State of Wisconsin Public Service Commission of Wisconsin

Focus on Energy Evaluation

Business Programs: Deemed Savings Manual V1.0

Update Date: March 22, 2010

Evaluation Contractor: PA Consulting Group Inc.

Prepared by: Tammy Kuiken, John Dendy, Ryan Barry, and Miriam Goldberg, KEMA, Inc.

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The power is within you.

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Liaison Contact: Dr. David Sumi
PA Consulting Group Inc.
6410 Enterprise Lane, Suite 300
Madison, WI 53719
Tel: +1 608 316 3700
Fax: +1 608 661 5181
E-mail: david.sumi@paconsulting.com

Prepared by: Tammy Kuiken, John Dendy, Ryan Barry, and Miriam Goldberg
KEMA, Inc.

Contributions by: Josh Venden, Peter McPhee, Brian Dunn, Jeremiah Robinson, and Dale Tutaj
KEMA, Inc.

Acknowledgment: Ralph Prahl, Prahl & Associates, contributed critical review and analysis.

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1. INTRODUCTION

This is the first iteration of the Wisconsin Focus on Energy Business Programs Deemed Savings Manual. The manual was developed under the Deemed Savings Parameter Development task, outlined in Section 2.5 of the 2009 Focus on Energy Evaluation Detailed Evaluation Plans (DEP) dated April 21, 2009. The work plan for this task was detailed in a June 8, 2009 memo titled *Deemed Savings Parameter Development Final Initial Plan*. This document is the second deliverable set forth by the work plan, the Deemed Savings Manual.

Deemed savings measures make up an increasingly significant portion of overall program savings. Measures have been deemed by a variety of processes over the past several years, but there has never been a single reference that identified how savings estimates were determined for each deemed measure. This has led to confusion during impact evaluations and deemed savings updates.

As set forth by the work plan, KEMA has collected the documentation and source data for all currently deemed measures and developed a manual that acts as a source document for the measures. The manual is organized by technology, and each entry includes:

- When the measure was deemed and, if applicable, when it was updated.
- The equation(s) used to estimate savings.
- Definitions of the variables used in the savings equation.
- The values used for all parameters in the savings estimate.
- The sources supporting the calculation method and all parameters or assumptions.

The manual also includes a glossary of key terms and variables, including a complete definition of peak kW savings for the Focus Business Programs. The final section of the manual is an archive with some previously deemed technologies or previous deemed savings estimates for technologies whose estimates have recently been changed. As deemed savings estimates continue to change, we anticipate that current manual entries will be moved to the archive section and be replaced with the updated versions.

This manual includes all of the deemed savings changes made through the 18-month Contract Period. All of the savings estimates reported in this document were in effect as of January 1, 2010, and are consistent with the current deemed savings spreadsheet.[1]

[1] Nonres Final Deemed Savings 091130.xls

2. GLOSSARY

This section defines some key terms and variables. It also contains a complete definition of peak kW savings for the Focus on Energy Business Programs.

2.1 KEY TERMS AND VARIABLES

The variables used in the deemed savings calculation for each measure are defined in the manual entry for that measure. Certain terms that are used often throughout the document are also defined below.

Annual Operating Hours. The number of hours that a given piece of equipment operates in a year.

Boiler Horsepower. A measure of the output capacity of a boiler, equivalent to 33,469.8 Btu per hour.

Capacity. Rated power input of the equipment in kW or Btu/hr.

Coincidence Factor, CF. The fraction of full load capacity (kW) used on average during the peak demand period. In other words, the average kW used during the peak demand period divided by the kW used at full or maximum load.

Duty Cycle, DC. Average percent of time that a given piece of equipment is operating.

Energy Savings. A general term to describe any type of energy savings: kW, kWh, or therm savings.

Equivalent Full Load Hours, EFLH. Total annual energy consumption of a given piece of equipment divided by the full load capacity of the equipment.

kW Savings. Peak electrical demand savings. A complete definition of peak demand savings as defined for the Focus program can be found in the next section.

kWh Savings. Annual electric energy savings. The actual units of this value are kWh/yr, but the divisor is assumed to be understood.

Load Factor, LF. The average fraction of full load capacity at which equipment operates over a given time period.

Motor Horsepower. The nominal input power rating of a motor, equivalent to 0.746 kW.

Peak Demand Period. The peak electric demand period is 1 pm – 4 pm, Monday through Friday, June through August.

Therms. Measurement of natural gas usage, defined as 100,000 Btu of heat energy**.**

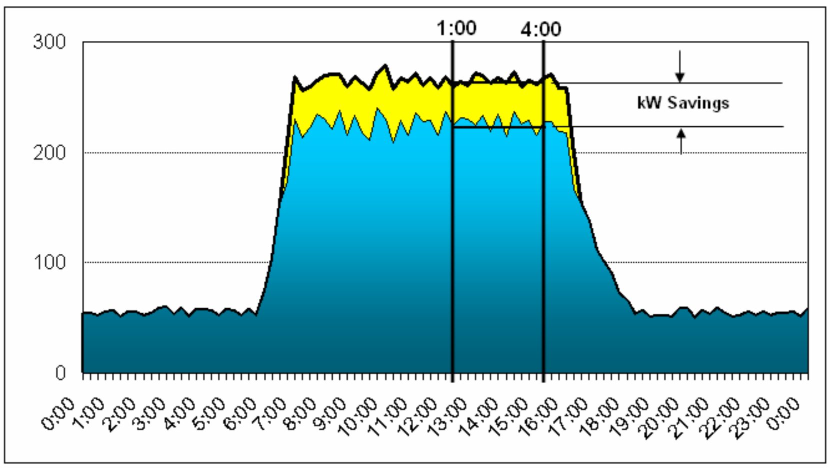
Therm Savings. Annual natural gas savings. The actual units of this value are therms/yr, but the divisor is assumed to be understood.

2.2 PEAK KW DEFINITION

For calculating changes in peak electrical demand, use the following guidance:

- The equipment or system being replaced or modified must be in use during the months of June though August (inclusive) between 1:00 pm and 4:00 pm Monday to Friday. This is an average kW savings over the period from 1 pm to 4 pm, Monday through Friday, during the months of June through August. Average kW is the kWh savings realized over the three hour peak period (1:00 pm to 4 pm), divided by these same three hours per day. See the illustration below.

