Subject	**Focus on Energy Evaluation** **RESIDENTIAL DEEMED SAVINGS REVIEW**
To	Oscar Bloch, Public Service Commission of Wisconsin Sara Van de Grift, Wisconsin Energy Conservation Corporation Ralph Prahl, Prahl & Associates, contributed critical review and analysis
From	Ron Swager Patrick Engineering, Inc.
Date	February 2, 2009

Introduction

In a memo dated October 27, 2008, Wisconsin Energy Conservation Corporation (WECC) made a formal request from the Residential Program to make adjustments to the deemed savings or to add new deemed savings for the residential technologies listed below. If approved, the deemed savings adjustment will be applied from the date of the Public Service Commission of Wisconsin's approval.

- Adjustments
  - Water heater fuel conversion (electric to natural gas)
  - Power vent natural gas water heater EF 0.64–0.79
  - Power vent natural gas water heater EF 0.80 or greater
  - ECM furnaces.
- New
  - ENERGY STAR televisions
  - ENERGY STAR monitors
  - ENERGY STAR computer
  - Sub slab ventilation.

PA Consulting Group (PA) has requested that Patrick Engineering Inc. (Patrick) provide comments and recommendations regarding these proposals. The adjustment requests from the WECC memo and Patrick's analyses are provided below. Table 1 provides a summary of the recommended deemed values.

The power is within you.

Table 1. Summary of Recommended Deemed Values

Measure	kWh	Therms
Adjustments		
1. Water heater fuel conversion (electric to natural gas)		-143
2. Power vent natural gas water heater EF 0.64–0.79		18
3. Power vent natural gas water heater EF 0.80 or greater		49
4. ECM furnaces.		730
New		
1. ENERGY STAR televisions	52	
2. ENERGY STAR monitors	35	
3. ENERGY STAR computer	76	
4. Sub slab ventilation.	No deemed values specified at this time	

Adjustment Request 1: Water Heater Fuel Conversion (Electric to Natural Gas)

An adjustment to the water heater fuel conversion savings is needed after it was discovered that the potential study number used for the therm penalty (-78 therms/yr) was actually the weighted amount based on the number of natural gas and LP units. The program calculated the therm penalty as -194; however, the number was adjusted downward to reflect the percentage of conversions going to propane rather than natural gas—only natural gas savings were being counted. The program proposes rectifying this oversight and to use -194 therms for fuel conversion to natural gas going forward. The program proposes adjusting the deemed savings value from -78 therms to -194 therms.

Background

WECC 2002[1] calculated the energy use of water heaters from the equations below.

Energy use = Gallons/yr * (T_{out} - T_{in}) ^{0}F * 8.34 lb/gal * 1 BTU/lb - ^{0}F / (Energy Factor * BTU/unit)

Therm use = (64*365) gallons/yr * 60^{0}F * 8.34 / (0.6 * 100,000 BTU/therm) = 195 therms/yr

kWh use = (64 *365 * 0.95) gallons/yr * 60^{0}F * 8.34 / (0.88 * 3,413 BTU/kWh) = 3,680 kWh/yr *(sic, actual result would be 3697)*

Where: 0.95 reduces the use of hot water by 5% to reflect consumer price elasticity from the higher cost of electricity

Thus, replacing an existing electric water heater with a gas water heater would eliminate 3,680 kWh/yr of electricity but would incur an energy penalty of 195 therms/yr. ECW 2005[2]

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[1] Wisconsin Energy Conservation Corporation, *Residential Default Savings for Wisconsin Focus on Energy*, April 2002.

[2] Energy Center of Wisconsin, *Energy Efficiency and Customer-Sited Renewable Energy: Achievable Potential in Wisconsin 2006–2015*, November 2005.

references this result as -194 therms but adjusted it to -78 therms to “account for the prevalence of conversions from electricity to propane.”

Analysis

The most significant variable in this calculation is the average household daily usage of hot water. This is strongly dependent on the family size and may vary greatly due to the type of appliances in the home. For example, it can be expected that a single person using a laundromat will use less hot water at home than a household with children that is doing laundry for five people. Table 2 provides estimates from The Renewable Energy Resource Center[3] of typical household hot water consumption based on household size.

Table 2. Daily Household Hot Water Consumption (Gallons)

Number of Household Members				
1	2	3	4	5
30–40	40–50	55–65	65–75	75+

From this table, the 64 gallons/day estimate in the original calculation would correspond to a household size of 3+ persons.

An additional check can be found in LBNL 1997[4]. The average annual electricity consumption for water heating for a family of two is given as 2,340 kWh/yr and 4,770 kWh/yr for a family of four. If we interpolate the family size from the WECC 2002 estimate of 3,680 kWh/yr using these figures, we find it again represents a household size of approximately 3.1 persons.

RECS 2001[5] found that the average household size using electric water heating was 2.4 persons in the Midwest and 2.3 persons for the East North Central region, which includes Wisconsin. The corresponding estimates for energy consumption were 2,515 kWh/yr and 2,337 kWh/yr. The US Census[6] estimates the average household size of owner-occupied housing in Wisconsin to be 2.55 persons.

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[3] The Renewable Energy Resource Center, *Investing in a Solar Hot Water System*, http://www.rerc-vt.org/shw-investing.htm, site visited November 25, 2008.

[4] Lawrence Berkeley National Laboratory, *Energy Data Sourcebook for the US Residential Sector*, LBNL-40295, April 1998.

[5] Energy Information Administration, *A Look at Residential Energy Consumption in 2001*, Table CE4-1c., May 2004.

[6] US Census Bureau, *Wisconsin Selected Housing Characteristics 2007*, 2007 *American Community Survey*, http://factfinder.census.gov/servlet/ADPTable?_bm=y&-qr_name=ACS_2007_1YR_G00_DP4&-geo_id=04000US55&-context=adp&-ds_name=&-tree_id=307&-_lang=en&-redoLog=false&-format=, site visited November 26, 2008.

