial	Industrial	Schools & Government

Annual Energy Savings (kWh)	1,405	1,115	1,419	968
Peak Demand Reduction (kW)	0.200	0.230	0.230	0.191
Lifecycle Energy Savings (kWh)	18,261	14,499	18,444	12,590

Deemed Savings for Delamping ≥ 400-Watt Light Fixtures

	Agriculture	Commercial	Industrial	Schools & Government
Annual Energy Savings (kWh)	2,175	1,727	2,197	1,500
Peak Demand Reduction (kW)	0.310	0.357	0.357	0.296
Lifecycle Energy Savings (kWh)	28,277	22,451	28,560	19,496

Sources

1. WI PSC Database for High Bay Flourescent Lighting
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. Ohio Technical Reference Manual prepared by VEIC. August 2010.

Revision History

Version Number	Authored by	Date	Description of Change
01	GDS	01/08/2013	New Measure
02	GDS	02/18/2013	New Measure

Exterior – Induction, PSMH, CMH, Linear Florescent Fixtures

	Measure Details
Measure Master ID	Exterior PSMH, CMH, Induction, or Linear Fluorescent Replacing 70-watt to 100-watt HID 3087 Exterior PSMH, CMH, Induction, or Linear Fluorescent Replacing 150-watt to 175-watt HID 3078 Exterior PSMH, CMH, Induction, or Linear Fluorescent Replacing 250-watt HID 3081 Exterior PSMH, CMH, Induction, or Linear Fluorescent Replacing 320-watt HID 3084 Exterior PSMH, CMH, Induction, or Linear Fluorescent Replacing 400-watt HID 3086
Measure Unit	Fixture
Measure Type	Prescriptive
Program(s)	Business Incentives, Chains & Franchise, Large Energy Users
Sector(s)	Commercial, Schools & Government, Industrial, Agricultural
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]

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.[2]

Description of Efficient Condition

The efficient measure is induction, PSMH, CMH, and linear fluorescent fixtures between 35 watts and 250 watts.[2]

Annual Energy-Savings Algorithm

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

Where:

$\text{Watts}_{\text{BASE}}$ = Watts of baseline equipment (standard HID fixture)

Watts_{EE} = Watts of efficient equipment (induction fixture, PSMH fixture, CMH fixture, or linear fluorescent fixture)

1,000 = Kilowatt conversion factor

HOU = Average annual run hours (= 4,380)

Summer Coincident Peak Savings Algorithm

$\text{kW}_{\text{SAVED}} = (\text{Watts}_{\text{BASE}} - \text{Watts}_{\text{EE}})/1{,}000 * \text{CF}$

Where:

CF = Coincidence factor (= 0)

Lifecycle Energy-Savings Algorithm

$\text{kWh}_{\text{LIFETIME}} = \text{kWh}_{\text{SAVED}} * \text{EUL}$

Where:

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

Assumptions

The induction wattage shown below includes 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 of the total number of 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 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

Deemed Savings

Measure	Annual Savings (kWh)	Peak Demand Savings (kW)	Lifecycle Savings (kWh)
Exterior PSMH, CMH, Induction, or Linear Fluorescent Replacing 70-watt to 100-watt HID	247	0.000	3,712
Exterior PSMH, CMH, Induction, or Linear Fluorescent Replacing 150-watt to 175-watt HID	329	0.000	4,938
Exterior PSMH, CMH, Induction, or Linear Fluorescent Replacing 250-watt HID	605	0.000	9,076
Exterior PSMH, CMH, Induction, or Linear Fluorescent Replacing 320-watt HID	556	0.000	8,344
Exterior PSMH, CMH, Induction, or Linear Fluorescent Replacing 400-watt HID	972	0.000	14,585

Sources

5. Focus on Energy Evaluation Business Programs: Measure Life Study Final Report: August 25, 2009
6. Based on Market Research

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	12/28/2012	New Measure

Parking Garage Induction PSMH CMH LF Fixtures

	Measure Details
Measure Master ID	Parking Garage Induction PSMH CMH LF Fixtures, 3079, 3080, 3082, 3083, 3088, 3089
Measure Unit	Fixture
Measure Type	Prescriptive
Program(s)	Business Incentives, Chains & Franchise, Large Energy Users
Sector(s)	Commercial, Schools & Government, Industrial, Agricultural
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]

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:

$Watts_{BASE}$ = Watts of baseline equipment (standard HID fixture)[2]

$Watts_{EE}$ = Watts of efficient equipment (induction fixture, PSMH fixture, CMH fixture, or linear fluorescent fixture)[2]

1,000 = Kilowatt conversion factor

HOU = Average annual run hours (varies by hours of operation; = 4,380 for night run only and = 8,760 if on 24/7)

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= 0 for evening use and 1 for all day)

Lifecycle Energy-Savings Algorithm

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

Where:

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

Assumptions

The induction wattage shown below includes ballast wattage, 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

Deemed Savings

Average Annual Deemed Savings for Parking Garage Induction PSMH/CMH Linear Fluorescent Fixtures

Measure	kWh	kW
Parking Garage PSMH, CMH, Induction, or Linear Fluorescent, 70 watt to 100 watt, 8,760 annual run hours	495	0.057
Parking Garage PSMH, CMH, Induction, or Linear Fluorescent, 70 watt to 100 watt, 4,380 annual run hours	247	0.000
Parking Garage PSMH, CMH, Induction, or Linear Fluorescent, 150 watt to 175 watt, 8,760 annual run hours	658	0.075
Parking Garage PSMH, CMH, Induction, or Linear Fluorescent, 150 watt to 175 watt, 4,380 annual run hours	329	0.000
Parking Garage PSMH, CMH, Induction, or Linear Fluorescent, 250 watt, 8,760 annual run hours	1.210	0.141
Parking Garage PSMH, CMH, Induction, or Linear Fluorescent, 250 watt, 4,380 annual run hours	605	0.000

Average Lifecycle Deemed Savings for Parking Garage Induction PSMH/CMH Linear Fluorescent Fixtures

Measure	kWh
Parking Garage PSMH, CMH, Induction, or Linear Fluorescent, 70 watt to 100 watt, 8,760 annual run hours	7,424
Parking Garage PSMH, CMH, Induction, or Linear Fluorescent, 70 watt to 100 watt, 4,380 annual run hours	3,712
Parking Garage PSMH, CMH, Induction, or Linear Fluorescent, 150 watt to 175 watt, 8,760 annual run hours	9,877
Parking Garage PSMH, CMH, Induction, or Linear Fluorescent, 150 watt to 175 watt, 4,380 annual run hours	4,938
Parking Garage PSMH, CMH, Induction, or Linear Fluorescent, 250 watt, 8,760 annual run hours	18,152
Parking Garage PSMH, CMH, Induction, or Linear Fluorescent, 250 watt, 4,380 annual run hours	9,076

Sources

7. Focus on Energy Evaluation Business Programs: Measure Life Study Final Report: August 25, 2009
8. Based on Market Research

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	12/28/2012	New Measure

Linear Fluorescent Delamping, 4'; Linear Fluorescent Delamping, 8'

	Measure Details
Measure Master ID	Linear Fluorescent Delamping, 4', 2276, 2277 Linear Fluorescent Delamping, 8', 3184
Measure Unit	Lamp
Measure Type	Prescriptive
Program(s)	Linear Fluorescent Delamping, 4': Business Incentives, Chains & Franchise, Large Energy Users, Multifamily Energy Savings, Small Business Linear Fluorescent Delamping, 8': Small Business
Sector(s)	Commercial, Schools & Government, Industrial, Agricultural
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)	10[1]
Important Comments	See Excel Calculation: Linear Fluorescent Delamping Calculation_FES_MESP_BIP_CSF_LEU_05.28.13

Measure Description

This measure is for 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 system, for which the incentives relate to the number of lamps found 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 qualify only 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:

- Delamping T12 to T8 (4')
    - 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')
    - T12 - 2 Lamp (80%)
    - HOT12 - 2 Lamp (20%)

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:

- Delamping T12 to T8 (4')
    - 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')
    - T8 – 2 Lamp (8') to 2 Lamp (4') (100%)

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 = Average annual run hours, see table below

Sector	HOU[4]
Agriculture	4,698
Commercial	3,730
Industrial	4,745
Schools & Government	3,239
Multifamily	5,950[5]

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor, see table below

Sector	CF[4]
Agriculture	0.67
Commercial	0.77
Industrial	0.77
Schools & Government	0.64
Multifamily	0.77

Lifecycle Energy-Savings Algorithm

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

Where:

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

Assumptions

Weighting of delamping quantities is based on historical program data.

Deemed Savings

Average Annual Deemed Savings for Linear Fluorescent Delamping

Measure	Commercial		Schools & Gov		Industrial		Agricultural		Multifamily	
	kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
Delamping T12 to T8 (4’)	192	0.040	167	0.033	244	0.040	242	0.035	306	0.040
Delamping T8 to T8	96	0.020	83	0.017	122	0.020	121	0.017	153	0.020
Delamping T12 to T8 (8’)	357	0.074	310	0.061	454	0.074	450	0.064	N/A	N/A

Average Lifecycle Deemed Savings for Linear Fluorescent Delamping

Measure	Commercial	Schools & Gov	Industrial	Agricultural	Multifamily
	kWh	kWh	kWh	kWh	kWh
Delamping T12 to T8 (4’)	1,920	1,670	2,440	2,420	3,060
Delamping T8 to T8	960	830	1,220	1,210	1,530
Delamping T12 to T8 (8’)	3,570	3,100	4,540	4,500	N/A

Sources

1. Wisconsin PSC EUL database, 2013.
2. State of Wisconsin Public Service Commission. *Business Programs: Measure Life Study*. Final Report. Evaluated by PA Consulting Group, Inc. August 25, 2009. Appendix B.
3. Focus on Energy Business Programs Deemed Savings Manual V1.0 March 22, 2010. Table 3.2 Lighting Hours of Use in Commercial Applications.
4. Focus on Energy Business Programs Deemed Savings Manual V1.0 March 22, 2010. Table 3.2 Coincidence Factor for Lighting in Commercial Applications.
5. ACES Deemed Savings Desk Review 11/03/10

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	01/02/2013	Revised Savings
02	Franklin Energy Services	04/19/2013	Adjusted Savings to Account Only for Delamping so Measure can be Paired With a HP or RW Measure.
03	Franklin Energy Services	04/25/2013	Adjusted Savings to Align Across all Sectors. Included all Sectors and Programs.

Exterior LED Replacing 250-Watt to 399-Watt HID

	Measure Details
Measure Master ID	Exterior LED Replacing 250-Watt to 399-Watt HID
Measure Unit	Per fixture
Measure Type	Prescriptive
Program(s)	Small Business
Sector(s)	Commercial, Schools & Government, Industrial, Agricultural
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)	11[1]
Important Comments	

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.

Description of Baseline Condition

The baseline condition is standard 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 with a total power reduction of 40% or more. Lamp-only replacements are not eligible for an incentive. LEDs must be on the qualifying list for the Design Lights Consortium.[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 = Annual hours-of-use (= 4,380)

Lifecycle Energy-Savings Algorithm

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

Where:

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

Assumptions

Calculations are based on exterior lighting that operates 4,380 hours annually, dusk to dawn.

LED lamps can achieve a 40% reduction in power requirements.

Deemed Savings

Average Annual Deemed Savings for Exterior LED Fixtures

Measure	kWh
EXT LED replacing 70-watt to 100-watt HID Average	317
EXT LED replacing 150-watt to 175-watt HID Average	534
EXT LED replacing 250-watt HID Average	808
EXT LED replacing 320-watt HID	820
EXT LED replacing 400-watt HID	1,123

Average Lifecycle Deemed Savings for Exterior LED Fixtures

Measure	kWh
EXT LED replacing 70-watt to 100-watt HID Average	3,804
EXT LED replacing 150-watt to 175-watt HID Average	6,408
EXT LED replacing 250-watt HID Average	9,696
EXT LED replacing 320-watt HID	9,840
EXT LED replacing 400-watt HID	13,476

Sources

6. Wisconsin PSC EUL database, 2013.
7. Based on market research
8. Design Lights Consortium Qualified Parts List

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	12/28/2012	New Measure

Exterior LED Fixtures – Replacement

	Measure Details
Measure Master ID	Exterior LED Fixtures - Replacement, 3099, 3102, 3105, 3106, 3107, 3108
Measure Unit	Fixture
Measure Type	Prescriptive
Program(s)	Business Incentives, Chains & Franchise, Large Energy Users, Small Business
Sector(s)	Commercial, Schools & Government, Industrial, Agricultural
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)	12[1]
Important Comments	See Excel Calculation: Exterior LED HID Replacement Fixtures Calculation_FES_BIP_CSF_LEU_01.01.13

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 replacement of 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 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 list for the Design Lights Consortium.[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 = Annual hours-of-use (= 4,380)

Wattages Used for Deemed Savings Calculations

Measure	$\text{Watts}_{\text{BASE}}$[5]	Watts_{EE}[4]
EXT LED replacing 70-watt to 100-watt HID Average	111.5	31
EXT LED replacing 150-watt to 175-watt HID Average	194.5	59
EXT LED replacing 250-watt HID Average	299	94
EXT LED replacing 320-watt HID	368	160
EXT LED replacing 400-watt HID	463	178

Lifecycle Energy-Savings Algorithm

$\text{kWh}_{\text{LIFETIME}} = \text{kWh}_{\text{SAVED}} * \text{EUL}$

Where:

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

Assumptions

Calculations are based on exterior lighting that operates 4,380 hours annually, 12 hours/day (dusk to dawn).

LED lamps can achieve a 40% reduction in power requirements.

Deemed Savings

Average Annual Deemed Savings for Exterior LED Fixtures

Measure	kWh	kW
EXT LED replacing 70-watt to 100-watt HID Average	344	0.000
EXT LED replacing 150-watt to 175-watt HID Average	594	0.000
EXT LED replacing 250-watt HID Average	870	0.000
EXT LED replacing 320-watt HID	859	0.000
EXT LED replacing 400-watt HID	1,215	0.000

Average Lifecycle Deemed Savings for Exterior LED Fixtures

Measure	kWh
EXT LED replacing 70-watt to 100-watt HID Average	4,131
EXT LED replacing 150-watt to 175-watt HID Average	7,127
EXT LED replacing 250-watt HID Average	10,438
EXT LED replacing 320-watt HID	10,312
EXT LED replacing 400-watt HID	14,575

Sources

1. Wisconsin PSC EUL database, 2013.
2. Based on market research.
3. Design Lights Consortium Qualified Products List

4. Focus on Energy Default Wattage Guide 2013, Version 1.0

5. More Excel calculations referenced on page 125

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	12/28/2012	New Measure

High Bay LED Fixtures

	Measure Details
Measure Master ID	High Bay LED Fixtures, 3091, 3092, 3093, 3094, 3095, 3096
Measure Unit	Fixture
Measure Type	Prescriptive
Program(s)	Business Incentives, Chains & Franchise, Large Energy Users, Small Business
Sector(s)	Commercial, Schools & Government, Industrial, Agricultural
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)	18[1]
Important Comments	See Excel Calculation: High Bay LED HID Replacement Fixtures Calculation_FES_BIP_CSF_LEU_01.01.13

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 list developed by the Design Lights Consortium. 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

$Watts_{BASE}$ = Electricity consumption of standard HID fixture (baseline)

Qty_{EE} = Quantity of LED fixture

$Watts_{EE}$ = Electricity consumption of LED fixture (efficient)

1,000 = Kilowatt conversion factor

HOU = Average annual run hours, see table below

Sector	HOU[2]
Agriculture	4,698
Commercial	3,730
Industrial	4,745
Schools & Government	3,239

Wattages Used for Deemed Savings Calculations

Measure	$Watts_{BASE}$	$Watts_{EE}$
HB LED High bay < 155 watts Replacing 250-watt HID	293	119
HB LED < 250 watts Replacing 400-watt HID	455	169
HB LED < 250 watts Replacing 320-watt to 400-watt PSMH NC (based on 320 watt savings)	356	169
HB LED < 365 watts Replacing 400-watt HID	455	296
HB LED < 800 watts Replacing 1,000-watt HID	1,079	690
HB LED < 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, see table below

Sector	CF[2]
Agriculture	0.67
Commercial	0.77
Industrial	0.77
Schools & Government	0.64

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 18 years)[1]

Assumptions

LED lamps are capable of achieving a 40% reduction in power requirements.

Annual and Lifecycle Deemed Savings

Average Annual Deemed Savings for High Bay LED Fixtures

Measure	Commercial		School & Gov		Industrial		Agricultural	
	kWh	kW	kWh	kW	kWh	kW	kWh	kW
HB LED High bay < 155 watts Replacing 250-watt HID	649	0.134	564	0.111	826	0.134	817	0.117
HB LED < 250 watts Replacing 400-watt HID	1,067	0.220	926	0.183	1,357	0.220	1,344	0.192
HB LED < 250 watts Replacing 320-watt to 400-watt PSMH NC (based on 320 watt savings)	698	0.144	606	0.120	887	0.144	879	0.125
HB LED < 365 watts Replacing 400-watt HID	593	0.122	515	0.102	754	0.122	747	0.107
HB LED < 800 watts Replacing 1,000-watt HID	1,451	0.300	1,260	0.249	1,846	0.300	1,828	0.261
HB LED < 500 watts Replacing 1,000-watt HID	2,160	0.446	1,875	0.371	2,747	0.446	2,720	0.388

Average Lifecycle Deemed Savings for High Bay LED Fixtures (kWh)

Measure	Commercial	School & Gov	Industrial	Agricultural
HB LED High bay < 155 watts Replacing 250-watt HID	11,682	10,145	14,861	14,714
HB LED < 250 watts Replacing 400-watt HID	19,202	16,674	24,427	24,185
HB LED < 250 watts Replacing 320-watt to 400-watt PSMH NC (based on 320 watt savings)	12,555	10,902	15,972	15,813
HB LED < 365 watts Replacing 400-watt HID	10,675	9,270	13,580	13,446
HB LED < 800 watts Replacing 1,000-watt HID	26,117	22,679	33,224	32,895
HB LED < 500 watts Replacing 1,000-watt HID	38,874	33,757	49,452	48,963

Sources

1. Design Lights Consortium *Qualified Parts List, Average* rated life of DLC-listed qualifying equipment.
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.
4. Focus on Energy Default Wattage Guide 2013. All values are based on pulse start metal halide (PSMH) fixtures.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	12/28/2012	New Measure

Horizontal LED Case Lighting

	Measure Details
Measure Master ID	Horizontal LED Case Lighting,3114
Measure Unit	Per Linear Foot
Measure Type	Prescriptive
Program(s)	Chains & Franchise, Business Incentives, Large Energy Users, Small Business
Sector(s)	Commercial, Industrial, Schools & Government, Agriculture
Annual Energy Savings (kWh)	55 per linear foot
Peak Demand Reduction (kW)	0.006 per linear foot
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	1,100 per linear foot
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Important Comments	See Horizontal LED Case Lighting, Calculation_FES_BIP_CSF_LEU_01.01.13

Measure Description

Horizontal LED case lighting will replace 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 assumed to be a mix of fluorescent T8 lamps, T12 lamps, and HOT12 lamps in a multideck refrigerated or freezer case.

Description of Efficient Condition

The efficient equipment to be installed are LED fixtures in a multideck refrigerated or freezer case.

Annual Energy-Savings Algorithm

$$\text{kWh}_{\text{SAVED}} = \left[P_E - P_P + \left(\frac{P_E * F_{FH} - P_P * F_{LH}}{COP_{COOLING}}\right)\right] * HOU$$

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%)

F_{LH} = LED lighting to heat factor (= 80%)

$COP_{COOLING}$ = Coefficient of performance of refrigeration system (= 2.22)

HOU = Annual operating hours (= 8,760)

Summer Coincident Peak Savings Algorithm

$$\mathrm{kW_{SAVED}} = \left[\mathrm{P_E} - \mathrm{P_P} + \left(\frac{\mathrm{P_E} * \mathrm{F_{FH}} - \mathrm{P_P} * \mathrm{F_{LH}}}{\mathrm{COP_{COOLING}}}\right)\right]$$

Lifecycle Energy-Savings Algorithm

$$\mathrm{kWh_{LIFETIME}} = \mathrm{kWh_{SAVED}} * \mathrm{EUL}$$

Where:

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

Assumptions

The deemed value of the existing fluorescent wattage 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.[2]

The deemed value for the LED replacement lamp is 6.29 watts per linear foot of multideck case, based on Design Lights Consortium qualifying products. The deemed wattage value was taken from specifications for a standard refrigeration multideck case with LED lighting.[1]

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.[3]

The deemed value for the LED lighting to heat factor is 80%, 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.[4] The deemed value of 80% is the midpoint of the range of the DOE EERE estimate.

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 a value of 2.22.[4]

The deemed annual operating hours is 8,760, the number of hours in a year.[4]

Sources

1. Wisconsin PSC EUL database, 2013.

2. Arthur D. Little, Inc. *Energy Savings Potential for Commercial Refrigeration Equipment – Final Report.* 1996. and Navigant Consulting, Inc. *Energy Savings Potential and R&D Opportunities for Commercial Refrigeration.* 2009.
3. 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
4. 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	Authored by	Date	Description of Change
01	Franklin Energy Services	01/22/2013	New Measure

LED Lamp Replacing Incandescent Lamp ≤ 40 Watts

	Measure Details
Measure Master ID	LED Lamp Replacing Incandescent Lamp ≤ 40 Watts, 3112
Measure Unit	Lamp
Measure Type	Prescriptive
Program(s)	Business Incentives, Chains & Franchise, Large Energy Users
Sector(s)	Commercial, Schools & Government, Industrial, Agricultural
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)	6[1]
Important Comments	See Excel Calculation: LED Lamp Replacing Incandescent Lamp less than 40 watts, Calculation_FES_BIP_CSF_LEU_01.01.13

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

Standard 25-watt and 40-watt incandescent lamps.

Description of Efficient Condition

Equipment must be an ENERGY STAR-rated LED lamp.

Annual and Lifecycle Deemed Savings

Average Annual Deemed Savings for LED Lamp Replacing Incandescent Lamp ≤ 40 Watts

Measure	Commercial		School & Gov		Industrial		Agricultural	
	kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED Lamps ENERGY STAR ≤ 40 Watts	100	0.021	87	0.017	127	0.021	126	0.018

Average Lifecycle Deemed Savings for LED Lamp Replacing Incandescent Lamp ≤ 40 Watts

Measure	Commercial	School & Gov	Industrial	Agricultural
	kWh	kWh	kWh	kWh
LED Lamps ENERGY STAR ≤ 40 Watts	601	522	765	757

Annual Energy-Savings Algorithm

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

Where:

$Watts_{BASE}$ = 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 = Average annual run hours, see table below

Sector	HOU[2]
Agriculture	4,698
Commercial	3,730
Industrial	4,745
Schools & Government	3,239

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor, see table below

Sector	CF[3]
Agriculture	0.67
Commercial	0.77
Industrial	0.77
Schools & Government	0.64

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 6 years)[1]

Assumptions

Assumes an average of 25-watt and 40-watt incandescent lamps in calculation of baseline usage.

Assumes that average ENERGY STAR-rated LED (5.64 watts average) for ≤ 40-watt replacement products.[2]

Sources

1. Cadmus research of manufacturer product life rating = ~25,000 hrs
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. Source for CF

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	12/27/2012	New Measure

LED Lamp Replacing Incandescent Lamp > 40 Watts

	Measure Details
Measure Master ID	LED Lamp Replacing Incandescent Lamp > 40 Watts, 3113
Measure Unit	Lamp
Measure Type	Prescriptive
Program(s)	Business Incentives, Chains & Franchise, Large Energy Users
Sector(s)	Commercial, Schools & Government, Industrial, Agricultural
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)	6[1]
Important Comments	See Excel Calculation: LED Lamp Replacing Incandescent Lamp greater than 40 watts, Calculation_FES_BIP_CSF_LEU_01.01.13

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

Standard 53-watt, 60-watt, 65-watt, 70-watt, 72-watt, and 80-watt incandescent lamps.

Description of Efficient Condition

Equipment must be an ENERGY STAR-rated LED lamp.

Annual and Lifecycle Deemed Savings

Average Annual Deemed Savings for LED Lamp Replacing Incandescent Lamp > 40 Watts

Measure	Commercial		School & Gov		Industrial		Agricultural	
	kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED Lamps ENERGY STAR > 40 Watts	191	0.039	166	0.033	243	0.039	241	0.034

Average Lifecycle Deemed Savings for LED Lamp Replacing Incandescent Lamp > 40 Watts

Measure	Commercial	School & Gov	Industrial	Agricultural
	kWh	kWh	kWh	kWh
LED Lamps ENERGY STAR > 40 Watts	1,147	996	1,460	1,445

Annual Energy-Savings Algorithm

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

Where:

$Watts_{BASE}$ = Power consumption of standard 53-watt, 60-watt, 65-watt, 70-watt, 72-watt, and 80-watt 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 = 15.4 Watts

HOU = Average annual run hours, see table below

Sector	HOU[2]
Agriculture	4,698
Commercial	3,730
Industrial	4,745
Schools & Government	3,239

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor, see table below

Sector	CF[3]
Agriculture	0.67
Commercial	0.77
Industrial	0.77
Schools & Government	0.64

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 6 years)[1]

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.[4]

An average of 20% each of 9, 11, 13, 18 & 20-watt ENERGY STAR-rated LED lamps was used to generate the new wattage.[4]

Sources

1. Multiple manufacturers product life rating = ~25,000 hrs
2. State of Wisconsin Public Service Commission. *Business Programs Deemed Savings Manual V1.0.* March 22, 2010.
3. Department of Energy, *ENERGY STAR Lighting Qualified Parts List.*
4. Based on market knowledge.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	12/26/2012	New Measure

LED, Replacing Neon Sign

	Measure Details
Measure Master ID	LED, Replacing Neon Sign, 3003, 3353
Measure Unit	Per Fixture (or per sign)
Measure Type	Prescriptive
Program(s)	Small Business
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]
Important Comments	

Measure Description

Theis measure is the installation of a new LED “open” sign to replace 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 depending on the size of the sign, but averages 10 feet. Electrical drive levels vary depending on the brightness, but neon tubing of this diameter typically operates at about 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 milliamperes. 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 in 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 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 base case for this measure is the 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

$Watts_{EE}$ = Wattage of LED sign with low voltage transformer = 20 Watts

1,000 = Kilowatt conversion factor

HOU = Annual hours of operation, estimated as a fraction of that listed in the Deemed Savings Manual (= 80% to account for when the facility is occupied but not open). See table below.

Sector	HOU[4]
Agriculture	80% of 4,698 = 3,758
Commercial	80% of 3,730 = 2,984
Industrial	80% of 4,745 = 3,796
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 agricultural, industrial, and commercial; = 0.59 for schools & government)

Lifecycle Energy-Savings Algorithm

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

Where:

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

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.

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 (in California) findings revealed a power factor of 0.41. In order for the grid to supply the power, the wattage draws of the neon signs must be the wattage draw 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 wattage is 189 to account for the varying real power requirements that are between 90 and 100 watts.

Deemed Savings

Sector	Agriculture	Commercial	Industrial	Schools & Government
Annual Energy Savings (kWh)	635	504	642	438
Peak Demand Reduction (kW)	0.169	0.169	0.169	0.100
Lifecycle Energy Savings (kWh)	9,527	7,564	9,623	6,568

Sources

1. Open sign manufacturers offer 10-yr warranty. Life most likely 15 yrs. Product doesn't have rating.Itron. *2004-2005 DEER Update Study Final Report.* Table 3-8, pg. 3-12. December 2005.
2. Pacific Gas & Electric. *Lighting Rebate Catalog and Application.* 2007. Retrieved February 2008. 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. U.S. Department of Energy. (n.d.). Save Energy, Money, and Prevent Pollution with Light-Emitting Diode (LED) Exit Signs.. Retrieved February 2008. Available online: http://www.energystar.gov/ia/business/small_business/led_exitsigns_techsheet.pdf.
4. GDS. *LED Open Signs*. Work Paper PGEPLTG018. August 20, 2009.

Revision History

Version Number	Authored by	Date	Description of Change
01	GDS	01/08/2013	New measure
02	GDS	02/18/2013	New measure

Bi-Level 4-Foot Two Lamp Linear Fluorescent and LED Stairwell Fixtures

	Measure Details
Measure Master ID	Bi-Level 4-Foot Two Lamp Linear Fluorescent and LED Stairwell Fixtures, 3097 (LED), 3117 (fluorescent)
Measure Unit	Fixture
Measure Type	Prescriptive
Program(s)	Business Incentives, Chains & Franchise, Large Energy Users
Sector(s)	Commercial, Schools & Government, Industrial, Agricultural
Annual Energy Savings (kWh)	Varies by lighting type
Peak Demand Reduction (kW)	Varies by lighting type
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by lighting type
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	Varies by lighting type[1]
Important Comments	LED and Linear Fluorescent Bi-Level Stairway Fixtures, Calculation_FES_BIP_CSF_LEU_01.01.13

Measure Description

Numerous existing facilities use 4-foot, two-lamp linear fluorescent fixtures to light stairwells and passageways. These fixtures commonly operate in full light output 24 hours per day. LED and linear fluorescent bi-level replacement products use ultrasonic and PIR sensors to adjust the light output to a safe but energy-conserving low light level when these spaces are unoccupied. These products save energy by more efficiently lighting the spaces based on occupancy.

Description of Baseline Condition

The baseline is 4-foot, two-lamp, T8 32-watt fixtures.

Description of Efficient Condition

The Design Lights Consortium listed LED bi-level stairwell and passageway fixtures with integrated occupancy controls, or bi-level linear fluorescent 4-foot, two-lamp HPT8/RWT8 products with integrated occupancy controls.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh/year_{BASE} – kWh/year_{EE}$

$kWh/year_{BASE} = Watts_{BASE} / 1{,}000 * HOU_{BASE}$

$kWh/year_{EE} = Watts_{EE} / 1{,}000 * HOU_{EE}$

Where:

$Watts_{BASE}$ = Annual electricity consumption of a standard 4-foot two lamp fixture

$Watts_{EE}$ = Annual electricity consumption of LED or linear fluorescent product

1,000 = Kilowatt conversion factor

HOU_{BASE} = Average annual run hours of baseline (= 8,760)

HOU_{EE} = Average annual run hours of efficient measure (= 4,380)

Wattages Used for Deemed Savings Calculations

Measure	$Watts_{BASE}$	$Watts_{EE}$
Bi-Level Linear Fluorescent Stairwell Fixtures	64	15
Bi-Level LED Stairwell Fixtures	64	5

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kW_{BASE} – kW_{EE}$

$kW_{BASE} = Watts_{BASE} / 1,000 * CF$

$kW_{EE} = Watts_{EE} / 1,000 * CF$

Where:

CF = Coincidence factor (= 0.77)[2]

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 6 years for linear fluorescent, = 15 years for LED)[1]

Annual and Lifetime Deemed Savings

Average Annual Deemed Savings for Linear Fluorescent and LED Stairwell Fixtures

Measure	kWh	kW
Bi-Level LED Stairwell Fixtures	539	0.045
Bi-Level Linear Fluorescent Stairwell Fixtures	495	0.038

Average Lifecycle Deemed Savings for Linear Fluorescent and LED Stairwell Fixtures

Measure	kWh
Bi-Level LED Stairwell Fixtures	7,425
Bi-Level Linear Fluorescent Stairwell Fixtures	3,234

Assumptions

Annual operating hours are 8,760 for existing baseline, with 50% projected occupancy (4,380 hours) for new efficient condition measure(s).

100% T8s were used to generate the baseline usage for LED and linear fluorescent fixtures.

The kW attributed to the LED option was based on the requirement that all LED options must be ≤ 55 watts, which is less than the existing baseline wattage; therefore, the LED option results in less kW savings.

Sources

1. Engineering Judgment

   Linear Fluorescent

   a. EnvirOasis. *Fluorescent Bi-Level Stairwell/Garage Fixture - Radial Wrap 2 T8 description.* Accessed 2013. Available online: http://www.enviroasis.com/fluorescent-bi-level-stairwell-garage-fixture-radial-wrap-2-t8/.

   b. Superior Lighting. *Motion Sensor Stairwell Lighting details*. Accessed 2013. Available online: http://www.superiorlighting.com/Motion_Sensor_Stairwell_Lighting_s/2444.htm.

   LED

   a. Bulbs.com. *30 Watt, Wall/Ceiling Mounted Stairwell LED Fixture details.* Accessed 2013. Available online: http://www.bulbs.com/espec.aspx?ID=19733.

   b. State of California Energy Commission. *Case Study: Bi-level Stairwell Lighting.* Pub # CEC-500-2005-141-A26. Available online: http://www.archenergy.com/lrp/products/brochures/deliverable_6.2.5_CaseStudy_5.1.pdf.