Figure 2-1. Average Peak kW Savings Illustration



- Peak demand savings for weather dependent measures, such as air conditioning, will not be the average demand savings over the defined peak period. Rather, they will be calculated based on statewide average design-day conditions as defined by the latest version of ASHRAE Fundamentals. For weather related custom technology evaluations, accepted ASHRAE calculation methods will be used along with weather data from the nearest city with weather data provided by ASHRAE, or other appropriate source. The diversified demand factor (DDF) will be calculated for each piece of equipment, given design-day conditions.

- Generally, the change in electrical demand must be due to a less efficient technology being replaced with a more efficient technology (e.g., replace T12 lighting with high performance T8 lighting), that results in kWh energy savings. However, **customer controlled** load management measures (i.e. ice storage, or demand load shifting controls) also are eligible for incentives based on a reduction in peak electrical demand. These load management strategies (e.g., demand load shifting) must shift the load until after 9 pm to reduce the possibility of equipment operation causing a secondary peak both for the customer and electric utility.

- Any interaction of customer controlled load management with utility provided load management programs must also be accounted for. Program implementers will verify that there is no overlap between customer-controlled load management being recommended by the program, and utility provided load management services. If there is overlap between the two, the program will need to show evidence that the program's intervention enhanced/added to the reliability of the combined (utility and program) load management services.

- For operation or controls based changes, demand savings should be calculated using accepted industry practice or through measurement and verification which has determined that demand savings exist for each unit or end-use affected by the load management strategy or equipment.

3. DEEMED PARAMETERS

Some parameters are used in a number of measures. To maintain consistency across measures, these parameters have been investigated and "deemed" on their own. In this section, we develop each parameter and identify the source material used in that development.

These parameters are still be referenced in the write-ups for the individual measures in which they are used. Those references lead back to the discussions in this section that provide further detail on the development of the parameters.

Table 3-1 shows a list of the deemed parameters included in this section.

Table 3-1. Deemed Parameter Entries

Description	Manual Entry
Parameters	Lighting Hours of Use and Coincidence Factors
	Heating Degree Days (HDD)
	Cooling Degree Days (CDD)
	Heating Design Temperature
	Cooling Design Temperature

3.1 LIGHTING HOURS OF USE AND COINCIDENCE FACTORS

Group: Lighting

Category: N/A

Technology Description: Lighting hours of use and coincidence factor (CF) values for all lighting measures.[2]

Qualifying Equipment: N/A

Date Deeming Last Modified: December 2009

Date Previously Deemed: Pre-2006 (exact date unclear)

Summarized by: Jeremiah Robinson

Table 3-2. Lighting Hours of Use and Coincidence Factors by Sector

Sector	Hours	CF
Agriculture	4,698	67%
Commercial	3,730	77%
Industrial	4,745	77%
Schools-Government	3,239	64%

A. DEFINITIONS AND DISCUSSION OF PARAMETERS

These parameters are used in the savings estimates of almost all lighting measures. They are defined as follows:

Hours of Use. Hours of use refers to the average annual operating hours of a light fixture and is measured in hour/year.

Coincidence Factor, CF. Coincidence factor refers to the average percentage of total system wattage that is operating during the peak period and is measured in percent.

B. DEVELOPMENT AND BASIS OF DEEMED VALUES

Values for hours of use and coincidence factor are based on secondary research for all but the Agriculture sector. The development of each of the parameters for the other three sectors is discussed first, followed by a discussion of both parameters for the Agriculture sector.

[2] The recommended hours of use value for CFLs in the Agriculture Sector is not covered in this section of the report. It is addressed in the CFL measure entries.

i. Hours of Use

Values for hours of use are based on values by building type reported in six studies. Four of the studies are based on metering. They are: RLW Schools,[3] PG&E RightLights,[4] SDG&E Time of Use,[5] and SDG&E 2006.[6] The other two studies are based on surveys. They are: PG&E 1996[7] and a U.S. Department of Energy[8] study. The values reported by each study are shown in Table 3-3.

Table 3-3. Hours of Use Values by Building Use

Building Use	PG&E 1996	DOE	RLW Schools	PG&E RightLights	SDG&E TOU	SDG&E 2006
Food Sales	5,800	5,256	-	4,636	6,390	5,058
Food Service	4,600	4,599	-	4,278	4,450	4,305
Health Care	4,400	4,617	-	-	2,689	2,504
Hotel/Motel	5,500	3,687	-	-	2,307	-
Office	4,000	3,760	-	2,558	3,792	2,698
Public Assembly	-	2,665	-	-	-	2,961
Public Services (non-food)	3,400	3,431	-	-	-	-
Retail	4,450	4,258	-	1,621	5,435	3,640
Warehouse	3,550	3,705	-	-	3,211	3,250
School	2,150	2,774	2,147	-	1,795	2,795
College	3,900	-	-	-	-	-
Industrial	-	5,054	-	3,547	5,512	2,895
Other	4,500	3,723	-	-	3,667	2,804

These sources are not equal in their value to the Focus program. Each has a different sample size and some are based on surveys, while others are based on metering. A larger sample size or number of data points translates into greater accuracy. So, the values reported in each of these sources are weighted based on sample size and whether the study is based on metering or surveys.

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[3] RLW Analytics. *CT & MA Utilities 2004-2005 Lighting Hours of Use for School Buildings Baseline Study*. September 7, 2006.

[4] Quantec. *Evaluation of the 2004-2005 RightLights Program*. April 21, 2006.

[5] RLW Analytics. *SDG&E 2004-05 Express Efficiency Lighting Program Time of Use Study.* February 15, 2007.

[6] KEMA Services, Inc. *Small Business Super Saver Program Hours of Operation Study*. September 2006.

[7] Quantum Consulting. *Evaluation Of Pacific Gas & Electric Company's 1996 Commercial Energy Efficiency Incentives Program: Lighting Technologies.* March 1, 1998.

[8] Navigant Consulting. *U.S. Lighting Market Characterization – Volume 1: National Lighting Inventory and Energy Consumption Estimate*. September 2002.

In order to compare studies based on metering with those based on surveys, a relative weight or value of a metered sample as compared to a survey sample is needed. In this analysis, a survey is weighted as having ten percent of the value of a meter. That is, a meter is given the worth of ten surveys. There is no source for this value, and deeming documentation acknowledges that the relationship is somewhat arbitrary, but necessary.

Table 3-4 shows the number of meters or surveys used in each cited study. When applicable, the number of surveys is then divided by 10 to yield the value in the “meter equivalent sample size” row, with the number of meters from the other studies transferred to that row. The “weight” column represents the percent of the total sample size contributed by each study.