From this, we conclude that the WECC estimates of 64 gal/day and 3,680 kWh/yr are excessive for typical Wisconsin household sizes. To obtain an estimate of typical electric water heater consumption, we calculated a trend line using the four points from LBNL and RECS to interpolate the energy consumption for a household size of 2.55. We chose to use this value rather than those from RECS because the RECS values include apartment units that typically have smaller household sizes. The program's tracking database includes a field to indicate single and multifamily residences; however, it does not establish how many participants are renters. We presume that program participants are primarily homeowners and not renters and that the few participating households renting single-family dwellings have average household sizes close to the average size for owner-occupied dwellings. Table 3 summarizes the data and result.

Table 3. Summary of Electricity Consumption for Water Heating Estimates.

Source	Household size	kWh/yr	Gal/day
LBNL 1997	2	2,340	32
	4	4,770	64
RECS 2001	2.4	2,515	
	2.3	2,337	
US Census	2.55	**2,890** **(interpolated from above)**	

The value of 2,890 kWh/yr corresponds to approximately 46 gal/day of hot water consumption using the same 60^{o}F temperature rise and 0.88 energy factor. Using this value for electric water heaters, we can then derive the energy consumption for a replacement gas water heater as follows:

Therm use = kWh use *(EF_{elec} / (EF_{gas}) * 0.03412 therms/kWh

kWh = 2890 * (0.88 /(0.64) * 0.03412 = 135.88 Therms

Where: EF_{elec} = 0.88 is from BEDS 2008[7] for stock electric water heaters, and

EF_{gas} = 0.64 program requires a power vent unit with an EF of .64 or greater to qualify for fuel conversion reward.

Recommendation

Adjust the water heater fuel conversion savings from -78 therms to -136 therms. The reduction from the requested -194 therms results from lower estimates of hot water consumption and improved efficiencies of newer gas storage water heaters. This may be adjusted by five percent to -143 therms as was done in the WECC 2002 calculation to adjust for consumer price elasticity (more water use may occur due to lower cost of heating water with gas). It may also be advisable to consider adjusting the savings from energy-efficient gas and electric water heater retrofits using the water consumption estimates used here.

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[7] US Department of Energy, *2008 Building Energy Data Book*, September 2008.

Adjustment Request 2: Power Vent Natural Gas EF 0.64–0.79

The current savings for power vent water heaters was based on the Potential Study (ECW 2005[2]) which contained the best estimates available at the time. More information has since been made available including the *ENERGY STAR Residential Water Heaters: Final Criteria Analysis*[8] and calculations done at WECC based on the GAMA assumptions[9]. The ENERGY STAR analysis shows savings of 19 therms per year between standard 50 gallon (EF 0.575) and high-efficiency models (EF 0.62). Calculation based on GAMA assumptions shows a savings of 24 therms between standard (EF 0.58) compared to EF 0.64. The program proposes adjusting the deemed savings value from 15 therms to 24 therms.

Background

Both the ENERGY STAR analysis and the GAMA assumptions are based on the DOE standard test procedure[10]. This procedure assumes hot water consumption of 64 gal/day and a temperature rise of 77°F.

Analysis

As indicated in the analysis in the previous section, the assumption of 64 gal/day for hot water consumption may be excessive for the typical Wisconsin household. Also, previous calculations by WECC have assumed a 60°F temperature rise.

Table 4 summarizes the LBNL and RECS data for natural gas water heating. To obtain an estimate of typical gas water heater consumption, we calculated a trend line using the four points from LBNL and RECS to interpolate the energy consumption for a household size of 2.55.

Table 4. Summary of Energy Consumption for Gas Water Heating Estimates.

Source	Household size	Therms/yr	Gal/day
LBNL 1997	2	120	32
	4	260	64
RECS 2001	2.6	206 (Midwest)	
	2.6	208 (East North Central)	
US Census	2.55	**180 (interpolated from above)**	

[8] *ENERGY STAR Residential Water Heaters: Final Criteria Analysis*, http://www.energystar.gov/index.cfm?c=new_specs.water_heaters, site visited November 29, 2008.

[9] Air Conditioning, Heating and Refrigeration Institute*, Consumers' Directory of Certified Efficiency Ratings for Heating and Water Heating Equipment*, September 30, 2008.

[10] US Department of Energy, *Energy Conservation Program for Consumer Products; Test Procedure for Water Heaters; Final Rule, 10 CFR Part 430,* May 11, 2008.

The value of 180 therms/yr corresponds to approximately 55 gal/day assuming a 60°F temperature rise and 0.56 energy factor[11]. The energy savings is calculated below.

Therm Savings = $(1/EF_{std} - 1/EF_{new})$ * (55*365) gallons/yr * 60°F * 8.34 lb/gal * 1 BTU/lb - °F / 100,000 BTU/therm.

Where: EF_{std} = 0.575 from DOE minimum standard for 50 gallon unit, and

EF_{new} = 0.64 from incentive program lower limit for power vent water heaters

Therm Savings = 18 therms

Recommendation

Adjust the default deemed savings for power vent, natural gas water heaters (EF 0.64–0.79) from 15 to 18 therms/yr. The lower recommended change results from lower estimates of both water and energy consumption for a typical household and provides a more conservative estimate than those based on the DOE test procedure. This analysis did not address nor does it recommend any changes in the kWh penalty resulting from a powered vent fan or potential savings in space heating requirements from closing a natural draft vent.

Adjustment Request 3: Power Vent Natural Gas EF 0.80 or Greater

The current savings for power vent water heaters was based on the potential study, which contained the best estimates available at the time. More information has since been made available including the ENERGY STAR analysis and calculations done at WECC based on the GAMA assumptions. ENERGY STAR analysis shows savings of 78 therms per year between standard 50 gallon (EF 0.575) and high-efficiency models (EF 0.82). Calculation based on GAMA assumptions shows a savings of 71 therms between standard (EF 0.58) compared to EF 0.80. The program proposes adjusting the deemed savings value from 45 therms to 71 therms.

Background

Both the ENERGY STAR analysis and the GAMA assumptions are based on the DOE standard test procedure. This procedure assumes hot water consumption of 64 gal/day and a temperature rise of 77°F.

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[11] BEDS 2008, for stock electric water heaters.