2. State of Wisconsin Public Service Commission. *Business Programs Deemed Savings Manual V1.0*. March 22, 2010.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	12/26/2012	New Measure

Interior, Exterior, Parking Garage - Reduced Wattage HID Direct Replacement Lamps

	Measure Details
Measure Master ID	Interior, Exterior, Parking Garage - Reduced Wattage HID, Interior: 3068, 3070, 3072, 3073, 3067 Exterior: 3040, 3039, 3038, 3037, 3036, 3069, 3071 Direct Replacement Lamps
Measure Unit	Lamp
Measure Type	Prescriptive
Program(s)	Business Incentives, Chains & Franchise, Large Energy Users
Sector(s)	Commercial, Schools & Government, Industrial, Agricultural
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)	4[1]

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 wattage HID lamp)

$Watts_{EE}$ = Wattage of efficient equipment (RW direct replacement HID lamp)

1,000 = Kilowatt conversion factor

HOU = Average annual run hours (= 4,380 for exterior and 8,760 for parking garages), see table below

Sector	HOU^2
Agriculture	4,698
Commercial	3,730
Industrial	4,745
Schools & Government	3,239

Wattages Used 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

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= 0.00 for exterior and 1.0 for parking garages), see table below

Sector	CF^2
Agriculture	0.67
Commercial	0.77
Industrial	0.77
Schools & Government	0.64

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 4 years)[1]

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 were:

- 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.

Deemed Savings

Average Annual Deemed Savings for Reduced Wattage HID Direct Replacement Lamps

Annual Savings	Commercial		School & Gov		Industrial		Agricultural	
Measure	kWh	kW	kWh	kW	kWh	kW	kWh	kW
Exterior RW HID Lamp 1,000-Watt Replacement	718	0.000	718	0.000	718	0	718	0.000
Interior HID Lamp 1,000-Watt Replacement	560	0.116	486	0.096	713	0	706	0.101
Exterior RW HID Lamp 400-Watt Replacement	278	0.000	278	0.000	278	0	278	0.000
Interior HID Lamp 400-Watt Replacement	217	0.045	189	0.037	276	0	274	0.039
Exterior RW HID Lamp 320-Watt Replacement	272	0.000	272	0.000	272	0	272	0.000
Interior HID Lamp 320-Watt Replacement	213	0.044	185	0.036	270	0	268	0.038
Exterior RW HID Lamp 250-Watt Replacement	202	0.000	202	0.000	202	0	202	0.000
PG HID Lamp 250-Watt Replacement	370	0.042	370	0.042	370	0	370	0.042
Interior HID Lamp 250-Watt Replacement	158	0.033	137	0.027	200	0	198	0.028
Exterior RW HID Lamp 175-Watt Replacement	158	0.000	158	0.000	158	0	158	0.000
PG HID Lamp 175-Watt Replacement	289	0.033	289	0.033	289	0	289	0.033
Interior HID Lamp 175-Watt Replacement	123	0.025	107	0.021	157	0	155	0.022

Average Lifecycle Deemed Savings for Reduced Wattage HID Direct Replacement Lamps

Lifecycle Savings (kWh)	Commercial	School & Gov	Industrial	Agricultural
Exterior RW HID Lamp 1,000-Watt Replacement	2,872	2,872	2,872	2,872
Interior HID Lamp 1,000-Watt Replacement	2,241	1,946	2,851	2,823
Exterior RW HID Lamp 400-Watt Replacement	1,114	1,114	1,114	1,114
Interior HID Lamp 400-Watt Replacement	869	755	1,106	1,095
Exterior RW HID Lamp 320-Watt Replacement	1,090	1,090	1,090	1,090
Interior HID Lamp 320-Watt Replacement	850	738	1,082	1,071
Exterior RW HID Lamp 250-Watt Replacement	808	808	808	808
PG HID Lamp 250-Watt Replacement	1,480	1,480	1,480	1,480
Interior HID Lamp 250-Watt Replacement	630	547	802	794
Exterior RW HID Lamp 175-Watt Replacement	631	631	631	631
PG HID Lamp 175-Watt Replacement	1,156	1,156	1,156	1,156
Interior HID Lamp 175-Watt Replacement	492	428	626	620

Sources

1. Multiple manufacturers’ product life rating ~20,000 hours.
2. State of Wisconsin Public Service Commission. *Business Programs Deemed Savings Manual V1.0.* March 22, 2010.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	12/28/2012	New Measure
02	Franklin Energy Services	04/19/2013	Proposed Fixture Wattage for 1,000-Watt Replacement Updated Based on Manufacturer Wattage Change (830 watts to 860 watts)

High Bay Fluorescent Lighting

	Measure Details
Measure Master ID	High Bay Fluorescent Lighting, 2890 2891 2884 2892 2893 2885 2886 2894 2895 2896 2897 2887 2888 2889
Measure Unit	Lamp
Measure Type	Prescriptive
Program(s)	Business Incentive, Chains& Franchise, Large Energy Users, Small Business
Sector(s)	Agriculture, 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)	14[1]
Important Comments	

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 deemed savings charts below.

Annual Energy-Savings Algorithm

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

Where:

$Watts_{BASE}$ = Watts of a HID lamp
$Watts_{EE}$ = Watts of HOT5 or HOT8 lamp (see deemed savings charts)

1,000 = Kilowatt conversion factor

HOU = Average annual run hours, see table below

Sector	HOU[2]
Agriculture	4,698
Commercial	3,730
Industrial	4,745
Schools & Government	3,239

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	1079	355
8L HOT5	1079	585
(2) 4L HOT5	1079	468
(2) 6L HOT5	1079	709
8L T8	1079	291
10L T8	1079	366
(2) 6L T8	1079	447

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor, see table below

Sector	CF[2]
Agriculture	0.67
Commercial	0.77
Industrial	0.77
Schools & Government	0.64

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 14 years)[1]

Deemed Savings

Annual Electric Savings (kWh/year/lamp removed)

Existing Wattage	New Fixture Type	Agricultural	Commercial	Industrial	Schools & Government
250 - 399 watts	2L HOT5	827	656	835	570
	3L HOT5	536	425	541	369
	4L T8	669	532	676	462
	4L HOT5	573	455	579	395
	6L T8	622	494	629	429
400 watts - 999 watts	4L HOT5	1,038	824	1,049	716
	6L HOT5	472	375	477	326
	6L T8	1,088	863	1,098	750
	8L T8	770	612	778	531
1,000 watts	6L HOT5	3,401	2,701	3,435	2,345
	8L HOT5	2,318	1,841	2,342	1,598
	(2) 4L HOT5	2,868	2,277	2,897	1,977
	(2) 6L HOT5	1,736	1,378	1,753	1,197
	8L T8	3,700	2,937	3,737	2,551
	10L T8	3,347	2,658	3,381	2,308
	(2) 6L T8	2,967	2,355	2,996	2,045

Summer Peak Savings (kW/lamp removed)

Existing Wattage	New Fixture Type	Agricultural	Commercial	Industrial	Schools & Government
250 – 399 watts	2L HOT5	0.118	0.136	0.136	0.113
	3L HOT5	0.076	0.088	0.088	0.073
	4L T8	0.095	0.110	0.110	0.091
	4L HOT5	0.082	0.094	0.094	0.078
	6L T8	0.089	0.102	0.102	0.085
400 watts - 999 watts	4L HOT5	0.148	0.170	0.170	0.141
	6L HOT5	0.067	0.077	0.077	0.064
	6L T8	0.155	0.178	0.178	0.148
	8L T8	0.110	0.126	0.126	0.105
1,000 watts	6L HOT5	0.485	0.557	0.557	0.463
	8L HOT5	0.331	0.380	0.380	0.316
	(2) 4L HOT5	0.409	0.470	0.470	0.391
	(2) 6L HOT5	0.248	0.285	0.285	0.236
	8L T8	0.528	0.606	0.606	0.504
	10L T8	0.477	0.549	0.549	0.456
	(2) 6L T8	0.423	0.486	0.486	0.404

Lifetime Savings (kWh)

Existing Wattage	New Fixture Type	Agricultural	Commercial	Industrial	Schools & Government
250 - 399 watts	2L HOT5	11,576	9,191	11,692	7,981
	3L HOT5	7,498	5,953	7,573	5,169
	4L T8	9,373	7,441	9,466	6,462
	4L HOT5	8,024	6,371	8,104	5,532
	6L T8	8,715	6,919	8,802	6,008
400 watts - 999 watts	4L HOT5	14,536	11,541	14,681	10,021
	6L HOT5	6,610	5,248	6,676	4,557
	6L T8	15,226	12,089	15,379	10,498
	8L T8	10,787	8,564	10,895	7,437
1,000 watts	6L HOT5	47,619	37,807	48,095	32,831
	8L HOT5	32,458	25,771	32,783	22,378
	(2) 4L HOT5	40,154	31,880	40,556	27,684
	(2) 6L HOT5	24,303	19,295	24,546	16,755
	8L T8	51,795	41,123	52,314	35,710
	10L T8	46,863	37,207	47,331	32,309
	(2) 6L T8	41,535	32,977	41,951	28,636

Sources

1. Wisconsin PSC EUL database, 2013.

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.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	12/31/2012	New Measure

DLC Listed 2x4 HELG Fixture

	Measure Details
Measure Master ID	DLC Listed 2x4 HELG Fixture, 3111
Measure Unit	Luminaire or Complete Retrofit Kit
Measure Type	Prescriptive
Program(s)	Business Incentives, Chains & Franchise, Large Energy Users, Small Business
Sector(s)	Commercial, Schools & Government, Industrial, Agricultural
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]
Important Comments	See Excel Calculation: DLC listed 2x4 HELG Fixture Calculation_FES_BIP_CSF_LEU_01.01.13

Measure Description

Using LED 2x4 troffers saves energy over 3-lamp or 4-lamp T8 products because they provide a similar lumen output but 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 a four-foot 3-lamp or 4-lamp T8 troffer in an existing building or new construction.

Description of Efficient Condition

The efficient condition is LED fixures that meet program requirements. Lamp only replacements are not eligible for on incentice. LED's must be on the qualified products list, Design Lights Consortium.Annual Energy-Savings Algorithm

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

Where:

$Watts_{BASE}$ = Wattage of 3- or 4-lamp T8 troffer luminaires = 115.5 Watts

$Watts_{EE}$ = Wattage of DLC listed 2x4 troffers that consume ≤ 55 watts and have ≥ 4,000 initial lumen output = 49 Watts

HOU = Average annual run hours, see table below

Sector	HOU[2]

Agriculture	4,698
Commercial	3,730
Industrial	4,745
Schools & Government	3,239

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor, see table below

Sector	CF[3]
Agriculture	0.67
Commercial	0.77
Industrial	0.77
Schools & Government	0.64

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 13 years)[1]

Assumptions

Baseline wattages were generated using 3-lamp troffers for 50% of the calculations and 4-lamp troffers for the remaining 50%.

Annual and Lifecycle Deemed Savings

Average Annual Deemed Savings for DLC-Listed 2x4 Troffers

Measure	Commercial		School & Gov		Industrial		Agricultural	
	kWh	kW	kWh	kW	kWh	kW	kWh	kW
DLC Listed HELG Fixtures	248	0.051	215	0.043	316	0.051	312	0.045

Average Lifecycle Deemed Savings for DLC-Listed 2x4 Troffers

Measure	Commercial	School & Gov	Industrial	Agricultural
	kWh	kWh	kWh	kWh
DLC Listed HELG Fixtures	3,225	2,800	4,102	4,061

Sources

1. Design Lights Consortium Qualified Parts List.
2. Focus on Energy Business Programs Deemed Savings Manual, Version 1.0, March 22, 2010. Table 3.2 Lighting Hours of Use in Commercial Applications.
3. Focus on Energy Business Programs Deemed Savings Manual, Version 1.0 ,March 22, 2010. Table 3.2 Coincidence Factor for Lighting in Commercial Applications.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	01/01/2013	New Measure

ECM Compressor Fan Motor

	Measure Details
Measure Master ID	ECM Compressor Fan Motor, 2306
Measure Unit	Per Motor
Measure Type	Prescriptive
Program(s)	Business Incentives, Large Energy Users
Sector(s)	Agriculture, Commercial, Industrial, and 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]
Important Comments	

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 shaded pole (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

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

Where:

$Watts_{BASE}$ = Wattage of the existing SP fan motor (average = 142)[2]

$Watts_{EE}$ = Wattage of the proposed motor (= 54)[2]

1,000 = Kilowatt conversion factor

HOU = Average annual run hours (= 4,500)[3]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{base} - Watts_{efficient})/1{,}000 * CF$

Where:

CF = Coincidence factor (= 0.90)

Lifecycle Energy-Savings Algorithm

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

Where:

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

Assumptions

A 50% SP motor and 50% PSC motor were assumed for the baseline.

Sources

1. Wisconsin PSC EUL database, 2013.
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.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	03/20/2012	Original
02	Franklin Energy Services	04/01/2013	Updates by PI

Evaporator Fan Motor Controls

	Measure Details
Measure Master ID	Install Controls on SP Type Motors, Install Controls on PSC Type Motors, Install Controls on ECM Type Motors,
Measure Unit	Per Fan Motor
Measure Type	Prescriptive
Program(s)	Business Incentives, Large Energy Users
Sector(s)	Commercial and Industrial
Annual Energy Savings (kWh)	Varies by type of motor
Peak Demand Reduction (kW)	Varies by type of motor
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by type of motor
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	16[1]
Important Comments	

Measure Description

Walk-in cooler and freezer refrigeration systems typically operate 24 hours per day, 365 days per year. These systems must run when the compressor is running to provide cooling, and they must run when the compressor is not running to provide air circulation, thus preventing the coil from freezing. The only time these fans do not operate is during the defrost cycle.

Significant energy savings can be realized by installing an evaporator fan control system, which regulates the speed of the evaporator fan motor to meet the need during each phase of the refrigeration cycle. Fan controller systems save energy in two ways: (1) the evaporator fans consume less energy, and (2) they result in less heat being introduced to the refrigerated chamber from the evaporator fan motors, which decreases the overall box load, thereby reducing the compressor/condenser on-duty cycle.

Description of Baseline Condition

The baseline condition is a refrigeration system without an evaporator fan controller. It is assumed that these fans run at constant speed for 8,578 hours per year.

Description of Efficient Condition

- Controls must be added to evaporator fan motors in walk-in coolers or freezers.
- Controls must sense the temperature of the walk-in equipment and regulate the fans based on the temperature reading.
- Evaporator fan motor controls can either be combined with an ECM upgrade or be installed on an existing system with an SP motor or PSC motor.
- The energy savings associated with the controls vary, depending on the fan motor installed.

- Requires number of fans and type of motor controlled by each sensor.
- This measure does not apply to condenser fan motors.
- If the motor type is unknown, the default savings values may be used.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = \Delta kW * HOU$

$$\Delta kW = \left((kWevap * \ nfans * \ DCevap) - kWcirc\right) * (1 - DCcomp) * \ BF$$

Where:

ΔkW = Demand savings

kWevap = Connected load kW of each evaporator fan (= 0.107 kW)[2,3,4]

nfans = Number of evaporator fans controlled

DCevap = Duty cycle of the evaporator fan (= 97%)[3,5]

kWcirc = Connected load kW of the circulating fan (0.035 kW)[3]

DCcomp = Duty cycle of the compressor (= 50%)[3]

BF = Bonus factor to account for a reduced cooling load on the compressor, thus refrigeration savings (= 1.4)[3,6]

HOU = Annual operating hours of fans (= 8,578)[1,7]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} \ / \ (8{,}760) * CF$

Where:

8,760 = Total annual operating hours of building

CF = Coincidence factor (= 1)

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 16 years)[1]

Deemed Savings

Motor Type	Annual Energy Savings (kWh)	Peak Demand Savings (kW)	Lifetime Energy Savings (kWh)
Shaded Pole (SP)	553	0.063	2,763
Permanent Split Capacitor (PSC)	299	0.034	1,495
Electronically Commutated Motor (ECM)	138	0.016	688
Weighted Average	427	0.049	2,134

Sources

1. Wisconsin PSC EUL database, 2013.
2. This is based on a weighted average of evaporator fan types: 60% SP, 25% PSC, and 15% ECM. It is assumed that the average fan size is 1/15 HP and that the rated wattages for the fan types are these: SP = 132, PSC = 88, and ECM = 60.
3. Efficiency Maine Commercial Technical Reference Manual, Version 2013.1, January 1, 2013, pg. 67.
4. Regional Technical Forum Evaporator Fan Controls and Evaporator Fan Uniform Energy Savings measures calculations, 2010.
5. The assumption is that the application of this measure would occur 50% of the time in a cooler and 50% of the time in a freezer. The associated duty cycle assumed for coolers is 100% and for freezers is 100% and 94%.
6. The assumption is that the application of this measure would occur 50% of the time in a cooler and 50% of the time in a freezer. The assumed bonus factor for coolers is 1.3 and for freezers is 1.5.
7. The assumption is that the application of this measure would occur 50% of the time in a cooler and 50% of the time in a freezer. The assumed number of operating hours for coolers is 8,760 per year and for freezers is 8,273 per year (with for 4 x 20-minute defrost cycles per day).

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	04/26/2012	Original
02	Franklin Energy Services	04/01/2013	Updates by the PI

Residential—Mass Markets

The Mass Markets Portfolio delivers cost-effective energy efficiency and renewable energy programs to Wisconsin's residential energy sector. Through these programs, Focus on Energy provides information, incentives, and implementation support to help residential customers access energy-efficient technologies that help them 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 Mass Markets portfolio for 2014 includes 11 programs that Focus on Energy designed to help different types of residential customers access these technologies, using different approaches to outreach and financial support.

All types of residential homeowners can take advantage of the **Residential Lighting and Appliance Program**, in which they can receive in-store discounts that reduce the initial cost for high-efficiency CFLs and LEDs, washing machines, and showerheads.

Residential customers that live in single-family homes[3] can participate in the following programs that offer incentives for different types of energy-saving measures:

- The **Express Energy Efficiency Program** provides a quick assessment of the home's energy use as well as free direct installation of CFLs, low-flow showerheads, and other energy-saving measures.
- The **Appliance Recycling Program** offers a financial incentive for residents to recycle old refrigerators and freezers, as well as free pickup and disposal.
- The **Residential Rewards Program** offers incentives for customers to install energy-efficient furnaces, water heaters, and other heating equipment.
- The **Home Performance with ENERGY STAR® Program** offers comprehensive energy audits and incentives for whole-house energy-savings measures, such as insulation and air sealing.
- The **Enhanced Rewards Program** and **Assisted Home Performance with ENERGY STAR Program** offer enhanced incentives for income-qualified participants.
- The **Renewable Energy Program** connects customers with experts that help them determine whether their property could effectively support a renewable system, and offers financial incentives for customers who proceed to install these systems.

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[3] This includes single-family detached homes, mobile homes, and single-family attached homes with three or fewer units.

Owners, managers, and residents of multifamily buildings (such as apartments and condominiums) are served through two related programs.

1. The **Multifamily Direct Install Program** offers free installation of CFLs, low-flow showerheads, and other energy-savings measures in tenant units, as well as walk-through assessments of the whole building.
2. Those assessments can identify additional incentives that property owners and managers can take advantage of through the **Multifamily Energy Savings Program**, which provides information, financial incentives, and implementation support to install measures in resident units and common areas.

Residential customers who are building a new home can receive assistance through the **New Homes Program**, in which Focus on Energy works with owners, builders, and energy experts to construct homes that are more energy efficient than required by Wisconsin building codes.

Boiler, Hot Water, Near Condensing, ≥ 85% AFUE, 300-1,000 MBh

	Measure Details
Measure Master ID	Boiler, Hot Water, Near Condensing, ≥ 85% AFUE, 300-1,000 MBh, 3277
Measure Unit	Boiler
Measure Type	Prescriptive
Program(s)	Multifamily Energy Savings
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by boiler type
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	Varies by boiler type
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Important Comments	The analysis assumes residential furnaces are operated similarly to this type of large, multi-family boiler (i.e. both measures use EFLH based on single unitary residential furnace data).

Measure Description

This measure is the installation of a near-condensing, mid-efficiency hot water boiler with a TE ≥ 87% and an MBh between 300 and 1,000. Mid-efficiency boilers take advantage of modern technology but do not allow for return water temperatures that are low enough to condense. These boilers are typically used in applications where high efficiency sealed combustion, condensing, and modulating (HESCCM) boilers cannot be vented or where they will not have low enough return water temperatures to condense. Mid-efficiency boilers can also be larger than HESCCM boilers, and are therefore used in large boiler plants.

Description of Baseline Condition

Replace on Fail – 80% AFUE

- TE = 80% for hot water boilers[2]
- TE = 79% for steam boilers[2]

Description of Efficient Condition

The efficient condition for a mid-efficiency boiler is:

- TE ≥ 87% for hot water boilers
- TE ≥ 83% for steam boilers
- Capable of modulating the firing rate
- Forced draft (steam boilers)
- < 500 MBh, low/high/low burner (steam boilers)

- > 500 MBh, fully modulating burner (steam boilers)
- Redundant or backup boilers do not qualify

Annual Energy-Savings Algorithm

$\text{Therms}_{\text{SAVED}} = \text{BC} * \text{EFLH} * (1\text{-}\text{EFF}_{\text{BASELINE}} / \text{EFF}_{\text{EE}}) / 100$

Where:

BC = Boiler Input Capacity (= Actual or 373 MBh[4])

EFLH = 1,759 hours[5]

$\text{EFF}_{\text{BASELINE}}$ = TE of the baseline measure (= 80% for hot water boilers, = 79% for steam boilers)[2]

EFF_{EE} = TE of the efficient measure (= 87% for hot water boilers, = 83% for steam boilers)

100 = Conversion factor from MBtu to therms

Lifecycle Energy-Savings Algorithm

$\text{Therms}_{\text{LIFETIME}} = \text{Therms}_{\text{SAVED}} * \text{EUL}$

Where:

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

Sources

1. Wisconsin PSC EUL database, 2013.
2. Code of Federal Regulations Energy Efficiency Standards, Title 10 Part 431 Section 87
3. DEER Database
4. Average boiler size of boilers tuned and cleaned in the ACES program 2008-2010
5. Full load hours for all residential gas measures are estimated from characterization study of Wisconsin homes (Pigg and Nevius, 2000. Online: http://www.doa.state.wi.us/docview.asp?docid=1812) with average furnace size from SPECTRUM database. Wisconsin study found 800 therms consumed by 90% AFUE furnaces (i.e. 720 therms output). With average furnace size of 72,000 BTU (13,000 furnaces from Focus Prescriptive 2012 database), 1,000 full load heating hours are estimated.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	10/29/2012	Initial Draft
02	Shaw Group	01/08/2013	Updated to New Template
03	Franklin Energy Services	03/15/2013	PI Comments and Calculation Uploaded

High-Efficiency Space Heating Boiler

	Measure Details
Measure Master ID	High-Efficiency Space Heating Boiler, 1982 (tier 1) and 1983 (tier 2) High-Efficiency Space Heating Boiler, 1978
Measure Unit	Per Boiler
Measure Type	Prescriptive
Program(s)	Residential Rewards, Enhanced Rewards
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by efficiency
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	Varies by efficiency
Effective Useful Life (years)	20[1]
Important Comments	The analysis assumes residential furnaces are operated similarly to this type of large, multi-family boiler (i.e. both measures use EFLH based on single unitary residential furnace data).

Measure Description

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 qualifying space heating boilers must meet the qualifications listed in the table below.

Type	Input Rating	Required Efficiency
90% Efficient Boiler	≤ 300 Mbtuh	AFUE ≥ 90%
95% Efficient Boiler	≤ 300 Mbtuh	AFUE ≥ 95%

Description of Baseline Condition

The baseline equipment is a hot water boiler with 82% AFUE.

Description of Efficient Condition

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. Energy-efficient units 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

$$Therms_{SAVED} = BC * EFLH * (1 - EFF_{BASELINE} / EFF_{EE}) / 100$$

Where:

BC = Boiler Capacity (= 110 MBh[2])

EFLH = 1000 hours[3]

$EFF_{BASELINE}$ = AFUE of baseline measure (= 82%)

EFF_{EE} = AFUE of efficient measure (either 90% or 95%)

100 = Conversion factor from MBtu to therms

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Deemed Savings Values per MBh Input

	Annual Therms Savings	Lifecycle Therms Savings
Tier 1 Savings	98	1,956
Tier 2 Savings	151	3,011

Sources

1. Wisconsin PSC EUL database, 2013.
2. Average input caacity of boilers under 300 Mbh in the 2013 SPECTRUM Database.
3. Full load hours for all residential gas measures are estimated from characterization study of Wisconsin homes (Pigg and Nevius, 2000. Online: http://www.ecw.org/sites/default/files/230-1.pdf) with average furnace size from SPECTRUM database. Wisconsin study found 800 therms consumed by 90% AFUE furnaces (i.e. 720 therms output). With average furnace size of 72,000 BTU, (13,000 furnaces from Focus Prescriptive 2012 database) 1,000 full load heating hours are estimated.

Revision History

Version Number	Authored by	Date	Description of Change
01	RSG	03/05/2012	Original
02	RSG	11/06/2012	Updated Memo
03	RSG	02/20/2013	Reviewed & Revised for Formatting

Hot Water Boiler, 90%+ AFUE

	Measure Details
Measure Master ID	Hot Water Boiler, 90%+ AFUE, 1978
Measure Unit	Per Boiler
Measure Type	Prescriptive
Program(s)	
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by timing
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	Varies by timing
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Important Comments	The analysis assumes residential furnaces are operated similarly to this type of single family boiler (i.e. both measures use EFLH based on single unitary residential furnace data).

Measure Description

Space heating boilers are pressure vessels that transfer heat to water for use primarily in space heating applications. Boilers 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 being connected to the boiler. Energy-efficient units often feature high-efficiency and/or low-Nox burners, and typically have features such as forced air burners and relatively large heat exchange surfaces, and/or they use heat recovery from stack gases.

This measure is applicable to any residential boiler used for space heating, and is not applicable to boilers used for process end uses, DHW, pools, or spas.

Description of Baseline Condition

EPCA sets energy conservation standards for residential furnaces and boilers (42 U.S.C. 6291-6309).[2] EISA prescribes additional standards for residential boilers.[3]

The baseline efficiency is the minimum standard efficiency required by EPCA, which was prescribed as 80% AFUE, but was shifted to 82% AFUE from manufacturing criteria in September 2012. This baseline increase started impacting the market in May 2013. The table below lists the base case efficiencies as stated by EPCA and EISA 2007.

Measure	Base Efficiency
Space Heating Boilers (Before May 2013)	AFUE = 80%
Space Heating Boilers (After May 2013)	AFUE = 82%

Description of Efficient Condition

Space heating boilers are pressure vessels that transfer heat to water for use primarily in space heating applications. Boilers 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. Energy-efficient units often feature high-efficiency and/or low-NOx burners, and typically have features such as forced air burners and relatively large heat exchange surfaces, and/or they use heat recovery from stack gases. The qualifying space heating boilers must meet the qualifications listed in the table below.

Measure	Input Rating	Required Efficiency
90% Efficient Boiler	≤ 300 MBtuh	AFUE ≥ 90%

Annual Energy-Savings Algorithm

$\text{Therms}_{\text{SAVED}} = \text{BC} * \text{EFLH} * (1\text{-EFF}_{\text{BASELINE}} / \text{EFF}_{\text{EE}}) / 100)$

Where:

BC = Boiler capacity rating (actual) (= 110 MBth[4])

EFLH = 1000 hours[5]

$\text{EFF}_{\text{BASELINE}}$ = AFUE of baseline measure (= 80% for units manufactured before September 1, 2012; = 82% for units manufactured after September 1, 2012)

EFF_{EE} = AFUE of efficient measure (= 90%)

100 = Conversion factor from MBtus to therms

Lifecycle Energy-Savings Algorithm

$\text{Therms}_{\text{LIFETIME}} = \text{Therms}_{\text{SAVED}} * \text{EUL}$

Where:

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

Deemed Savings

Savings for Hot Water Boiler With 90% AFUE

	Unit Manufactured Before September 1, 2012	Unit Manufactured After September 1, 2012
Annual Therm Savings	122	98
Lifecycle Therm Savings	2,444	1,956

Sources

1. Wisconsin PSC EUL database, 2013.
2. 42 U.S.C. 6291-6309. http://www1.eere.energy.gov/buildings/appliance_standards/residential/furnaces_boilers.html
3. EISA 2007, Pub. L. 110-140.
4. Average input capacity of boilers under 300 Mbh in the 2013 SPECTRUM Database.
5. Full load hours for all residential gas measures are estimated from characterization study of Wisconsin homes (Pigg and Nevius, 2000. Online: http://www.ecw.org/sites/default/files/230-1.pdf) with average furnace size from SPECTRUM database. Wisconsin study found 800 therms consumed by 90% AFUE furnaces (i.e. 720 therms output). With average furnace size of 72,000 BTU, (13,000 furnaces from Focus Prescriptive 2012 database) 1,000 full load heating hours are estimated.

Revision History

Version Number	Authored by	Date	Description of Change
01	RSG	03/05/2012	Original
02	RSG	02/29/2013	Reviewed and Revised for Formatting

Boiler Control – Outside Air Temperature Reset/Cutout Control – Prescriptive

	Measure Details
Measure Master ID	Boiler Control – Outside Air Temperature Reset/Cutout Control – Prescriptive, 2221
Measure Unit	Boiler
Measure Type	Prescriptive
Program(s)	Multifamily Energy Savings
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	603
Lifecycle Energy Savings (kWh)	0.00
Lifecycle Therm Savings (Therms)	3,017
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Important Comments	The analysis assumes residential furnaces are operated similarly to this type of large, multi-family boiler (i.e. both measures use EFLH based on single unitary residential furnace data).

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 setpoint to prevent overheating.

Description of Baseline Condition

The baseline condition is no input/output reset.

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 degrees 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

$\text{Therms}_{\text{SAVED}}$ = BC * EFLH / (Eff * 100) * SF

Where:

BC = Boiler Capacity (= 373 MBh)[2]

EFLH = 1,759 hours[4]

SF = Savings factor (= 8%)[3]

Eff = Combustion efficiency of the boiler (= 87%)

100 = Conversion factor from therm to MBtu

Lifecycle Energy-Savings Algorithm

$\text{Therms/MBh}_{\text{LIFETIME}} = \text{Therms}_{\text{SAVED}} * \text{EUL}$

Where:

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

Sources

1. Wisconsin PSC EUL database, 2013.
2. Average boiler size of boilers tuned and cleaned in the ACES program 2008-2010
3. Michigan Energy Measures Database. Available online: http://www.michigan.gov/mpsc/0,1607,7-159-52495_55129---,00.html.
4. Full load hours for all residential gas measures are estimated from characterization study of Wisconsin homes (Pigg and Nevius, 2000. Online: http://www.doa.state.wi.us/docview.asp?docid=1812) with average furnace size from SPECTRUM database. Wisconsin study found 800 therms consumed by 90% AFUE furnaces (i.e. 720 therms output). With average furnace size of 72,000 BTU (13,000 furnaces from Focus Prescriptive 2012 database) 1,000 full load heating hours are estimated.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	10/25/2012	Initial Draft
02	Shaw Group	01/07/2012	Updated to New Template
03	Franklin Energy Services	03/21/2013	Comments

Natural Gas Boiler Tune-Up

	Measure Details
Measure Master ID	Natural Gas Boiler Tune-Up, 2744
Measure Unit	Unit
Measure Type	Prescriptive
Program(s)	Multifamily Energy Savings
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]

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/hr. The incentive is available once in a 24-month period. The service provider must perform before and after combustion efficiency tests and records 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

$\text{Therms}_{\text{SAVED}}$= 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/hr)[3]

Lifecycle Energy-Savings Algorithm

$\text{Therms}_{\text{LIFETIME}} = \text{Therms}_{\text{SAVED}} * \text{EUL}$

Where:

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

Sources

1. Wisconsin PSC EUL database, 2013.
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

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	??	Initial Draft
02	Franklin Energy Services	03/08/13	Updated by PI

Natural Gas Boiler with DHW (Boiler = 90%+ AFUE)

	Measure Details
Measure Master ID	Natural Gas Boiler With DHW (Boiler = 90%+ AFUE) – Custom
Measure Unit	
Measure Type	Custom
Program(s)	
Sector(s)	Residential
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Calculated
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	Calculated
Water Savings (gal/yr)	0
Effective Useful Life (years)	Varies by measure[1]
Important Comments	

Measure Description

High efficiency sealed combustion, condensing, and modulating (HESCCM) boilers operate by taking advantage of condensation to lower energy consumption. Condensing boilers are designed to capture the latent heat of water vapor condensation in the exhaust stream, which in turn 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.