Table 3-4. Hours of Use Study Weighting by Sample Size

Study	Meters	Surveys	Meter Equivalent Sample Size	Weight
PG&E 1996	0	1,270	127	6%
DOE	0	5,430	543	27%
RLW Schools	600	0	600	29%
PG&E RightLights	184	0	184	9%
SDG&E TOU	431	0	431	21%
SDG&E 2006	150	0	150	7%
Total	**1,365**	**6,700**	**2,035**	**100%**

If all building types had values reported for all six sources, the weights above would be the relative weight of each survey, across all building types. However, none does. Each building type has values from between one and five sources. So, the weights presented above act as relative weights between the applicable sources by building type.

Table 3-5 shows the hours of use values cited for each study for each building type, the weighting factors determined using the method described above, and the resulting weighted average Hours of Use by building type.

Table 3-5. Hours of Use Values and Weighted Averages

Building Use	PG&E 1996	DOE	RLW Schools	PG&E RightLights	SDG&E TOU	SDG&E 2006	Weighted Average
Food Sales	5,800	5,256	-	4,636	6,390	5,058	5,544
Food Service	4,600	4,599	-	4,278	4,450	4,305	4,482
Health Care	4,400	4,617	-	-	2,689	2,504	3,677
Hotel/Motel	5,500	3,687	-	-	2,307	-	3,356
Office	4,000	3,760	-	2,558	3,792	2,698	3,526
Public Assembly	-	2,665	-	-	-	2,961	2,729
Public Services (non-food)	3,400	3,431	-	-	-	-	3,425
Retail	4,450	4,258	-	1,621	5,435	3,640	4,226
Warehouse	3,550	3,705	-	-	3,211	3,250	3,464
School	2,150	2,774	2,147	-	1,795	2,795	2,302
College	3,900	-	-	-	-	-	3,900
Industrial	-	5,054	-	3,547	5,512	2,895	4,745
Other	4,500	3,723	-	-	3,667	2,804	3,672
Weight	6%	27%	29%	9%	21%	7%	100%

These average hours of use by building type, are then combined into the four sectors using more weighting systems. The weighting systems are determined by the percentage of lighting kWh used by each building type, in each Focus sector, in Wisconsin where possible or nationally where not. The two sectors where this type of weighting system is required are the Commercial and Schools & Government sectors.

According to the deeming documentation, a source was not found for the percentage of lighting kWh used by the various building types in Wisconsin for the Commercial sector. Therefore, the national DOE Study[8] is used. It provides the percentage of lighting kWh used by each building type nationally, as shown in Table 3-6. This table shows the average hours of use for each building use in the Average Hours column. These values are then weighted and combined to create the overall average for the Commercial sector.

Table 3-6. Commercial Hours of Use from DOE Study

Building Use	Weight	Average Hours
Food Sales	3.6%	5,544
Food Service	3.6%	4,482
Health Care	8.5%	3,677
Hotel/Motel	6.0%	3,356
Office	25.3%	3,526
Public Assembly	7.3%	2,729
Public Services (non-food)	6.0%	3,425
Retail	24.0%	4,226
Warehouse	15.7%	3,464
Average	**100%**	**3,730**

The overall average Commercial hours of use across all sources and all building uses is 3,730 hours/year.

For the Schools & Government sector, a Wisconsin-specific approach was possible, using the WISeerts database to determine the percentage of Focus on Energy Schools & Government sector lighting savings which could be categorized as "k-12 school," "college/university," and "office." Projects are categorizing based on the name of the institution. Using this analysis, a kWh-weighted average of Schools & Government lighting projects that fall into the three building use types is produced. The results were used to determine the weighted average hours of use for the sector. The resulting average hours of use for the Schools and Government sector is 3,239 hours, as shown in Table 3-7.

Table 3-7. Schools & Government Hours of Use

Building Use	Weight	Average Hours
Office	23%	3,526
School	36%	2,302
College	41%	3,900
Average	**100%**	**3,239**

For the Industrial sector, no weighting system was necessary as the sources generally included "industrial" as a building use. The average hours of use for Industrial are 4,745 hours/year. The hours of use for the Agriculture sector are discussed in a later section.

ii. Coincidence Factor

Coincidence factor refers to the percentage of total system wattage that is operating during the peak demand period, and is deemed for each sector.

Coincidence factor values are based on four sources that provide coincidence factors for at least one building type, with most providing values for approximately ten building types. These sources include three of those cited for the hours of use analysis. They are PG&E 1996, RLW Schools, and SDG&E Time of Use. Also cited is an RLW coincidence factor study.[9] Again, not all of these studies are of equal value to the program. The same considerations for sampling method (survey or meter) and sample size discussed for hours of use above apply to coincidence factors as well. These factors are dealt with in the same way for coincidence factor as they were for hours of use. A meter is considered to be worth ten surveys, and sample sizes are weighted accordingly.

However, in addition to these factors, another very important consideration is the peak periods used by each study. Each study cited uses a different definition for peak period. Since coincidence factor is defined as the average percentage of total system wattage on during the peak period, when the peak period occurs may have a significant effect on the coincidence factor value for that study. Thus, a weighting system was developed to include both sample size and the degree to which the peak periods for each study overlap with the Focus peak period.

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[9] RLW Analytics. *Coincidence Factor Study - Residential and Commercial Industrial Lighting Measures*. Spring 2007.

All cited studies define peak period in the summer, Monday through Friday, and primarily in the afternoon. This is consistent with the program's definition. However, the months and hours included is different for each. The peak months and hours for each cited study are presented in Table 3-8 below.

Table 3-8. Coincidence Factor Study Weighting by Sample Size and Peak Period Overlap

	PG&E 1996	RLW Schools	RLW CF	SDG&E Time of Use	Focus	Total
Peak Months	May-Oct	Jun-Sept	Jun-Aug	May-Sept	Jun-Aug	
Peak Hours	12 - 6 pm	3 - 5 pm	1 - 5 pm	1 - 4 pm	1 - 4 pm	
Total Peak Hours	1,104	244	368	459	276	
Hours In Focus Peak	276	92	276	276	276	
Percent in Focus Peak	25%	38%	75%	60%	100%	
Peak Period Weighting Factor	13%	19%	38%	30%	-	100%
Sample Size	127	600	1,415	431	-	-
Sample Size Weighting Factor	5%	23%	55%	17%	-	100%
Overall Weighting Factor	9%	21%	46%	24%	-	100%

The total peak hours for each program were calculated, as are the number of these hours that are contained in the Focus peak period. A ratio of the former to the latter is reported in the "Percent in Focus Peak" row in the above table. Each of these "Percent in Focus Peak" values was divided by the sum of the percentages to yield Peak Period Weighting Factors that sum to 100 percent.