Analysis

The same analysis found in the previous section is appropriate here. The calculation for the energy savings for these increased efficiency units is as follows:

Therm Savings = $(1/EF_{std} - 1/EF_{new})$ * (55*365) gallons/yr * 60 ^{0}F * 8.34 lb/gal * 1 BTU/lb- ^{0}F / 100,000 BTU/therm

Where: EF_{std} = 0.575 from DOE minimum standard for 50 gallon unit, and

EF_{new} = 0.80 from program requirement for $100 reward

Therm Savings = 49 therms

Recommendation

Adjust the default deemed savings for condensing, power vent, natural gas water heaters (EF <0.80) from 45 to 49 therms/yr. The lower recommended change results from lower estimates of both water and energy consumption for a typical household and provides a more conservative estimate than those based on the DOE test procedure.

Adjustment Request 4: ECM Furnaces

Current deemed savings are based on the *ECM Furnace Impact Assessment Report* dated June 2004. The program was recently re-evaluated and a draft report was presented to the program in October 2008. Based on this updated report, the program proposed to decrease the ECM Furnace deemed savings values as shown in Table 5.

Table 5. Proposed Changes to ECM Furnace Deemed Savings

	Current Deemed Savings (kWh)	Proposed Deemed Savings (kWh)
Retrofit/ Existing Home Installation	759	733
New Construction Installation	1,116	1,078

Background

The calculations for the current deemed savings were detailed in the 2004 Furnace report[12] and were based on the results of a 2003 field study[13]. The raw energy savings from ECM use

[12] State of Wisconsin, Department of Administration, Division of Energy, *ECM Furnace Impact Assessment Report*, June 28, 2004.

were adjusted for consumer usage patterns using both a sample group of program participants and a control group of consumers who had recently obtained a new furnace but were not program participants. Groups for both retrofit applications and new home construction were used.

The current evaluation report[14] addresses only retrofit applications with new sample and control groups in the same manner as the 2004 report and includes a reduction in the estimated annual central air conditioning (CAC) cooling hours from 400 to 310 resulting from a new CAC field study[15] and a change in the percentage of participants owning CAC. The reduced hours and the new groups' responses resulted in a slightly lower estimate of average annual energy savings. Since the same process is used to determine savings for both applications, program evaluators agreed that it would be reasonable to reduce new construction deemed savings by the same percentage as the retrofit savings.

Analysis

The 2003 and 2008 field studies are Wisconsin specific and provide the best available data on the operation of home heating and cooling systems in the state. The average connected electrical loads for furnaces in different modes found by the current evaluation report[15] are shown in Table 6. The estimated hours of operation from the field studies and the current evaluation report are shown in Table 7.

Table 6. Average Connected Loads (in Watts)

Type of Operation	Type of Furnace		Difference
	Non-ECM	ECM	
Heating	800	400	400
Cooling	193	120	73
Standby	8	12	-4
Fan Only	500	100	400

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[13] State of Wisconsin, Department of Administration, Division of Energy, *Electricity Use by New Furnaces, A Wisconsin Field Study*, October 2003.

[14] State of Wisconsin, Department of Administration, Division of Energy, *ECM Furnace Impact Assessment Report*, January 12, 2009.

[15] Scott Pigg, Energy Center of Wisconsin, *Central Air Conditioning in Wisconsin—A Compilation of Recent Field Study Research*, 2008.

Table 7. Hours of Fan Operation

Season	Type of Operation	Total Hours	Auto Mode Operation	Continuous Mode Operation
Heating Season	Furnace	4,500	1,000	1,000
	Standby		3,500	0
	Fan Only		0	3,500
Cooling Season	CAC	2,400	310	310
	Standby		2,090 (2,400 if no AC)	0
	Fan Only		0	2,090 (2,400 if no AC)
Shoulder Periods	Standby	1,900	1,900	0
	Fan Only		0	1,900

We note here that the total annual operating hours proposed is 40 hours longer than an actual year (8,800 hrs vs. 8,760 hrs).

Comparing the estimated heating and cooling operating hours to the ARI heating and cooling load hour charts[16], we find the charts indicate a range for heating load hours from 2,500–3,000 hrs/yr and for cooling load hours of 400–600 hrs/year for Wisconsin. The difference between these figures and the estimates in Table 7 can be found in the practice of oversizing heating and cooling systems to assure adequate capacity and to reduce response times to thermostat setting changes. The 2003 furnace field study found that the typical furnace would need to operate only 40 percent to 60 percent of the time to meet the design load. The 2008 CAC field study found the average central air system to be oversized by 12 percent and that discretionary use reduced run times by an additional 25 percent to 33 percent. Applying these percentages to the ARI ranges gives 1,000–1,800 hrs/yr heating operation and 264–358 hrs/yr cooling operation. The assumptions of 1,000 hrs/yr and 313 hrs/yr are within these expected ranges.

The calculation of the deemed savings progresses as follows:

1. The energy consumption for each season is calculated for ECM and non-ECM furnaces, with and without air conditioning, and with the fan operating in auto mode and continuous mode. A third fan mode, sporadic, is defined for consumers who manually switch between auto and continuous modes. The mix of auto and continuous modes in sporadic mode is based on survey results from the sample participants group.

2. Two energy savings estimates are calculated for each season and each of nine fan operation scenarios: the first estimate where each practice is used both before and after installation and the second estimate where each practice is switched to one of the

[16] Air Conditioning and Refrigeration Institute, *ARI Unitary Directory*, August 1, 1992–January 31, 1993.

other two. The two savings estimates are based on two optional baseline choices—calculate the baseline based on fan operation practices before installation or calculate the baseline based on fan operation practices after installation. The "before installation" choice assumes that any changes in fan operation practice results from the installation of an ECM furnace. The "after installation" choice assumes that any changes in fan operation practice results from a new installation in general—ECM furnace or not.

3. The saving estimates for each fan operation scenario is weighted according to the survey results from the participant sample group, and the baseline choice of before or after installation is weighted according to results from the control group survey.

4. The weighted savings estimates for installations with and without CAC are totaled over all seasons, fan operation practices, and baseline choices, then weighted by the percentage of program participants with and without CAC.