These HESCCM boilers can be paired with an indirect storage tank, which is an insulated storage tank with a hot water coil.

Description of Baseline Condition

Replacement of an existing boiler and water heater is 82% AFUE boiler and DHW.

Description of Efficient Condition

The efficient condition is a boiler AFUE of 90% or greater. The boiler must have a sealed combustion unit and be capable of modulating the firing rate. The new indirect storage tank replaces a standalone storage-type water heater. Redundant or backup boilers do not qualify.

Annual Energy-Savings Algorithm

$\text{Therms}_{\text{SAVED}} = \text{Therms}_{\text{SAVED FROM BOILER}} + \text{Therms}_{\text{SAVED FROM TANK}}$

$$\text{Therms}_{\text{SAVED FROM BOILER}} = BC * EFLH * \left(1 - \frac{\text{AFUE}_{\text{BASELINE}}}{\text{AFUE}_{\text{EE}}}\right)$$

$$\text{Therms}_{\text{SAVED FROM TANK}} = \frac{\text{GPD}*365*8.33*\Delta\overline{\text{T}}_{\text{W}}}{100{,}000} * \left[\frac{1}{\text{RE}_{\text{BASELINE}}} - \frac{1}{\text{E}_{\text{C,EE}}}\right] + \left[\frac{\text{UA}_{\text{BASELINE}}}{\text{RE}_{\text{BASELINE}}} - \frac{\text{UA}_{\text{EE}}}{\text{E}_{\text{C,EE}}}\right] * \frac{\Delta\text{T}_{\text{S}}*8{,}760}{100{,}000}$$

Where:

$\text{Therms}_{\text{SAVED FROM BOILER}}$ = Annual savings from the installation of a more efficient boiler

$\text{Therms}_{\text{SAVED FROM TANK}}$= Annual savings from the installation of a new indirect water heater

BC = Boiler input capacity (= 110 MBh[3])

EFLH = 1759 hours[7]

$\text{AFUE}_{\text{BASELINE}}$ = Annual fuel utilization efficiency of baseline measure (= 82%)

AFUE_{EE} = Annual fuel utilization efficiency of efficient measure (= 90%)

GPD = Average water consumption, gallons per day (= 51.5 gallons)

$\Delta\overline{T}_w$ = Average difference between the cold water inlet temperature (52.3°F) and the hot water delivery temperature (125°F) (=72.7°F)

$\text{RE}_{\text{BASELINE}}$ = Recovery efficiency of the baseline tank type water heater(= 76%)[4]

$\text{E}_{\text{C,EE}}$ = Combustion efficiency of energy efficient boiler used to heat indirect water heater (= 90%)[5]

$\text{UA}_{\text{BASELINE}}$ = Overall heat loss coefficient of base tank type water heater (= 14)[6]

UA_{EE} = Overall heat loss coefficient of indirect water heater storage tank (= 6.1)[7]

ΔT = Temperature difference between desired indoor heating setpoint (65°F) and outside winter design temperature (-15°F) (= 80°F)

ΔT_s = Temperature difference between the stored hot water temperature (13°F) and the ambient indoor temperature (70°F) (= 57°F)

365 = Conversion factor, days/yr

8.33 = Conversion factor, 8.33 density of water in lbs/gal (x) 1.0 specific heat capacity of water in Btu/lb °F, (Btu/gallon/°F)

8,760 = Conversion factor, hours/yr

100,000 = Conversion factor, Btu/therm

Typical values for UA_{base} are:[2,8]

Water Heater Type	Standby Heat Loss Coefficient (UA) (Btu/hr-°F)
Electric	3.64
Natural Gas	13.99
Oil	14.49

Typical values for UA_{ee} are:[8]

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

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 15 years for indirect water heater and = 20 years for boiler)[1]

Assumptions

It is assumed that the existing water heater is a standalone gas storage water heater with a recovery efficiency of 76%.

Deemed Savings

	Annual Therm Savings	Lifecycle Therm Savings
Water Heater Savings	79	1,178
Boiler Savings	98	1,956
Total Savings	**177**	**3,134***

* This total includes a normalized EUL.

Sources

1. State of Wisconsin Public Service Commission. Business Programs: Measure Life Study. Final Report. Evaluated by PA Consulting Group, Inc. August 25, 2009.
2. United States Department of Energy. Technical Support Document: Energy Efficiency Standards for Consumer Products: Residential Water Heaters, Including Regulatory Impact Analysis. 2000.
3. Average input capacity of boilers under 300 Mbh in the 2013 SPECTRUM Database.
4. Most common RE for non-heat pump water heaters: http://www.ahridirectory.org/ahridirectory/pages/rwh/defaultSearch.aspx
5. Assumed the combustion efficiency is a proxy for AFUE, where the program minimum is 90% AFUE.

6. United States Department of Energy. Technical Support Document: Energy Efficiency Standards for Consumer Products, Residential Water Heaters, Including Regulatory Impact Analysis. 2000.
7. Full load hours for all residential gas measures are estimated from characterization study of Wisconsin homes (Pigg and Nevius, 2000. Online: http://www.doa.state.wi.us/docview.asp?docid=1812) with average furnace size from SPECTRUM database. Wisconsin study found 800 therms consumed by 90% AFUE furnaces (i.e. 720 therms output). With average furnace size of 72,000 BTU, (13,000 furnaces from Focus Prescriptive 2012 database) 1,000 full load heating hours are estimated
8. *New York Technical Reference Manual*. Indirect Water Heaters, pg. 87. 2010.

Revision History

Version Number	Authored by	Date	Description of Change

Natural Gas Boilers (≤ 300 MBh) 90%+ AFUE

	Measure Details
Measure Master ID	Natural Gas Boilers (≤ 300 MBh) 90%+ AFUE, 2747
Measure Unit	Boiler
Measure Type	Hybrid
Program(s)	Multifamily Energy Savings
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	583
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	11,664
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Important Comments	Natural Gas Boilers (≤ 300 MBh), Calculation_FES_MESP_01.01.13

Measure Description

High efficiency sealed combustion, condensing, and modulating (HESCCM) 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 90%+[3] AFUE boiler 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.

$$\text{Therms}_{\text{SAVED}} = \text{BC} * \text{EFLH} * (1\text{-EFF}_{\text{BASELINE}}/\text{EFF}_{\text{EE}}) / 100)$$

Where:

BC = Boiler Capacity (= Actual or 373 MBh)[4]

EFLH = 1759 hours[5]

$EFF_{BASELINE}$ = AFUE of baseline measure (=82%)

EFF_{EE} = AFUE of efficient measure (=90%)

100 = Conversion factor from MBtu to therms

Lifecycle Energy-Savings Algorithm

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

Where:

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

Assumptions

Boiler baseline efficiency is based on the EISA requirements of 82%.

Sources

1. Focus on Energy EUL Database 2013.
2. Annual Fuel Utilization Efficiency, as determined in section 10 CFR 430.23(n)(2). http://www.regulations.gov/#!documentDetail;D=EERE-2006-STD-0102-0009.
3. State of Wisconsin Public Service Commission. *Business Programs: Measure Life Study*. Final Report. Evaluated by PA Consulting Group Inc. August 25, 2009.
4. Average boiler size of boilers tuned and cleaned in the ACES program 2008-2010

   Full load hours for all residential gas measures are estimated from characterization study of Wisconsin homes (Pigg and Nevius, 2000. Online: http://www.doa.state.wi.us/docview.asp?docid=1812) with average furnace size from SPECTRUM database. Wisconsin study found 800 therms consumed by 90% AFUE furnaces (i.e. 720 therms output). With average furnace size of 72,000 BTU, (13,000 furnaces from Focus Prescriptive 2012 database) 1,000 full load heating hours are estimated

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	01/02/2013	Updated Baseline Efficiency From 80% to 82%

Building Envelope, Not Otherwise Specified

	Measure Details
Measure Master ID	Building Envelope, Not Otherwise Specified, 2229
Measure Unit	Custom
Measure Type	Custom
Program(s)	Multifamily Energy Savings
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by weather, HVAC efficiency, envelope thermal resistance, and solar gain
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by weather, HVAC efficiency, envelope thermal resistance, and solar gain
Lifecycle Energy Savings (kWh)	Varies by weather, HVAC efficiency, envelope thermal resistance, and solar gain
Lifecycle Therm Savings (Therms)	Varies by weather, HVAC efficiency, envelope thermal resistance, and solar gain
Water Savings (gal/yr)	0
Effective Useful Life (years)	25[1]
Important Comments	

Measure Description

This measure is improvements to the building shell or building envelope of a facility, which results in higher thermal insulation values and/or reduced levels of unwanted airflow (infiltration or exfiltration). This measure includes any envelope upgrade to the insulation or air tightness of a building.

Description of Baseline Condition

The baseline condition is the Wisconsin State standard code. For early replacement, the calculations use the existing R-value.

Description of Efficient Condition

The efficient condition is a decreased heating and cooling load through the building shell because of an increased R-value.

Annual Energy-Savings Algorithm

Annual energy savings are calculated using an appropriate energy simulation that includes, at a minimum:

- Local weather conditions,
- HVAC efficiency,
- Envelope thermal resistance, and
- Solar gain.

Software can include REM/Rate, TREAT, BeOPT, DOE2, or Energy+. Ideally, the calculations are performed by a HERS rater, BPI-accredited professional or engineer.

Summer Coincident Peak Savings Algorithm

Summer coincidence peak savings are calculated using an appropriate energy simulation that includes, at a minimum:

- Local weather conditions,
- HVAC efficiency,
- Envelope thermal resistance, and
- Solar gain.

Software can include REM/Rate, TREAT, BeOPT, DOE2, or Energy+. Ideally, the calculations are performed by a HERS rater, BPI-accredited professional, or engineer.

Lifecycle Energy-Savings Algorithm

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

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

Where:

EUL = Effective useful life (= 25 years)[1]

Sources

1. Wisconsin PSC EUL database, 2013.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	10/25/2012	Original Draft
02	Franklin Energy Services	03/08/2013	Comments

Cooling System Tune-Up

	Measure Details
Measure Master ID	Chiller System Tune Up, Air Cooled, ≤ 500 Tons, 2666 Chiller System Tune Up, Air Cooled, > 500 Tons, 2667 Chiller System Tune Up, Water Cooled, ≤ 500 Tons, 2668 Chiller System Tune Up, Water Cooled, > 500 Tons, 2669
Measure Unit	Ton
Measure Type	Prescriptive
Program(s)	Multifamily Energy Savings
Sector(s)	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]
Important Comments	

Measure Description

The chiller system tune-up for air and water cooled chillers must be 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
- Condenser fan amp draw
- 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

Chiller system tune-ups are conducted to ensure that equipment is operating at its best and as preventative maintenance in order to extend the life of the equipment. Tune-ups improve the chiller’s efficiency and performance and are useful system checks to ensure that regular maintenance keeps the equipment operating as specified.

Annual Energy-Savings Algorithm

Because existing chiller efficiency cannot be determined without extensive testing, ASHRAE 90.1-2007[3] minimum efficiency for chillers will be 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
Water Cooled, Electrically Operated, Positive Displacement (Rotary Screw and Scroll)	≥ 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
Water Cooled, Electrically Operated, Centrifugal	≥ 150 tons and < 300 tons	5.55 COP; 5.90 IPLV
Water Cooled, Electrically Operated, Centrifugal	≥ 300 tons	6.10 COP; 6.40 IPLV

The annual energy and demand savings are calculated by applying a percent savings to the baseline consumption. Parametric runs were applied to estimate a deemed savings for this measure.

Existing Equipment as a Baseline:

$kWh_{SAVED} = (IPLV_{Baseline\ Existing})$ * ton-hours * % savings

Where:

$IPLV_{Baseline\ Existing}$ = Integrated part load value of baseline chiller (ASHRAE 90.1-2007)

Ton-hours = Determined from weather bin hours and building design cooling load, (~1,440)

% savings = Percent 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 (ASHRAE 90.1-2007)

% savings = Percent savings associated with a chiller tune-up (= 5%)

CF = Coincidence factor (= 0.8)

Tons = Full load tons of chiller (Varies between 50 and 300 depending on type. Average Air Cooled 100, average Water Cooled, 200)

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

	Measure	
	Air Cooled	Water Cooled
Average Annual Deemed Savings (kWh/yr/ton)	83	44
Peak Demand Reduction (kW/ton)	0.054	0.030
Average Lifecycle Deemed Savings (kWh/yr/ton)	415	218

Sources

1. Wisconsin PSC EUL database, 2013.
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 measure associated with this cooling tune-up measure, reduces annual cooling energy consumption by 5-7%.
3. ASHRAE 90.1-2007 air cooled and water cooled chiller efficiencies.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	10/25/2012	Initial Draft
02	Shaw Group	01/08/2013	Updated to New Template
03	Franklin Energy Services	03/08/2013	Update Based on Evaluation Comments

Air Sealing

	Measure Details
Measure Master ID	Air Sealing, 2745[1]
Measure Unit	Per CFM Leakage Reduction Per Site
Measure Type	Custom
Program(s)	Multifamily Energy Savings
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by heat and cooling system
Peak Demand Reduction (kW)	Varies by heat and cooling system
Annual Therm Savings (Therms)	Varies by heating system
Lifecycle Energy Savings (kWh)	Varies by heat and cooling system
Lifecycle Therm Savings (Therms)	Varies by heating system
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[2]
Important Comments	

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[3]

$kWh_{SAVED} = kWh_{SAVED\ COOL} + kWh_{SAVED\ HEAT}$

<u>For systems with cooling installed:</u>

$$kWh_{SAVED\ COOL} = \frac{((CFM50_{pre} - CFM50_{post}) / N_{cool}) * 60 * 24 * CDD * 0.018}{1{,}000 * Cool_{eff}} * LM$$

<u>For systems with electric heat:</u>

$$kWh_{SAVED\ HEAT} = \frac{((CFM50_{pre} - CFM50_{post}) / N_{heat}) * 60 * 24 * HDD * 0.018}{3{,}412 * Heat_{eff}}$$

For systems with gas heat:

$$\text{Therms}_{\text{SAVED}} = \frac{((\text{CFM50}_{\text{pre}} - \text{CFM50}_{\text{post}}) / \text{N}_{\text{heat}}) * 60 * 24 * \text{HDD} * 0.018}{100{,}000 * \text{Heat}_{\text{eff}}}$$

Where:

$\text{CFM50}_{\text{pre}}$ = Blower door test result before air sealing is performed

$\text{CFM50}_{\text{post}}$ = 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)

CDD = Cooling degree days (= 565, see table below)

0.018 = Specific heat capacity of air (Btu/ Cubic ft – °F)

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 (= 6.6 as an average of Chicago and Minneapolis)[4]

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, and = 13.3 if 3-stories)[5]

60 = Constant to convert minutes to hours

24 = Hours per day

HDD = Heating degree days (= 7,616, see table below)

100,000 = Conversion factor from BTU to therms

1,000 = Conversion factor from kW to W

3,412 = Conversion factor from kW-hr to BTU

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**

Heat_{eff} = Heating system efficiency (Fraction of heat output per unit of energy input expressed as a decimal)

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 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

$$kW_{SAVED} = \frac{kWh_{SAVED\ COOL}}{EFLH_{cool}} * CF$$

Where:

$EFLH_{cool}$ = 380 hours

Supporting inputs for load hours in several Wisconsin cities are[7]:

Location	$EFLH_{cooling}$
Green Bay	344
La Crosse	323
Madison	395
Milwaukee	457
Wisconsin Average	380

CF = Coincidence factor (= 0.66)[8]

Lifecycle Energy-Savings Algorithm

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

$Therm_{LIFETIME} = Therms_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 20 years)[2]

Sources

1. Wisconsin PSC EUL database, 2013.
2. Illinois Energy Efficiency Statewide Advisory Group. *Illinois Statewide Technical Reference Manual*.

3. LM is used to convert the calculated sensible cooling savings to a value representing sensible and latent cooling loads. The values are derived from Harriman et al "Dehumidification and Cooling Loads From Ventilation Air", ASHRAE Journal, by adding the latent and sensible loads to determine the total, then dividing the total by the sensible load. Values from Chicago and Minneapolis were averaged to develop a representative number for Wisconsin.
4. Lawrence Berkeley National Laboratory. *Building Performance Institute Building Analyst Technical Standards*. Available online: http://www.bpi.org/tools_downloads.aspx?selectedTypeID=1&selectedID=2.
5. 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.
6. Full load hours were calculated using an average FLH/Cooling Degree Day from values in *Illinois Statewide Technical Reference Manual* and applying to Wisconsin Cooling Degree Days.
7. http://www.dnrec.delaware.gov/energy/information/otherinfo/Documents/EM-and-V-guidance-documents/DELAWARE_TRM_August%202012.pdf

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	02/17/2012	Original
02	Franklin Energy Services	03/21/2013	Comments

Attic Insulation

	Measure Details
Measure Master ID	Attic Insulation, 2986
Measure Unit	Per Residence
Measure Type	Prescriptive
Program(s)	Residential Rewards
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	62
Peak Demand Reduction (kW)	0.046
Annual Therm Savings (Therms)	136
Lifecycle Energy Savings (kWh)	1,550
Lifecycle Therm Savings (Therms)	3,400
Water Savings (gal/yr)	0
Effective Useful Life (years)	25[1]
Important Comments	

Measure Description

This measure is the installation of attic insulation in an existing single-family residence. The associated measure characteristics are from the Focus on Energy single-family residential proposal calculator that was provided in 2011,[2] and they assume a natural gas heated and electrically cooled home.

An additional requirement of this measure is that the existing condition of the space have less than or equal to R-11 insulation (excluding assembly section), and be insulated to a minimum of R-38. This specific measure detail was not provided in the Focus on Energy calculator, but was determined through additional analysis and calculations in reference to the Illinois TRM attic insulation methodologies.[3] In absence of measure detail, specific program installation guidelines developed for the Focus on Energy Home Performance Program should be referenced to ensure consistency.

The 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. Where possible, parameters of each installation should be gathered to calculated energy savings.

Description of Baseline Condition

The baseline is an attic insulated to R-11 or below.

Description of Efficient Condition

The efficient condition is an attic insulated to a minimum level of R-38.

Annual Energy-Savings Algorithm

For cooling:

$$kWh_{SAVED} = ((1 / R_{BASE} - 1 / R_{EE}) * CDD * 24 * Area) / 1{,}000 / SEER$$

For gas heating:

$\text{Therms}_{\text{SAVED}} = ((1 / R_{\text{BASE}} - 1 / R_{\text{EE}}) * \text{HDD} * 24 * \text{Area}) / 100{,}000 / \text{AFUE}$

Where:

R_{BASE} = Existing R-value of attic (= 11)

R_{EE} = Proposed R-value of attic after retrofit (= 38)

CDD = Cooling degree days (= 565, see table below)

Area = Attic area to be insulated (= 922 square feet)[4]

1,000 = Kilowatt conversion factor

SEER = Cooling system efficiency (= 10 SEER if manufactured before 2006, = 13 SEER if manufactured in 2006 or later)

HDD = Heating degree days (= 7,616, see table below)

24 = Hours per day

100,000 = Conversion from Btu to therms

AFUE = Gas heating system efficiency (= 80%)

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**

Summer Coincident Peak Savings Algorithm

Summer peak savings were determined using a BeOPT Version 2.0 hourly energy simulation. Demand savings were calculated during the peak period from June through August, 1:00 p.m. to 4:00 p.m. The selected weather location was Milwaukee, Wisconsin.

The final savings value derived from this model was 0.046 kW annually per residence.

Lifecycle Energy-Savings Algorithm

$\text{kWh}_{\text{LIFETIME}} = \text{kWh}_{\text{SAVED}} * \text{EUL}$

$\text{Therms}_{\text{LIFETIME}} = \text{Therms}_{\text{SAVED}} * \text{EUL}$

Where:

EUL = Effective useful life (= 25 years)[1]

Assumptions

Attic areas are assumed to be 922 square feet, which represents the average attic area across all residential building types, not specifically single family.[4] The default savings is based on existing heating and cooling equipment efficiencies of 80% AFUE and SEER 13, 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. Wisconsin PSC EUL database, 2013.
2. Focus On Energy Cost-Effectiveness Calculator, Mass Markets – Residential SF Program, July 2011.
3. Illinois Energy Efficiency Statewide Advisory Group, Illinois Statewide Technical Reference Manual – Section 5.6.4 Wall and Ceiling/Attic Insulation, August 2012, http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf Weight average of housing unit areas and number of floors from 2011 American Housing Survey day for Milwaukee, WI.
4. 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.

Revision History

Version Number	Authored by	Date	Description of Change
01	RSG	11/07/2012	Original
02	RSG	01/17/2013	Added Supplemental Information
03	RSG	02/19/2013	Updated to Address Evaluator Comments

Attic Insulation – Add Additional Insulation - Custom

	Measure Details
Measure Master ID	Attic Insulation – Add Additional Insulation – Custom, 235
Measure Unit	Custom
Measure Type	Custom
Program(s)	Multifamily Energy Savings
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by site specific parameters
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by site specific parameters
Lifecycle Energy Savings (kWh)	Varies by site specific parameters
Lifecycle Therm Savings (Therms)	Varies by site specific parameters
Water Savings (gal/yr)	0
Effective Useful Life (years)	25[1]
Important Comments	

Measure Description

Adequate levels of properly installed insulation will reduce heating and cooling energy use and also increase occupant comfort. This measure covers the installation of insulation in the attic, ceiling, or roof of a building. Savings are based on the difference between the existing insulation level and the proposed installed level. When increases are required by building code, the increase above code is the only eligible savings. The effectiveness of insulation is measured in R-value, which will vary by type. Common insulating materials include fiberglass batting, blown-in cellulose and fiberglass, rigid board insulation, and sprayed foam insulation.

Description of Baseline Condition

The baseline condition uses early replacement-existing attic R-value (average R-30.5).

Description of Efficient Condition

The efficient condition is the condition of the attic roof insulation after the retrofit.

Annual Energy-Savings Algorithm

For cooling:

$kWh_{SAVED} = ((1 / R_{BASE} – 1 / R_{EE}) * CDD *24* Area) / 1,000 / SEER$

For gas heating:

$Therms_{SAVED} = ((1 / R_{BASE} – 1 / R_{EE}) * HDD * 24 * Area) / 100,000 / AFUE$

For electric heating:

$kWh_{SAVED} = ((1 / R_{BASE} – 1 / R_{EE}) * HDD * 24 * Area) / 1,000 / HSPF$

Where:

R_{BASE} = Existing R-value of attic, BTU/ft^2 - °F – hr (cannot be lower than 3)

R_{NEW} = Proposed R-value of attic after retrofit, BTU/ft^2 - °F – hr

CDD = Cooling degree days (= 565, see table below)

HDD = Heating degree days (= 7,616, see table below)

Area = Attic area to be insulated, sqft

24 = Hours per day

1,000 = Kilowatt conversion factor

100,000 = Conversion from Btu to therms

SEER = Cooling system efficiency of existing system, BTU/W-hr

AFUE = Gas heating system efficiency of existing system

HSPF = Electric heating systems efficiency (= 3.412 if electric resistance)

Location	HDD[2]	CDD[2]
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**

Lifecycle Energy-Savings Algorithm

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

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

Where:

EUL = Effective useful life (= 25 years)[1]

Assumptions

A non-insulated attic has an effective R-value of 3.

Sources

1. Wisconsin PSC EUL database, 2013.

2. 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.

Revision History

Version Number	Authored by	Date	Description of Change
01	Shaw Group	01/07/2012	Updated to New Template
02	Franklin Energy Services	10/25/2012	Initial Draft
03	Franklin Energy Services	03/21/2013	Updates From PI

ENERGY STAR® Windows – Custom

	Measure Details
Measure Master ID	ENERGY STAR® Windows – Custom, 2773
Measure Unit	Per 100-square-foot window area
Measure Type	Custom
Program(s)	Multifamily Energy Savings
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by site specific parameters
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by site specific parameters
Lifecycle Energy Savings (kWh)	Varies by site specific parameters
Lifecycle Therm Savings (Therms)	Varies by site specific parameters
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Important Comments	

Measure Description

Compared to standard-efficiency windows, high-efficiency windows have lower U-values, shading coefficients, and emissivity. Lower U-values decrease heat conduction. Lower shading coefficients reduce solar gain. Lower emissivity decreases radiation heat loss in the winter. The main heat losses from high-efficiency windows are due to conduction and infiltration.

ENERGY STAR®-rated patio doors are also included in this measure if all standard single-pane windows in the facility are replaced at the same time..

Description of Baseline Condition

The baseline condition is standard single-pane window with vinyl sash, (u-0.49, SHGC-0.58).

Description of Efficient Condition

The efficient condition is ENERGY STAR-qualified windows rated for the climate zone in which the facility is located (and Energy-Star qualified patio doors, if eligible).

Annual Energy-Savings Algorithm

The annual energy savings for this measure are calculated the change in kilowatts and therms. These savings are generated by an eQuest model, and the results are compared to external sources.

Lifecycle Energy-Savings Algorithm

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

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

Where:

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

Assumptions

A potential coincidence factor of 0.195 is assumed for HVAC; this was done by calculating 0.5 for HVAC, 39% of which is attributed to HVAC size from savings associated with increased window efficiency.

Deemed Savings

The savings from the eQuest model are calculated at 335 kWh/100 square feet/year for electric heated and cooled units and 24 therms/100 square feet for gas heated units. This is consistent with results from external sources, which range as follows depending on the HVAC equipment and window orientation:

- 237 to 356 kWh/100 square feet/year[2]
- 18.4 to 21.7 therms/100 square feet/year[3]

The summer peak savings, based on an eQuest model, is calculated as 0.065 kW. Outside sources give a range of 0.046 kW to 0.069 kW.

Sources

1. Wisconsin PSC EUL database.
2. Northeast Energy Efficiency Partnerships. *Mid-Atlantic Technical Reference Manual*. Prepared by VEIC. May 2010. Page 55.
3. State of Ohio Public Utility Commission. *Energy Efficiency Technical Reference Manual.* Prepared by VEIC. August 6, 2010. Page 36

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	06/07/2012	New Measure

Faucet Aerator, 1.0 GPM, Bathroom, Electric

	Measure Details
Measure Master ID	Faucet Aerator, 1.0 GPM, Bathroom, Electric, 2127, 2143
Measure Unit	Single, Low-Flow, 1.0 GPM Bathroom Aerator
Measure Type	Prescriptive
Program(s)	Assisted Home Performance with ENERGY STAR, Home Performance with ENERGY STAR, Express Energy Efficiency
Sector(s)	Residential
Annual Energy Savings (kWh)	70
Peak Demand Reduction (kW)	0.0015
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	835
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	829
Effective Useful Life (years)	12[1]
Important Comments	

Measure Description

A 1.0 GPM low-flow bathroom aerator is installed by the Program Implementer or a subcontractor of the Program Implementer in place of a higher flow rate bathroom aerator. Assumptions are based on a direct installation, not a time-of-sale purchase.

Description of Baseline Condition

The baseline equipment is assumed to be a higher flow rate bathroom aerator.

Description of Efficient Condition

This measure applies to standard 1.0 GPM low-flow bathroom aerators.

Annual Energy-Savings Algorithm

$$\text{Gallons}_{\text{SAVED}} = (\text{GPM}_{\text{existing}} - \text{GPM}_{\text{new}}) * (\text{PH}/\text{FH}) * \text{FLU} * 365 \text{ days}$$

$$\text{kWh}_{\text{SAVED}} = ((\Delta\text{Gallons} * 8.33 * 1 * (T_{\text{point of use}} - T_{\text{entering}}))/\text{RE})/3{,}412$$

Where:

ΔGallons = First-year water savings measured in gallons

$\text{GPM}_{\text{existing}}$ = Baseline flow rate in gallons per minute (= 2.2 GPM)[2]

GPM_{new} = Efficient flow rate in gallons per minute (= 1.0 GPM)

PH = Persons/house (= 2.52)[3]

FH = Fixtures/house (= 2.13) [3]

FLU = Faucet length of use in minutes (= 1.6)[4]

ΔkWh = First-year electric savings measured in kWh

$T_{point\ of\ use}$ = Temperature of water at point of use in degrees (= 86°F)[4]

$T_{entering}$ = Temperature of water entering water heater in degrees (= 52.3°F)[5]

RE = Average estimated recovery efficiency of electric water heater (= 98%)[6]

8.33 = Density of water, lbs/gal

1 = Specific heat of water, Btu/lb °F

3,412 = Convert Btu to kWh (= 3,412 Btu/kWh)

Summer Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} * CF / (PH * FLU * 365*SPD / (60mins/hr) / FH)$

Where:

CF = Coincidence factor (= 0.1156%)[7]

Lifecycle Energy-Savings Algorithm

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

Where:

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

Sources

1. Wisconsin PSC EUL database.
2. Federal minimum at 80 psi
3. Residential Energy Consumption Survey (RECS). 2009 RECS Micro Survey Data. Structural and Geographic Characteristics, Wisconsin.
4. Cadmus. 2012 Michigan Water Meter Study.
5. DoE DHW Scheduler, average water main temp. of all locations measured in WI by scheduler, weighted by city populations
6. NREL, Building America Research Benchmark Definition, 2009, p.12, http://www.nrel.gov/docs/fy10osti/47246.pdf
7. Calculated as follows: Assume 13% faucet use take place during peak hours (http://www.aquacraft.com/sites/default/files/pub/DeOreo-%282001%29-Disaggregated-Hot-Water-Use-in-Single-Family-Homes-Using-Flow-Trace-Analysis.pdf) 13% * 1.6 minutes per day /180 (minutes in peak period) = 0.1156%

Revision History

Version Number	Authored by	Date	Description of Change
01	Conservation Services Group	01/01/2012	New Measure
02	Conservation Services Group	03/18/2013	Update to New Template & Add
03	Conservation Services Group	04/22/2013	Revisions/Corrections

Faucet Aerator, Direct Install, 1.0 GPM, Bathroom, Natural Gas

	Measure Details
Measure Master ID	Faucet Aerator, 1.0 GPM, Bathroom, NG, 2121, 2137
Measure Unit	Single, Low-Flow, 1.0 GPM Bathroom Aerator
Measure Type	Prescriptive
Program(s)	Assisted Home Performance with ENERGY STAR, Home Performance with ENERGY STAR, Express Energy Efficiency
Sector(s)	Residential
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	3.1
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	36.8
Water Savings (gal/yr)	829
Effective Useful Life (years)	12[1]
Important Comments	

Measure Description

A 1.0 GPM low-flow bathroom aerator is installed by the Program Implementer or a subcontractor of the Program Implementer in place of a higher flow rate bathroom aerator. Assumptions are based on a direct installation, not a time-of-sale purchase.

Description of Baseline Condition

The baseline equipment is assumed to be a higher flow rate bathroom aerator.

Description of Efficient Condition

This measure applies to standard 1.0 GPM low-flow bathroom aerators.

Annual Energy-Savings Algorithm

$Gallons_{SAVED} = (GPM_{existing} - GPM_{new}) * (PH/FH) * FLU * 365\text{ days}$

$Therms_{SAVED} = ((\Delta Gallons\ * 8.33 * 1 * (T_{point\ of\ use} - T_{entering}))/RE)/100{,}000\text{ Btu/Therm}$

Where:

$\Delta Gallons$ = First-year water savings measured in gallons

$GPM_{existing}$ = Baseline flow rate in gallons per minute (= 2.2 GPM)[2]

GPM_{new} = Efficient flow rate in gallons per minute (= 1.0 GPM)

PH = Persons/house (= 2.52)[3]

FH = Fixtures/house (= 2.13)[3]

FLU = Faucet length of use in minutes (= 1.6)[4]

$\Delta Therms$ = First-year natural gas savings

$T_{point\ of\ use}$ = Temperature of water at point of use (= 86°F)[4]
$T_{entering}$ = Temperature of water entering water heater (= 52.3°F)[5]
RE = Average estimated recovery efficiency of natural water heater (= 76%)[6]
8.33 = Density of water, lbs/gal
1 = Specific heat of water, Btu/lb °F
100,000 = Convert Btu to therms, 100,000 Btu/therm

Lifecycle Energy-Savings Algorithm

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

Where:

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

Sources

1. Wisconsin PSC EUL database.
2. Federal minimum at 80 psi
3. Residential Energy Consumption Survey (RECS). 2009 RECS Micro Survey Data. Structural and Geographic Characteristics, Wisconsin
4. Cadmus. 2012 Michigan Water Meter Study.
5. DoE DHW Scheduler, average water main temp. of all locations measured in WI by scheduler, weighted by city populations
6. NREL, Building America Research Benchmark Definition, 2009, p.12, http://www.nrel.gov/docs/fy10osti/47246.pdf

Revision History

Version Number	Authored by	Date	Description of Change
01	Conservation Services Group	01/01/2012	New Measure
02	Lifecycle Savings	03/18/2013	Update to New Template & Add
03	Conservation Services Group	04/22/2013	Revisions/Corrections

Faucet Aerator, Direct Install, 1.5 GPM, Kitchen, Electric

	Measure Details
Measure Master ID	Faucet Aerator, 1.5 GPM, Kitchen, Electric, 2126, 2142
Measure Unit	Single, Low-Flow, 1.5 GPM Kitchen Aerator
Measure Type	Prescriptive
Program(s)	Assisted Home Performance with ENERGY STAR, Home Performance with ENERGY STAR, Express Energy Efficiency
Sector(s)	Residential
Annual Energy Savings (kWh)	294
Peak Demand Reduction (kW)	0.013
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	3,525
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	2,897
Effective Useful Life (years)	12[1]
Important Comments	

Measure Description

A 1.5 GPM low-flow kitchen aerator is installed by the Program Implementer or a subcontractor of the Program Implementer in place of a higher flow rate bathroom aerator. Assumptions are based on a direct installation, not a time-of-sale purchase.