Sample Size Weighting Factors were developed using the method described for hours of use. The two weighting factors, Peak Period and Sample Size, are given equal importance and averaged to yield the Overall Weighting Factors for each study, as shown in Table 3-8. For each building type, these act as relative weights of the values reported by each study for that building type.

The CF values reported by each study by building type are reported in Table 3-9 along with their relative weights and the resulting weighted average.

Table 3-9. Coincidence Factor Values and Weighted Averages

Building Use	PG&E 1996	RLW Schools	RLW CF	SDG&E Time of Use	Weighted Average
Food Sales	81%	-	95%	90%	92%
Food Service	68%	-	81%	96%	84%
Health Care	74%	-	77%	82%	78%
Hotel/Motel	67%	-	-	23%	35%
Office	81%	-	75%	78%	77%
Public Services (non-food)	64%	-	-	-	64%
Retail	88%	-	82%	88%	84%
Warehouse	84%	-	78%	79%	79%
School	42%	33%	63%	53%	51%
College	68%	-	68%	-	68%
Industrial	-	-	73%	85%	77%
Other	76%	-	54%	88%	67%
Weighting Factor	**9%**	**21%**	**46%**	**24%**	**100%**

Note that there is only one cited value for Public Services (non-food) buildings, so that one value is the "weighted average" value even though no actual weighting has occurred.

Once the average coincidence factor was determined by building type, the building type values were combined into sector-level estimates using the method outlined in the Hours of Use section. Table 3-10 shows the coincidence factor for each building use, the weighting factor used, and the overall weighted average coincidence factor for the Commercial sector.

Table 3-10. Commercial Coincidence Factor Weighting by Building Use

Building Use	Weight	Average CF
Food Sales	3.9%	92%
Food Service	3.9%	84%
Health Care	9.2%	78%
Hotel/Motel	6.5%	35%
Office	27.3%	77%
Public Services (non-food)	6.5%	64%
Retail	25.9%	84%
Warehouse	16.9%	79%
Average	**100%**	**77%**

For the Schools & Government sector, coincidence factors were determined based on the results from each source as shown below in Table 3-11.

Table 3-11. Schools & Government Coincidence Factor

Building Use	Weight	Average CF
Office	23%	77%
School	36%	52%
College	41%	68%
Average	**100%**	**64%**

For the Industrial sector, no weighting system was necessary as the sources generally included "industrial" as a building use. The average coincidence factor for the Industrial sector is 77 percent.

iii. The Agricultural Sector

Hours of use and coincidence factor values for the Agriculture sector are based on an analysis of existing engineering reviews that were performed on installed projects during Focus on Energy's 18-month Contract Period (18MCP).[10] There were six engineering reviews done of lighting projects during 18MCP in which hours of use was collected, representing 362 light fixtures of various types.

[10] Secondary sources with parameter values for the Agriculture sector were not available at the time these parameters were deemed.

The proposed value for Agriculture lighting hours was based on an average of this sample weighted according to the number of fixtures installed. Coincidence factor was determined using a weighting system based on both hours of use and whether the respondents indicated that the lights were on during the day or during the night. These results are shown below in Table 3-12.

Table 3-12. Agricultural Hours of Use and Coincidence Factor

Sector	Hours	CF
Agriculture	4,698	67%

3.2 HEATING DEGREE DAYS (HDD)

Date Deeming Last Modified: 2006

Summarized by: John Dendy

Deemed Value: 7,699 °F-day

Table 3-13. Measures to which Deemed HDD Value Applies[11]

WISeerts Tech Codes	Measure Description	Number of Measures
1.2700 - 1.2712	Hot Water Boiler for Space Heating	13
1.2790, 1.2791	Hot Water Boiler, High Efficiency, Modulating	2
4.1000	HVAC Steam Trap Repair	1
4.1697 - 4.1708	Furnace	11
4.3822 - 4.3831	Packaged Terminal Heat Pumps	8

A. PARAMETER DEFINITION AND DISCUSSION

Heating Degree Days (HDD) is the sum of the number of degrees that the average daily temperature is less than a base temperature for a given time period. The standard base temperature in the HVAC industry is 65 °F.

Heating degree days are calculated and reported by various public and private entities. Typically, heating degree days are calculated as follows:

- Find the mean daily temperature by averaging the maximum and minimum measured temperature for the day.
- Subtract the average daily temperature from the base temperature to find daily heating degrees. Ignore all negative results.
- Sum all positive results over a given time period. For annual HDD, the time period is one year.

Heating degree days can be calculated for any location with adequate weather data. HDD can be reported for a specific time period, such as May 2009. "Normal" HDD values are also reported and represent the weather for a typical year for a given location. These are often based on 30-year averages.

For these calculations, HDD is the population-weighted statewide average normal annual HDD for Wisconsin.

[11] Does not apply to guest room energy management controls (measure 4.500), which uses another value for HDD.

B. PARAMETER BASIS AND VALUE

In a 2005 memo,[12] the deemed HDD value is reported to be a population weighted average from the 2004 version of the Wisconsin Energy Statistics, published by the Wisconsin Division of Energy.[13] The 2004 version of this source is unavailable. However, the same data is available in the 2008 version of the report, currently available online.[14]

Data are provided by for each of the eleven Division of Energy Services Degree Day Zones. The source of these data is the National Oceanic and Atmospheric Administration averages for 1971–2000.[15] Since the data was generated in 2000, the data in the 2008 report is identical to that in the 2004 report.

In addition to the HDD values by zone, the 2008 version also reports the deemed value of 7,699 HDD. It is defined in the report as the population weighted statewide average based on the 2000 census.

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[12] Deemed savings calculation dated 11/3/2005 for measure 1.27, which at the time was for replacing a non-operational boiler with a high efficiency boiler (>90% efficient).

[13] *2004 Wisconsin Energy Statistics,* Wisconsin Department of Administration, 2004, page 130 - Wisconsin Normal Heating Degree Days, by Zone and Month.

[14] *2008 Wisconsin Energy Statistics,* Wisconsin Department of Administration, Division of Energy Services, page 130 - Wisconsin Normal Cooling Degree Days, by Zone and Month. http://energyindependence.wi.gov/docview.asp?docid=15569&locid=160.