We have reviewed both the 2004 and 2008 evaluation reports and find no logical or calculation errors in the procedures. The final steps of both evaluations are shown in Tables 8 and 9.

Table 8. Overall Impact Estimates for Existing Homes by Baseline Scenario (2004)

CAC Ownership	Percent of HPWES Participants (n=150)	Savings Estimate (kWh/yr)		
		Baseline (Practices Before Installation)	Baseline (Practices After Installation)	Baseline (Control Group Weighted)
CAC	92.0%	652	1,413	779
No CAC	8.0%	572	1,373	709
Savings Weighted by CAC Ownership		**646**	**1,410**	**774**

Table 9. Overall Impact Estimates for Existing Homes by Baseline Scenario (2008)

CAC Ownership	Percent of Participants (n=150)	Savings Estimate (kWh/yr)		
		Baseline (Practices Before Installation)	Baseline (Practices After Installation)	Baseline (Control Group Weighted)
CAC	95.3%	629	1,218	736
No CAC	4.7%	566	1,182	678
Savings Weighted by CAC Ownership		**626**	**1,216**	**733**

Findings from previous Focus evaluation reports have suggested that it would be reasonable to reduce new construction deemed savings by the same percent as the retrofit savings. However if we examine the results of the 2008 study for existing homes (Table 8) and new construction (Table 10), we see that the new construction control-group-adjusted estimate (1,126 kWh/yr) was closer to the practices-after-installation baseline (1,363 kWh/yr) than to the practices-before-installation baseline (772 kWh/yr). For existing homes in both the 2004 and 2008 studies, the retrofit control-group-adjusted baseline estimates (774 and 773) were closer to the practices-before-installation-baselines (646 and 647). It seems ill advised to assume that a new sample and control group for new construction installations would result in the same adjustment as groups from retrofit installations.

Table 10. Overall Impact Estimates for New Homes by Baseline Scenario

CAC Ownership	Percent of WESH Homeowners (n=150)	Savings Estimate (kWh/yr)		
		Baseline (Practices Before Installation)	Baseline (Practices After Installation)	Baseline (Control Group Weighted)
CAC	97.4%	774	1,364	1,127
No CAC	2.6%	702	1,318	1,079
Savings Weighted by CAC Ownership		**772**	**1,363**	**1,126**

Recommendation

The request to adjust the ECM furnace retrofit deemed saving from 759 to 733 kWh/yr seems justified. However, we recommend adjusting it by the fraction (8,760/8,800) to 730 kWh/yr to compensate for the overage in total operating hours used in the calculation. We do not recommend adjusting the new construction deemed savings using a sample and control group from retrofit installations.

However, if sample and control groups from new construction participants are not practical at this time, it may be reasonable to adjust the 2004 calculation using only the 2008 changes in the CAC operating hours and CAC ownership rates and retaining the adjustment for ownership practices based on 2004 sample and control groups.

New Deemed Savings Request 1: Consumer Electronics (Televisions)

The program is proposing adding deemed savings for consumer electronics at this time in anticipation of possible future program activities and not because of any current offerings. Energy savings for the electronic products listed below are based on savings information provided in the *CEE Electronics Program Guide*. Detailed information on the ENERGY STAR specifications for these products can be found on energystar.gov.

- ENERGY STAR televisions. Version 3.0 effective 11/1/2008: 52 kWh per year

Background

The ENERGY STAR Program Requirements for Televisions Eligibility Criteria, effective November 1, 2008, set maximum standards for “On Mode” and “Standby” power consumption. The annual power consumption estimate will be based on a daily usage pattern of five hours in “On Mode” and nineteen hours in “Standby.” The assumptions used to calculate the proposed savings of 52 kWh/yr are not known to this reviewer although the value is referenced in CEE 2008[17].

Analysis

As power consumption can vary greatly by type and size of the television, the ENERGY STAR program establishes standards in four categories as shown in Table 11.

Table 11. On Mode Power Level Requirements for TV Products

Tier 1: Effective November 1, 2008	
Screen Area (A)	**Maximum On Mode Power Consumption in Watts (for A in inches^2)**
Non-High Definition TVs (i.e. ≤ 480 Native Vertical Resolution)	
All Screen Areas	PMax = 0.120*A + 25
High Definition and Full High Definition TVs (i.e. > 480 Native Vertical Resolution)	
A < 680 inch^2	PMax = 0.200*A + 32
680 inch^2 ≤ A < 1045 inch^2	PMax = 0.240*A + 27
A ≥1045 inch^2	PMax = 0.156*A + 151

ENERGY STAR televisions also may not exceed a power consumption of 1 Watt in standby. Thus, the annual energy consumption estimate becomes…

Energy Consumption (kWh/yr) = (PMax * 5 hrs/day) + (1 Watt * 19hrs/day) * 365 / 1000.

For example, for a 37” diagonal, wide screen HDTV (32.24 x 18.15 in. or 585 in^2) we get…

Energy Consumption = (((0.200 * 585 + 32) x 5) + 19) * 365 /1000 = 279 kWh/yr.

To calculate an average savings of an ENERGY STAR model relative to a standard model we use the ENERGY STAR calculator[18]. The results of running a calculation using the default assumptions for each screen size category provided in the calculator are shown in Table 12.

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[17] Consortium for Energy Efficiency, *Consumer Electronics Program Guide*, 2008.

[18] http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_Televisions.xls, site visited December 1, 2008.

Table 12. Estimated Annual ENERGY STAR TV Energy Savings (kWh/yr)

Diagonal Screen Size	Average Savings	Sales % (1)	Weighted Average Savings (1)	Sales % (2)	Weighted Average Savings (2)
0"-20"	19	12%	2.3	25%	4.8
21"-30"	16	14%	2.2	26%	4.2
31"-40"	49	32%	15.7	23%	11.3
41"-50"	132	27%	35.6	16%	21.1
51"-60"	99	11%	10.9	9%	8.9
>60"	208	4%	8.3	1%	2.1
All	**87**	**100%**	**75.1**	**100%**	**52.3**

Although no actual sales data or sales projections by screen size were available to this reviewer, Table 12 also includes two ***hypothetical*** sales distributions to assess the potential savings. As can be seen, the proposed savings value of 52 kWh/yr is feasible depending on the distribution of sales.