Description of Baseline Condition

The baseline equipment is assumed to be a higher flow rate kitchen aerator.

Description of Efficient Condition

This measure applies to standard 1.5 GPM low-flow kitchen aerators.

Annual Energy-Savings Algorithm

$Gallons_{SAVED} = (GPM_{existing} - GPM_{new}) * (PH/FH) * FLU * 365 \text{ days}$

$kWh_{SAVED} = ((\Delta Gallons * 8.33 * 1 * (T_{point\ of\ use} - T_{entering}))/RE)/3,412$

Where:

$\Delta Gallons$ = First-year water savings measured in gallons

$GPM_{existing}$ = Baseline flow rate in gallons per minute (= 2.2 GPM)[2]

GPM_{new} = Efficient flow rate in gallons per minute (= 1.5 GPM)

PH = Persons/house (= 2.52)[3]

FH = Fixtures/house (= 1.0)

FLU = Faucet Length of use in minutes (= 4.5)[4]

ΔkWh = First-year electric savings

$T_{\text{point of use}}$ = Temperature of water at point of use (= 93°F)[4]

T_{entering} = Temperature of water entering water heater (= 52.3°F)[5]

8.33 = Density of water, lbs/gal

1 = Specific heat of water, Btu/lb °F

RE = Average estimated recovery efficiency of electric water heater (= 98%)[6]

3,412 = Convert Btu to kWh (= 3,412 Btu/kWh)

Summer Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} * CF / (PH * FLU * 365*SPD / (60mins/hr) / FH)$

Where:

CF = Coincidence factor (= 0.325%)[7]

Lifecycle Energy-Savings Algorithm

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

Where:

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

Sources

1. Wisconsin PSC EUL database.
2. Federal minimum at 80 psi
3. Residential Energy Consumption Survey (RECS). 2009 RECS Micro Survey Data. Structural and Geographic Characteristics, Wisconsin.
4. Cadmus. 2012 Michigan Water Meter Study.
5. DoE DHW Scheduler, average water main temp. of all locations measured in WI by scheduler, weighted by city populations
6. NREL, Building America Research Benchmark Definition, 2009, p.12, http://www.nrel.gov/docs/fy10osti/47246.pdf
7. Calculated as follows: Assume 13% faucet use take place during peak hours (http://www.aquacraft.com/sites/default/files/pub/DeOreo-%282001%29-Disaggregated-Hot-Water-Use-in-Single-Family-Homes-Using-Flow-Trace-Analysis.pdf) 13% * 4.5 minutes per day /180 (minutes in peak period) = 0..3250

Revision History

Version Number	Authored by	Date	Description of Change
01	Conservation Services Group	01/01/2012	New Measure
02	Conservation Services Group	03/18/2013	Update to New Template & Add
03	Conservation Services Group	04/22/2013	Revisions/Corrections

Faucet Aerator, Direct Install, 1.5 GPM, Kitchen, Natural Gas

	Measure Details
Measure Master ID	Faucet Aerator, 1.5 GPM, Kitchen, NG, 2120, 2136
Measure Unit	Single, Low-Flow, 1.5 GPM Kitchen Aerator
Measure Type	Prescriptive
Program(s)	Assisted Home Performance with ENERGY STAR, Home Performance with ENERGY STAR, Express Energy Efficiency
Sector(s)	Residential
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	12.9
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	155.1
Water Savings (gal/yr)	2,897
Effective Useful Life (years)	12[1]
Important Comments	

Measure Description

A 1.5 GPM low-flow kitchen aerator is installed by the Program Implementer or a subcontractor of the Program Implementer in place of a higher flow rate bathroom aerator. Assumptions are based on a direct installation, not a time-of-sale purchase.

Description of Baseline Condition

The baseline equipment is assumed to be a higher flow rate kitchen aerator.

Description of Efficient Condition

This measure applies to standard 1.5 GPM low-flow kitchen aerators.

Annual Energy-Savings Algorithm

$$\text{Gallons}_{\text{SAVED}} = (\text{GPM}_{\text{existing}} - \text{GPM}_{\text{new}}) * (\text{PH}/\text{FH}) * \text{FLU} * 365 \text{ days}$$

$$\text{Therms}_{\text{SAVED}} = ((\Delta\text{Gallons} * 8.33 * 1 * (T_{\text{point of use}} - T_{\text{entering}}))/\text{RE})/100{,}000$$

Where:

ΔGallons = First-year water savings measured in gallons

$\text{GPM}_{\text{existing}}$ = Baseline flow rate (= 2.2 GPM)[2]

GPM_{new} = Efficient flow rate (= 1.5 GPM)

PH = Persons/house (= 2.52)[3]

FH = Fixtures/house (= 1.0)

FLU = Faucet length of use (= 4.5 minutes)[4]

ΔTherms = First-year natural gas savings

$T_{\text{point of use}}$ = Temperature of water at point of use (= 93°F)[4]

T_{entering} = Temperature of water entering water heater (= 52.3°F)[5]

RE = Average estimated recovery efficiency of natural water heater (= 76%)[6]

8.33 = Density of water, lbs/gal

1 = Specific heat of water, Btu/lb °F

100,000 = Convert Btu to therms, 100,000 Btu/therm

Lifecycle Energy-Savings Algorithm

$\text{Therms}_{\text{LIFETIME}} = \text{Therms}_{\text{SAVED}} * \text{EUL}$

Where:

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

Sources

1. Wisconsin PSC EUL database.
2. Federal minimum at 80 psi
3. Residential Energy Consumption Survey (RECS). 2009 RECS Micro Survey Data. Structural and Geographic Characteristics, Wisconsin.
4. Cadmus. 2012 Michigan Water Meter Study.
5. DoE DHW Scheduler, average water main temp. of all locations measured in WI by scheduler, weighted by city populations
6. NREL, Building America Research Benchmark Definition, 2009, p.12, http://www.nrel.gov/docs/fy10osti/47246.pdf

Revision History

Version Number	Authored by	Date	Description of Change
01	Conservation Services Group	01/01/2012	New Measure
02	Conservation Services Group	03/18/2013	Update to New Template & Add
03	Conservation Services Group	04/22/2013	Revisions/Corrections

Low-Flow Kitchen, Bath, and Shower Aerators

	Measure Details
Measure Master ID	Low-Flow Kitchen, Bath, and Shower Aerators,
Measure Unit	Aerator, Showerhead
Measure Type	Prescriptive
Program(s)	Multifamily Energy Savings
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by location
Peak Demand Reduction (kW)	Varies by location
Annual Therm Savings (Therms)	Varies by location
Lifecycle Energy Savings (kWh)	Varies by location
Lifecycle Therm Savings (Therms)	Varies by location
Water Savings (gal/yr)	Varies by location
Effective Useful Life (years)	Varies by measure
Important Comments	

Measure Description

This measure is the installation of low-flow kitchen, bath, and/or shower aerators in new construction. It saves either 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 bath 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 GPM, bath aerator at 1.5 GPM, and showerhead at 1.5 GPM.

Annual Energy-Savings Algorithm

For aerators:

$$Gallons_{SAVED} = (GPM_{existing} - GPM_{new}) * (PH/FH) * FLU * 365 \text{ days}$$

For showerheads:

$$Gallons_{SAVED} = (GPM_{existing} - GPM_{new}) * ((PH* SPD)/FH) * SLU * 365 \text{ days}$$

$$kWh_{SAVED}= ((\Delta Gallons\ * 8.33 * 1* (T_{point\ of\ use} - T_{entering}))/RE)/3{,}412$$

$$Therms_{SAVED}= ((\Delta Gallons\ * 8.33 * 1\ * (T_{point\ of\ use} - T_{entering}))/RE)/100{,}000$$

Where:

<u>Low-Flow Kitchen Aerator, Electric</u>

$\Delta Gallons_{Aerator}$ = First-year water savings measured in gallons

$GPM_{existing}$ = Baseline flow rate (= 2.2 GPM)[1]

GPM_{new} = Efficient flow rate (= 1.5 GPM)

PH = Persons/house (= 1.93)[2]

FH = Fixtures/house (= 1.00)

FLU = Faucet length of use in minutes (= 4.5)[3]

ΔkWh = First-year electric savings measured in kWh

$T_{point\ of\ use}$ = Temperature of water at point of use (= 93°F)[3]

$T_{entering}$ = Temperature of water entering water heater (= 52.3°F)[4]

RE = Average estimated recovery efficiency of electric water heater (= 98%)[5]

8.33 = Density of water, lbs/gal
1 = Specific heat of water, Btu/lb °F
100,000 = Convert Btu to therms, 100,000 Btu/therm
3,412 = Convert Btu to kWh (= 3,412 Btu/kWh)

<u>Low-Flow Kitchen Aerator, Natural Gas</u>

$\Delta Gallons_{Aerator}$ = First-year water savings measured in gallons

$GPM_{existing}$ = Baseline flow rate (= 2.2 GPM)[1]

GPM_{new} = Efficient flow rate in (= 1.5 GPM)

PH = Persons/house (= 1.93)[2]

FH = Fixtures/house (= 1.00)

FLU = Faucet length of use in minutes (= 4.5)[3]

$\Delta Therms$ = First-year natural gas savings measured in therms

$T_{point\ of\ use}$ = Temperature of water at point of use (= 93°F)[3]

$T_{entering}$ = Temperature of water entering water heater (= 52.3°F)[4]

RE = Average estimated recovery efficiency of natural gas water heater (= 76%)[5]

8.33 = Density of water, lbs/gal
1 = Specific heat of water, Btu/lb °F

100,000 = Convert Btu to therms, 100,000 Btu/therm

3,412 = Convert Btu to kWh (= 3,412 Btu/kWh)

<u>Low-Flow Bathroom Aerator, Electric</u>

$\Delta Gallons_{Aerator}$ = First-year water savings measured in gallons

$GPM_{existing}$ = Baseline flow rate (= 2.2 GPM)[1]

GPM_{new} = Efficient flow rate (= 1.5 GPM)

PH = Persons/house (= 1.93)[2]

FH = Fixtures/house (= 1.11)[2]

FLU = Faucet length of use in minutes (= 1.6)[3]

ΔkWh = First-year electric savings measured in kWh

$T_{point\ of\ use}$ = Temperature of water at point of use (= 86°F)[3]

$T_{entering}$ = Temperature of water entering water heater (= 52.3°F)[4]

RE = Average estimated recovery efficiency of electric water heater (= 98%)[5]

8.33 = Density of water, lbs/gal

1 = Specific heat of water, Btu/lb °F

100,000 = Convert Btu to therms, 100,000 Btu/therm

3,412 = Convert Btu to kWh (= 3,412 Btu/kWh)

<u>Low-Flow Bathroom Aerator, Natural Gas</u>

$\Delta Gallons_{Aerator}$ = First-year water savings measured in gallons

$GPM_{existing}$ = Baseline flow rate (= 2.2 GPM)[1]

GPM_{new} = Efficient flow rate (= 1.5 GPM)

PH = Persons/house (= 1.93)[2]

FH = Fixtures/house (= 1.11)[2]

FLU = Faucet length of use in minutes (= 1.6)[3]

ΔTherms = First-year natural gas savings measured in therms

$T_{point\ of\ use}$ = Temperature of water at point of use (= 86°F)[3]

$T_{entering}$ = Temperature of water entering water heater (= 52.3°F)[4]

RE = Average estimated recovery efficiency of natural gas water heater (= 76%)[5]

8.33 = Density of water, lbs/gal

1 = Specific heat of water, Btu/lb °F
100,000 = Convert Btu to therms, 100,000 Btu/therm
3,412 = Convert Btu to kWh (= 3,412 Btu/kWh)

Low-Flow Showerhead Aerator, Electric

$\Delta Gallons_{Shower}$ = First-year water savings measured in gallons
$GPM_{existing}$ = Baseline flow rate (= 2.5 GPM)[1]
GPM_{new} = Efficient flow rate (= 1.5 GPM)
PH = Persons/house (= 1.93)[2]
FH = Fixtures/house (= 1.0)[2]
SLU = Shower length of use in minutes (= 7.8)[3]
SPD = Showers per person per day (= 0.6)[3]
ΔkWh = First-year electric savings measured in kWh
$T_{point\ of\ use}$ = Temperature of water at point of use (= 101°F)[3]
$T_{entering}$ = Temperature of water entering water heater (= 52.3°F)[4]
RE = Average estimated recovery efficiency of electric water heater (= 98%)[5]

8.33 = Density of water, lbs/gal
1 = Specific heat of water, Btu/lb °F
100,000 = Convert Btu to therms, 100,000 Btu/therm
3,412 = Convert Btu to kWh (= 3,412 Btu/kWh)

Low-Flow Showerhead Aerator, Natural Gas

$\Delta Gallons_{Shower}$ = First-year water savings measured in gallons
$GPM_{existing}$ = Baseline flow rate (= 2.5 GPM)[1]
GPM_{new} = Efficient flow rate (= 1.5 GPM)
PH = Persons/house (= 1.93)[2]
FH = Fixtures/house (= 1.0)[2]
SLU = Shower length of use in minutes (= 7.8)[3]
SPD = Showers per person per day (= 0.6)[3]
ΔTherms = First-year natural gas savings measured in therms
$T_{point\ of\ use}$ = Temperature of water at point of use (= 101°F)[3]

$T_{entering}$ = Temperature of water entering water heater (= 52.3°F)[4]

RE = Average estimated recovery efficiency of natural gas water heater (= 76%)[5]

8.33 = Density of water, lbs/gal

1 = Specific heat of water, Btu/lb °F

100,000 = Convert Btu to therms, 100,000 Btu/therm

3,412 = Convert Btu to kWh (= 3,412 Btu/kWh)

Summer Coincident Peak Savings Algorithm

$kW_{SAVED}= \Delta kWh * CF / (PH * LU * 365 \text{ days} / (60 \text{ mins/hr})/ FH)$

Where:

$CF_{Showerhead}$ = Coincidence factor for showerheads (= 0.0039)[6]

$CF_{Aerator\ Bath}$ = Coincidence factor for bathroom aerators (= 0.0011)[6]

$CF_{Aerator\ Kitchen}$ = Coincidence factor for kitchen aerators (= 0.0032)[6]

Lifecycle Energy-Savings Algorithm

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

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

Where:

EUL = Effective useful life (= 5 years for aerators and 12 years for showerheads)[7]

Deemed Savings

Type of Savings	Kitchen	Bath	Showerhead
Annual Energy Savings (kWh) per fixture	225	60	400
Peak Demand Reduction (kW) per fixture	0.0138	0.0033	0.0284
Annual Therm Savings (Therms) per fixture	9.9	2.6	17.6
EUL Natural Gas[7]	10	10	10
EUL Electric[7]	10	10	9
Lifecycle Energy Savings (kWh) per fixture	2250	597	3599
Lifecycle Therm Savings (Therms) per fixture	99.0	26.3	176.0
Water Savings (gal/yr) per fixture	2,185	700	3,246

Sources

1. Federal minimum at 80 psi.
2. *Residential Energy Consumption Survey, Micro Survey Data.* Structural and Geographic

Characteristics, Wisconsin. 2009.

3. Cadmus. *Michigan Water Meter Study*. 2012.
4. U.S. Department of Energy. *Domestic Hot Water Scheduler.* Aaverage water main temperature of all locations measured in Wisconsin by scheduler, weighted by city populations
5. NREL, *Building America Research Benchmark Definition*, 2009, p.12, http://www.nrel.gov/docs/fy10osti/47246.pdf.
6. Calculated as follows: The fraction of use that takes place during peak hours (9% showers, 13% aerators)(% * min/use/day /180 (minutes in peak period) = CF
7. Wisconsin PSC EUL database.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	01/02/2012	New Measure

Condensing Water Heater, NG, 90%+

	Measure Details
Measure Master ID	Condensing Water Heater, NG, 90%+, 1986
Measure Unit	Per Water Heater
Measure Type	Prescriptive
Program(s)	Residential Rewards
Sector(s)	Residential-single family
Annual Energy Savings (kWh)	-50
Peak Demand Reduction (kW)	-0.005
Annual Therm Savings (Therms)	54 (pre January 1, 2016), 46 (post January 1, 2016)
Lifecycle Energy Savings (kWh)	-600
Lifecycle Therm Savings (Therms)	648 (pre January 1, 2016), 552 (post January 1, 2016)
Water Savings (gal/yr)	0
Effective Useful Life (years)	12[1]
Important Comments	

Measure Description

This measure covers 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 0.575 EF if the unit is purchased before January 1, 2016 and 0.600 if purchased after January 1, 2016. This updated baseline reflects the new federal standard that takes effect April 2015. The criteria date used here is rounded to January 1, 2016, but the code actually takes affect mid-year 2015.[2]

This was calculated as: 0.670 - 0.0019 * 50 = 0.575, per 2001 federal standard that took effect in 2004. The new baseline per federal standard was adopted in 2010 and will take effect in April 2015. This is calculated as 0.675 - 0.0015 * 50 = 0.600. Both calculations assume a 50 gallon tank.

Description of Efficient Condition

The efficient condition is upgrading from the code standard minimum gas storage residential water heater to a higher efficiency 90% TE commercial gas storage-type water heater. Gas storage water heaters are used to supply DHW.

Annual Energy-Savings Algorithm

Because the efficiency of traditional 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 baseline energy and efficient energy use.

$\text{Therms}_{\text{SAVED}} = \text{Therms}_{\text{BASELINE}} - \text{Therms}_{\text{MEASURE}}$

The baseline energy usage is calculated using the following equation:

$$\text{Therms}_{\text{BASELINE}} = \frac{\dot{\text{M}} * \text{c}_{\text{P}} * (\text{T}_{\text{TANK}} - \text{T}_{\text{INLET}})}{\text{EF}} * \frac{365}{100{,}000}$$

Where:

$\dot{\text{M}}$ = Mass of water drawn (= 429 lbs/day)

c_{P} = Specific heat of water (= 1 Btu/lb-°F)

T_{TANK} = Water heater thermostat setpoint temperature (= 125°F) [3]

T_{INLET} = Inlet water temperature (= 52.3°F)[4]

EF = Energy factor (= 0.575 pre January 1, 2016, and = 0.600 post January 1, 2016)

365 = Days per year

100,000 = Conversion factor from Btu to Therms

The following shows this equation solved for the pre January 1, 2016 scenario:

$$\text{Therms}_{\text{BASELINE}} = \frac{429\ {}^{\text{lbs}}/_{\text{day}} * 1\ {}^{\text{BTU}}/_{\text{lb°F}} * (125\text{°F} - 52.3\text{°F})}{0.575} * \frac{365\,\frac{\text{days}}{\text{yr}}}{100{,}000\,\frac{\text{BTU}}{\text{therm}}} = 198\,\frac{\text{therms}}{\text{year}}$$

The calculation above is repeated using an EF of 0.600 to solve for the post January 1, 2016 scenario, resulting in 190 therms/year.

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 = 16.286 x + 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/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 loses, 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 commercial water heater consumes can be defined as:

$$\text{Therms}_{\text{MEASURE}} = \text{Q}_{\text{USAGE}} + \text{Q}_{\text{STANDBY}}$$

Q_{USAGE} can be determined with the equation below:

$$\text{Q}_{\text{USAGE}} = \frac{\dot{\text{M}} * c_{\text{P}} * (\text{T}_{\text{TANK}} - \text{T}_{\text{INLET}})}{\text{TE}}$$

Using this equation, Q_{USAGE} is solved for below:

$$\text{Q}_{\text{USAGE}} = \frac{429\ ^{\text{lbs}}/_{\text{day}} * 1\ ^{\text{BTU}}/_{\text{lb}-{}^\circ\text{F}} * (125^\circ\text{F} - 52.3^\circ\text{F})}{0.90} * \frac{365\,\frac{\text{days}}{\text{yr}}}{100{,}000\,\frac{\text{BTU}}{\text{therm}}} = 126\,\frac{\text{therms}}{\text{year}}$$

In addition to the energy needed to reheat the water usage, standby loses must be taken into account. According to the DOE Water Heater Analysis Model:[5]

$$\text{Q}_{\text{STANDBY}} = \text{UA} * (\text{T}_{\text{TANK}} - \text{T}_{\text{AMB}}) * \left(24 - \frac{\text{Q}_{\text{USAGE}}}{\text{RE} * \text{P}_{\text{ON}}}\right)$$

Where:

TE = Thermal efficiency of measure (= 0.90)
UA = Standby heat loss coefficient (= 3.319 Btu/hr- °F)
T_{AMB} = Ambient temperature (= 65°F)
RE = Recovery efficiency (= 0.90, assume TE as approxy)[6]
P_{ON} = Rated input power (= 76,000 Btu/hr, which is conservative)

The standby loses are solved for below:

$$\text{Q}_{\text{STANDBY}} = 3.319\,\frac{\text{BTU}}{\text{hr}-{}^\circ\text{F}} * (125\,^\circ\text{F} - 65\,^\circ\text{F}) * \left(24 - \frac{133\text{ therms}}{0.90 * 76{,}000\,^{\text{BTU}}/_{\text{hr}}}\right) * \frac{365\,\frac{\text{days}}{\text{yr}}}{100{,}000\,\frac{\text{BTU}}{\text{therm}}}$$
$$= 17\ ^{\text{therms}}/_{\text{year}}$$

Combining Q_{USAGE} and $\text{Q}_{\text{STANDBY}}$:

$\text{Therms}_{\text{MEASURE}}$ = 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:

$\text{Therms}_{\text{SAVED}}$ = 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 0.005 kW.

Lifecycle Energy-Savings Algorithm

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

Where:

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

Lifecycle Energy Savings

Deemed Savings	Measure Lifecycle Energy Savings	Lifecycle Savings
54 Therms (pre January 1, 2016) 46 Therms (post January 1, 2016)	12	649 Therms (pre January 1, 2016) 550 Therms (post January 1, 2016)
-50.00 kWh	12	-650.00 kWh

Assumptions

The electric values (kWh and kW) were reviewed from the supplied RFP calculator, which appeared to reasonably align with expected savings.

Additional Information

- State of Wisconsin Public Service Commission. *Request for Proposals.* July 26, 2011. Issued for Mass Markets Portfolio Residential Energy Efficiency Program Implementation. U.S. Department of Energy, E*nergy Efficiency and Renewable Energy. Residential Water Heater Technical Support Document for the January 17, 2001, Final Rule.* Chapter 10: Consumer Sub Group Analysis. Available online: http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/10.pdf.U.S.
- Department of Energy, E*nergy Efficiency and Renewable Energy. Baseline Results and Methodology of the Consumer Sub-group Analysis for Residential Water Heater Efficiency Standard.* Submitted to the U.S. Department of Energy Office of Codes and Standards. October 1998. Available online: http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/waterheater_lifecycle_1098.pdf.*Electronic Code of Federal Regulations, 430.32.* Energy and water conservation standards and their effective dates. Available online: http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=87e71213c848dd8dd92b27cdbb6ae10e&rgn=div5&view=text&node=10:3.0.1.4.18&idno=10#10:3.0.1.4.18.3.9.2.LARA Public Service Commission, Department of Licensing and Regulatory Affairs. *Michigan Energy Measures Database.* 2011. Available online: http://michigan.gov/mpsc/0,1607,7-159-52495_55129---,00.html.

Sources

1. Wisconsin PSC EUL database 2013.
2. *Electronic Code of Federal Regulations.* Title 10 Energy, Part 431—Energy Efficiency Program For Certain Commercial and Industrial Equipment. Available online: http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr;sid=038e9e4d6f73f1b57c7b090187464e0b;rgn=div5;view=text;node=10%3A3.0.1.4.19;idno=10;cc=ecfr#10:3.0.1.4.19.7.
3. 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 set points typically range between 120°F and 140°F because temperatures below 120 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 set points between 120 and 130 degrees.
4. U.S. Department of Energy. DHW Scheduler. (The average water main temperature is for all locations measured in Wisconsin, weighted by city population.)
5. 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.PG&E Applied Technology Services Performance Testing and Analysis Unit ATS Report #: 491-08.5, PY2008 Emerging Technologies Program, 2008, page 8. Available online: http://www.etcc-ca.com/sites/default/files/OLD/images/stories/reswhtestreport1.pdf

Revision History

Version Number	Authored by	Date	Description of Change
01	RSG	03/05/2012	Original
02	RSG	02/19/2013	Updated Content & Format

DHW Plant Replacement

	Measure Details
Measure Master ID	DHW Plant Replacement, 2760 Water Heater, Not Otherwise Specified, 2659
Measure Unit	Number of plants or number of apartments
Measure Type	Hybrid
Program(s)	Multifamily Energy Savings
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	324
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	4,860
Water Savings (gal/yr)	0
Effective Useful Life	15[1]
Important Comments	

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 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

New water heaters must be:

- Commercially sized, high efficiency sealed combustion, condensing, and modulating (HESCCM),
- HESCC stand-alone water heaters, or
- Indirect storage tanks off of 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 will 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:

$$\text{Therms}_{\text{SAVED}} = \text{Therms}_{\text{BASE}} - \text{Therms}_{\text{EE}}$$

$$\text{Therms}_{\text{BASE}} = \frac{\text{GPD} * \text{N}_{\text{APTS}} * \text{C} * \text{C}_{\text{P}} * \Delta\text{T} * 365 \ {}^{\text{days}}/_{\text{yr}}}{\eta_{\text{BASE}} * 100{,}000 \ {}^{\text{Btu}}/_{\text{therm}}} + \frac{\text{Q}_{\text{LOSS-BASE}} * \text{N}_{\text{WH}} * 24 \text{ hrs} * 365 \ {}^{\text{days}}/_{\text{yr}}}{100{,}000 \ {}^{\text{Btu}}/_{\text{therm}}}$$

$$\text{Therms}_{\text{EE}} = \frac{\text{GPD} * \text{N}_{\text{APTS}} * \text{C} * \text{C}_{\text{P}} * \Delta\text{T} * 365 \ {}^{\text{days}}/_{\text{yr}}}{\eta_{\text{EE}} * 100{,}000 \ {}^{\text{Btu}}/_{\text{therm}}} + \frac{\text{Q}_{\text{LOSS-EE}} * \text{N}_{\text{WH}} * 24 \text{ hrs} * 365 \ {}^{\text{days}}/_{\text{yr}}}{100{,}000 \ {}^{\text{Btu}}/_{\text{therm}}}$$

Where:

GPD = Gallons per day (= 43.9)[3]

N_{APTS} = Total number of dwelling units served by system (= 11.5)[4]

C = Conversion from gallons to mass, 8.33 pounds per gallon

C_P = 1.0 Btu/lb-°F

ΔT = $T_{SET} - T_{INLET}$: 125°F hot water setpoint minus 52.3°F inlet water temperature (= 72.7°F difference)[5]

η_{BASE} = Baseline TE (= 80%)

η_{EE} = Efficient TE (=90%)

$Q_{LOSS\text{-}BASE}$ = Baseline standby heat loss (= 1,233 Btu/hour)[6]

$Q_{LOSS\text{-}EE}$ = Efficient standby heat loss (=929 Btu/hour)[7]

N_{WH} = Total number of DWH tanks (= 1)

Average Annual Deemed Savings for Water Heater, Not Otherwise Specified:$\text{Therms}_{\text{SAVED}} = 13.3 * N_{APTS} + 26.4 * N_{WH}$

Lifecycle Energy-Savings Algorithm

$\text{Therms}_{\text{LIFETIME}} = \text{Therms}_{\text{SAVED}} * \text{EUL}$

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. Wisconsin PSC EUL database 2013.
2. Evaluation tool is described in Strategy Guideline: Proper Water Heater Selection, August 2012: http://www.nrel.gov/docs/fy12osti/55074.pdf. The evaluation tool may be found here: 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/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 WI multi-family number of units was estimated at 11.5 units per apartment based on the data from the 2009 U.S. Census, table 989. Housing Units by Units in Structure and State; 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 temp. 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 set points typically range between 120°F and 140°F because temperatures below 120 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 assumptions are unsourced engineering assumptions.
6. Federal standard for gas storage water heater with 80 gallon storage and 199kBtu/h heat input.
7. Average standby loss of AHRI certified gas storage water heaters with TE > 94%, storage volume between 80 to 100 gallons, and heat input less than 200 kBtu/h.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	09/10/2012	New Measure

DHW Temperature Turn Down, Direct Install, Electric

	Measure Details
Measure Master ID	DHW Temperature Turn Down, Direct Install, Electric, 2131 Natural Gas, 2147
Measure Unit	Single Temperature Turn Down of Electric Water Heater
Measure Type	Prescriptive
Program(s)	Assisted Home Performance with ENERGY STAR, Home Performance with ENERGY STAR, Express Energy Efficiency
Sector(s)	Residential
Annual Energy Savings (kWh)	149
Peak Demand Reduction (kW)	0.017
Annual Therm Savings (Therms)	13.57
Lifecycle Energy Savings (kWh)	1,786
Lifecycle Therm Savings (Therms)	163
Water Savings (gal/yr)	0
Effective Useful Life (years)	12[1]
Measure Installed Cost ($/unit)	

Measure Description

The water heater temperature is turn downed to 120°F by the Program Implementer or a subcontractor of the Program Implementer. 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 hot water temperature (of 10°F - 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 gas heat; however, it should be accounted at an appropriate efficiency with heat pump or electric resistance heat.

Description of Baseline Condition

The baseline is to have a hot water temperature above 120°F.

Description of Efficient Condition

The efficient condition is for residential electric water heaters to be set to 120°F.

Annual Electric Energy-Savings Algorithm

The variables in the equations below that change between the baseline and efficient cases are GPD and $T_{WH.}$

$$kWh_{SAVED} = [(HW_{Base} + SB_{Base}) - (HW_{Eff} + SB_{Eff})] * 365 * \frac{1}{3{,}412}$$

$$HW = GPD * C_p * (T_{WH} - T_{Entering}) * \frac{1}{RE} * \left(1 - UA * \frac{T_{WH} - T_{Room}}{Input}\right)$$

$$SB = UA * 24 * (T_{WH} - T_{Room})$$

$$UA = \frac{\left(\frac{1}{EF} - \frac{1}{RE}\right)}{67.5 * \left(\frac{24}{Qout} - \frac{1}{RE * Input}\right)}$$

Where:

HW_{Base} = Hot water baseline load (= 24,912 Btu/day)

SB_{Base} = Standby baseload (= 4,125 Btu/day)

HW_{Eff} = Hot water efficient load (= 24,111 Btu/day)

SB_{Eff} = Standby efficient load (= 3,536 Btu/day)

3,412 = Conversion from Btu to kWh (3,412 Btu/kWh)

GPD = Gallons of hot water use per day (= 38.1 with baseline measure, = 42.3 with efficient measure)

C_P = Heat capacity of water (= 8.33 Btu/gallon/°F)

T_{WH} = Temperature in tank (= 130°F with baseline measure, = 120°F with 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)

Qout = Energy content of water drawn from water heater during 24 hour test (41,094 btu/day)[4]

T_{ROOM} = Ambient temperature surrounding tank (= 65°F)

Input = Firing rate (=15,350 Btu/hr)

EF = Energy factor (= 0.904)[5]

Annual Therm Energy-Savings Algorithm

The variables in the equations below that change between the baseline and efficient cases are GPD and $T_{WH.}$

$$\text{Therms}_{\text{SAVED}} = [(\text{HW}_{\text{Base}} + \text{SB}_{\text{Base}}) - (\text{HW}_{\text{Eff}} + \text{SB}_{\text{Eff}})] * 365 * \frac{1}{1{,}000}$$

$$\text{HW} = \text{GPD} * \text{C}_{\text{p}} * \left(\text{T}_{\text{WH}} - \text{T}_{\text{Entering}}\right) * \frac{1}{\text{RE}} * \left(1 - \text{UA} * \frac{\text{T}_{\text{WH}} - \text{T}_{\text{Room}}}{\text{Input}}\right)$$

$$\text{SB} = \text{UA} * 24 * (\text{T}_{\text{WH}} - \text{T}_{\text{Room}})$$

$$\text{UA} = \frac{\left(\frac{1}{\text{EF}} - \frac{1}{\text{RE}}\right)}{67.5 * \left(\frac{24}{\text{Qout}} - \frac{1}{\text{RE} * \text{Input}}\right)}$$

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)

100,000 = Conversion from Btu to therms

GPD = Gallons of hot water use per day (= 38.1 with baseline measure, = 42.3 with efficient measure)

C_P = Heat capacity of water (= 8.33 Btu/gallon/°F)

T_{WH} = Temperature in tank (= 130°F with baseline measure, = 120°F with efficient measure)

T_{Entering} = Cold water mains temperature (= 52.3°F)[2]

RE = Water heater recovery efficiency (=0.76)[3]

UA = Water heater equivalent heat loss factor (= 11.38 Btu/hr-°F)

Qout = Energy content of water drawn from water heater during 24 hour test (41,094 btu/day)

T_{ROOM} = Ambient temperature surrounding tank (= 65°F)

Input = Firing rate (=40,000 Btu/hr)[4]

EF = Energy factor (= 0.575)[5]

Summer Coincident Peak Savings Algorithm

$$kW_{SAVED} = \frac{kWh_{SAVED}}{8760} * CF$$

Where:

8,760 = Hours in one year

CF = Coincidence factor (= 1)

Lifecycle Energy-Savings Algorithm

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

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

Where:

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

Assumptions

The gallons per day assumptions were as follows:

- Total hot water use at the tap = 51.5 GPD.[5] 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/home was used for Wisconsin, based on RECS 2009 data. Calculated by using the linear relationship is used in the 2012 Indiana TRM and the 2010 NY TRM. Calculated by using the linear relationship of y = 16.286 x + 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.