[15] National Oceanic and Atmospheric Administration, "Monthly Normals of Temperature, Precipitation, and Heating and Cooling Degree Days, 1971-2000 Wisconsin" *Climatology of the United States No. 81 (by State).*

3.3 COOLING DEGREE DAYS (CDD)

Date Deeming Last Modified: 2006

Summarized by: John Dendy

Deemed Value: 535 °F-day

Table 3-14. Measures to which CDD Value Applies[16]

WISeerts Tech Codes	Measure Description	Number of Measures
4.3530, 4.3540, 4.2550	A/C Split Systems <65 MBH	3
4.3805 - 4.3831	Packaged Terminal Units (PTACs and PTHPs)	15
4.5110 - 4.5175	Rooftop A/C	66

A. PARAMETER DEFINITION AND DISCUSSION

Cooling Degree Days (CDD) are the sum of the number of degrees that the average daily temperature is greater than a base temperature for a given time period. The standard base temperature used in the HVAC industry is 65 °F.

Cooling degree days are calculated and reported by various public and private entities. Typically, cooling degree days are calculated as follows:

- Find the mean daily temperature by averaging the maximum and minimum measured temperature for the day.
- Subtract the base temperature from the average daily temperature to find the daily cooling degrees. Ignore all negative results.
- Sum all positive results over a given time period. For annual CDD, the time period is one year.

Cooling degree days can be calculated for any location with adequate weather data. CDD can be reported for a specific time period such as May 2009. "Normal" CDD values are also reported and represent the weather for a typical year for a given location. These are often based on 30 years of historical data.

For these calculations, CDD is the population-weighted statewide average annual CDD for Wisconsin.

B. PARAMETER BASIS AND VALUE

In a 2006 spreadsheet,[17] the CDD value is reported to be a population weighted average from the 2005 version of the Wisconsin Energy Statistics, published by the Wisconsin

[16] Does not apply to guest room management controls (measure 4.500), which uses another value for CDD.

Division of Energy. The 2005 version of this source is unavailable. However, the same data is available in the 2008 version of the report, currently available online.[18]

Data are provided for each of the eleven Division of Energy Services Degree Day Zones. The source of these data is the National Oceanic and Atmospheric Administration averages for 1971–2000.[19] Since the data was generated in 2000, the data in the 2008 report is identical to that in the 2005 report.

In addition to the CDD values by zone, the 2008 version also reports the deemed value of 535 CDD. It is defined in the report as the population weighted statewide average based on the 2000 census.

[17] Deemed savings calculation spreadsheet entitled "FY07 EFCI Cooling Incentive Calcs tk."

[18] *2008 Wisconsin Energy Statistics,* Wisconsin Department of Administration, Division of Energy Services, page 130 - Wisconsin Normal Cooling Degree Days, by Zone and Month. http://energyindependence.wi.gov/docview.asp?docid=15569&locid=160.

[19] National Oceanic and Atmospheric Administration, "Monthly Normals of Temperature, Precipitation, and Heating and Cooling Degree Days, 1971–2000 Wisconsin" *Climatology of the United States No. 81 (by State).*

3.4 HEATING DESIGN TEMPERATURE

Date Deeming Last Modified: May 2008

Summarized by: John Dendy

Deemed Value: - 15 °F

Table 3-15. Measures to which Deemed Heating Design Temperature Applies[20]

WISeerts Tech Codes	Measure Description	Number of Measures
1.2700 - 1.2712	Hot Water Boiler for Space Heating	13
1.2790, 1.2791	Hot Water Boiler, High Efficiency, Modulating	2
4.1000	HVAC Steam Trap Repair	1
4.1697 - 4.1708	Furnace	11
4.3822 - 4.3831	Packaged Terminal Heat Pumps	8

A. PARAMETER DEFINITION AND DISCUSSION

Outdoor heating design temperature represents the coldest dry bulb temperature for which heating equipment is designed to meet heat load for a space. It is impossible to design systems to meet the load that would result from the coldest temperature that could occur at a given location, since record lows continue to be set. Further, it is impractical to design systems to meet the load resulting from coldest recorded temperature for a given location, because this would result in excessive equipment oversizing and inefficient operation.

Heating equipment is therefore designed to meet heating load for a great percentage of outdoor temperatures. There are two standards for outdoor design temperatures, 99.6 percentile and 99 percentile.[21] The percentile refers to the frequency of occurrence of the temperature. For the 99 percentile standard, the recorded outdoor temperature is colder than the outdoor design temperature one percent of the time.

Outdoor design temperatures can be calculated for any location for which adequate weather data is available. In program calculations, the outdoor heating design temperature is a population-weighted average for the state of Wisconsin.

B. PARAMETER BASIS AND VALUE

For several years, the program used a heating design temperature of -17.5 °F rather than the current deemed value of -15 °F. This value was based on an average for Wisconsin, but not a population-weighted average. The design temperatures upon which

[20] Does not apply to guest room energy management controls (measure 4.500), which uses a different value for heating design temperature.

[21] 2009 ASHRAE Handbook – Fundamentals, p. 14.1.

the average was based are reported to be from the Wisconsin Department of Commerce, as shown in Table 3-16.

Table 3-16. Wisconsin Design Temperatures by Department of Administration Zone

Department of Commerce Zone	Department of Administration Zone	Design Temperature (F)
Zone 1	1, 2, 4	-25
Zone 2	3, 5, 7, 8	-20
Zone 3	6, 9, 10	-15
Zone 4	11	-10
Statewide Average		**-17.5**

The average of -17.5 °F is a simple average of the design temperatures in the rightmost column. These values are thought to be 99 percentile heating design temperatures, since that is typical, but this is not known.

According to a deeming memo,[22] in May 2008 the deemed heating design temperature was changed to -15 °F to reflect a population weighted average design temperature, rather than a simple average. The memo reports that the calculation was done by Ron Swager of Patrick Engineering. No additional information about the calculation and associated assumptions or sources is available.

[22] *Spring '08 Deemed Savings Review (Step 4)*, KEMA, May 21, 2008.