Recommendation

Without Wisconsin-specific sales data on televisions, it is difficult to determine a single deemed savings value. It is recommended that the proposed savings value of 52 kWh/yr be adopted at this time, but that the size of the televisions receiving incentives be tracked so the value may be adjusted according to sales distribution at a later date.

New Deemed Savings Request 2: Consumer Electronics (LCD Monitors)

The program is proposing adding deemed savings for consumer electronics at this time in anticipation of possible future program activities and not because of any current offerings. Energy savings for the electronic products listed below are based on savings information provided in the CEE Electronics Program Guide. Detailed information on the ENERGY STAR specifications for these products can be found on energystar.gov.

- ENERGY STAR LCD monitors. Version 4.1 effective 1/1/2006 (Version 5.0 is in development but expected to be announced 1/21/09 and be effective 10/21/09): 35 kWh per year.

Background

The ENERGY STAR Program Requirements Computer Monitors Eligibility Criteria, Tier II requirements effective January 1, 2006, set maximum standards for “On Mode”, “Sleep Mode,” and “Standby/Off” power consumption. No average daily usage pattern is established in the criteria. The assumptions used to calculate the proposed savings of 35 kWh/yr are not known to this reviewer, although the value is referenced in CEE 2008[19].

Analysis

To qualify as ENERGY STAR, computer monitor models must not exceed the following maximum active power consumption equation.

If X < 1 megapixel, then PMax = 23;

If X > 1 megapixel, then PMax = 28X

Where: X = Screen resolution in megapixels, or

horizontal resolution (pixels) X vertical resolution (pixels) / 1,000,000

For example, a 1,280 x 1,024 resolution monitor would have 1.31 megapixels and could not exceed 36.7 (1.31 * 28) watts. ENERGY STAR monitors also may not exceed two watts in sleep mode or one watt in standby/off mode.

Typical energy consumption values for standard monitors and typical usage in terms of time in active, sleep, and standby modes may be found in the ENERGY STAR Monitors Calculator[20]. Table 13 shows the calculator results with various assumptions regarding software settings and usage habits.

Table 13. Estimated Annual ENERGY STAR Monitor Energy Savings (kWh/yr)

Standard Monitor	ENERGY STAR Monitor					
	Power Management Enabled			Power Management Disabled		
	Always turned off when not in use	Sometimes turned off when not in use	Never turned off when not in use	Always turned off when not in use	Sometimes turned off when not in use	Never turned off when not in use
Power Management Enabled	18.4	18.4	18.4	-10.4	-10.4	-188.6
Power Management Disabled	60.4	227.1	320.8	31.6	84.3	113.9

As can be seen from the table, the potential savings is strongly dependent on user behavior. It can even be negative if previous power management efforts are abandoned with the new ENERGY STAR monitors.

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[19] Consortium for Energy Efficiency, *Consumer Electronics Program Guide*, 2008.

[20] http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_monitorsBulk.xls, site visited December 1, 2008.

The CEE estimate of 35 kWh/yr appears to be a reasonable and relatively conservative estimate within the range of possible savings and corresponds closely to that derived for the situation where power management is not used and monitors are turned off when not in use.

Recommendation

It is recommended that the 35 kWh/yr savings estimate be adopted at this time. However, because the savings are so dependent on user behavior, it is also recommended that the program approach for offering the measure attempts to influence that behavior and that research on user habits be conducted to enable adjusting the savings at a later date.

New Deemed Savings Request 3: Consumer Electronics (Desktop and Notebook Computers)

The program is proposing adding deemed savings for consumer electronics at this time in anticipation of possible future program activities and not because of any current offerings. Energy savings for the electronic products listed below are based on savings information provided in the CEE Electronics Program Guide. Detailed information on the ENERGY STAR specifications for these products can be found on energystar.gov.

- ENERGY STAR computers. Version 4.0 effective 7/20/07 (Version 5.0 in development): PCs 76 kWh per year and Notebooks 11 kWh per year.

Background

The ENERGY STAR Program Requirements for Computer Monitors, Eligibility Criteria, Version 5.0 have been finalized and will become effective July 1, 2009. They set maximum standards for typical energy consumption (TEC) for four classes of desktop computers and three classes of notebook computers. ENERGY STAR computers are also required to be equipped with power management hardware and software that must be activated in the default settings. The assumptions used to calculate the proposed savings of 76 kWh/yr for desktops and 11 kWh/yr for notebooks are not known to this reviewer, although the values are referenced in CEE 2008[21] in reference to the Version 4.1 criteria.

Analysis

The energy consumption of a computer can vary widely depending on the hardware installed (number, speed and type of processors, amount of memory, graphics processors, hard drives), as well as the software (power management, etc.) and the user's habits and preferences.

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[21] Consortium for Energy Efficiency*, Consumer Electronics Program Guide*, 2008.

To qualify as ENERGY STAR, computer models must not exceed the following TEC.

Table 14. ENERGY STAR TEC Requirement—Desktops and Notebooks

Desktops and Integrated Computers (kWh)	Notebook Computers (kWh)
Category A: ≤ 148.0 Category B: ≤ 175.0 Category C: ≤ 209.0 Category D: ≤ 234.0	Category A: ≤ 40.0 Category B: ≤ 53.0 Category C: ≤ 88.5

Some additional energy consumption is allowed for computers with added capabilities such as increased memory, additional hard drives, and premium graphics processors. Class A represents most of the typical configurations. The other classes represent high-end, high-performance computers such as those supporting multiple processors.

The formula for TEC is given in the criteria as:

$$TEC = (8760/1000) * (P_{off} * T_{off} + P_{sleep} * T_{sleep} + P_{idle} * T_{idle})$$

Where: P_{off}, P_{sleep}, P_{idle} are power consumption in Watts for various operational modes, and

the T values are given in Table 14.

Table 15. Operational Mode Weighting—Desktops and Notebooks

Mode	Conventional Desktop	Conventional Notebook
T_{off}	55%	60%
T_{sleep}	5%	10%
T_{idle}	40%	30%

The assumptions used in the ENERGY STAR savings calculator for computers[22] provide estimates of the power consumption for a typical, standard model computer.