Sources

1. Wisconsin PSC EUL Database.
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. http://hes-documentation.lbl.gov/Home-Energy-Saver/calculation-methodology/calculation-of-energy-consumption/water-heater-energy-consumption/standby-heat-loss-coefficient
5. U.S. Department of Energy. Federal standard for residential water heaters effective in 2004.

Revision History

Version Number	Authored by	Date	Description of Change
01	Conservation Services Group	01/01/2012	New Measure
02	Conservation Services Group	03/09/2013	Update to New Template & Add Lifecycle Savings
03	Conservation Services Group	04/22/2013	Revisions/Comments

Insulation, Direct Install, 6' Pipe, Electric

	Measure Details
Measure Master ID	Insulation, Direct Install, 6' Pipe, Electric, 2128, 2144
Measure Unit	Single, 6-foot pipe insulation for electric water heater, 3 feet on cold pipe and 3 feet on hot pipe
Measure Type	Prescriptive
Program(s)	Assisted Home Performance with ENERGY STAR, Home Performance with ENERGY STAR, Express Energy Efficiency
Sector(s)	Residential
Annual Energy Savings (kWh)	162
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	1,944
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	12[1]
Important Comments	

Measure Description

This measure is non-insulated water heater pipes being insulated for 6-feet by the Program Implementer or a subcontractor of the Program Implementer

Pipe insulation near the tank saves energy by reducing standby losses from pipes that are hot from conducting heat from the storage tank. This happens by convective currents within the pipe(s), or by eventually drawing and using hot water in the pipe.

In the following calculations, the reduction in electric hot water internal gains from pipe insulation is ignored, assuming that most water heaters in Wisconsin are in basements, and that basements have little or no direct air conditioning. For gas hot water, the regain from reduced pipe heat loss (for the duration of the heating season) is subtracted from the direct savings to arrive at the net gas savings.

Heating effects are ignored for electric water heaters, assuming a predominance of gas heat. For heat pump or electric resistance heat, the heating effects should account for an appropriate efficiency, as with gas heat.

Description of Baseline Condition

The baseline condition is no pipe insulation.

Description of Efficient Condition

The efficient condition is pipe insulation on a residential electric water heater.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (\Delta Btu/yr) / 3,412$

ΔBtu/yr = ((1/R_{EXIST} – 1/R_{NEW}) * (L * C) * ΔT * 8,760 / RE

Where:

R_{EXIST} = Pipe heat loss coefficient of existing uninsulated pipe (= 1 Btu/hr-°F-ft)

R_{NEW} = Pipe heat loss coefficient of new insulated pipe (= 1/4 Btu/hr-°F-ft)

L = Length of pipe from water heating source covered by pipe wrap (= 6 feet)

C = Circumference of pipe, inches of outer diameter * π * 0.083 (= 0.229 feet)

ΔT = Average temperature difference from pipe to ambient air (= 60°F)

8,760 = Conversion for hours per year

RE = Water heater recovery efficiency (= 0.98)

3,412 = Conversion factor from Btu to kWh

Lifecycle Energy-Savings Algorithm

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

Where:

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

Assumptions

Assumptions are based on a direct installation, not a time-of-sale purchase.

The average difference of 60°F assumes pipe and ambient air temperatures of 125°F and 65°F, respectively.

The pipe inner and outer diameters are assumed to be 3/4-inch and 7/8-inch, respectively.

Sources

1. Wisconsin PSC EUL database 2013.

Revision History

Version Number	Authored by	Date	Description of Change
01	Conservation Services Group	01/01/2012	New Measure
02	Conservation Services Group	03/19/2013	Update to New Template & Add Lifecycle Savings
03	Conservation Services Group	04/22/2013	Revisions & Comments

Insulation, Direct Install, 6' Pipe, NG

	Measure Details
Measure Master ID	Insulation Direct Install, 6' Pipe, NG, 2122
Measure Unit	Single, 6-foot pipe insulation for natural gas water heater, 3 feet on cold pipe and 3 feet on hot pipe
Measure Type	Prescriptive
Program(s)	Assisted Home Performance with ENERGY STAR, Home Performance with ENERGY STAR, Express Energy Efficiency
Sector(s)	Residential
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	3.12
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	37.38
Water Savings (gal/yr)	0
Effective Useful Life (years)	12[1]
Important Comments	

Measure Description

This measure is non-insulated water heater pipes being insulated for 6-feet by the Program Implementer or a subcontractor of the Program Implementer.

Pipe insulation near the tank saves energy by reducing standby losses from pipes that are hot from conducting heat from the storage tank. This happens by convective currents within the pipe(s), or by eventually drawing and using hot water in the pipe.

In the following calculations, the reduction in electric hot water internal gains from pipe insulation is ignored, assuming that most water heaters in Wisconsin are in basements, and that basements have little or no direct air conditioning. For gas hot water, the regain from reduced pipe heat loss (for the duration of the heating season) is subtracted from the direct savings to arrive at the net gas savings.

Heating effects are ignored for electric water heaters, assuming a predominance of gas heat. For heat pump or electric resistance heat, the heating effects should account for an appropriate efficiency, as with gas heat.

Description of Baseline Condition

The baseline condition is no pipe insulation.

Description of Efficient Condition

The efficient condition is pipe insulation on a residential natural gas water heater.

Annual Energy-Savings Algorithm

$\text{Therms}_{\text{SAVED}} = (\Delta\text{Btu/yr}) * (1 - \text{PCT}_{\text{HEAT}}) * \text{RE} / \text{HE} / 100{,}000$

ΔBtu/yr = ((1/R_{EXIST} – 1/R_{NEW}) * (L * C) * ΔT * 8,760 / RE

Where:

R_{EXIST} = Pipe heat loss coefficient of existing uninsulated pipe (= 1 Btu/hr-°F-ft)

R_{NEW} = Pipe heat loss coefficient of new insulated pipe (= 1/4 Btu/hr-°F-ft)

L = Length of pipe from water heating source covered by pipe wrap (= 6 feet)

C = Circumference of pipe, inches of outer diameter * π * 0.083 (= 0.229 feet)

ΔT = Average temperature difference from pipe to ambient air (= 60°F)

8,760 = Conversion for hours per year

RE = Water heater recovery efficiency (= 0.76)[2]

PCT_{HEAT} = Portion of year the house is mechanically heated (= 0.54)

HE = Gas system heating efficiency (= 0.8)

100,000 = Btu to therm conversion

Lifecycle Energy-Savings Algorithm

$kWh_{LIFETIME}$ = ΔkWh/yr * EUL

Where:

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

Assumptions

Assumptions are based on a direct installation, not a time-of-sale purchase.

The average difference of 60°F assumes pipe and ambient air temperatures of 125°F and 65°F, respectively.

The pipe inner and outer diameters are assumed to be 3/4-inch and 7/8-inch, respectively.

Sources

1. Wisconsin PSC EUL database.
2. NREL, Building America Research Benchmark Definition, 2009, p.12, http://www.nrel.gov/docs/fy10osti/47246.pdf

Revision History

Version Number	Authored by	Date	Description of Change
01	Conservation Services Group	01/01/2012	New Measure
02	Conservation Services Group	03/19/2013	Update to New Template & Add Lifecycle Savings
03	Conservation Services Group	04/22/2013	Revisions & Comments

Pipe Insulation (Space Heat and DHW)

	Measure Details
Measure Master ID	Pipe Insulation (Space Heat and DHW) – Custom
Measure Unit	Project
Measure Type	Custom
Program(s)	Multifamily Energy Savings
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by length of insulated pipe
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	Varies by length of insulated pipe
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Important Comments	

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 the insulation job was not completed. Insulating pipes reduces heat losses to unheated building areas and decreases problems with overheating in areas with uninsulated pipe. Insulation is required for occupant safety and for energy efficiency. Some types of insulation can also act as a corrosion inhibitor.

Insulating DHW pipes can save energy. However, the method for calculating savings and deemed savings (described below) should not be used for DHW pipes unless those pipes have a hot water recirculation system. Standard DHW systems are not static systems that maintain temperature in the piping at all times. These systems contain hot water only when there is a draw on the hot water system. After the draw, pipes cool to ambient temperatures. Adding insulation to standard DHW systems generally only slows the rate of cooling. The savings associated with those systems is transient, so the method and deemed savings described below are not applicable.

Description of Baseline Condition

The baseline condition corresponds to pipes as part of how water recirculation systems with no insulation.

Description of Efficient Condition

All hot surfaces should be insulated. These include:

- Hot water pipes (non-DHW)
- Condensate return lines and collection vessels

- Boilers
- Blowdown vessels used for heat recovery

Insulation used for pipes will be of these general types:

- High density fiberglass shaped for pipes or flat sections
- Blankets or batts of fiberglass or mineral wool
- Polyethylene chemically inert pipe insulation that has a closed-cell structure

- Pipe under 1.5 inches nominal insulated with a minimum of 1.5 inches of K-value 0.27 Btu-in/hr-ft^2-°F, or approximately R-5.
- Pipe over 1.5 inches nominal size insulated with a minimum of 3 inches of K-value 0.27 BTU-in/hr-ft^2-°F, or approximately R-11.

Annual Energy-Savings Algorithm

$Therms_{SAVED} = Insul_{SAVINGS}*Length*HOU/Boiler\ Efficiency/100,000$

Where:

$Insul_{SAVINGS}$ = Energy savings through insulating nominal pipe sizes (as shown in table)

Length = Length of insulated pipe in feet

HOU = Annual hours of operation

Boiler Efficiency = Thermal efficiency of boiler as a decimal (0.0 to 1.0)

100,000 = Conversion Btu to therms

Pipe Outside Diameter (inches)	Savings Btu/ hour-In-ft				
	140°F	180°F	0 PSIG* 212°F	10 PSIG* 239°F	25 PSIG* 266°F
1/2	40	62	83	102	122
3/4	49	77	102	125	149
1	61	95	126	155	186
1 1/2	90	141	188	230	276
2	110	174	231	283	340
4	203	319	425	522	626
8	378	599	795	978	1,174

*Steam pressure in PSIG (pounds-per-square-inch gauge)

Source: 3E Plus developed by North American Insulation Manufacturers Association (NAIMA)[2]

Lifecycle Energy-Savings Algorithm

$Therm_{LIFETIME} = Therms_{SAVED}* EUL$

Where:

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

Assumptions

Use project level information. Where project level information is missing, refer to the assumptions below. The pipe insulation is being applied to multifamily central heating system supply and return pipes.

Pipe will be kept hot for 4,000 hours per year.

The average nominal pipe size is 1 inch nominal diameter.

Boiler system efficiency is 80%.

Boiler supplies 180°F hot water.

Pipe is in a covered location that is exposed to average annual temperatures near a soil temperature of 46°F.

Sources

1. Wisconsin PSC EUL database 2013.
2. This program is available through NAIMA at http://www.pipeinsulation.org/

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	05/14/2012	New Measure

Showerhead, Direct Install, 1.5 GPM, Electric

	Measure Details
Measure Master ID	Showerhead Direct Install, 1.5 GPM, Electric, 2129, 2145
Measure Unit	Single, Low-Flow, 1.5 GPM Showerhead
Measure Type	Prescriptive
Program(s)	Assisted Home Performance with ENERGY STAR, Home Performance with ENERGY STAR, Express Energy Efficiency
Sector(s)	Residential
Annual Energy Savings (kWh)	318
Peak Demand Reduction (kW)	0.0284
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	3,821
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	2,625
Effective Useful Life (years)	12[1]
Important Comments	

Measure Description

A 1.5 GPM low-flow showerhead is installed by the Program Implementer or a subcontractor of the Program Implementer in place of a higher flow rate showerhead. Assumptions are based on a direct installation, not a time-of-sale purchase.

Description of Baseline Condition

The baseline equipment is assumed to be a higher flow rate showerhead.

Description of Efficient Condition

The efficient measure is 1.5 GPM low-flow showerheads.

Annual Energy-Savings Algorithm

$$Gallons_{SAVED} = (GPM_{BASE} - GPM_{EE}) * ((PH * SPD)/FH) * SLU * 365 \text{ days/yr}$$

$$kWh_{SAVED} = ((\Delta Gallons/yr * 8.33 * 1 * (T_{POINT\ OF\ USE} - T_{ENTERING}))/RE)/3{,}412$$

Where

GPM_{BASE} = Baseline flow rate (= 2.5 GPM)[2]

GPM_{EE} = Efficient flow rate (= 1.5 GPM)

PH = Persons/house (= 2.52)[3]

SPD = Showers/day/person (= 0.6)[4]

FH = Fixtures/house (= 1.64)[3]

SLU = Shower length in minutes (= 7.8)[4]

$T_{POINT\ OF\ USE}$ = Temperature of water at point of use (= 101°F)[4]

$T_{ENTERING}$ = Temperature of water entering water heater (= 52.3°F)[5]

RE = Average estimated recovery efficiency of electric water heater (= 98%)[6]

3,412 = Convert Btu to kWh (= 3,412 Btu/kWh)

8.33 = Density of water, lbs/gal
1 = Specific heat of water, Btu/lb °F

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = ΔkWh * CF / (PH * SLU * 365*SPD / (60mins/hr) / FH)

Where:

CF = Coincidence factor (= 0.0039)[7]

Lifecycle Energy-Savings Algorithm

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

Where:

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

Sources

1. Wisconsin PSC EUL database 2013.
2. Federal minimum at 80 psi.
3. Residential Energy Consumption Survey (RECS). 2009 RECS Micro Survey Data. Structural and Geographic Characteristics, Wisconsin.
4. Cadmus. 2012 Michigan Water Meter Study.
5. DoE DHW Scheduler, average water main temp. of all locations measured in WI by scheduler, weighted by city populations
6. NREL, Building America Research Benchmark Definition, 2009, p.12, http://www.nrel.gov/docs/fy10osti/47246.pdf
7. Calculated as follows: Assume 9% showers take place during peak hours (http://www.aquacraft.com/sites/default/files/pub/DeOreo-%282001%29-Disaggregated-Hot-Water-Use-in-Single-Family-Homes-Using-Flow-Trace-Analysis.pdf) 9% * 7.8 minutes per day /180 (minutes in peak period) = 0.0039

Revision History

Version Number	Authored by	Date	Description of Change
01	Conservation Services Group	01/01/2012	New Measure
02	Conservation Services Group	03/19/2013	Update to New Template & Add Lifecycle Savings
03	Conservation Services Group	04/22/2013	Revisions/Corrections

Showerhead, Direct Install, 1.5 GPM, NG

	Measure Details
Measure Master ID	Showerhead, Direct Install, 1.5 GPM, NG, 2123, 2139
Measure Unit	Single, Low-Flow, 1.5 GPM Showerhead
Measure Type	Prescriptive
Program(s)	Assisted Home Performance with ENERGY STAR, Home Performance with ENERGY STAR, Express Energy Efficiency
Sector(s)	Residential
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	14
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	168
Water Savings (gal/yr)	2,625
Effective Useful Life (years)	12[1]
Important Comments	

Measure Description

A 1.5 GPM low-flow showerhead is installed by the Program Implementer or a subcontractor of the Program Implementer in place of a higher flow rate showerhead. Assumptions are based on a direct installation, not a time-of-sale purchase.

Description of Baseline Condition

The baseline equipment is assumed to be a higher flow rate showerhead.

Description of Efficient Condition

The efficient measure is 1.5 GPM low-flow showerheads.

Annual Energy-Savings Algorithm

$$\text{Gallons}_{\text{SAVED}} = (\text{GPM}_{\text{BASE}} - \text{GPM}_{\text{EE}}) * ((\text{PH} * \text{SPD})/\text{FH}) * \text{SLU} * 365 \text{ days/yr}$$

$$\text{Therms}_{\text{SAVED}} = ((\Delta\text{Gallons/yr} * 8.33 * 1 * (\text{T}_{\text{POINT OF USE}} - \text{T}_{\text{ENTERING}}))/\text{EE})/100{,}000$$

Where:

GPM_{BASE} = Baseline flow rate (= 2.5 GPM)[2]

GPM_{EE} = Efficient flow rate (= 1.5 GPM)

PH = Persons/house (= 2.52)[3]

SPD = Showers/day/person (= 0.6)[4]

FH = Fixtures/house (= 1.64)[3]

SLU = Shower length in minutes (= 7.8)[4]

$\text{T}_{\text{POINT OF USE}}$ = Temperature of water at point of use (= 101°F)[4]

$T_{ENTERING}$ = Temperature of water entering water heater (= 52.3°F)[5]

EE = Average estimated recovery efficiency of electric water heater (= 76%)[6]

8.33 = Density of water, lbs/gal
1 = Specific heat of water, Btu/lb °F
100,000 = Convert Btu to therms, 100,000 Btu/therm

Lifecycle Energy-Savings Algorithm

$Therm_{LIFETIME} = Therms_{SAVED} * EUL$

Where:

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

Sources

1. Wisconsin PSC EUL database.
2. Federal minimum at 80 psi
3. Residential Energy Consumption Survey (RECS). 2009 RECS Micro Survey Data. Structural and Geographic Characteristics, Wisconsin.
4. Cadmus. 2012 Michigan Water Meter Study.
5. DoE DHW Scheduler, average water main temp. of all locations measured in WI by scheduler, weighted by city populations
6. NREL, Building America Research Benchmark Definition, 2009, p.12, http://www.nrel.gov/docs/fy10osti/47246.pdf

Revision History

Version Number	Authored by	Date	Description of Change
01	Conservation Services Group	01/01/2012	New Measure
02	Conservation Services Group	03/19/2013	Update to New Template & Add Lifecycle Savings
03	Conservation Services Group	04/22/2013	Revisions/Corrections

Low-Flow Showerheads

	Measure Details
Measure Master ID	Showerheads, Retail Store Markdown, 3017
Measure Unit	Per Showerhead
Measure Type	Prescriptive
Program(s)	Upstream Lighting & Appliance
Sector(s)	Residential- single family, Residential- multifamily
Annual Energy Savings (kWh)	96
Peak Demand Reduction (kW)	0.0025
Annual Therm Savings (Therms)	8.6
Lifecycle Energy Savings (kWh)	1,150
Lifecycle Therm Savings (Therms)	103
Water Savings (gal/yr)	2,632
Effective Useful Life (years)	12
Important Comments	

Measure Description

This measure is a showerhead with a flow rate of 1.75 GPM or less based on a time-of-sale purchase, for installation in a residential location.

The energy and therm savings were adjusted based on the saturation of fuel types for water heating in Wisconsin (30% electric and 61% gas). Therefore, the values in this TRM do not reflect the full energy or 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 the most recent sales data as of October, 2013.

Annual Energy-Savings Algorithm

Water Savings:

$$\text{Gallons}_{SAVED} = (\text{GPM}_{BASE} - \text{GPM}_{EE}) * ((\text{PH} * \text{SPD})/\text{FH}) * \text{SLU} * 365 \text{ days/yr}$$

Electric Water Heater:

$$\text{kWh}_{SAVED} = (((\Delta\text{Gallons/yr} * 8.33 * 1 * (T_{POINT\ OF\ USE} - T_{ENTERING}))/\text{RE})/3{,}412 \text{ Btu/kWh})*\text{WHS}$$

Gas Water Heater

$$\text{Therms}_{SAVED} = (((\Delta\text{Gallons/yr} * 8.33 * 1 * (T_{POINT\ OF\ USE} - T_{ENTERING}))/\text{RE})/100{,}000) *\text{WHS}$$

Where:

GPM_{BASE} = Baseline flow rate in gallons per minute (= 2.5 GPM)[2]

GPM_{EE} = Efficient flow rate in gallons per minute (= 1.54 GPM)

PH = Persons/house (= 2.36)[3]

SPD = Showers/day/person (= 0.6)[4]

FH = Fixtures/house (= 1.47)[3]

SLU = Shower length in minutes (= 7.8)[4]

$T_{POINT\ OF\ USE}$ = Temperature of water at point of use (= 101°F)[4]

$T_{ENTERING}$ = Temperature of water entering water heater (= 52.3°F)[5]

RE = Average estimated recovery efficiency of electric water heater (= 98%)[6]

WHS = Water heater fuel type saturation (= 30% for electric,= 61% for gas)[3]

8.33 = Density of water, lbs/gal

1 = Specific heat of water, Btu/lb °F

100,000 = Convert Btu to therms, 100,000 Btu/therm

3,412 = Convert Btu to kWh (= 3,412 Btu/kWh)

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = \Delta kWh * CF / (PH * SLU * 365*SPD / (60mins/hr) / FH)$

Where:

CF = Coincidence factor (= 0.0039%)[7]

Lifecycle Energy-Savings Algorithm

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

$Therm_{LIFETIME} = Therms_{SAVED} * EUL$

Where:

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

Sources

1. Wisconsin PSC EUL database.
2. Federal minimum at 80 psi
3. Residential Energy Consumption Survey (RECS). 2009 RECS Micro Survey Data. Structural and Geographic Characteristics, Wisconsin.
4. Cadmus. 2012 Michigan Water Meter Study.
5. DoE DHW Scheduler, average water main temp. of all locations measured in WI by scheduler,

weighted by city populations

6. NREL, Building America Research Benchmark Definition, 2009, p.12, http://www.nrel.gov/docs/fy10osti/47246.pdf
7. Calculated as follows: Assume 9% showers take place during peak hours (http://www.aquacraft.com/sites/default/files/pub/DeOreo-%282001%29-Disaggregated-Hot-Water-Use-in-Single-Family-Homes-Using-Flow-Trace-Analysis.pdf) 9% * 7.8 minutes per day /180 (minutes in peak period) = 0.0039

Revision History

Version Number	Authored by	Date	Description of Change
01	Applied Proactive Technologies	02/14/2013	Original
02	Applied Proactive Technologies	04/08/2013	Addressed Comments From Cadmus Dated 03/15/2013

Tankless Water Heater, Natural Gas, Energy Factor ≥ 0.82

	Measure Details
Measure Master ID	Tankless Water Heater, NG, EF ≥ 0.82, 1987
Measure Unit	Per Water Heater
Measure Type	Prescriptive
Program(s)	Residential Rewards
Sector(s)	Residential
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	59 (pre-January 1, 2016), 51 (post-January 1, 2016)
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	1,183 (pre- January 1, 2016), 1,018 (post-January 1, 2016)
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Important Comments	

Measure Description

Incentives are offered to residential customers for installing qualified tankless water heaters. This measure is applicable to any tankless water heater that has an energy factor (EF) of 0.82 or greater. Qualifying tankless water heaters must be whole-house units used for domestic water heating and must be fueled by natural gas. Only participants who have a natural gas account with a participating natural gas utility are eligible for this rebate. New federal efficiency standards that take effect in April 2015 raise the minimum EF baseline from 0.575 to 0.600. The criteria date is delayed to January 1, 2016, because this code takes effect mid-year 2015.

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.[1]

Description of Baseline Condition

The base case EF for residential, gas-fueled, storage water heaters is 0.575, as described in a 2008 ENERGY STAR® criteria analysis of water heaters.[2] 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

The qualifying tankless water heaters must meet the qualifications in the table.

Type	Input Rating	Required Energy Factor
Tankless Water Heater	≥ 50,000 Bth/hour ≤ 200,000 Btu/hour	≥ 0.82

Annual Gas-Savings Algorithm

$$\Delta\text{Therms} = \left(\text{T}_{\text{WH}} - \text{T}_{\text{entering}}\right) * \text{GPD} * 8.33 * 1 * 365 * \left(\frac{1}{\text{EF}_{\text{Base}}} - \frac{1}{\text{EF}_{\text{Eff}}}\right) * \frac{1}{100{,}000}$$

Where:

T_{WH} = Water heater temperature set point (= 125°F)

$T_{Entering}$ = Temperature of water entering water heater (= 52.3°F)[3]

GPD = Gallons of hot water used by the home (= 51.5 gal/day)[4]

8.33 = Density of water, lbs/gal

1 = Specific heat of water, Btu/lb °F

365 = Days per year, days

$EF_{Base, pre}$ = Baseline EF for units sold before January 1, 2016 (= 0.575)[5]

$EF_{Base, post}$ = Efficiency EF for units sold after January 1, 2016 (= 0.600)[5]

EF_{Eff} = Efficiency EF, 0.820

100,000 = Convert Btu to therms, 100,000 Btu/therm

Summer Coincident Peak Savings Algorithm

There are no peak demand savings for this measure.

Lifecycle Energy-Savings Algorithm

$Therm_{LIFETIME} = Therms_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 20 years)[2]

Deemed Savings

Average Annual Deemed Savings

Measure	Therms
Natural Gas Tankless Water Heater, EF ≥ 82%	59 (pre-January 1, 2016) 51 (post-January 1, 2016)

Average Lifecycle Deemed Savings

Measure	Therms
Natural Gas Tankless Water Heater, EF ≥ 82%	1,183 (pre-January 1, 2016) 1,018 (post-January 1, 2016)

Sources

1. ENERGY STAR residential water heaters key product criteria: http://www.energystar.gov/index.cfm?c=water_heat.pr_crit_water_heaters
2. Wisconsin PSC EUL database 2013.
3. United States Department of Energy. Domestic Hot Water (DWH) Scheduler, average water main temperature of all locations measured in Wisconsin by scheduler, weighted by city populations.
4. 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. A average value of 2.36 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.

5. Calculated as 0.67-0.0019*50 = 0.575, per 2001 federal standard that took effect in 2004. New baseline per federal standard adopted in 2010 and effective April 2015. Calculated as 0.675-0.0015*50 = 0.600. Both calculations assume a 50-gallon tank.

Revision History

Version Number	Authored by	Date	Description of Change
01	RSG	01/01/2012	New Measure

Tankless Water Heater, NG, ≥ 0.82 EF

	Measure Details
Measure Master ID	Tankless Water Heater, NG, ≥ 0.82 EF , 2652
Measure Unit	Per Water Heater
Measure Type	Prescriptive
Program(s)	Multifamily Energy Savings
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by date
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	Varies by date
Water Savings (gal/yr)	0
Effective Useful Life (years)	13[1]

Measure Description

This measure is small tankless water heaters that have an EF of 0.82 or greater and are ENERGY STAR-qualified. To be considered small, water heaters must have 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.

Description of Baseline Condition

The base case EF for residential, gas-fueled, storage water heaters is 0.575.[2] 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

Type	Input Rating	EF
Tankless Water Heater	≤ 75,000 Btu/hour	≥ 0.82

Annual Energy-Savings Algorithm

$$\text{Therms}_{\text{SAVED}} = (T_{WH} - T_{entering}) * GPD * 8.33 * 1 * 365 * \left(\frac{1}{EF_{Base}} - \frac{1}{EF_{Eff}}\right) * \frac{1}{100{,}000}$$

Where:

T_{WH} = Water heater temperature setpoint (= 125°F)[3]

$T_{Entering}$ = Temperature of water entering water heater (= 52.3°F)[4]

GPD = Gallons of hot water used by the home (= 44.4 gal/day)[5]

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)[6]

EF_{Eff} = Efficiency energy factor (= 0.820)

100,000 = Conversion from Btu to therms

Lifecycle Energy-Savings Algorithm

$Therm_{LIFETIME} = Therms_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 13 years)[1]

Annual and Lifecycle Deemed Savings

Average Annual Deemed Savings for Natural Gas Tankless Water Heaters

Measure	Therms
Natural Gas Tankless Water Heater, EF ≥ 82%	51 (before January 1, 2016) 44 (after January 1, 2016)

Average Lifecycle Deemed Savings for Natural Gas Tankless Water Heaters

Measure	Therms
Natural Gas Tankless Water Heater, EF ≥ 82%	663 (before January 1, 2016) 572 (after January 1, 2016)

Sources

1. Wisconsin PSC EUL Database 2013.
2. *ENERGY STAR Residential Water Heaters: Final Criteria Analysis.* April 1, 2008. Available online: http://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/water_heaters/WaterHeaterAnalysis_Final.pdf.
3. 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 set points typically range between 120°F and 140°F because temperatures below 120 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 assumptions are unsourced engineering assumptions. (Residential water heater set points found in TRMs include-

Connecticut 2012 PSD: 130°F for 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 V2.0: 125°F for pipe insulation, gas water heater, HPWH and tank wrap and 120°F for temperature reduction. Indiana V1.0: 130°F for pipe insulation.)

4. United States Department of Energy. *DHW Scheduler*. (average water main temperature for all Wisconsin locations as measured by scheduler and weighted by city population)
5. 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/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. 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 takes effect in April 2015; this was calculated as 0.675 - 0.0015 * 50 = 0.600. Both calculations assume a 50 gallon tank.
7. United States Department of Energy. R*esidential Heating Products Final Rule Technical Support Document.* Tables 8.2.13-14 and 8.2.16. 2010. Available online: http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/htgp_finalrule_ch8.pdf.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	10/25/2012	New Measure
02	Franklin Energy Services	03/08/2013	PI Update

Water Heater, Electric, Energy Factor ≥ 0.93

	Measure Details
Measure Master ID	Water Heater, Electric, EF ≥ 0.93, 1989
Measure Unit	Per Water Heater
Measure Type	Prescriptive
Program(s)	Residential Rewards
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	103
Peak Demand Reduction (kW)	0.012
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	1,545
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Important Comments	

Measure Description

This measure is the installation of qualified electric water heaters, applicable to any tank-type storage water heater with the following criteria:

- Used for DHW
- Whole-house unit
- Electric-fueled
- Not a heat pump water
- Installed before January 1, 2016

Only participants who have an electric account with a participating electric utility are eligible. Furthermore, natural gas cannot be an available fuel source in the participant's area.

Description of Baseline Condition

The baseline EF or electric water heaters is 0.904, as found in a 2008 ENERGY STAR® criteria analysis of water heaters.[2]

New federal efficiency standards that take effect in April 2015 raise the minimum EF baseline to 0.945 for 50 gallon units, which will render this measure obsolete. The criteria date is advanced to January 1, 2016, because this code takes effect mid-year 2015.

Description of Efficient Condition

The qualifying electric water heaters must meet the requirements in the table.