3.5 COOLING DESIGN TEMPERATURE

Date Deeming Last Modified: 2006

Summarized by: John Dendy

Deemed Value: 87.3 °F

Table 3-17. Measures to which Deemed Cooling Design Temperature Applies[23]

WISeerts Tech Codes	Measure Description	Number of Measures
4.3530, 4.3540, 4.2550	A/C Split Systems <65 MBH	3
4.3805 - 4.3831	Packaged Terminal Units (PTACs & PTHPs)	15
4.5110 - 4.5175	Rooftop A/C	66

A. PARAMETER DEFINITION AND DISCUSSION

Outdoor cooling design temperature represents the warmest outdoor dry bulb temperature for which cooling equipment is designed to meet the cooling load for a space. It is impossible to design systems to meet the load resulting from the warmest temperature that may occur at a given location, since record high temperatures continue to be set. Further, it is impractical to design systems to meet the load resulting from warmest recorded temperature for a given location, because this would result in excessive equipment oversizing and inefficient operation.

Cooling equipment is therefore designed to meet cooling load for a great percentage of outdoor temperatures. Outdoor cooling design temperatures are reported for 96.6, 98, and 99 percentiles.[24] The percentile refers to the percent of measured dry bulb temperatures that are cooler than the cooling design temperature.

Outdoor design temperatures can be calculated for any location for which adequate weather data is available. In program calculations, the outdoor cooling design temperature is an average for the state of Wisconsin.

B. PARAMETER BASIS AND VALUE

A 2006 spreadsheet[25] contains the calculation for outdoor cooling design temperature. It is an average of the Wisconsin code[26] design temperatures specified by Department of Commerce Zone, and results in the deemed value of 87.3 °F.

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[23] Does not apply to guest room energy management controls (measure 4.500), which uses a different value for cooling design temperature.

[24] 2009 ASHRAE Handbook – Fundementals, p. 14.1.

[25] FY07 EHCI Cooling Incentive Calcs tk.

Table 3-18. Wisconsin Cooling Design Temperatures by Department of Commerce Zone

Department of Commerce Zone	State Code Cooling Design Temperature (F)
1	86
2	87
3	87
4	89
Average	**87.3**

As an alternative method and check, the same calculation spreadsheet also presents ASHRAE[27] values for 0.4 percent, 1 percent, and 2 percent dry bulb cooling design temperatures for six Wisconsin cities, as shown in Table 3-19.

Table 3-19. ASHRAE Cooling Design Temperatures by City

City	ASHRAE (0.4% DB)	ASHRAE (1% DB)	ASHRAE (2% DB)
Eau Claire	90	87	84
Green Bay	88	85	82
La Crosse	91	88	85
Madison	90	87	84
Milwaukee	89	86	83
Wausau	88	85	82
Average	**89.3**	**86.3**	**83.3**

The deemed value most closely corresponds to the ASHRAE one percent dry bulb cooling design temperature average.

[26] Cited code is "State Code Comm 63."

[27] ASHRAE Fundamentals 1997.

4. DEEMED SAVINGS ESTIMATES

This section is a summary of the documentation and source data for all currently deemed measures. The section is organized by measure group description, which is an overall technology category. Most measure groups have multiple technology entries, and most technologies have multiple deemed savings measures. Measures are grouped into single technology sections when the calculation method for the measures is the same or very similar.

Each entry includes:

- When the measure was deemed and, if applicable, when it was updated.
- The equation(s) used to estimate savings.
- Definitions of the variables used in the savings equation.
- The values used for all parameters in the savings estimate.
- The sources supporting the calculation method and all parameters or assumptions.

The manual entries are summarized by measure group in Table 4-1.

Table 4-1. Deemed Savings Manual Entries

Group Description	Manual Entry
Boilers and Burners	Boiler Oxygen Trim Controls
	Linkageless Boiler Controls
	Boiler Tune-ups
	Industrial Steam Trap Repair
	Hot Water Boiler for Space Heating
	Hot Water Boiler, High Efficiency Modulating
	Boiler Reset/Cutout Controls
Food Service	Fryers
	Steamers
	Hot Food Holding Cabinet
	Ovens
	Griddles
	Refrigerators and Freezers
	Ice Machines
	Dishwashers
Plug Loads	ENERGY STAR Vending Machines
	Vending Machine Controls, Cold Beverage Machine
	Snack Machine Vending Miser Controller
	Beverage Cooler Controls
	Engine Block Heater Timer

Group Description	Manual Entry
Refrigeration	Commercial Refrigeration Tune-up, Non-self-contained
	Commercial Refrigeration Tune-up, Self-contained
	Anti-sweat Heater Control
	Freezer and Refrigerated Case Doors
	ECM/PSC Motor in Refrigerated/Freezer Case
	ECM Motor in Walk-in Coolers and Freezers
	Night Curtains on Open Coolers
HVAC	Agricultural Exhaust Fans
	HVAC Steam Traps
	Furnace
	A/C Split System < 65MBh
	Packaged Terminal Units
	Guest Room Energy Management Controls
	Rooftop A/C
Process	Extraction Plate for Repulper Motor
Domestic Hot Water	Showerhead
	Aeration
	Pre-rinse Sprayer
Motor	NEMA Premium Motors
Lighting	LED Exit Lighting
	Low Wattage CFLs
	High Wattage CFLs
	CFL Cold Cathode
	Occupancy Sensors -- Wall or Ceiling Mount
	High/Low Control for 320W PSMH
	Daylighting Controls
	4' T-8 Replacing 8' T-12 Fluorescent Lighting
	T8 Low Watt with CEE Ballast
	T8 Low Watt Relamp
	T8 High Lumen Lamp with Low Ballast Factor
	T5 2-Lamp Replacing 3-Lamp T8 or 4-Lamp T12
	LED Recessed Downlight
	Metal Halide Ceramic, Pulse Start, and Electronic Ballast Pulse Start
	LED Reach-in Refrigerated Case Lighting
	High Bay Fluorescent Replacing HID
	Occupancy Sensors for High Bay Fluorescent Fixtures
	T8 HP 2L Recessed Fixture Replacing 3L or 4L T8 or T12
	T12 Bounty

4.1 BOILERS AND BURNERS

The Boilers and Burners section contains the technologies outlined in Table 4-2.

Table 4-2. Deemed Savings Manual Entries, Boilers and Burners

Group Description	Manual Entry
Boilers and Burners	Boiler Oxygen Trim Controls
	Linkageless Boiler Controls
	Boiler Tune-ups
	Industrial Steam Trap Repair
	Hot Water Boiler for Space Heating
	Hot Water Boiler, High Efficiency Modulating
	Boiler Reset/Cutout Controls

4.1.1 Boiler Oxygen Trim Controls

Group: Boilers & Burners

Category: Controls

Technology Description: Oxygen Trim Controls

Tech Code: 1.0710.085

Qualifying Equipment: Controls must be installed on a natural gas forced draft boiler 200 hp or greater that operates for a minimum of 4,000 hours per year.