P_{off} = 3 Watts, P_{sleep}= 6 Watts, P_{idle}= 84 Watts

For a standard model desktop.

$$TEC = (8760/1000) \times ((3 * .55) + (6 * .05) + (84 * .40)) = 311 \text{ kWh/yr}$$

If we compare this to the Category A, ENERGY STAR Model we can see a potential energy savings of 163 kWh/yr. Compared to Category D the savings is 77 kWh/yr.

[22] http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_computers_bulk.xls, site visited December 2, 2008.

No data on typical notebook power consumption was available, but a smaller percentage of savings should be expected since notebook manufacturers have always tried to extend battery life.

It is important to note that the power consumption values in this calculation for the non-ENERGY STAR computers were from a 2007 report by LBNL and may be obsolete by this time. Computer technology changes rapidly and the “average” computer from two years ago will likely not represent the processors, memory configurations, power supplies, and average energy consumption of today’s or next year’s computers.

Recommendation

In lieu of specific sales data on current typical computer configurations and on consumer usage behavior, we recommend adopting the CEE estimate of 76 kWh/yr for desktops and 11 kWh/yr for notebooks as the deemed savings for computers. This represents savings of 34 percent for desktops and 22 percent for notebooks (assuming category A) and should be a more conservative estimate than that calculated above. Should ENERGY STAR computers be added to future program activities, it is recommended that current information be sought on computer sales statistics and frequent updates to the deemed savings be planned.

New Deemed Savings Request 4: Sub Slab Ventilation

The program is proposing adding deemed savings for sub slab ventilation. When the sub slab system is installed, it reduces the amount of moisture available to wick up through the footings and into the walls. This moisture evaporates into the home 365 days of the year adding to interior moisture loads. This moisture is traditionally dealt with by running a dehumidifier. Any reduction of moisture getting into the building reduces the load on a dehumidifier and the A/C system in the summer. Further energy savings may be had from reducing the wintertime ventilation run times due to a reduction in moisture load. Most folks ventilate for excess moisture. Reducing the wall surface “evaporation” also reduces the cooling effect in the winter. This cooling effect can reduce basement temperatures adding to the heating load. Basements often feel “cool” due to this effect.

- Savings proposed: 1,296 kWh/year – 745 kWh/year = 551 kWh/year

Background

The proposed savings are derived by assuming that a sub slab ventilation system will eliminate the need for a dehumidifier for moisture control. The annual energy consumption of a dehumidifier was derived by assuming a 600W unit operating 240 hrs/month for nine months of the year (9 x 240 x 600/1000 = 1296 kWh/yr). The consumption of the ventilation system assumes an 85W fan operating continuously (85 x 8760/1000 = 745 kWh/yr).

Analysis

The 2005 Residential Energy Consumption Survey (RECS 2005)[23] found that dehumidifiers were used in 28.2 percent of all households in the East North Central States, which includes Wisconsin, Illinois, Indiana, Michigan, and Ohio. Dehumidifiers are more common in the East North Central States than in the United States as a whole. Nationwide, the share of households with dehumidifiers was only 11.7 percent. In this region, dehumidifiers are used primarily in basements in the summer months. RECS 2005 reports an average usage of 4.9 months/yr. A survey conducted for the 2000 residential characterization study[24] suggested that 64.3% of Wisconsin homes have dehumidifiers. Newly constructed homes had slightly fewer at 58.8%.

A 2007 study for the US EPA[25] investigated sub slab ventilation (referred to as active soil depressurization or ASD in this report) for its impact on basement moisture levels in three houses near Harrisburg, Pennsylvania over an 18-month period. All of the occupants of the study houses reported that they used dehumidifiers in the basements to control dampness during the summers prior to the study. The ASD systems consisted of an in-line exhaust fan connected to 3- or 4-inch PVC pipe penetrating the slab floor or in one case the open core of the block wall. Moisture levels were measured in walls and slab floors, indoor and outdoor air, surrounding soil, and wood framing members in the basement. Air flows to and from the basement from the outside and the upstairs were monitored. The following were some of their findings:

- ASD operation can produce significant moisture reductions in basement air (4–10 percent) and basement walls (18–30 percent), especially during non-summer months.
- Moisture reductions were much smaller or negligible during the summer months.
- The ASD system caused a smaller reduction in basement air relative humidity (RH) than the dehumidifier did during a contiguous period.
- A dehumidifier has little or no effect on moisture levels in basement walls or floors.
- With the ASD system operating, outdoor air infiltration rates were boosted both in the basement and upstairs (on average, outdoor to upstairs infiltration increased by 0.07 air changes per hour). It is possible, under some circumstances, that these identified air flows could contribute moisture to the basement rather than extract moisture (e.g., periods of high outdoor air humidity).

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[23] Energy Information Administration*, 2005 Residential Energy Consumption Survey*, September 2008.

[24] Energy Center of Wisconsin, *Energy and Housing in Wisconsin - A Study of Single-family Owner-occupied Homes,* November 2000.

[25] Bradley Turk and Jack Hughes, *Exploratory Study of Basement Moisture During Operation of ASD Radon Control Systems*, US Environmental Protection Agency, Indoor Environments Division, December 6, 2007.

- While the ASD systems probably do not eliminate the need for dehumidification during warm and humid periods of summer, they may reduce the moisture load in the basement and usage of the dehumidifier.

With these results in mind, we will compare the expected reduction in dehumidifier energy use to the energy consumption of the ventilation system. Table 16 summarizes the annual usage of dehumidifiers based on several studies and sources. Unfortunately, none of the studies are based on metered data. The studies rely on power measurements and assumptions regarding usage to derive the annual energy consumption values.