Type	Input Rating	Required Energy Factor
Electric Storage Water Heater	≤ 40,956 Btuh	≥ 0.93

Residential electric storage water heaters are defined as having a nominal input of 40,956 Btu/hour or less and a rated storage volume between 20 gallons and 120 gallons. [2]

Annual Energy-Savings Algorithm

$$\text{kWh}_{\text{SAVED}} = \left(T_{WH} - T_{entering}\right) * GPD * 8.33 * 1 * 365 * \left(\frac{1}{EF_{Base}} - \frac{1}{EF_{Eff}}\right) * \frac{1}{3{,}412}$$

Where:

T_{WH} = Water heater temperature setpoint (= 125°F) [3]

$T_{Entering}$ = Temperature of water entering water heater (= 52.3°F)[4]

GPD = Gallons of hot water used by the home (= 51.5 gal/day)[5]

8.33 = Density of water, lbs/gal

1 = Specific heat of water, Btu/lb °F

365 = Days per year, days

EF_{Base} = Baseline EF (= 0.904)[6]

EF_{Eff} = Efficiency EF (= 0.930)

3,412 = Convert Btu to kWh (= 3,412 Btu/kWh)

Summer Coincident Peak Savings Algorithm

$\text{kW}_{\text{SAVED}} =* \text{CF}$

Where:

8,760 = Hours in one year

CF = Coincidence factor (= 1)

Lifecycle Energy-Savings Algorithm

$\text{kWh}_{\text{LIFETIME}} = \text{kWh}_{\text{SAVED}} * \text{EUL}$

Where:

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

Sources

1. Wisconsin PSC EUL database 2013.
2. ENERGY STAR Residential Water Heaters: Final Criteria Analysis. April 1, 200 8. Available online: http://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/water_heaters/WaterHeaterAnalysis_Final.pdf
3. 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 set points typically range between 120°F and 140°F because temperatures below 120 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 set points between 120 and 130 degrees.
4. United States Department of Energy. Domestic Hot Water (DHW) Scheduler, average water main temperature of all locations measured in Wisconsin by scheduler, weighted by city populations.
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 2.36 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. Calculated as 0.97-0.00132*50 = 0.904, per 2001 federal standard that took effect in 2004. Assumes average tank size of 50 gallons. United States Department of Energy Final Rule, pg 31. http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/htgp_finalrule_fedreg.pdf

Revision History

Version Number	Authored by	Date	Description of Change
01	RSG	01/01/2013	New Measure
02	RSG	02/20/2013	Updated for Review and Formatting
03	Franklin Energy Services	03/08/2013	PI Update

Water Heater, Indirect

	Measure Details
Measure Master ID	Water Heater, Indirect, 1988
Measure Unit	Per Water Heater
Measure Type	Prescriptive
Program(s)	Residential Rewards
Sector(s)	Residential
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	101
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	1,212
Water Savings (gal/yr)	0
Effective Useful Life (years)	12[1]

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 that are 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.[2]

Description of Baseline Condition

Because an indirect water heater is fueled by a boiler, the baseline condition is related to the actual characteristics of the boiler.

Description of Efficient Condition

Indirect water heaters must be ≥ 90% AFUE.

Annual Energy-Savings Algorithm

$$\text{Therms}_{\text{SAVED}} = \frac{GPD*365*8.33*1*\Delta T_W}{100{,}000} * \left[\frac{1}{RE_{BASELINE}} - \frac{1}{E_{C,EE}}\right] + \left[\frac{UA_{BASELINE}}{RE_{BASELINE}} - \frac{UA_{EE}}{E_{C,EE}}\right] * \frac{\Delta T_S*8{,}760}{100{,}000}$$

Where:

GPD = Average daily hot water consumption (= 51.5 gallons per day)[4]

365 = Conversion factor (days/year)

8.33 = Conversion factor (lb/gallon)

1 = Conversion factor (Btu/lb-°F)

ΔT_W = Average difference between the cold water inlet temperature (52.3°F)[5] and the hot water delivery temperature (125°F) (= 77.7°F)

100,000 = Conversion factor (Btu/therm)

$RE_{BASELINE}$ = Recovery efficiency of the baseline tank type water heater (=76%)[5]

$E_{C,EE}$ = Combustion efficiency of energy-efficient boiler used to heat indirect water heater (=90%)[6]

$UA_{BASELINE}$ = Overall heat loss coefficient of base tank type water heater (= 14.0 Btu/hr-°F)[7]

UA_{EE} = Overall heat loss coefficient of indirect water heater storage tank (= 6.1 Btu/hr-°F)[8]

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 savings. Typical values for UA_{ee}[8] are shown below.

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

Lifecycle Energy-Savings Algorithm

$Therm_{LIFETIME} = Therms_{SAVED} * EUL$

Where:

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

Sources

1. Wisconsin PSC EUL database 2013.
2. Public Service Commission of Wisconsin. Focus on Energy Evaluation. *Residential Programs: CY09 Deemed Savings Review*. March 26, 2010.
3. Public Service Commission of Wisconsin. *Request for Proposals*. Issued for Mass Markets Portfolio Residential Energy Efficiency Program Implementation. July 26, 2011.
4. 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

2.261 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.

5. Most common RE for non-heat pump water heaters: http://www.ahridirectory.org/ahridirectory/pages/rwh/defaultSearch.aspx
6. Assumed the combustion efficiency is a proxy for AFUE, where the program minimum is 90% AFUE.
7. United States Department of Energy. Technical Support Document: Energy Efficiency Standards for Consumer Products, Residential Water Heaters, Including Regulatory Impact Analysis. 2000.
8. *New York Technical Reference Manual*. Indirect Water Heaters, pg. 87. 2010.
9. Focus on Energy Evaluation, Business Programs: Measure Life Study. August 25, 2009.

Revision History

Version Number	Authored by	Date	Description of Change
01	RSG	01/01/2012	New Measure

Water Heater, Natural Gas, Energy Factor ≥ 0.67

	Measure Details
Measure Master ID	Water Heater, NG, EF ≥ 0.67, 1985
Measure Unit	
Measure Type	
Program(s)	Residential Rewards
Sector(s)	Residential
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	28 (pre-January 1, 2016), 20 (post-January 1, 2016)
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	336 (pre- January 1, 2016), 240 (post-January 1, 2016)
Water Savings (gal/yr)	0
Effective Useful Life (years)	12[1]
Important Comments	

Measure Description

This measure covers residential-sized tank-type storage domestic water heaters (small-storage water heater). Small-storage water heaters are defined as equipment with an input rating ≤ 75,000 Btu/hour and a storage volume from 40 to 100 gallons. Gas storage water heaters are used to supply hot water for residential buildings.

The incentive will be given to program participants who install a small storage water heater that has an EF of 0.67 or greater. Only participants who have a natural gas account are eligible for this measure.

Description of Baseline Condition

The base case EF for residential, gas-fueled, storage water heaters is 0.575.[2] 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 Storage Water Heaters

Type	Input Rating	EF
Storage Water Heater	≤ 75,000 Btu/hour	≥ 0.67

Annual Energy-Savings Algorithm

$$\text{Therms}_{\text{SAVED}} = \left(\text{T}_{\text{WH}} - \text{T}_{\text{entering}}\right) * \text{GPD} * 8.33 * 1 * 365 * \left(\frac{1}{\text{EF}_{\text{Base}}} - \frac{1}{\text{EF}_{\text{Eff}}}\right) * \frac{1}{100{,}000}$$

Where:

T_{WH} = Water heater temperature setpoint (= 125°F)[3]

$T_{Entering}$ = Temperature of water entering water heater (= 52.3°F)[4]

GPD = Gallons of hot water used by the home (= 51.5 gal/day)[5]

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)[6]

EF_{Eff} = Efficiency energy factor (= 0.67)

100,000 = Conversion from Btu to therms

Lifecycle Energy-Savings Algorithm

$Therm_{LIFETIME} = Therms_{SAVED} * EUL$

Where:

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

Annual and Lifecycle Deemed Savings

Average Annual Deemed Savings for Natural Gas Water Heaters

Measure	Therms
Natural Gas Storage Water Heater, EF ≥ 67%	28 (before January 1, 2016) 20 (after January 1, 2016)

Average Lifecycle Deemed Savings for Natural Gas Water Heaters

Measure	Therms
Natural Gas Storage Water Heater, EF ≥ 67%	337(before January 1, 2016) 238 (after January 1, 2016)

Sources

1. Wisconsin PSC EUL Database 2013.
2. *ENERGY STAR Residential Water Heaters: Final Criteria Analysis.* April 1, 2008. Available online: http://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/water_heaters/WaterHeaterAnalysis_Final.pdf.
3. 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 set points typically range between 120°F and 140°F because temperatures below 120 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 assumptions are unsourced engineering assumptions. (Residential water heater set points found in TRMs include- Connecticut 2012 PSD: 130°F for 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 V2.0: 125°F for pipe insulation, gas water heater, HPWH and tank wrap and 120°F for temperature reduction. Indiana V1.0: 130°F for pipe insulation.)

4. United States Department of Energy. *DHW Scheduler*. (average water main temperature for all Wisconsin locations as measured by scheduler and weighted by city population)
5. 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 2.36 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. 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 takes effect in April 2015; this was calculated as 0.675 - 0.0015 * 50 = 0.600. Both calculations assume a 50 gallon tank.
7. United States Department of Energy. R*esidential Heating Products Final Rule Technical Support Document.* Tables 8.2.13-14 and 8.2.16. 2010. Available online: http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/htgp_finalrule_ch8.pdf.

Revision History

Version Number	Authored by	Date	Description of Change

Chiller, High Efficiency, Air and Water Cooled, Replacement

	Measure Details
Measure Master ID	Chiller, High Efficiency, Air Cooled, Replacement, 2249 Chiller, High Efficiency, Water Cooled, Replacement, 2755
Measure Unit	Chiller
Measure Type	Custom
Program(s)	Multifamily Energy Savings
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by size and type
Peak Demand Reduction (kW)	Varies by size and type
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by size and type
Lifecycle Therm Savings (Therms)	Varies by size
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Important Comments	

Measure Description

A chiller produces chilled water or another liquid for use as a cooling medium. Typically, the chilled water is pumped through a cooling coil, where a fan draws air over the coil to transfer energy to conditioned spaces. The performance of a chiller is impacted by how it rejects heat through the condenser. A chiller can be air, water, or evaporative cooled. Water-cooled chillers are inherently more efficient then air-cooled chillers. Another characteristic that impacts chiller performance is the type of compressor it employs (reciprocating, scroll, screw, or centrifugal). Each type of compressor operates differently at part-load efficiency.

This measure is the installation of a high-efficiency, water- or air-cooled chiller to replace an existing unit.

Description of Baseline Condition

Baseline was provided from ASHRAE 90.1 – 2007 Table 6.8.1C – Minimum Efficiency Requirements.[2] The minimum efficiency values were provided per AHRI Standard 550/590.[3]

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
Water Cooled, Electrically Operated, Positive Displacement (Rotary Screw and Scroll)	≥ 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
Water Cooled, Electrically Operated, Centrifugal	≥ 150 tons and < 300 tons	5.55 COP; 5.90 IPLV
Water Cooled, Electrically Operated, Centrifugal	≥ 300 tons	6.10 COP; 6.40 IPLV

Description of Efficient Condition

The retrofit chiller must perform better at full-load and part-load efficiency than chiller minimum efficiency standards listed in the table above.

Annual Energy-Savings Algorithm

ASHRAE 2007 minimum efficiency for chillers is the proposed efficiency.

Existing Equipment as a Baseline:

$kWh_{SAVED} = (IPLV_{Baseline\ Existing} – IPLV_{Proposed})$ * ton-hours

Where:

$IPLV_{Baseline\ Existing}$ = Integrated part load volume of baseline chiller (user input)

$IPLV_{Proposed}$ = Integrated part load volume of efficient chiller (user input)

Ton-hours = Determined from weather bin hours and building design cooling load, user input

Summer Coincident Peak Savings Algorithm

Existing Equipment as a Baseline:

kW_{SAVED} = (Full Load $kW/Ton_{Baseline\ Existing}$ – Full Load $kW/Ton_{Baseline\ Proposed}$) * CF * Tons

Code Minimum Efficiencies as a Baseline:

kW_{SAVED} = (Full Load $kW/Ton_{Baseline\ Code}$ – Full Load $kW/Ton_{Baseline\ Proposed}$) * CF * Tons

Where:

Full Load $kW/ton_{Baseline\ Existing}$ = Full load power draw of baseline chiller, user input

Full Load $kW/ton_{Baseline\ Proposed}$ = Full load power draw of efficient chiller, user input

Full Load $kW/Ton_{Baseline\ Code}$ = Full load power draw of baseline chiller using code standard

CF = Coincidence factor (= 0.8)[8]

Tons = Full load tons of chiller

Lifecycle Energy-Savings Algorithm

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

Summer Coincident Peak Savings Algorithm

Peak savings for existing and code equipment are calculated using the specific full load efficiencies in the following equations.

Existing Equipment as a Baseline

$kW_{SAVED} = (\text{Full Load kW/Ton}_{\text{Baseline Existing}} - \text{Full Load kW/Ton}_{\text{Baseline Proposed}}) * CF$

Code Minimum Efficiencies as a Baseline

$kW_{SAVED} = (\text{Full Load kW/Ton}_{\text{Baseline Baseline Code}} - \text{Full Load kW/Ton}_{\text{Baseline Proposed}}) * CF$

Where:

$\text{Full Load kW/ton}_{\text{Baseline Existing}}$ = Full load power draw of baseline chiller (user input)

$\text{Full Load kW/ton}_{\text{Proposed}}$ = Full load power draw of efficient chiller (user input)

$\text{Full Load kW/ton}_{\text{Baseline Code}}$ = Full load power draw of chiller meeting code standards

CF = Coincidence factor (= 0.8)

Lifecycle Energy-Savings Algorithm

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

Where:

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

Parameter	Comment
Design Load & Building Information Input	
Minimum Part Load (%)	Minimum chiller load defines the minimum load at the facility and is used in estimating a load profile for the bin analysis.
Chiller Type	Type of chiller: air cooled, positive displacement water cooled, centrifugal water cooled.
Baseline and Proposed Chiller	
Chiller Capacity (tons)	Capacity of the baseline and proposed chiller.
Full Load (kW/ton)	Full load efficiency of the baseline and proposed chiller at ARI conditions.
IPLV (kW/ton)	Part load efficiency of the baseline and proposed chiller at ARI conditions.

Assumptions

- Chiller specifications must include full load efficiency values and IPLV vales in kW/ton AHRI standard 550/590 test procedures.
- The full product identification/model number must be shown on the AHRI specification sheets and invoices.

- Chillers purchased or installed for backup or redundant systems are not eligible for this measure.
- Equipment must meet full-load efficiency, part-load efficiency, or both.
- Electric chiller incentives are available only for HVAC space-cooling applications.

Sources

1. Wisconsin PSC EUL database 2013.
2. ASHRAE. Minimum Efficiency Requirements 90.1. 2007. Table 6.8.1C.
3. AHRI Standard 550/590.
4. JCI Chiller Calculation Program
5. IECC. Water Chilling Packages, Efficiency Requirements: 2009 pg. 48
6. State of Wisconsin Public Service Commission. *Business Programs: Measure Life Study*. Final Report. Evaluated by PA Consulting Group, Inc. August 25, 2009.
7. The total ton-hours is calculated from the load profile generated and bin hour assumptions. The formulas are used to establish energy savings based on the existing equipment and the code minimum efficiencies as baseline.
8. Engineering estimate. Assumes system is operating 100% of the hour at peak conditions but average load is 80% of peak load.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	10/29/2012	Initial Draft
02	Shaw Group	01/08/2013	Updated to New Template
03	Franklin Energy Services	03/08/2013	Document Updated by PI

Parking Garage Ventilation Controls

	Measure Details
Measure Master ID	Parking Garage Ventilation Controls, 3016
Measure Unit	Per Exhaust Fan System (Total Fan Motor HP)
Measure Type	Hybrid
Program(s)	Multifamily Energy Savings
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Based on inputs per exhaust fan hp
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Based on inputs per exhaust fan hp
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[3]

Measure Description

This measure requires controlling ventilation airflow in enclosed parking garages based on carbon monoxide concentrations, while maintaining the code-required run hours. By controlling airflow based on need rather than running constantly, the system saves energy while maintaining a safe environment.

Description of Baseline Condition

The baseline condition is having a garage exhaust fan operate 24 hours per day.

Description of Efficient Condition

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

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{BASE} – kWh_{EE}$

$kWh_{BASE} = HP_{FAN} *0.746 \text{ kW/HP} * 24 \text{ hrs/day} * 365 \text{ days/yr} * LOAD$

$kWh_{EE} = HP_{FAN} *0.746 \text{ kW/HP} * HOU_{DAY} * 365 \text{ days/yr} * LOAD$

Where:

kWh_{BASE} = Annual electricity consumption of baseline fan control system

kWh_{EE} = Annual electricity consumption of efficient fan control system

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

LOAD = Load on the fan motor by the fan, fraction between 0 and 1 (= 0.80)

0.746 kW/HP = Conversion factor from exhaust fan motor hp to kilowatts

HOU_{DAY} = Average daily exhaust run hours for efficient fan control system (accounting for 5 hour minimum, plus an additional 2.85 hours of run time (5 + (24 – 5) * (1-85%) = 7.85 hours)

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= 0, there are no kW savings)

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 5 years)[3]

Sources

1. *Wisconsin* Department of Safety and Professional Services.. Chapter SPS 364: Heating, Ventilation and Air Conditioning. SPS 364.0404 2(c). December 2011. The exhaust ventilation controls must provide 0.75 CFM/square foot for at least five hours in each 24-hour period. Available online: https://docs.legis.wisconsin.gov/code/admin_code/sps/safety_and_buildings_and_environment/361_366/364/II/0404.
2. California Utilities Statewide Codes and Standards Team. *2013 California Building Energy Efficiency Standards: Garage Exhaust*. September 2011. Available online: http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/current/Reports/Nonresidential/Covered_Processes/2013_CASE_ASHRAE8-GarageExhaust_09.30.2011.pdf.
3. Wisconsin PSC EUL database 2013.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	12/31/2012	New Measure

Air Source Heat Pump, ≥ 16 SEER

	Measure Details
Measure Master ID	Air Source Heat Pump, ≥ 16 SEER, 2992
Measure Unit	Unit
Measure Type	Prescriptive
Program(s)	Residential Rewards
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	1,098
Peak Demand Reduction (kW)	0.309
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	19,764
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	18[1]
Important Comments	

Measure Description

A residential-sized air source heat pump has an input capacity of ≤ 65,000 Btu/hr. The deemed measure algorithms and associated savings were derived from Section 5.3.1 Air Source Heat Pumps of the Illinois Statewide TRM.[2]

Description of Baseline Condition

The baseline measure is a federal standard baseline air source heat pump (≥ 13 SEER) in a residential home.

Description of Efficient Condition

The efficient measure is a residential-sized air source heat pump with an input capacity ≤ 65,000 Btu/hr.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = ((EFLH_{cooling} * CAP * (1 / SEER_{BASE} - 1 / SEER_{EE})) / 1{,}000) + ((EFLH_{heating} * CAP * (1 / HSPF_{BASE} - 1 / HSPF_{EE})) / 1{,}000)$

Where:

$EFLH_{cooling}$ = Effective Full load cooling (= 337)[5]

CAP = Capacity (= 42,000 Btu/hour)

$SEER_{BASE}$ = Baseline seasonal energy efficiency ratio (= 13)

$SEER_{EE}$ = Efficient measure seasonal energy efficiency ratio (= 16)

1,000 = Kilowatt conversion factor

$EFLH_{heat}$ = Effective Full load heating (= 1,816)[5]

$HSPF_{BASE}$ = 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)

EER_{EE} = Baseline energy efficiency ratio (= 12.8)

1,000 = Kilowatt conversion factor

CF = Coincidence factor (= 0.66)[4]

Lifecycle Energy-Savings Algorithm:

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

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 3.5 tons for equipment installed in the Wisconsin market. If ACCA Quality Installation guidelines are followed, it is anticipated that equipment will be selected on a heat loss balance point analysis and will lead to larger system specification.[3] Therefore, a 3.5-ton system is a conservative assumption for deemed saving purposes. Supporting inputs for load hours and capacity in several Wisconsin cities are:

Location	$EFLH_{cooling}$	$EFLH_{heating}$
Green Bay	344	1852
La Crosse	323	1966
Madison	395	1934
Milwaukee	457	1883
Wisconsin Average	380	1909

Sources

1. Wisconsin PSC EUL database 2013.
2. Illinois Energy Efficiency Statewide Advisory Group. *Illinois Statewide Technical Reference Manual.* August 2012. http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf
3. ACCA. Quality Installation Guidelines.
4. http://www.dnrec.delaware.gov/energy/information/otherinfo/Documents/EM-and-V-guidance-documents/DELAWARE_TRM_August%202012.pdf
5. Several Cadmus metering studies show equivalent full load hours (EFLH) in the Energy Star calculator are over-estimated by 30% for cooling. EFLH heating hours for heat pumps are over-

estimated by 25%. The heating and cooling EFLH values used are adjusted by population-weighted CDD and HDD TMY-3 values.

Revision History

Version Number	Authored by	Date	Description of Change
01	RSG	11/06/2012	Original
02	RSG	01/16/2012	Added Supplemental Information
03	RSG	02/19/2013	Addressed Evaluator Comments
04	RSG	03/07/2013	Revised for Comments

Residential Ground Source Heat Pump, Electric Back-Up

	Measure Details
Measure Master ID	Ground Source Heat Pump, Electric Back-Up, 2820
Measure Unit	Per Heat Pump
Measure Type	Prescriptive
Program(s)	Residential Renewables
Sector(s)	Residential-single family
Annual Energy Savings (kWh)	4,207
Peak Demand Reduction (kW)	0.929
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	75,726
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	18[1]
Important Comments	

Measure Description

Residential-sized geothermal (ground source) heat pump systems use the earth to heat and cool through the installation of an exterior underground loop that works in combination with an interior heat pump unit. The measure provides residences 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 and must consist of a closed-loop application only. Additionally, the procedures followed to install the equipment must conform to the ACCA Standard 5 Quality Installation requirements.

Annual Energy-Savings Algorithm

$$\text{kWh}_{\text{SAVED}} = \frac{FLH_{COOL} * {}^{BTU}/_{h_{COOL}} * \left[{}^{1}/_{SEER_{BASE}} - \left({}^{1}/_{EER_{EE}} * 1.02\right)\right]}{1000} + \frac{FLH_{HEAT} * {}^{BTU}/_{h_{HEAT}} * \left[{}^{1}/_{HSPF_{BASE}} - \left({}^{1}/_{COP_{EE}} * 3.412\right)\right]}{1000}$$

Where:

FLH_{COOL} = Full load hours cooling (= 380 hours)[2]

$Btuh_{COOL}$ = Cooling capacity of equipment (= 40,089 Btuh)[3]

$SEER_{BASE}$ = Seasonal energy-efficiency ratio (= 13)[4]

EER_{EE} = Energy-efficiency ratio (= 22.43 kBtu/kWh)[3]

GSER = Factor to determine SEER based on its EER (= 1.02)[5]

FLH_{HEAT} = Full load hours heating (= 1,909 hours)[2]

$Btuh_{HEAT}$ = Heating capacity of equipment (= 30,579 Btuh)[3]

$HSPF_{BASE}$ = Heating seasonal performance factor (7.7 kBtu/kWh)[4]

COP_{EE} = Coefficient of performance (= 4.18)[3]

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 savings were calculated with the following algorithms and methodology:

$$\mathrm{kW_{SAVED}} = \frac{\left[\mathrm{BTU}/\mathrm{h_{COOL}} * \left(1/\mathrm{EER_{BASE}} - 1/\mathrm{EER_{EE}}\right)\right]}{1{,}000} * \mathrm{CF}$$

Where:

EER_{BASE} = Energy-efficiency ratio (= 11)[4]

CF = Coincidence factor (= 0.5)[6]

Lifecycle Energy-Savings Algorithm

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

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[2]:

Location	$EFLH_{cooling}$	$EFLH_{heating}$
Green Bay	344	1852
La Crosse	323	1966
Madison	395	1934
Milwaukee	457	1883
Wisconsin Average	380	1909

Sources

1. Wisconsin PSC EUL database, 2013.
2. Several Cadmus metering studies show equivalent full load hours (EFLH) in the Energy Star calculator are over-estimated by 30% for cooling. EFLH heating hours for heat pumps are over-estimated by 25%. 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, August 31 2009, Pg. 19-21, http://www.ecw.org/ecwresults/249-1.pdf

Revision History

Version Number	Authored by	Date	Description of Change
01	RSG	06/18/2012	Original

A/C Split System, ≤ 65 MBh, SEER 14/15/16+

	Measure Details
Measure Master ID	A/C Split System, ≤ 65 MBh, SEER 14, 2194 A/C Split System, ≤ 65 MBh, SEER 15, 2192 A/C Split System, ≤ 65 MBh, SEER 16+, 2193
Measure Unit	Per Split System Installed
Measure Type	Prescriptive
Program(s)	Multifamily Energy Savings
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
Effective Useful Life (years)	15[7]

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

A SEER value of 13 is assumed for the baseline unit.[8]

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

$kWh_{SAVED} = (CAP / 1,000) * (1 / SEER_{BASE} – 1 / SEER_{EE}) * EFLH_{C}$

Where:

CAP = Rated cooling capacity of the energy-efficient unit (= 29,100 in BtuHcool)[4]

1,000 = Kilowatt conversion factor

$SEER_{BASE}$ = Seasonal efficiency rating of the baseline unit (= 13)

$SEER_{EE}$ = Seasonal efficiency rating of the energy-efficiency unit (= 14, 15, or 16)

$EFLH_c$ = Equivalent full load hours for the cooling season (= 380)[6]

Summer Coincident Peak Savings Algorithm

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

Where:

CF = 0.66 coincidence factor[5]

EER_{ee} = 11.7 for 14 SEER, 12.2 for 15 SEER, and 12.7 for 16 SEER

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 18 years)[7]

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.

Deemed Savings

SEER	Annual kWh Savings	kW Savings	Lifecycle kWh Savings
14	60.7	0.104	1,093
15	113.3	0.172	2,040
16	159.4	0.234	2,869

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. http://www.dnrec.delaware.gov/energy/information/otherinfo/Documents/EM-and-V-guidance-documents/DELAWARE_TRM_August%202012.pdf
6. Several Cadmus metering studies show equivalent full load hours (EFLH) in the Energy Star calculator are over-estimated by 30% for cooling. The cooling EFLH values used are adjusted by population-weighted CDD TMY-3 values.
7. Wisconsin PSC EUL database 2013.
8. Federal minimum efficiency standard.

Supporting inputs for load hours in several Wisconsin cities are[2]:

Location	$EFLH_{cooling}$
Green Bay	344
La Crosse	323
Madison	395
Milwaukee	457
Wisconsin Average	380

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	10/25/2012	Initial Draft
02	Franklin Energy Services	03/08/2013	Edits by PI

Steam Trap Repair, < 10 psig, General Heating

	Measure Details
Measure Master ID	Steam Trap Repair, < 10 psig, General Heating
Measure Unit	Per Steam Trap
Measure Type	Prescriptive
Program(s)	Multifamily Energy Savings
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	245
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	1,225
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Important Comments	

Steam Trap Repair, < 50 psig, General Heating

	Measure Details
Measure Master ID	Steam Trap Repair, < 50 psig, General Heating
Measure Unit	Per Steam Trap
Measure Type	Prescriptive
Program(s)	Multifamily Energy Savings
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	1,423
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	7,115
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Important Comments	

Measure Description

These measures are the repair of a radiator steam trap that is < 10 psig and the repair of general heating steam trap that is < 50 psig.

Steam systems distribute heat from boilers to satisfy space heating requirements. Steam distribution systems contain steam traps, which are automatic valves that remove condensate, air, and other non-condensable gases, while preventing or minimizing steam loss. Steam traps that fail may allow excess steam to escape, thus increasing the amount of steam that must be generated to meet end-use requirements.

All traps are susceptible to wear and dirt contamination and require periodic inspection and maintenance to ensure correct operation. Faulty steam traps (with blocked, leaking, or blow-through) can be diagnosed with ultrasonic, temperature, or conductivity monitoring techniques. Regular steam trap maintenance and faulty steam trap replacement are steps that minimize steam loss. There are four major types of steam traps: 1) thermostatic (including float and thermostatic), 2) mechanical, 3) thermodynamic, and 4) fixed orifice (fixed orifice traps do not qualify for incentives).

Individual steam traps must be failed open to qualify. When mass replacing steam traps, 30% of traps replaced will qualify. Systems on a city steam do not qualify for incentives. Traps can be repaired or replaced.

Description of Baseline Condition

The baseline condition is that a steam trap failed open.

Description of Efficient Condition

The efficient condition is that the steam trap is operating per design with the same specifications as the baseline.

Annual Energy-Savings Algorithm

The steam leakage rate is calculated using the Napier equation:

$$\text{Energy Loss (therms)} = \frac{24.24 * (P_1 - P_2) * D^2 * h_{fg} * HOU * \beta}{100{,}000 * \eta}$$

Where:

P_1 = Steam pressure (psig)

P_2 = Condensate tank pressure (psig)

D = Size of steam trap orifice (inches)

h_{fg} = Heat of evaporation of water to steam at P_1 (Btu/lb)

HOU = Average annual run hours (hours/year)

β = Adjustment factor to account for actual vs. theoretical steam loss (%)

100,000 = Btu/therm conversion factor

η = Combustion efficiency of boiler (%)

Lifecycle Energy-Savings Algorithm

$Therm_{LIFETIME} = Therms_{SAVED} * EUL$

Where:

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

Assumptions

The following assumptions are true for both types of steam traps (< 50 psig and < 10 psig operating pressure, general heating):

- Average diameter of steam trap orifice (D) = default of 1/4-inch
- Hours-of-use (HOU) = 5,392 hours/year (based on a WI temp bin analysis – see Appendix B)
- P_2 = 0 psig
- η[1] = 80%
- β[1] = 50%

For steam traps < 50 psig operating pressure, general heating:

- P_1 = 30 psig
- h_{fg} = 929 Btu/lb

For steam traps < 10 psig operating pressure, radiators:

- P_1 = 5 psig
- h_{fg} = 961 Btu/lb

The HOUs for the steam systems were calculated using bin analysis of weather data across Wisconsin and a 55°F balance point on the heating system.

Sources

1. Wisconsin PSC EUL database 2013.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	10/25/2012	Original Draft
02	Franklin Energy Services	03/08/2013	PI Update

HVAC, Not Otherwise Specified

	Measure Details
Measure Master ID	HVAC, Not Otherwise Specified, 2386
Measure Unit	Custom
Measure Type	Custom
Program(s)	Multifamily Energy Savings
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Custom calculation, if deemed: 5,219
Peak Demand Reduction (kW)	Custom calculation, ifdeemed: 0.610
Annual Therm Savings (Therms)	Custom calculation, ifdeemed: 692
Lifecycle Energy Savings (kWh)	Custom calculation, if deemed: 78,285
Lifecycle Therm Savings (Therms)	Custom calculation, if deemed: 10,380
Water Savings (gal/yr)	0
Effective Useful Life (years)	If deemed: 15[1]
Important Comments	

Measure Description

This measure is the installation or replacement of an HVAC measure that does not conform to another standard measure, but that provides quantifiable energy savings. The deemed values presented are an average of historic measures in this category.

Description of Baseline Condition

Early replacement measures are calculated with a baseline of the existing equipment for the first four years of its effective useful life, and then the code or industry standard baseline is applied for the remaining useful life.

Replace-upon-failure measures are calculated with a baseline of energy code or industry standard efficiency.

Description of Efficient Condition

Custom HVAC projects involve improvements to a facility's HVAC system that do not fall under existing standard measures. This may include the installation of ventilation heat recovery systems, water loop heat pumps, and boilers paired with indirect water heaters that are rated at 85% to 89% TE, as well as other improvements that result in quantifiable energy savings while maintaining occupant comfort and normal operation.