Date Deeming Last Modified: November 2009

Date Previously Deemed: November 2008

Summarized by: John Dendy

Table 4-3. Oxygen Trim Control Measure[28]

Tech Code	Measure Description	Deemed Savings (therms per year per HP)
1.0710.085	Boiler Oxygen Trim Controls, per hp	11

A. SAVINGS BASIS, EQUATION, AND PARAMETERS

Although boilers require some excess oxygen to ensure the complete combustion of fuel, too much excess oxygen decreases boiler efficiency. An increase in excess oxygen requires an increase in combustion air. The higher volume of combustion air will heat up during combustion and this heat energy is lost up the stack. Installing a system to monitor excess oxygen in the flue allows excess air to be reduced to optimal levels. This improves the efficiency of the boiler.[29]

Savings are deemed per horsepower of boiler output capacity and are determined using the following equation:

$$\frac{Therm_{savings}}{BoilerHP} = \left(\frac{33{,}469.8 \times BLF \times hours}{100{,}000}\right) \times \left(\frac{1}{EFF_{Boiler}} - \frac{1}{EFF_{Boiler} + EI}\right)$$

[28] According to the Deemed Savings Parameter Development report, the deemed value should be 11.3 therms per year per hp of output capacity. However, a data entry in the deemed savings spreadsheet has the value set at 11.0 therms per year per hp of output capacity. The deemed value should be adjusted during the next round of deemed savings review.

[29] Oxygen trim controls are generally an add-on feature to linkageless boiler controls and could be included as part of a linkageless control system. The savings deemed in this document are only for the portion of savings related to oxygen trim control.

where:

- *33,469.8 = Conversion Factor, BtuH per Boiler HP*
- *BLF = Boiler Load Factor, deemed 5 percent*
- *Hours = Annual boiler operating hours, deemed 4,000 hours*
- *EFF_{Boiler} = Boiler Efficiency, deemed 8 percent*
- *EI = Efficiency Improvement, deemed 1.1 percent*
- *100,000 = Conversion factor, Btu per therm.*

Boiler Load Factor, BLF. The boiler load factor is the estimated load on the boiler in percent of full capacity. It is the average percent of boiler capacity at which the boiler operates.

Operating Hours, hours. Operating hours refers to the average annual hours that the boiler operates.

Boiler Efficiency, EFF_{Boiler}. Boiler efficiency refers to the average combustion efficiency of the boiler on which the oxygen trim controls are to be installed.

Efficiency Improvement, EI. The efficiency improvement is the change in combustion efficiency due to installing oxygen trim controls.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

This savings estimate is primarily based on operating conditions for HVAC boilers. These boilers may have lower savings than process boilers, but the resulting estimate will be conservative and will likely be achieved regardless of the mix of process and HVAC boilers participating in the program.

Parameter values are deemed as follows:

Boiler Load Factor, BLF. The boiler load factor is deemed to be 50 percent. When the measure was deemed, no studies or reports were found to suggest an appropriate load factor. However, it was agreed between evaluation and the program that the deemed value is reasonable.

Operating Hours, hours. Operating hours are deemed to be 4,000 hr/yr. This is based on the minimum operating hours required to qualify for this measure. Process boilers may operate year round, so 4,000 hr/yr is presented in deeming documentation as a conservative estimate.

Boiler Efficiency, EFF_{Boiler}. Boiler efficiency is deemed to be 80 percent. This is based on the Wisconsin Commercial Code. Also cited is an estimate by the Natural Gas Boiler Burner Consortium, which reports that the typical boiler efficiency will be in the 75 to 85 percent range.[30] This yields further support to the value, since the midpoint is 80 percent, which agrees with code.

Efficiency Improvement, EI. The efficiency improvement that results from this measure is deemed at 1.1 percent. This is calculated using information from the Steam Survey Guide.[31] If the percent excess oxygen and net stack temperature are known then Table 4-4 can be used to provide combustion losses.[32]

Table 4-4. Boiler Combustion Losses Based on Excess Oxygen and Net Stack Temperature

	Percent Combustion Losses by Net Stack Temperature														
O2 %	230 F	250 F	270 F	290 F	310 F	330 F	350 F	370 F	390 F	410 F	430 F	450 F	470 F	490 F	510 F
1.0	14.49	14.92	15.36	15.79	16.23	16.67	17.11	17.55	17.99	18.43	18.88	19.32	19.77	20.21	20.66
2.0	14.72	15.17	15.63	16.09	16.55	17.01	17.47	17.93	18.39	18.86	19.32	19.79	20.26	20.73	21.20
3.0	14.98	15.46	15.94	16.42	16.90	17.38	17.87	18.36	18.84	19.33	19.82	20.31	20.80	21.30	21.79
4.0	15.26	15.77	16.28	16.79	17.29	17.81	18.32	18.83	19.35	19.86	20.38	20.90	21.41	21.93	22.46
5.0	15.59	16.12	16.66	17.20	17.74	18.28	18.82	19.36	19.91	20.46	21.00	21.55	22.10	22.65	23.20
6.0	15.96	16.52	17.10	17.67	18.24	18.82	19.39	19.97	20.55	21.13	21.71	22.29	22.88	23.46	24.05
7.0	16.38	16.98	17.59	18.20	18.82	19.43	20.04	20.66	21.28	21.90	22.52	23.14	23.77	24.39	25.02
8.0	16.86	17.51	18.16	18.82	19.48	20.14	20.80	21.46	22.12	22.79	23.46	24.12	24.79	25.47	26.14
9.0	17.42	18.13	18.83	19.54	20.25	20.96	21.68	22.39	23.11	23.83	24.55	25.27	25.99	26.72	27.44
10.0	18.09	18.86	19.62	20.39	21.16	21.94	22.71	23.49	24.27	25.05	25.83	26.62	27.41	28.19	28.98
11.0	18.89	19.73	20.57	21.42	22.26	23.11	23.96	24.81	25.67	26.52	27.38	28.24	29.10	29.97	30.83
12.0	19.87	20.80	21.73	22.66	23.60	24.54	25.48	26.43	27.37	28.32	29.27	30.22	31.18	32.13	33.09

An oxygen trim control system should be able to control excess oxygen in the flue gas to a range of 1.5 to 3 percent (2 percent is optimum). A traditional controller should be able to control excess oxygen in the flue gas to a range of 3 to 7 percent. The difference provides the basis for our efficiency improvement estimate. The efficiency improvement is calculated using the following assumptions:

- The oxygen trim control keeps excess oxygen at the optimum 2 percent and a traditional control keeps excess oxygen at an average of 5 percent, the midpoint of the range cited.
- The system operates at 10 pounds per square inch. HVAC systems typically operate between 5 and 15 pounds per square inch, and 10 is the midpoint of that range. The temperature of saturated steam at this pressure is 240°F.
- Based on information in the *Guide to Industrial Assessments for Pollution Prevention and Energy Efficiency,*[33] it is assumed that the flue gas temperature

[30] http://www.energysolutionscenter.org/boilerburner/Eff_Improve/Primer/Boiler_Introduction.asp. Accessed July 6, 2009.