Table 16. Dehumidifier Annual Usage Data[26]

Study/Source	Annual Energy Use (kWh)	Power Use (Watts)	Operating Hours/Year
LBNL (1992)[27]	Average: 400 Range: 200–1000	NA	NA
ADL (1998)[28]	Average: 972	Average: 600	1,620
LBNL (2005)[29]	Range: 500–4650	Range: 520–710	1,620, 4,320
Energy Center of Wisconsin (2005)[30]	Average: 600 Range: ±300 (WI only)	Average: 350 Range: ±250	NA
Central Maine Power Co. (2006)[31]	Average: 540 (Maine only)	NA	NA

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[26] US Department of Energy, *Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment*, November 2007.

[27] A. Meier, L. Rainer, S. Greenberg, "Miscellaneous Electrical Energy Use in Homes," *Energy,* Vol. 17, No. 5: pp. 509–518, 1992.

[28] R. Zogg and D. Alberino, *Electricity Consumption by Small End Uses in Residential Buildings: Final Report, 1998. Report to Office of Building Equipment,* US Department of Energy. Arthur D. Little, Cambridge, MA, 1998.

[29] M. McWhinney, A. Fanara, R. Clark, C. Hershberg, R. Schmeltz, and J. Roberson, "ENERGY STAR Product Specification Development Framework: Using Data and Analysis to Make Program Decisions," *Energy Policy*, 33 (2005): pp. 1613–1625, 2005.

[30] Energy Center of Wisconsin, *Energy Efficiency and Customer-Sited Renewable Energy: Achievable Potential in Wisconsin 2006–2015. Volume II: Technical Appendix*, ECW Report Number 236-2, November 2005.

[31] Personal communication, John Davoulis, Central Maine Power Company. Telephone call with Lawrence Berkeley National Laboratory, March 1, 2006.

Study/Source	Annual Energy Use (kWh)	Power Use (Watts)	Operating Hours/Year
ENERGY STAR Fact Sheet (from website, 2006)[32]	ENERGY STAR: 2,161 Non-ENERGY STAR: 2,378	ENERGY STAR: 1,334 Non-ENERGY STAR: 1,368	1620
ENERGY STAR Calculator (from website, 2006)[33]	ENERGY STAR: 937–2061 Non-ENERGY STAR: 1022–2616	ENERGY STAR: 329–723, Non-ENERGY STAR: 358–918	2851

DOE[3] reports that during rulemaking the Association of Home Appliance Manufacturers (AHAM) commented that it is not aware of any data related to the typical annual hours of operation for dehumidifiers. In consultation with manufacturers and others familiar with the product, AHAM and some of the sources identified in Table 16 provided estimates of typical dehumidifier usage in monthly and annual operating hours. Table 17 summarizes the monthly usage data.

Table 17. Dehumidifier Monthly Usage (Hours of Operation)

Source	Jan-Mar	Apr	May	June	July	Aug	Sep	Oct	Nov-Dec	Annual
AHAM Low	0	0	70	210	245	245	70	35	0	875
AHAM Mid	0	14	86	231	288	288	130	58	0	1,095
AHAM High	0	37	110	256	329	329	183	73	0	1,315
ADL*	0	0	180	360	360	360	180	180	0	1,620
ENERGY STAR[#]	0	0	475	475	475	475	475	475	0	2,851
LBNL-High[†]	1,080	360	360	360	360	360	360	360	720	4,320

* Based on peak dehumidification period of three months (at 360 hours/month) with half the usage (180 hours/month) during the remaining three months.

[#] Based on six-month operation with 0.66 duty cycle.

[†] Monthly operation equal to ADL peak dehumidification period.

Because of the wide variation in estimated annual operating hours, it was decided to compare the various estimates with Wisconsin weather data on humidity from NOAA[34]. NOAA calculates an index from the outdoor humidity records, akin to heating and cooling degree days, referred to as the average latent cooling (drying) load (ALCL). It provides a measure of the raw energy necessary to reduce outside air humidity levels to indoor levels of 60 percent relative humidity

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[32] US Environmental Protection Agency and US Department of Energy, *ENERGY STAR, Qualified Appliance Savings Fact Sheets, Inputs, 2006,* http://www.energystar.gov/ia/partners/manuf_res/SavingFactSheets_backup_calcs.pdf, accessed March 8, 2006.

[33] US Department of Commerce, National Climatic Data Center*, Engineering Weather Data Products*, December 1999.

[34] US Department of Commerce, National Climatic Data Center*, Engineering Weather Data Products*, December 1999.

at 75°F during the cooling season. While this index cannot be directly related to average dehumidifier operating hours due to complications from varying infiltration rates, internal moisture gains and contributions to dehumidification by air conditioning systems, it can provide a measure of seasonal demand. Table 18 summarizes the data available for Wisconsin.

Table 18. Average Latent Cooling (Drying) Load (BTU/cfm)

	Eau Claire	Green Bay	La Crosse	Madison	Milwaukee	WI Average
January	0	0	0	0	0	0
February	0	0	0	0	0	0
March	0	0	0	0	0	0
April	7	6	14	7	11	9
May	377	404	712	458	419	474
June	1,667	1,675	2,876	1,989	1,905	2,022.4
July	4,475	4,484	6,680	5,134	5,366	5,227.8
August	3,587	4,279	6,051	4,526	5,366	4,761.8
September	1,085	1,243	1,871	1,436	1,820	1491
October	40	43	62	55	69	53.8
November	0	0	0	0	1	0.2
December	0	0	0	0	0	0

Upon comparison (illustrated in Figure 1), it was observed that the dehumidification load in Wisconsin peaks more strongly in the summer than the estimated operating hours in Table 17 would indicate.

To develop an estimate of operating hours for Wisconsin, we calculated the average of the peak, monthly operating hours of all the estimates (343 hrs/month) and adjusted it for each month based on the Wisconsin average ALCL. The results of this calculation are shown in Table 19.