Annual Energy-Savings Algorithm

Custom HVAC calculations vary by facility's HVAC system. Equipment installed must increase efficiency over existing equipment or system. All applicable electrical, safety, and energy codes must be met. Other specifications may need to be met depending on the project scope.

kWh_{SAVED} = 5,219[2]

$\text{Therms}_{\text{SAVED}} = 692$[2]

Summer Coincident Peak Savings Algorithm

$\text{kW}_{\text{SAVED}} = 0.613$ (only based on heat recovery peak savings)[2]

Lifecycle Energy-Savings Algorithm

$\text{kWh}_{\text{LIFETIME}} = \text{kWh}_{\text{SAVED}} * \text{EUL}$

$\text{Therms}_{\text{LIFETIME}} = \text{Therms}_{\text{SAVED}} * \text{EUL}$

Where:

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

Sources

2. Wisconsin PSC EUL database 2013.
3. Focus on Energy ACES Program, 2008-2010 average project savings for measure adjusted for dual baseline lifetime savings.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	10/25/2012	Original Draft
02	Franklin Energy Services	03/08/2013	Update Based on Evaluation Comments

ENERGY STAR Multifamily Common Area Clothes Washers

	Measure Details
Measure Master ID	ENERGY STAR Clothes Washer - Common Area Electric (CAE) Water Heater, 2756 ENERGY STAR Clothes Washer - Common Area Gas (CAG) Water Heater, 2757
Measure Unit	Per Clothes Washer
Measure Type	Prescriptive
Program(s)	Multifamily Energy Savings
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)	13,978
Effective Useful Life (years)	14[1]
Important Comments	

Measure Description

ENERGY STAR is a standard for energy-efficient consumer appliances. This standard increases savings for clothes washers in multifamily buildings 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

<u>Clothes washer with electric DHW:</u>

$$kWh_{SAVED} = [\Delta kWh(EG) * \%EG + \Delta kWh(EE) * \%EE + \Delta kWh(EnD) * \%EnD] * Cycles/year$$

$$Therms_{SAVED} = [\Delta Therm(EG) * \%EG] * Cycles/year$$

<u>Clothes washer with gas DHW:</u>

$$kWh_{SAVED} = [\Delta kWh(GE) * \%GE + \Delta kWh(GG) * \%GG + \Delta kWh(GnD) * \%GnD] * Cycles/year$$

$\text{Therms}_{\text{SAVED}}$ = [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/gas dryer (= 8.0%)

EE = Electric DHW/electric dryer (= 92.0%)

EnD = Electric DHW/no dryer (= 0.0%)

Cycles/year = Wash cycles/year (= 1,241)[2]

Mix of dryers for clothes washers with gas DHW[2]

GG = Gas DHW/gas dryer (= 26.5%)

GE = Gas DHW/electric dryer (= 74.5%)

Gnd = Gas DHW/no dryer (=0.0%)

Cycles/year = Wash cycles/year (= 1,241)[2]

Electric and gas savings for mixes of dryer and DHW types[1]

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) = Gas savings per cycle in therms (= 0.066)

ΔTherm(GE) = Gas savings per cycle in therms (= 0.011)

ΔTherm(EG) = Gas savings per cycle in therms (= 0.055)

ΔTherm(GnD) = Gas Savings per cycle in therms (= 0.011)

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = ΔkWh/(Cycles/year * Hours/cycle) * CF

Where:

Hours/cycle = 1 (estimated)

CF = Coincidence factor (= 0.045)[3]

Lifecycle Energy-Savings Algorithm

$\text{kWh}_{\text{LIFETIME}}$ = $\text{kWh}_{\text{SAVED}}$* EUL

$\text{Therm}_{\text{LIFETIME}}$ = $\text{Therms}_{\text{SAVED}}$* EUL

Where:

EUL = Effective useful life (= 14 years)[1]

Deemed Savings

	CAE	CAG
Annual Deemed Electricity Savings (kWh)	1,971	1,331
Deemed Summer Peak Electricity Demand Savings (kW)	0.071	0.048
Lifecycle Deemed Electricity Energy Savings (kWh)	27,594	18,634
Annual Deemed Natural Gas Energy Savings (therms)	5.3	31.9
Lifecycle Deemed Natural Gas Energy Savings (Therms)	74.2	446.6
Annual Demand Water Savings (gallons)	13,978	13,978
Lifecycle Deemed Water Savings (gallons)	195,692	195,692

Sources

1. Wisconsin PSC EUL Database 2013.
2. CPUC Res Retro HIM Evaluation Report - Weighted by quantity of each efficiency level from MESP Spectrum
3. RECs Database - Wisconsin Multifamily unit counts
4. Illinois Statewide Technical Reference Manual for Energy Efficiency, Version 2.0. June 7, 2013, p. 349

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	02/17/2012	Original
02	Franklin Energy Services	03/08/2013	PI Update

Clothes Washer, Retail Store Markdown

	Measure Details
Measure Master ID	Clothes Washer, Retail Store Markdown, 3035
Measure Unit	Per Clothes Washer
Measure Type	Prescriptive
Program(s)	Upstream Lighting & Appliance
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	161
Peak Demand Reduction (kW)	0.0321
Annual Therm Savings (Therms)	4.72
Lifecycle Energy Savings (kWh)	1,771
Lifecycle Therm Savings (Therms)	55
Water Savings (gal/yr)	3,267
Effective Useful Life (years)	11[1]
Important Comments	

Measure Description

The measure is for a top-load ENERGY STAR® clothes washer. The standard is based on the time-of-sale purchase (less than $800) and installed in a residential location.

Description of Baseline Condition

The baseline equipment is assumed to be a clothes washer model that meets the minimum federal baseline efficiency (MEF = 1.26; WF = 9.5).[1]

Description of Efficient Condition

The efficient condition is a top-load, ENERGY STAR clothes washer purchased for less than $800 and installed in a residential location.

Annual Energy-Savings Algorithm

$$\text{kWh}_{\text{SAVED}} = [\Delta\text{kWh(GE)/yr} * \%\text{GE} + \Delta\text{kWh(EG)/yr} * \%\text{EG} + \Delta\text{kWh(EE)/yr} * \%\text{EE} + \Delta\text{kWh(EnD)/yr} * \%\text{EnD} + \Delta\text{kWh(GG)/yr} * \%\text{GG} + \Delta\text{kWh(GnD)/yr} * \%\ \text{GnD}] * \text{Cycles/year}$$

$$\text{Therms}_{\text{SAVED}} = [\Delta\text{Therm(GG)/yr} * \%\text{GG} + \Delta\text{Therm(GE)/yr} * \%\text{GE} + \Delta\text{Therm(EG)/yr} * \%\text{EG} + \Delta\text{Therm(EnD)/yr} * \%\text{EnD}\ ] * \text{Cycles/year}$$

Where:

ΔkWh(GE)/yr = Annual kWh savings per cycle from gas DHW/electric dryer

ΔkWh(EG)/yr = Annual kWh savings per cycle from electric DHW/gas dryer

ΔkWh(EE)/yr = Annual kWh savings per cycle from electric DHW/electric dryer

ΔkWh(EnD)/yr = Annual kWh savings per cycle from electric DHW/no dryer

ΔkWh(GG)/yr = Annual kWh savings per cycle from gas DHW/gas dryer

ΔkWh(GnD)/yr = Annual kWh savings per cycle from gas DHW/no dryer
ΔTherm(GG)/yr = Annual therms savings per cycle from gas DHW/gas dryer
ΔTherm(GE)/yr = Annual therms savings per cycle from gas DHW/electric dryer
ΔTherm(EG)/yr = Annual therms savings per cycle from electric DHW/gas dryer
ΔTherm(GnD)/yr = Annual therms savings per cycle from gas DHW/no dryer
%GE = Proportion of households with gas DHW/electric dryer (= 43%)
%EG = Proportion of households with electric DHW/gas dryer (= 0%)
%EE = Proportion of households with electric DHW/electric dryer (= 34%)
%EnD = Proportion of households with electric DHW/no dryer (= 2%)
%GG = Proportion of households with gas DHW/gas dryer (= 18%)
% GnD = Proportion of households with gas DHW/no dryer (= 3%)

The following table provides the ENERGY STAR calculator annual savings and per cycle saving estimates

DHW Fuel	Dryer Fuel	ENERGY STAR Calculator Savings	kWh Savings/Cycle	ENERGY STAR Calculator Savings	Therm Savings/Cycle
Gas	Electric	132.1407	0.4390	6.4572	0.0215
Electric	Gas	177.4221	0.5894	3.2979	0.0110
Electric	Electric	274.0784	0.9106	-	-
Electric	None	177.4221	0.5894	-	-
Gas	Gas	35.4844	0.1179	9.7551	0.0324
Gas	None	35.4844	0.1179	6.4572	0.0215

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED}) / (Cycles/year * hours/cycle) * CF$

Where:

CF = Summer peak coincidence factor (= 6%)[2]

Lifecycle Energy-Savings Algorithm

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

$Therm_{LIFETIME} = Therms_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 11 years)[1]

Assumptions

The following assumptions are used with the EPA ENERGY STAR appliance calculator to generate this measure's electric, gas, and water savings:

- Clothes Washer Capacity = 3.10 cubic feet[3]
- Number of Loads = 5.79 loads/week, 301 loads/year[4]
- Baseline Modified EF = 1.26
- ENERGY STAR Modified EF = 2.00[5]
- Baseline Water Factor = 9.50
- ENERGY STAR Water Factor = 6.00
- Hrs/load = 1 (estimated)

The fuels used in water heating and clothes drying are also important for determining savings for this measure. Based on the 2009 EIA RECs data for Wisconsin, 64% of homes use gas to heat water while the remaining 36% use electricity. Also based on the 2009 EIA RECs data, 18% of homes have a gas dryer and 77% have electric dryers, while 5% of homes do not use a dryer. These figures reveal a clear preference for gas as the water heating fuel, where available. Accordingly, it is safe to assume that the 18% of homes with gas clothes dryers are all within the 64% that have gas water heating equipment.

Therefore, it can be derived that 34% of Wisconsin homes use electricity for both DHW and clothes drying and 43% use gas for DHW and electricity for drying, as shown in the table below. These percentages are used to generate the weighted average electricity and gas savings values.

Estimated Fuel Configurations in Wisconsin Homes

Clothes Dryer Fuel		Domestic Hot Water Fuel		Dryer Fuel Total
		Gas	Electricity	
Dryer Fuel	Gas	18%	0%	**18%**
	Electricity	43%	34%	**77%**
	None	3%	2%	**5%**
Total		**64%**	**36%**	**100%**

Sources

1. United States Environmental Protection Agency. ENERGY STAR Appliance Calculator, Version dated April 2013. http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=CW.
2. New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs. October 15, 2010.
3. United States Environmental Protection Agency. ENERGY STAR Appliance Calculator, Version dated April 2013.

http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=CW.

4. United States Energy Information Administration. Residential Energy Consumption Survey, HC3.9 Appliances in Homes in Midwest Region. 2009. http://www.eia.gov/consumption/residential/data/2009/. (Based on weighted average "loads per week" data for Wisconsin – 5.79 loads/wk = [(0.1*1 load/wk + 0.9*3.5 loads/wk + 0.7*7.5 loads/wk + 0.2*12.5 loads/wk)/1.9]. Total loads/year = 5.79 loads/wk * 52 wks/yr = 301 loads/yr.)
5. United States Department of Energy. Minimum criteria for ENERGY STAR. February 1, 2013. http://www.energystar.gov/index.cfm?c=clotheswash.pr_crit_clothes_washers.

Revision History

Version Number	Authored by	Date	Description of Change
01	Applied Proactive Technologies	02/15/2013	Original
02	Applied Proactive Technologies	04/08/2013	Addressed Comments from Cadmus dated 03/15/2013
03	Applied Proactive Technologies	04/16/2013	Addressed PSC Comment Regarding Installed Measure Cost
04	Applied Proactive Technologies	07/15/2013	Update Measure Unique Identifier

Variable Speed Drives for HVAC Applications (Multifamily)

	Measure Details
Measure Master ID	Variable Speed Drives for HVAC Applications (Multifamily), ####
Measure Unit	Horsepower
Measure Type	Hybrid
Program(s)	Multifamily Energy Savings
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	880 per horsepower[1]
Peak Demand Reduction (kW)	0.13 per horsepower[2]
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	13,200 per horsepower
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[3]
Important Comments	

Measure Description

This measure is a VSD installed on an existing HVAC fan or pump (retrofit only) in a multifamily building. Units must operate a minimum of 2,000 hours annually. This measure only applies to HVAC applications in multifamily buildings. The deemed savings values are based on average motor size of 7.5 hp.

Description of Baseline Condition

The baseline condition is a pump or fan that operates at a constant speed.

Description of Efficient Condition

VSDs 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 is VSDs installed on existing HVAC fans and pumps. The installation of a VSD 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. VSDs on new equipment are not eligible. Redundant, back-up units and replacement of existing VSDs do not qualify.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{BASE} – kWh_{VSD}$

$kWh_{BASE} = (Watts_{BASE} * HOU) / 1,000$

$kWh_{VSD} = \Sigma(Watts_{VSD,i} * CAP_i \times HOU) / 1{,}000$

Where:

$Watts_{BASE}$ = Power draw of baseline motor at constant baseline speed

$Watts_{VSD,i}$ = Power draw of motor with VSD at capacity *i*

CAP_i = Percentage of time motor runs at capacity *i* (CAP_i should add to 100%)

1,000 = Kilowatt conversion factor

HOU = Annual operating hours

Summer Coincident Peak Savings Algorithm

$kW_{BASE} = Watts_{BASE} * HOU_{PEAK}$

$kW_{VSD} = \Sigma(Watts_{VSD,i} * CAP_{i,PEAK} * HOU_{PEAK}) / 1{,}000$

$kW_{SAVED} = kW_{BASE} – kW_{VSD}$

Where:

$Watts_{BASE}$ = Power draw of baseline motor at constant baseline speed

$Watts_{VSD,i}$ = Power draw of motor with VSD at capacity *i*

$CAP_{i,PEAK}$ = Percentage of time motor runs at capacity *i* during the peak period ($CAP_{i,PEAK}$ should add to 100%)

HOU_{PEAK} = Annual operating hours during peak period

Lifecycle Energy-Savings Algorithm

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

Where:

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

Sources

1. State of Wisconsin Public Service Commission of Wisconsin. Focus on Energy ACES Program. 2008-2010 average project savings for measure (based on an average of 7.5 HP).
2. Michigan Public Service Commission. Department of Licensing and Regulatory Affairs. Michigan Energy Measures Database (MEMD) http://www.michigan.gov/mpsc/0,1607,7-159-52495_55129---,00.html

Focus on Energy Evaluation - Business Program: Measure Life Study 2009.Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	10/25/2012	Initial Draft
02	Franklin Energy Services	03/08/2013	Update Based on Evaluation Comments

Occupancy Sensors – Prescriptive

	Measure Details
Measure Master ID	Occupancy Sensor, Ceiling Mount, ≤ 500 Watts, 2471 Occupancy Sensor, Ceiling Mount, ≥ 1,001 Watts, 2472 Occupancy Sensor, Ceiling Mount, 501-Watts to 1,000 Watts, 2473 Occupancy Sensor, Wall Mount, ≤ 200 Watts, 2483 Occupancy Sensor, Wall Mount, > 200 Watts, 2484
Measure Unit	Sensor
Program(s)	Multifamily Energy Savings
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by connected wattage
Peak Demand Reduction (kW)	Varies by connected wattage
Annual Thermal 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]

Measure Description

Occupancy sensors reduce energy consumption by reducing the operating hours for lighting equipment in low occupancy areas such as halls, 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 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, but lighting fixtures being controlled by manual wall switches.

Description of Efficient Condition

The efficient condition is a hard-wired wall- or ceiling-mounted occupancy sensor, where lighting fixtures are controlled by the sensors based on detected occupancy.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = P_L /1{,}000 * F_S * HOU$

Where:

P_L = Controlled lighting wattage (see values in table below)

1,000 = Kilowatt conversion factor

F_S = Savings factor, deemed 41%[1]

HOU = Annual operating hours (see values in table below)

Summer Coincident Peak Savings Algorithm

The deemed summer peak savings is set to zero. Although occupancy sensors may reduce load during the peak period, most savings will occur during non-peak hours.

$kW_{SAVED} = P_L / 1{,}000 * CF$

Where:

CF = Coincidence factor (= 0 kW)

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 8 years)[1]

Deemed Savings

Deemed Annual and Lifetime Electricity Savings

Measure ID	Measure Name	Average Connected Wattage (W)[3]	Average HOU (hours/yr)[4]	Annual kWh Savings	Lifetime kWh Savings
2471	Occupancy Sensor, Ceiling Mount, ≤ 500 Watts	350	5,950	854	6,831
2472	Occupancy Sensor, Ceiling Mount, ≥ 1,001 Watts	1,200	5,950	2,927	23,419
2473	Occupancy Sensor, Ceiling Mount, 501-1,000 Watts	750	5,950	1,830	14,637
2483	Occupancy Sensor, Wall Mount, ≤ 200 Watts	150	5,950	366	2,927
2484	Occupancy Sensor, Wall Mount, > 200 Watts	350	5,950	854	6,831

Sources

1. Wisconsin PSC EUL database.

2. SPECTRUM Measure Master Database.
3. PA Consulting Group Inc. and Public Service Commission of Wisconsin. *Focus on Energy Evaluation, Business Programs: Measure Life Study*. Final Report, Table 4-163. August 25, 2009.
4. PA Consulting Group Inc. and Public Service Commission of Wisconsin. *Focus on Energy Evaluation, Business Programs: Measure Life Study*. Final Report, Table 3-5 (HOU value for Other). August 25, 2009.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	04/16/2012	New Measure

CFL, Direct Install, 9, 14, 19, or 23 Watts

	Measure Details
Measure Master ID	CFL, Direct Install, 9 Watts, 2116 CFL, Direct Install, 14 Watts, 2117 CFL, Direct Install, 19 Watts, 2118 CFL, Direct Install, 23 Watts, 2119 As well as 2132, 2133, 2134, and 2135
Measure Unit	Single, Spiral, Screw-in CFL
Measure Type	Prescriptive
Program(s)	Assisted Home Performance with ENERGY STAR, Home Performance with ENERGY STAR, Express Energy Efficiency
Sector(s)	Residential
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)	6[1]
Important Comments	

Measure Description

A 9-watt, 14-watt, 19-watt, and 23-watt ENERGY STAR-qualified screw-in CFL is installed by the Program Implementer or a subcontractor of the Program Implementer in place of an incandescent screw-in bulb. Assumptions are based on a direct installation, not a time-of sale-purchase.

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 installed by the Program Implementer or a subcontractor.

Annual Energy-Savings Algorithm

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

Where:

$Watts_{BASE}$ = Baseline wattage (= 40, 53, 60, or 72)

$Watts_{EE}$ = Efficient wattage (= 9, 14, 19, or 23)

1,000 = Kilowatt conversion factor

HOU = Average annual hours-of-use, based on 2.27 hrs/day (= 829)[2]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1{,}000 * CF^3$

Where:

CF = Demand coincident factor (= 0.075)[3]

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 6 years)[1]

Assumptions

A baseline adjustment was taken into account for this measure. Replacement involves a functioning bulb. In 2012, federal legislation stemming from EISA required that all general-purpose light bulbs between 40 watts and 100 watts be approximately 30% more energy efficient than incandescent bulbs. This legislation, in essence, began the phase out of standard incandescent bulbs. In 2012, 100-watt incandescents were no longer manufactured. There were restrictions on 75-watt bulbs in 2013, and there will be restrictions on both 40-watt and 60-watt bulbs in 2014. The 2014 baseline for this measure is therefore a combination of halogen and incandescent efficiencies, listed in the table below.

Lumen Output	Typical Wattage: Current Incandescent Technology	EISA Requirements		
		Maximum Wattage	Minimum Lifetime (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

$Watts_{BASE}$	$Watts_{EFFICIENT}$	Annual kWh_{SAVED}	$kW_{SAVED, SUMMER PEAK}$	Lifetime kWh_{SAVED}
72	23	41	0.004	244
60	19	34	0.003	204
53	14	32	0.003	194
40	9	26	0.002	154

Sources

1. Wisconsin PSC EUL database 2013.
2. Cadmus Research. *Field Study 2013: Residential Lighting*. October 18, 2013.
3. Cadmus Research. *Field Study 2013: Residential Lighting.* October 25, 2013.

Revision History

Version Number	Authored by	Date	Description of Change
01	Conservation Services Group	01/01/2012	New Measure
02	Conservation Services Group	03/19/2013	Update to New Template & Add Lifecycle Savings
03	Conservation Services Group	04/22/2013	Revisions/Corrections
04	CB&I	05/31/2013	Revision to EUL

Pin-Based, Reduced-Wattage CFL Lamps

	Measure Details
Measure Master ID	Pin-Based, Reduced-Wattage CFL Lamps, 3031, ,3032, 3033, 3034
Measure Unit	Lamp
Measure Type	Prescriptive
Program(s)	Multifamily Energy Savings
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)	3[1]
Important Comments	

Measure Description

Reduced-wattage (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

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

Where:

$Watts_{BASE}$ = Power consumption of baseline measure

$Watts_{EE}$ = Power consumption of efficient measure

1,000 = Kilowatt conversion factor

HOU = Average annual hours-of-use (= 5,949.5)[2]

	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

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

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

Where:

EUL = Effective useful life (= 3 years)[1]

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.

Deemed Savings

Average Annual Deemed Savings for Pin-Based, Reduced-Wattage CFL Lamps

Measure	Existing Building
Pin-Based, 18-Watt CFL Lamps	18 kWh / 0.002 kW
Pin-Based, 26-Watt CFL Lamps	24 kWh / 0.003 kW
Pin-Based, 32-Watt CFL Lamps	27 kWh / 0.003 kW
Pin-Based, 42-Watt CFL Lamps	39 kWh / 0.005 kW

Average Lifecycle Deemed Savings for Pin-Based, Reduced-Wattage CFL Lamps

Measure	Existing Building
Pin-Based, 18-Watt CFL Lamps	54 kWh
Pin-Based, 26-Watt CFL Lamps	72 kWh
Pin-Based, 32-Watt CFL Lamps	81 kWh
Pin-Based, 42-Watt CFL Lamps	117 kWh

Sources

1. Wisconsin PSC EUL database 2013.
2. ACES. *Deemed Savings Desk Review*. November 3, 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.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	12/27/2012	New Measure

CFL Reflector Lamps – Prescriptive

	Measure Details
Measure Master ID	CFL Reflector Lamps – Prescriptive, 2246
Measure Unit	Unit
Measure Type	Prescriptive
Program(s)	Multifamily Energy Savings
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
Effective Useful Life (years)	5[1]
Important Comments	

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:

$Watts_{BASE}$ = Watts of baseline measure (Incandescent lamp)

$Watts_{EE}$ = Watts of efficient measure (CFL lamp)

1,000 = Kilowatt conversion factor

HOU = Average annual run hours (= 829)[2]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED}= (Watts_{base}- Watts_{efficient})/1,000 * CF$

Where:

CF = Coincidence factor (= 0.075)[3]

Lifecycle Energy-Savings Algorithm

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

Where:

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

Assumptions

The savings for this measure were evaluated using a combination of the ENERGY STAR qualified product list (QPL) for CFL bulbs and information from the U.S. DOE EERE data book.[4] 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 below.

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. Wisconsin PSC EUL database 2013.
2. Cadmus Research. Field Study 2013: Residential Lighting. October 18, 2013.
3. Cadmus Research. Field Study 2013: Residential Lighting. October 25, 2013.
4. ENERGY STAR. Qualified Product List. October 25, 2013. Available online: https://data.energystar.gov/Government/ENERGY-STAR-Certified-Light-Bulbs/8qjd-zcsy.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	04/16/2012	New Measure

Exterior/Parking Induction PSMH/CMH Fixtures

	Measure Details
Measure Master ID	Exterior/Parking Induction PSMH/CMH Fixtures,
Measure Unit	Fixture
Measure Type	Prescriptive
Program(s)	Multifamily Energy Savings
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by measure and building contruction
Peak Demand Reduction (kW)	Varies by measure and building contruction
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by measure and building contruction
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Important Comments	

Measure Description

Induction, PSMH, and CMH 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 and parking lot applications.

Description of Baseline Condition

The baseline condition is standard HID lamps between 70 watts and 400 watts located on exterior poles, high canopies, or in parking garages.

Description of Efficient Condition

The efficient condition is induction, PSMH, and CMH fixtures between 35 watts and 250 watts.

Annual Energy-Savings Algorithm

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

Where:

$Watts_{BASE}$ = Power consumption of baseline equipment (standard HID fixture)

$Watts_{EE}$ = Power consumption of efficient equipment (induction lighting fixture, PSMH, CMHfixture, or linear fluorescent fixture)

1,000 = Kilowatt conversion factor

HOU = Average annual run hours (= 4,380 for exterior lighting, = 8,760 for parking garages)

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= 0 for exterior lighting, = 1 for parking garages)

Lifecycle Energy-Savings Algorithm

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

Where:

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

Assumptions

- The induction wattages included ballast wattage, which was calculated as 10% of lamp wattage based on the manufacturer specifications.
- All exterior replacement calculations use 4,380 hours of annual operation.
- All parking garage replacement calculations use 8,760 hours of annual operation.

The values used for savings algorithm were weighted using data in the following table.

	$Watts_{BASE}$	$Watts_{EE}$
70-watt to 100-watt HID replacement	70-watt HID: 94 watts 100-watt HID: 129 watts	35-watt induction: 39 watts 55-watt induction: 61 watts
150-watt HID replacement	150-watt HID: 179 watts	100-watt induction: 110 watts 100-watt PSMH or CMH: 128 watts
175-watt HID replacement	175-watt HID: 210 watts	100-watt induction: 110 watts 100-watt PSMH or CMH: 128 watts
250-watt HID replacement	250-watt HID: 299 watts	120-watt and 125-watt induction: 135 watts 150-watt induction: 165 watts 165-watt induction: 182 watts 125-watt PSMH or CMH: 150 watts
320-watt HID replacement	320-watt HID: 368 watts	200-watt induction: 220 watts 225-watt induction: 248 watts 250-watt induction: 275 watts 200-watt PSMH or CMH: 232 watts 210-watt PSMH or CMH: 229 watts 220-watt PSMH or CMH: 242 watts
400-watt HID replacement	400-watt HID: 463 watts	200-watt induction: 220 225-watt induction: 248 250-watt induction: 275 200-watt PSMH or CMH: 232 210-watt PSMH or CMH: 229 220-watt CMH: 242

Exterior replacements were weighted as follows:

- For 70-watt to 100-watt HIDs:
  - Baseline = 50% 70-watt HID and 50% 100-watt HID
  - Eligible Replacements = 50% 35-watt and 55-watt induction

- For 150-watt HIDs:
  - Baseline = 100% 150-watt HID
  - Eligible Replacements = 50% 100-watt induction and 50% 100-watt PSMH or CMH
- For 175-watt HIDs:
  - Baseline = 100% 175-watt HID
  - Eligible Replacements = 50% 100-watt induction and 50% 100-watt PSMH or CMH
- For 250-watt HIDs:
  - Baseline = 100% 250-watt HID
  - Eligible Replacements = 25% 120-watt to 125-watt, 150-watt, and 165-watt induction, and 25% 125-watt PSMH or CMH
- For 320-watt HIDs:
  - Baseline = 100% 320-watt HID
  - Eligible Replacements = 16.6% 200-watt, 225-watt, and 250-watt induction, and 16.6% 200-watt, 210-watt, and 220-watt PSMH or CMH
- For 400-watt HIDs:
  - Baseline = 100% 400-watt HID
  - Eligible Replacements = 16.6% 200-watt, 225-watt, and 250-watt induction, and 16.6% 200-watt, 210-watt, and 220-watt PSMH or CMH

Parking garage replacements were weighted as follows:

- For 70- to 100-watt HIDs:
  - Baseline = 50% 70-watt and 100-watt HID
  - Eligible Replacements = 50% 35-watt and 50% 55-watt induction
- For 150-watt HIDs:
  - Baseline = 100% 150-watt HID
  - Eligible Replacements = 50% 100-watt induction and 50% 100-watt PSMH or CMH
- For 175-watt HIDs:
  - Baseline = 100% 175-watt HID
  - Eligible Replacements = 50% 100-watt induction and 50% 100-watt PSMH or CMH
- For 250-watt HIDs:
  - Baseline = 100% 250-watt HID
  - Eligible Replacements = 25% 120- to 125-watt, 150-watt, and 165-watt induction, and 25% 125-watt PSMH or CMH

New construction exterior replacements were weighted as follows:

- For 70- to 100-watt HIDs:
  - Baseline = 50% 70-watt and 50% 100-watt HID
  - Eligible Replacements = 50% 35-watt and 50% 55-watt induction
- For 150-watt HIDs:
  - Baseline = 100% 150-watt HID
  - Eligible Replacements = 50% 100-watt induction and 50% 100-watt PSMH or CMH
- For 175-watt HIDs:
  - Baseline = 100% 175-watt HID
  - Eligible Replacements = 50% 100-watt induction and 50% 100-watt PSMH or CMH
- For 250-watt HIDs:
  - Baseline = 100% 250-watt HID
  - Eligible Replacements = 25% 120- to 125-watt, 25% 150-watt, and 25% 165-watt induction, and 25% 125-watt PSMH or CMH
- For 320- to 400-watt HIDs:
  - Baseline = 50% 320-watt and 50% 400-watt HID
  - Eligible Replacements = 16.6% 200-watt, 16.6% 225-watt, and 16.6% 250-watt induction, and 16.6% 200-watt, 16.6% 210-watt, and 16.6% 220-watt PSMH or CMH

New construction parking garage replacements were weighted as follows:

- For 70- to 100-watt HIDs:
  - Baseline = 50% 70-watt and 50% 100-watt HID
  - Eligible Replacements = 50% 35-watt and 50% 55-watt induction
- For 150-watt HIDs:
  - Baseline = 100% 150-watt HID
  - Eligible Replacements = 50% 100-watt induction and 50% 100-watt PSMH or CMH
- For 175-watt HIDs:
  - Baseline = 100% 175-watt HID
  - Eligible Replacements = 50% 100-watt induction and 50% 100-watt PSMH or CMH
- For 250-watt HIDs:
  - Baseline = 100% 250-watt HID
  - Eligible Replacements = 25% 120- to 125-watt, 25% 150-watt, and 25% 165-watt induction, and 25% 125-watt PSMH or CMH

Deemed Savings

Measure	Savings for Existing Buildings and New Construction		
	Annual kWh	kW	Lifetime kWh
Replace Exterior Pole Wall or High Canopy Mount 70-Watt to 100-Watt HID With 35-Watt to 55-Watt Induction	291	0	4,365
Replace Parking Garage 70- Watt to 100-Watt HID With 35-Watt to 55-Watt Induction	583	0.067	8,745
Replace Exterior Pole Wall or High Canopy Mount 150-Watt HID With 100-Watt Induction or PSMH/CMH	263	0	3,945
Replace Parking Garage 150-Watt HID With 100-Watt Induction or PSMH/CMH	526	0.060	7,890
Replace Exterior Pole Wall or High Canopy Mount 175-Watt HID With 100-Watt Induction or PSMH/CMH	399	0	5,985
Replace Parking Garage 175-Watt HID With 100-Watt Induction or PSMH/CMH	797	0.091	11,955
Replace Exterior Pole, Wall, or High Canopy Mount 250-Watt HID with 120-Watt, 125-Watt, 150-Watt, or 165-Watt Induction or 125-Watt PSMH/CMH	618	0	9,270
Replace Parking Garage 250-Watt HID With 120-Watt, 125-Watt, 150-Watt, or 165-Watt Induction or 125-Watt PSMH/CMH	1,235	0.141	18,525
Replace Exterior 320-Watt HID With 200-Watt to 250-Watt Induction or 200-Watt to 220-Watt PSMH/CMH(1)	510	0	7,650
Replace Exterior 400-Watt HID With 200-Watt to 250-Watt Induction or 200-Watt to 220-Watt PSMH/CMH(1)	972	0	14,580
Replace Exterior 320-Watt to 400-Watt HID With 200-Watt to 250-Watt Induction or 200-Watt to 220-Watt PSMH/CMH(2)	741	0	11,115

(1) This measure does not apply to new construction.

(2) This measure does not apply to existing buildings.