Figure 1. Dehumidification Demand

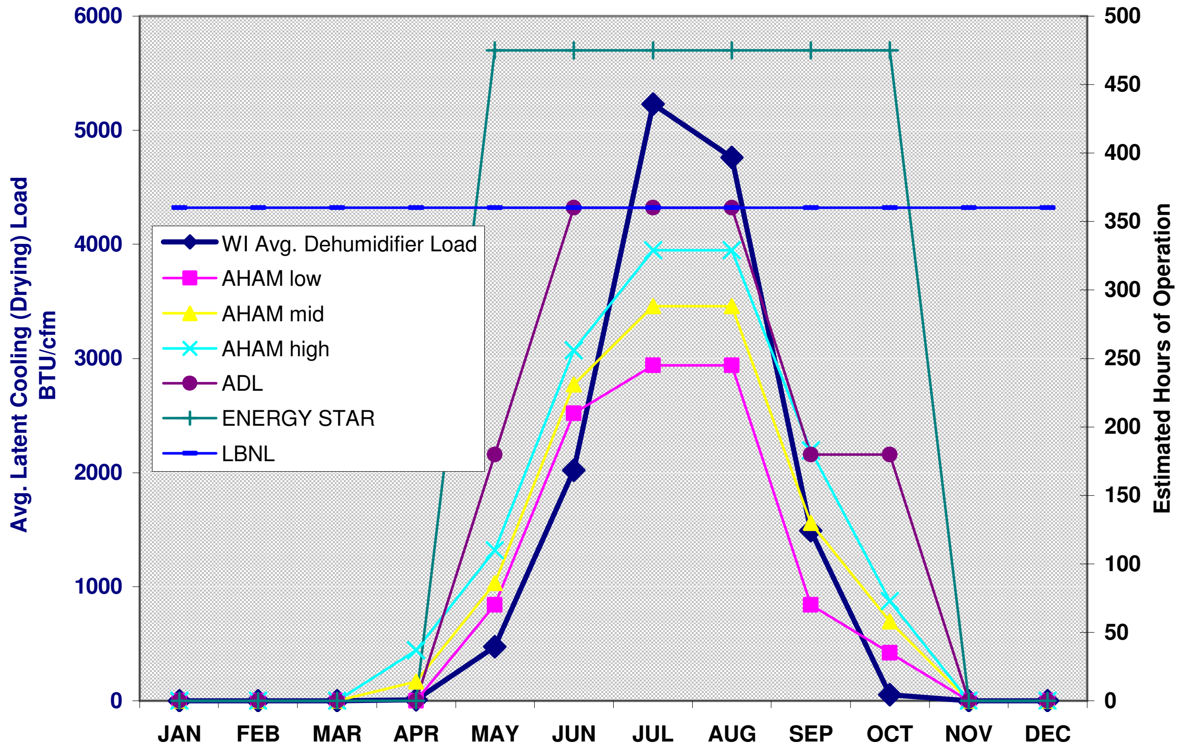

Table 19. Wisconsin Estimated Dehumidifier Operating Hours

	Wisconsin Average ALCL	Percent of Monthly Maximum Load	Climate-weighted Operating Hours
January	0	0.0%	0
February	0	0.0%	0
March	0	0.0%	0
April	9	0.2%	1
May	474	9.1%	31
June	2,022.4	38.7%	133
July	5,227.8	100.0%	343
August	4,761.8	91.1%	312
September	1,491	28.5%	98
October	53.8	1.0%	4
November	0.2	0.0%	0
December	0	0.0%	0
Annual			**921**

These results fall within the range of the other estimates and agrees well with the findings of RECS 2005 that dehumidifiers are used an average 4.9 months a year in the East North Central region.

To simulate the effects of sub slab ventilation based on the US EPA report, we assume a reduction of 15 percent in the operating hours for July and August and a 50 percent reduction in operating hours for the remaining months for a total reduction of 232 operating hours per year.

DOE bases the annual energy consumption of a dehumidifier on the following equation:

$$DEH\ ENERGY = CAP \times (0.473/24) \times Hours / Eff$$

where:

DEH *ENERGY* = Dehumidifier annual energy consumption (kWh/year),
CAP = Dehumidifier capacity (pints/day),
0.473 = Conversion factor for liters in a pint,
24 = Number of hours in a day
Hours = Annual operating hours, and
Eff = Dehumidifier efficiency (liters/kWh).

DOE and ENERGY STAR consider six product classes of dehumidifiers based on their capacity. DOE based the market shares for each of these six product classes on data provided by AHAM[35]. Using DOE's equation and weighting each class by its market share, we obtain the results shown in Table 20 for the average annual energy consumption of conventional (i.e., not ENERGY STAR) dehumidifiers.

Table 20. Estimated Average Annual Dehumidifier Energy Savings

Capacity Class (Pints/day)	Average Capacity (L/day)	Reduced Annual Operating Hours	"Conventional" Unit Energy Factor[36] (L/kWh)	Annual Energy Consumption (kWh/yr)	Market Share[12]	Weighted Annual Energy Savings (kWh/unit/year)
1–25	9.5	232	1.10	83	10%	8
25–35	14.2	232	1.20	115	23.4%	27
35–45	18.9	232	1.20	152	23.2%	35
45–54	23.4	232	1.23	184	20.9%	38
54–75	30.5	232	1.55	190	21.6%	41
75–185	61.5	232	1.90	313	1.0%	3
					100%	**153**

Thus, the expected energy savings from reduced dehumidifier use would be 153 kWh/year, far less than the expected cost of 745 kWh/yr for operating the ventilation system. Even eliminating the entire 921 estimated operating hours for the dehumidifier would save only 608

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[35] Association of Home Appliance Manufacturers. *AHAM Data on Dehumidifiers for Efficiency Standards Rulemaking*, Letter to Building Technologies Program, US Department of Energy, August 23, 2006.

[36] US Environmental Protection Agency and US Department of Energy, ENERGY STAR, *Savings Calculator–Dehumidifiers (Assumptions)*, 2008.

kWh/year. This analysis does not include increased energy consumption from increased infiltration due to ventilation system operation

Recommendation

The above analysis suggests that sub slab ventilation would not show a net energy saving except perhaps in some rare situations. However the analysis is based on widely varying estimates of dehumidifier run times and on an analysis of only three retrofitted homes in Pennsylvania. These assumptions and results may not be applicable to newly-constructed, well-sealed, energy efficient homes such as WESH homes. It is recommended that energy savings from sub slab ventilation systems not be deemed at this time. Should modeling indicate potential energy savings in specific designs, further research data should be gathered to better understand the mechanisms and potential amounts of energy savings from these systems.