Sources

1. Wisconsin PSC EUL database 2013.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	12/28/2012	New Measure

Exterior/Parking LED Fixtures

	Measure Details
Measure Master ID	Exterior/Parking LED Fixtures, 3100, 3101, 3103, 3104, 3109, 3110
Measure Unit	Fixture
Measure Type	Prescriptive
Program(s)	Multifamily Energy Savings
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)	12[1]
Important Comments	See Excel Calculation: Exterior LED HID Replacement Fixtures Calculation_FES_BIP_CSF_LEU_01.01.13 See Excel Calculation: Parking Garage LED HID Replacement Fixtures Calculation_FES_BIP_CSF_LEU_01.01.13

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 Design Lights Consortium qualifying list.[2]

Annual Energy-Savings Algorithm

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

Where:

$Watts_{BASE}$ = Annual electricity consumption of baseline measure (standard HID fixture)

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
400-watt HID replacement	400-watt HID: 463 watts

$Watts_{EE}$ = Annual electricity consumption of efficient measure (LED fixture)[2]

1,000 = Kilowatt conversion factor

HOU = Annual hours-of-use (= 4,380 for exterior lights, = 4,380 or 8,760 for garage lights)

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= 0 for exterior lights, = 0 for garage lights (4,380) or 1 for garage lights (8,760))

Lifecycle Energy-Savings Algorithm

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

Where:

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

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]

Deemed Savings

Average Annual Deemed Savings for Exterior LED Fixtures

Annual Savings Measure	kWh	kW
Exterior LED replacing 70-watt to 100-watt HID	195	0.000
Exterior LED replacing 150-watt to 175-watt HID	341	0.000
Exterior LED replacing 250-watt HID	524	0.000
Exterior LED replacing 320-watt HID	645	0.000
Exterior LED replacing 400-watt HID	811	0.000

Average Lifecycle Deemed Savings for Exterior LED Fixtures

Lifecycle Savings Measure	kWh
Exterior LED replacing 70-watt to 100-watt HID	2,344
Exterior LED replacing 150-watt to 175-watt HID	4,089
Exterior LED replacing 250-watt HID	6,286
Exterior LED replacing 320-watt HID	7,737
Exterior LED replacing 400-watt HID	9,734

Average Annual Deemed Savings for Parking LED Fixtures

Measure (hours)	kWh	kW
Parking LED replacing 70-watt to 100-watt (8,760)	391	0.045
Parking LED replacing 70-watt to 100-watt (4,380)	195	0.000
Parking LED replacing 150-watt to 175-watt (8,760)	682	0.078
Parking LED replacing 150-watt to 175-watt (4,380)	341	0.000
Parking LED replacing 250-watt (8,760)	1,048	0.120
Parking LED replacing 250-watt (4,380)	524	0.000

Average Lifecycle Deemed Savings for Parking LED Fixtures

Measure (hours)	kWh
Parking LED replacing 70-watt to 100-watt (8,760)	4,688
Parking LED replacing 70-watt to 100-watt (4,380)	2,344
Parking LED replacing 150-watt to 175-watt (8,760)	8,178
Parking LED replacing 150-watt to 175-watt (4,380)	4,089
Parking LED replacing 250-watt (8,760)	12,572
Parking LED replacing 250-watt (4,380)	6,286

Sources

1. Wisconsin PSC EUL database 2013.
2. Design Lights Consortium Qualified Parts List; http://www.designlights.org/

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	12/28/2012	New Measure

LED Exit Signs

	Measure Details
Measure Master ID	LED Exit Signs, 2768
Measure Unit	Per sign
Measure Type	Prescriptive
Program(s)	Multifamily Energy Savings, Small Business
Sector(s)	Residential- multifamily, Commercial, Schools & Government, Industrial, Agricultural
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]
Important Comments	

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 or CFL exit sign with one or two bulbs (40 watt or 16 watt, respectively).

Description of Efficient Condition

The efficient condition is an LED exit sign. The fixture must meet ENERGY STAR Version 2 specifications.

Annual Energy-Savings Algorithm

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

Where:

$Watts_{BASE}$ = Watts of baseline measure (= 16 for CFL exit sign and = 40 for incandescent exit sign)[2]

$Watts_{EE}$ = Watts of LED exit sign (= 2.9)[1]

1,000 = Kilowatt conversion factor

HOU = Average annual run hours = 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

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

Where:

EUL = Effective useful life (= 8 years MESP, 16 years Small Business)[4]

Deemed Savings

Deemed Savings for LED Exit Signs

Type of Savings	Baseline Measure Type		
	CFL	Incandescent	Default
Annual Energy Savings (kWh)	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. Available online: 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 (LED) Exit Signs.” Available online: http://www.energystar.gov/ia/business/small_business/led_exitsigns_techsheet.pdf.

3. Mid Atlantic Technical Reference Manual, Version 3. March 2013.
4. Wisconsin PSC EUL database 2013.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	06/07/2012	New Measure

LED, Recessed Downlight, ENERGY STAR

	Measure Details
Measure Master ID	LED, Recessed Downlight, ENERGY STAR, 2458
Measure Unit	Per fixture
Measure Type	Prescriptive
Program(s)	Multifamily Energy Savings, Small Business
Sector(s)	Residential- multifamily, Commercial, Schools & Government, Industrial, Agricultural
Annual Energy Savings (kWh)	Varies by type and location
Peak Demand Reduction (kW)	Varies by type and location
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by type and location
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Important Comments	

Measure Description

This measure is for replacing incandescent or CFL down lights with qualified LED fixtures.

Description of Baseline Condition

The baseline is an incandescent (65 watt) or CFL (16 watt) down light.[3]

Description of Efficient Condition

The efficient condition is replacing a complete luminaire unit. The down light (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 down light (= 12 watts)[3]

1,000 = Kilowatt conversion factor

HOU = Average annual run hours (= 5,949.5 for multifamily common areas[4], = 949 for in-residence lighting)[2]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{base}- Watts_{efficient})/1,000 * CF$

Where:

CF = Coincidence factor (=0.77 for multifamily common areas,[5] = 0.11for in-residence lighting)[2]

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Baseline Technology	Area Type	$Watts_{BASE}$	$Watts_{EFFICIENT}$	Annual kWh_{SAVED}	$kW_{SAVED, SUMMER PEAK}$	Lifetime kWh_{SAVED}
Incandescent	In Unit	65	12	50	0.006	754
CFL	In Unit	16	12	4	0.000	57
Incandescent	Common Area	65	12	315	0.041	4730
CFL	Common Area	16	12	24	0.003	357

Sources

1. Wisconsin PSC EUL database 2013.
2. Cadmus Research. Field Study 2013: Residential Lighting. October 18, 2013. (The report was based on using CFL bulbs to replace incandescent bulbs. It's believed that LEDs will initially be treated the same as CFLs, so those values were used.)
3. Mid-Atlantic TRM Version 3, March 2013.
4. Focus on Energy ACES Deemed Savings Desk Review 11/03/10 Multifamily Applications for Common Areas
5. Focus on Energy Business Programs Deemed Savings Manual V1.0 March 22, 2010. Table 3.2 Coincidence Factor for Lighting in Commercial Applications.
6. Cadmus Research. Field Study 2013: Residential Lighting. October 25, 2013. (The study was conducted for CFL and incandescent bulbs. It's believed that LEDs will initially be treated the same as CFLs, so those values were used.)

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	04/15/2012	New Measure

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 LED Fixture, Downlights, Accent Lights and Monopoint <= 18 Watts, In Unit, 3158
Measure Unit	Fixture
Measure Type	Prescriptive
Program(s)	Multifamily Energy Savings, Small Business
Sector(s)	Residential- multifamily, Commercial, Schools & Government, Industrial, Agricultural
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)	15[1]
Important Comments	

Measure Description

LED downlights, accent lights, and monopoint fixtures can replace existing incandescent fixtures without sacrificing performance. LED downlights, accent lights, and monopoint fixtures 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 measure (incandescent fixtures)

$Watts_{EE}$ = Power consumption of efficient measure (LED products)

1,000 = Kilowatt conversion factor

HOU = Average annual hours-of-use (= 5,949.5 in common area[2] and = 949 in unit[6])

Lifecycle Energy-Savings Algorithm

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

Where:

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

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= 0.77 in common area[5] and = 0.11 in unit[7])

Assumptions

A baseline adjustment is used for this measure because replacement involves a functioning bulb. In 2012, federal legislation stemming from ESIA began requiring that all general-purpose light bulbs, starting with 100-watt bulbs, be approximately 30% more energy efficient than incandescent bulbs. This, in essence, began the phase out of standard incandescent bulbs. Starting in 2012, 100-watt incandescent bulbs were no longer manufactured. In 2013, 75-watt bulbs underwent similar restrictions, and in 2014 both 40-watt and 60-watt bulbs will have the same restrictions. The baseline for this measure was therefore a combination of halogen and incandescent efficiencies for 2014, as listed in the tables below. 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%.

Lumen Output	Typical Wattage: Current Incandescent Technology	EISA Requirements		
		Maximum Wattage	Minimum Lifetime (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

In Unit

Lumen Output	Typical Wattage: Standard Incandescent Technology	$Watts_{BASE}$[3]	$Watts_{EFFICIENT}$[4]	Annual kWh_{SAVED}	$kW_{SAVED,\ SUMMER\ PEAK}$	Lifetime kWh_{SAVED}
750-1,049	60	49	13	34	0.009	512

1,050-1,489	75	58	16	40	0.005	598

Common Area

Lumen Output	Typical Wattage: Standard Incandescent Technology	Watts$_{BASE}$[3]	Watts$_{EFFICIENT}$[4]	Annual kWh$_{SAVED}$	kW$_{SAVED, SUMMER PEAK}$	Lifetime kWh$_{SAVED}$
750-1,049	60	49	13	214	0.028	3213
1,050-1,489	75	58	16	250	0.032	3748

Sources

1. Wisconsin PSC EUL database 2013.
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* March 22, 2010. Table 3.2 Coincidence Factor for Lighting in Commercial Applications
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.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	12/26/2012	New Measure

Custom Lighting-Noth Otherwise Specified

	Measure Details
Measure Master ID	Custom Lighting-Not Otherwise Specified, 2463
Measure Unit	Per project
Measure Type	Custom
Program(s)	Multifamily Energy Savings
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by project
Peak Demand Reduction (kW)	Varies by project
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by project
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	12[1]
Important Comments	

Measure Description

Custom lighting encompasses the replacement of underground parking, exterior, or interior lighting, the replacement or retrofit of fluorescent fixtures that do not use four-foot or eight-foot lamps, projects to change technologies (including HID-to-fluorescent replacements), projects to change quantities of lighting fixtures, and other projects that will result in a quantifiable energy savings but do not qualify under other existing measures.

To qualify, a project must result in a net reduction of annual electric usage.

Description of Baseline Condition

The existing fixture type and quantity could be replaced with efficient technologies that result in a net reduction of annual electricity usage.

Description of Efficient Condition

In addition to reducing annual electricity usage, the new equipment must meet all local code and IESNA standards for lighting levels, in addition to meeting all applicable electrical, safety, and energy codes.

Annual Energy-Savings Algorithm (a custom calculation)

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

Where:

$Watts_{BASE}$ = Watts of the existing lighting fixture

$Watts_{EE}$ = Watts of the new efficient lighting fixture

Qty_{BASE} = Quantity of existing fixtures

Qty_{EE} = Quantity of new efficient fixtures

1,000 = Kilowatt conversion factor

HOU = Average annual run hours

Space Type	HOU
In Unit	949
Common Area	5,950
Other Interior	5,950
Exterior	4,380
Parking Garage	8,760

Summer Coincident Peak Savings Algorithm

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

Where:

CF Coincidence factor

Space Type	CF
In Unit	0.11
Common Area	0.77
Other Interior	0.77
Exterior	0.00
Parking Garage	1.00

Lifecycle Energy-Savings Algorithm

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

Where:

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

Sources

1. Focus on Energy Prescriptive EUL Database, 2013.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	10/25/2012	Created

ENERGY STAR Integral LED Lamp – Time-of-Sale

	Measure Details
Measure Master ID	Residential ENERGY STAR Integral LED Lamp – Time-of-Sale,
Measure Unit	Single, Screw-in or Pin-Based LED Lamp
Measure Type	Prescriptive
Program(s)	
Sector(s)	
Annual Energy Savings (kWh)	35
Peak Demand Reduction (kW)[1]	0.003
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	530
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Important Comments	

Measure Description

This measure is an ENERGY STAR-certified 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 an incandescent light bulb (standard or EISA compliant halogen).

Description of Efficient Condition

The efficient equipment is an ENERGY STAR-certified LED bulb.

Annual Energy-Savings Algorithm

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

Where:

$Watts_{BASE}$ = Power consumption of baseline measure

$Watts_{EE}$ = Power consumption of efficient measure

1,000 = Kilowatt conversion factor

HOU = Annual hours-of-use, based on 2.27 hours/day (= 829)[5]

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= 0.075)[6]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFETIME} = \Delta kWh/yr * EUL$

Where:

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

Assumptions

For this measure, the baseline adjustment was a key component of the energy-savings calculations. EISA requires that all general-purpose light bulbs between 310 lumens and 2,600 lumens be approximately 30% more energy efficient than current, standard incandescent bulbs. This effectively phases out most standard incandescent bulbs. Beginning in 2012, 100-watt standard incandescent bulbs were no longer manufactured or imported into the U.S. market. In 2013, standards went into effect for 75-watt standard incandescent bulbs, and in 2014 standards will go into effect for 40-watt and 60-watt bulbs.

Phased-in EISA 2007 Standards

Lumen Output Range	Typical Wattage: Standard Incandescent Technology	EISA Requirements		
		Maximum Rated Wattage	Minimum Lifetime (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

Per-Unit Assumptions by Product

Lumen Output Range	$Watts_{BASE}$[3]	$Watts_{EFFICIENT}$[4]	Annual kWh_{SAVED}	$kW_{SAVED, SUMMER PEAK}$[7]	Lifetime kWh_{SAVED}	Percent Sales[2]
310-749	37	8	24	0.002	361	0%
750-1049	55	13	35	0.003	522	89%
1,050-1489	64	16	40	0.004	597	11%
1,490-2,600	80	20	50	0.005	746	0%

Additional consideration needs to be given to the in-service rate (ISR) for purchases that are not installed in the given program year. This value can range from 75-99% depending on the program design and evaluation findings[3].

Deemed Savings

The deemed savings value for this measure is the weighted average of the savings shown in the table above and are based on the percent sales of bulbs in each lumens bin from the FOE program in 2013. The deemed annual energy savings are 35 kWh, the demand reduction is 0.003 kW and the lifetime energy savings are 530 kWh.

Sources

1. Focus on Energy Prescriptive EUL Database, 2013.

2. Weighted average based on 2013 sales percentages provided by Applied Proactive (310-749 lumens = 0%; 750-1,049 lumens = 89%; 1,050-1,489 lumens = 11%; 1,490-2,600 = 0%).
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. Cadmus. Field Study Research: Residential Lighting. October 18, 2013. Conducted regarding CFL and incandescent bulbs.
6. Cadmus. Field Study Research: Residential Lighting. October 25, 2013. Conducted regarding CFL and incandescent bulbs.
7. Includes summer peak coincidence factor.
8. Focus on Energy https://focusonenergy.com/about/evaluation-reports

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	12/28/2012	New Measure

Residential ENERGY STAR Compact Fluorescent Lamp– Time of Sale

	Measure Details
Measure Master ID	Residential ENERGY STAR Compact Fluorescent Lamp– Time of Sale, SPECTRUM Measure Master ID Unassigned
Measure Unit	Single, Spiral, Screw-in CFL
Measure Type	Prescriptive
Program(s)	
Sector(s)	Residential
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)	8[1]
Important Comments	

Measure Description

An ENERGY STAR-certified screw-in CFL is 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).

Description of Efficient Condition

The efficient measure is an 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 for values)

$Watts_{EE}$ = Efficient wattage (see table below for values)

1,000 = Kilowatt conversion factor

HOU = Annual hours-of-use, based on 2.27 hrs/day (= 829)[2]

Summer Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= 0.075)[3]

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 8 years)[1]

Assumptions

The baseline adjustment is a key component of the energy-savings calculations for this measure. EISA requires that all general-purpose light bulbs between 310 lumens and 2,600 lumens be approximately 30% more energy efficient than current, standard incandescent bulbs, in essence phasing out most standard incandescent bulbs. Beginning in 2012, 100-watt standard incandescent bulbs were no longer manufactured or imported into the U.S. market. In 2013, the standard went into effect for 75-watt standard incandescent bulbs, which will be followed in 2014 by 40-watt and 60-watt bulbs. For that reason the baseline condition is a weight average, shown in the table below, for the 2014 year.

Phased-In EISA 2007 Standards

Lumen Output	Typical Wattage: Current Incandescent Technology	EISA Requirements		
		Maximum Wattage	Minimum Lifetime (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

Per-Unit Assumptions by Product Type for 2014

CFL Type	$Watts_{BASE}$[4]	$Watts_{EFFICIENT}$	Annual kWh_{SAVED}	$kW_{SAVED, SUMMER PEAK}$	Lifetime kWh_{SAVED}	Percent Sales[5]
> 22 Watts	76	23	44	0.004	264	14.9%
17-22 Watts	58	18	33	0.003	199	5.9%
12-16 Watts	49	13	30	0.003	179	72.3%
< 12 Watts	33	9	20	0.002	119	6.8%

Additional consideration needs to be given to the in-service rate (ISR) for purchases that are not installed in the given program year. This value can range from 75-99% depending on the program design and evaluation findings[5].

Sources

1. Wisconsin PSC EUL database 2013.

2. Field Research Study 2013: Residential Lighting. October 18, 2013.
3. Cadmus Research. *Field Study 2013: Residential Lighting*. October 25, 2013.
4. United States Environmental Protection Agency. “Next Generation Lighting Programs: Opportunities to Advance Efficient Lighting for a Cleaner Environment.” Pg. 27. EPA-430-R-11-115. October 2011. Available online: http://www.energystar.gov/ia/partners/manuf_res/downloads/lighting/EPA_Report_on_NGL_Programs_for_508.pdf.
5. Focus on Energy Evaluation Report https://focusonenergy.com/about/evaluation-reports

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	01/01/2012	New Measure

Refrigerator and Freezer Recycling

	Measure Details
Measure Master ID	Refrigerator Recycling, 2955 Freezer Recycling, 2956
Measure Unit	Per Unit
Measure Type	Prescriptive
Program(s)	Appliance Recycling
Sector(s)	Residential
Annual Energy Savings (kWh)	Varies by appliance
Peak Demand Reduction (kW)	Varies by appliance
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by appliance
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	8[1]
Important Comments	

Measure Description

This measure involves removing an operable refrigerator or freezer from service prior to its natural end of life. The average age of a harvested unit is anticipated to be 20+ years. Savings are based on the estimated energy consumption during the remaining life of the unit, per unit characteristics at the time of removal.

Description of Baseline Condition

The baseline is an existing, inefficient unit in working order not being removed from service.

Description of Efficient Condition

The efficient condition is to remove an existing inefficient unit from circulation and send it for recycling.

Annual Energy-Savings Algorithm

The annual energy savings is a deemed value based on EM&V analyses conducted by Cadmus,[2] with adjustments for envisioned 2012-2014 Wisconsin conditions as noted below.

Note that the DP&L study was used for the following reasons:

1. It is relatively recent,
2. It was created for Midwest implementation, and
3. It includes part-use factors and *in situ* effects.

Metric	Refrigerators	Freezers
Unadjusted gross annual kWh savings/unit[3]	1,190	1,283
Allowance for the passage of time between the 2010 DP&L Plan Year and the current 2012-2014 period	x 0.9 factor	x 0.9 factor
Adjusted gross annual kWh savings/unit	1,071	1,155

Summary Coincident Peak Savings Algorithm

$$kW_{SAVED} = \frac{\Delta kWh/yr}{HOU} * P$$

Where:

HOU = Annual operating hours (= 8,760)

P = Peak intensity factor, captures the increase in compressor cycling time in summer peak conditions relative to average annual conditions (= 1.01 for refrigerators and = 1.08 for freezers)[3]

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life of replaced refrigerator (= 8 years)[1]

For this technology, eight years is technically the remaining useful life of the equipment; however, for consistency it is represented as the EUL.

Assumptions

The per-unit deemed energy and demand savings values quantify the early retirement of inefficient refrigerators and freezers. These values should be reviewed and updated every two or three years to quantify expected gradual improvements in the average unit efficiency (i.e., as reflected in lower kWh/unit).

Deemed Savings

	Refrigerator	Freezer
Annual Energy Savings (kWh)	1,071	1,155
Peak Demand Reduction (kW)	0.123	0.142
Lifecycle Energy Savings (kWh)	8,568	9,240

Sources

1. Wisconsin PSC EUL database 2013.
2. The Cadmus Group, Inc. EM&V Report for Dayton Power & Light. March 15, 2011.
3. Memo to Michigan Evaluation Working Group from Cadmus RE: Appliance Recycling Measure Savings Study, August 20, 2012.

Revision History

Version Number	Authored by	Date	Description of Change
01	JACO	08/22/2012	Original

Solar Photovoltaic

	Measure Details
Measure Master ID	Solar Photovoltaic, 2819
Measure Unit	Per kWDC Installed
Measure Type	Hybrid
Program(s)	Residential Renewable
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)	22,420
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Important Comments	

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 be 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.

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, where there is 10% or less shading, they can have a tilt between 10-50 degrees of the local latitude, and they can be installed in a safe area. 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 = Accounts for amount of power lost in DC to AC conversion (= 0.80)

ShadeFactor = Percentage of time system is shaded (= 10 per program rules)

SnowFactor = Percentage of time system in covered in snow (= 2 for 34° tilt)

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

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

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

Where:

EUL = Effective useful life (= 20 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[5] 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 savings of a 1 kW system).

Sources

1. Wisconsin PSC EUL database 2013.
2. Analysis of 2012 Residential Rewards Program data for 79 funded PV systems.
3. State of Wisconsin Public Service Commission. *Focus on Energy Evaluation: Standard Calculation Recommendations for Renewable Energy Systems*.
4. Lawrence Berkley National Laboratory. *Tracking the Sun VI: An Historical Summary of the Installed Price of Photovoltaics in the United States from 1998 to 2012.* July 2013. Available online: http://emp.lbl.gov/sites/all/files/lbnl-6350e.pdf.

Revision History

Version Number	Authored by	Date	Description of Change
01	RSG	06/18/2012	Original
02	RSG	02/13/2013	Update per Cadmus Feedback

Solar Thermal

	Measure Details
Measure Master ID	Electric, 2905 Natural Gas, 2906
Measure Unit	Per System
Measure Type	Hybrid
Program(s)	Residential Renewables, Multifamily Energy Savings
Sector(s)	Residential- single family, Residential- multifamily
Annual Energy Savings (kWh)	Varies by types of fuel and residence
Peak Demand Reduction (kW)	Varies by types of fuel and residence
Annual Therm Savings (Therms)	Varies by types of fuel and residence
Lifecycle Energy Savings (kWh)	Varies by types of fuel and residence
Lifecycle Therm Savings (Therms)	Varies by types of fuel and residence
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Important Comments	

Measure Description

This measure applies to single-family and multifamily residential solar water heating (SWH) systems. SWH systems typically use one or more rooftop thermal collector to capture solar energy and transfer that energy to heat a working fluid, such as water or antifreeze solutions. The systems are typically integrated with a backup water heating system fueled by natural gas or electricity to provide residential DHW. Thermal collectors can also be used to heat swimming pools or be used to provide space heating.[2]

Typical single-family residential SWH systems consist of one or two collectors, a 40- to 80-gallon storage tank, and associated pumps and controllers. Collectors are most commonly flat-plate, though evacuated tube collectors are also available. There are a variety of system types. One type is a closed loop glycol system, which uses an antifreeze solution as a heat transfer medium. Another type is a drainback system, which uses water as a heat transfer medium but (as the name implies) drains the fluid from the collectors when there is no heat being drawn.

In multifamily applications, systems are similar to those for single-family use but on a larger scale. System size can vary widely, depending on the number of housing units served. There is little data available at this time on regional or national applications that are typical for multifamily SWH, but most systems consist of at least six solar collectors and storage tanks of 200 gallons or more.

Solar collectors and packaged systems are tested and rated by the Solar Rating and Certification Corporation. These ratings can provide a useful and consistent benchmark for comparing the performance of different SWH systems.[3]

Description of Baseline Condition

A baseline condition is a residential single-family house or multifamily facility that uses an electric resistive or natural gas fired water heater.

Description of Efficient Condition

The efficient condition is a solar water heating (SWH) system that is installed to supplant the use of electricity or natural gas for hot water heating.

Annual Energy Savings

Deemed savings for SWH systems are calculated separately for single-family and multifamily applications using the SAM developed by NREL.

Single-Family Applications

Substantial data are available on the performance of single-family SWH systems. An NREL report provides energy savings for a typical SWH system in every state, including Wisconsin.[4] This archetypal system has the following characteristics, which are consistent with residential SWH systems installed through the programs:

- Azimuth of 180° (true south)
- Collector tilt of 26.5°
- 40-square-foot gross collector area (equivalent to two typical collectors)
- 60-gallon storage tank
- 90% energy factor (electric)
- 60% energy factor (gas)/80% efficiency
- 60 gallons per day (gpd) hot water consumption

Using these parameters in NREL's System Advisor Model (SAM), annual energy savings for both electric and gas hot water heating fuel scenarios were predicted for locations nationwide.[5] For Madison, Wisconsin, the study reports typical annual energy savings of:

- 1,919 kWh for systems with electric backup hot water heating (solar fraction of 0.53)
- 73 therms for systems with gas backup hot water heating (solar fraction of 0.55)

Note that approximately 68.2% of single-family residences in the East-North Central Census region heat hot water with natural gas and 29.5% heat hot water with electricity.[4]

Multifamily Applications

A typical SWH system was modeled using SAM, using with the following key assumptions and variables:

- 20 residents at 15.6 gallons/person-day for a total daily use of 312 gallons of hot water
- 6 collectors with a total 180-square-foot gross area
- Collectors oriented at 180° (true south) and titled at 43° (latitude)

- 264-gallon storage tank
- 90% EF (electric)
- 60% EF (gas)

The results of the simulation indicate annual savings of:

- 13,060 kWh for systems with electric backup hot water heating
- 669 therms for systems with natural gas backup hot water heating

The savings estimated in both the single-family and multifamily cases should be viewed as general estimates only. Neither estimate includes losses due to shading or sub-optimal system orientation.

Coincident Peak Demand Savings

Accurately calculating peak demand savings due to SWH requires accurate knowledge of hourly hot water heating load profiles for residential customers. At this time, data is not available at that level of granularity, so peak demand savings for SWH systems should be estimated using the method provided in the Standard Calculations document.[6] These calculations assume there is a constant daily hot water heating load for the year and that the SWH system fully offsets use of the baseline hot water heater during summer peaks. This is reasonable because most SWH systems are designed to provide a very high proportion of hot water demand in the summer months. The peak demand savings for electrically backed up SWH systems are:

- 0.4 kW for single-family applications
- 2.1 kW for multifamily applications

Though SWH systems require the use of pumps and/or electronic controls, these loads are generally very small compared to the energy savings and will have a minimal impact on peak demand. These loads are included, however, in annual energy-savings projections.

There are no electrical demand savings associated with SWH systems using natural gas as the backup hot water heating fuel.

As discussed above, a deemed savings approach can be used to perform a preliminary energy-savings calculation for SWH systems, using the approach described above. Where possible, this deemed savings value should be replaced with site-specific system characteristics and modeling using SAM. Deemed energy savings are shown in the following table.

Hot Water Heating Fuel (Baseline)	Single-Family Annual Energy Savings	Multifamily Annual Energy Savings
Electric	1,919 kWh per year	13,060 kWh per year
Gas	73 Therms per year	669 Therms per year

Summer Coincident Peak Savings

The demand savings for SWH systems with electric backup hot water heating can be estimated using the deemed savings values shown in the following table.

Hot Water Heating Fuel (Baseline)	Single-Family Demand Savings	Multifamily Demand Savings
Electric	0.4 kW	2.1 kW
Gas	0	0

Lifecycle Energy Savings

The lifecycle energy savings for SWH systems is equal to the annual energy savings times the EUL. For the recommended EUL of 20 years,[1] the lifecycle energy savings are shown in the following table.

Hot Water Heating Fuel (Baseline)	Single-Family Lifecycle Energy Savings	Multifamily Lifecycle Energy Savings
Electric	38,380 kWh	261,200 kWh
Gas	1,450 Therms	13,380 Therms

Sources

1. Wisconsin PSC EUL database 2013.
2. Walker, Andy. *Solar Water Heating.* National Institute of Building Science. August 24, 2012. http://www.wbdg.org/resources/swheating.php
3. Solar Rating & Certification Corporation. Solar Facts – System Ratings. OG-300 Certification of Solar Water Heating Systems. http://www.solar-rating.org/facts/system_ratings.html
4. Cassard, Hannah, Paul Denholm, and Sean Ong. *Break-even Cost for Residential Solar Water Heating in the United States: Key Drivers and Sensitivities*. National Renewable Energy Laboratory. Feb 2011. http://www.nrel.gov/docs/fy11osti/48986.pdf
5. National Renewable Energy Laboratory. System Advisor Model. April 5, 2010. Available for download at: https://sam.nrel.gov/

6. State of Wisconsin Public Service Commission of Wisconsin. *Focus on Energy Evaluation: Standard Calculation Recommendations for Renewable Energy Systems.* Revised January 18, 2011. http://www.focusonenergy.com/sites/default/files/standardcalculationrecommendationsCY10_evaluationreport.pdf

Revision History

Version Number	Authored by	Date	Description of Change
01	RSG (Single Family)	06/18/2012	Original
02	Franklin Energy Service (Multifamily)	02/17/2012	Original
03	Franklin Energy Service (Multifamily)	03/08/2013	PI Update
04	Cadmus	10/22/2013	Combined single and multifamily workpapers, updated savings algorithms

ENERGY STAR Dehumidifier

	Measure Details
Measure Master ID	ENERGY STAR Dehumidifier, 2759
Measure Unit	Per Residence
Measure Type	Prescriptive
Program(s)	Multifamily Energy Savings
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	83
Peak Demand Reduction (kW)	0.032
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	1158
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	14[1]
Important Comments	

Measure Description

ENERGY STAR-certified models have more efficient refrigeration coils, compressors, and fans than conventional models, which means they use less energy to remove moisture. An ENERGY STAR-certified dehumidifier removes the same amount of moisture as a similarly sized conventional unit, but uses 15% less energy.

Description of Baseline Condition

The baseline unit is a non-ENERGY STAR dehumidifier.

Description of Efficient Condition

The efficient unit is an ENERGY STAR-rated dehumidifier.

Annual Energy-Savings Algorithm

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

$Watts_{BASE} = 0.473 *1{,}000 * Cap / 24 / EF_{BASE}$

$Watts_{EE} = 0.473 *1{,}000 * Cap / 24 / EF_{EE}$

Where:

ΔkWh_{SAVED} = Annual energy saved between baseline and energy-efficient dehumidifier

$Watts_{BASE}$ = Watts of a non- ENERGY STAR dehumidifier

$Watts_{EE}$ = Watts of an ENERGY STAR dehumidifier

1,000 = Kilowatt conversion factor

EF_{BASE} = Energy factor non-ENERGY STAR dehumidifier (liters/kWh)

EF_{EE} = Energy factor ENERGY STAR dehumidifier (liters/kWh)
Cap = Capacity of dehumidifier (pints/day)
0.473 = Conversion (liters/pint)
HOU = Average annual hours-of-use (= 921 hours)[3]
24 = Conversion (hours/day)

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = \Delta kWh/yr / HOU * CF$

Where:

CF = Coincidence factor (= 0.353)[4]

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 14 years) [1]

Assumptions

The assumptions in the following table were used to calculate savings.

Dehumidifier Savings

Size Range (Pints/Day)[3]	Average Size (Pints/day)[3]	Market Share[3]	Annual Hours-of-Use[3]	EF_{BASE}[2]	EF_{EE}[2]	Energy Use_{BASE} (kWh)	Energy Use_{EE} (kWh)	Savings (kWh)
Less than 25	20	10.00%	921	1.35	1.85	268.9	196.2	72.7
25.01–35.00	30	23.40%	921	1.35	1.85	403.4	294.3	109.0
35.01–45.00	40	23.20%	921	1.5	1.85	484.0	392.5	91.6
45.01–54.00	49	20.90%	921	1.6	1.85	555.9	480.8	75.1
54.01–74.99	64	21.60%	921	1.7	1.85	683.3	627.9	55.4
Greater than 75.00	130	1.00%	921	2.5	2.8	943.9	842.7	101.1
					Weighted average savings			**82.7**

Sources

1. Wisconsin PSC EUL database 2013.
2. ENERGY STAR appliance calculator. April 2013. www.energystar.gov/purchasing
3. PA Consulting. Memo regarding *Focus on Energy Evaluation: Dehumidifiers Deemed Savings Review for Targeted Home Performance with ENERGY STAR*. March 19, 2009. http://www.focusonenergy.com/sites/default/files/Dehumidifiers_Deemed_Savings_Review_for_Targeted_Home_Performance_with_ENERGY_STAR.pdf
4. *Efficiency Vermont Technical Reference User Manual (TRM)*, Measure Savings Algorithms and Cost Assumptions. March 22, 2013. P. 310.

Revision History

Version Number	Authored by	Date	Description of Change
01	Franklin Energy Services	02/17/2012	Original
02	Franklin Energy Services	03/08/2013	PI update

Appendix A: List of Acronyms

AC	Alternating current
AFUE	Annual Fuel Utilization Efficiency
BESS	Bioenvironmental and Structural System
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
DHW	Domestic hot water
ECM	Electronically commutated motor
EF	Energy factor
EISA	Energy Independence and Security Act
EM&V	Evalution, measurement, and verification
EPCA	Energy Policy and Conservation Act
ERV	Energy recovery ventilator
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
IECC	International Energy Conservation Code
IPLV	Integrated part load volume
kWDC	Direct current kilowatts
LED	Light-emitting diode
NREL	National Renewable Energy Laboratory
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
RW	Reduced wattage
SAM	System Advisor Model
SP	Shaded pole
STC	Standard test conditions
SWH	Solar water heating
TE	Thermal efficiency
TMY	Typical meteorological year
TRM	Technical Reference Manual
VFD	Variable frequency drive

VHO	Very high output
VSD	Variable speed drive

Appendix B: WI OAT 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