[31] Greg Harrell, Ph.D, PE, *Steam System Survey Guide.* Oak Ridge National Laboratory, ORNL/TM-2001/263. May 2002.

[32] Net stack temperature in this analysis refers to the difference in temperature between the combustion air and the flue gas temperature.

[33] Guide to Industrial Assessments for Pollution Prevention and Energy Efficiency, http://www.p2pays.org/ref/19/18351.pdf. Accessed July 7, 2009.

is 100°F greater than the saturated steam temperature. Therefore, the flue gas temperature is assumed to be 340°F.

In order to use Table 4-4 to determine combustion losses, the net stack temperature must be known. This is the difference between the flue gas temperature, which is 340 °F, and combustion air temperature. The calculation assumes that the boiler uses outdoor air for combustion air. Based on TMY2 data, the average outdoor temperature from October 1 to April 30 is 30.8°F. Subtracting this from the flue gas temperature (340°F) yields a net stack temperature of 309°F. Then Table 4-4 is used to find the percent stack losses at 309°F net stack temperature for 2 percent and 5 percent excess oxygen. Stack losses for 2 percent excess oxygen are 16.55 percent and stack losses for 5 percent excess oxygen are 17.74 percent. The improvement in efficiency is 1.19 percent.

The above calculation is for a boiler without an economizer or a combustion air preheater. These systems capture heat from the flue gas and use it to warm the combustion air, changing the combustion efficiency. Since some boilers do have these systems, the above analysis is repeated for this case, using a net flue gas temperature that is 50 degrees lower due to heat recovery, or 259°F. This temperature is rounded down to 250°F to match values in Table 4-4. For this case, the boiler stack losses at 2 percent excess oxygen are 15.17 percent and the stack losses at 5 percent excess oxygen are 16.12 percent. Therefore, the improvement in efficiency is 0.95 percent when some type of heat recovery is present.

The unweighted average of the efficiency improvements for each case is 1.07 percent. This value is rounded up to 1.1 percent efficiency improvement, based on the assumption that there are more boilers without heat recovery than with heat recovery.

Substituting the above deemed values into the savings equation yields the deemed savings value of 11.0 therm per boiler horsepower output capacity, as reported in Table 4-3.

4.1.2 Linkageless Boiler Controls

Group: Boilers & Burners

Category: Controls

Technology Description: Linkageless Boiler Controls

Tech Code: 1.0711.085

Qualifying Equipment: Controls must be installed on natural gas forced draft boilers 200 hp or greater that operate for a minimum of 4,000 hours per year.

Date Deeming Last Modified: November 2009

Date Deemed: November 2008

Summarized by: John Dendy

Table 4-5. Linkageless Boiler Control Measure

Tech Code	Measure Description	Deemed Savings (therms per year per HP)
1.0711.085	Linkageless Boiler Control, per hp	25

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Traditional boiler combustion controls consist of a single servo motor and a series of linkages to control the air and fuel flows into the combustion chamber. The linkage connections are susceptible to hysteresis, which limits the accuracy of the control. In addition, linkage controls are unable to match the combustion curve for airflow and fuel flow across a range of burn rates. Therefore, combustion efficiency is not optimized. Linkageless controls eliminate these issues and can improve the efficiency of the boiler.[34]

Savings due to the installation of linkageless controls are calculated per horsepower of boiler output capacity and are described by the following equation:

$$\frac{Therm_{savings}}{BoilerHP} = \left(\frac{33{,}469.8 \times BLF \times hours}{Eff_{Boiler} \times 100{,}000} \right) \times SF$$

where:

- *33,469.8 = Conversion Factor, Btuh per Boiler HP.*

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[34] Oxygen trim controls are generally an add-on feature to linkageless boiler controls and could even be included as part of a linkageless control system. The savings deemed in this document are only for the portion of savings related to linkageless control. If oxygen trim is an option installed as part of the linkageless system, the savings need to be estimated separately.

- *BLF = Boiler Load Factor, deemed 50 percent*
- *hours = Annual boiler operating hours, deemed 4,000 hours*
- *EFF_{Boiler} = Boiler Efficiency, deemed 80 percent*
- *100,000 = Conversion factor, BTU per therm*
- *SF = Savings Fraction due to linkageless controls, deemed 3 percent.*

Boiler Load Factor, BLF. The boiler load factor is the estimated average percent load on the boiler. It is the average percent of boiler capacity at which the boiler operates.

Operating Hours, hours. Operating hours refers to the average annual operating hours of the boiler on which linkageless controls are being installed.

Boiler Efficiency, EFF_{Boiler}. Boiler efficiency in this calculation refers to the average combustion efficiency of a boiler on which linkageless controls are installed.

Savings Fraction, SF. Savings fraction is the percent of annual consumption that will be saved due to installing linkageless controls.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The values used for each parameter in the current deemed savings calculation are discussed below.

Boiler Load Factor, BLF. The boiler load factor is deemed to be 50 percent. When the measure was deemed, no studies or reports were found to suggest an appropriate load factor. However, it was agreed between evaluation and the program that the deemed value is reasonable.

Operating Hours, hours. Operating hours are deemed to be 4,000 hr/yr. This is based on the minimum operating hours required to qualify for this measure. Process boilers may operate year round, so 4,000 hr/yr is presented in deeming documentation as a conservative estimate.

Boiler Efficiency, EFF_{Boiler}. Boiler efficiency is deemed to be 80 percent. This is based on the Wisconsin Commercial Code. Also cited is an estimate by the Natural Gas Boiler Burner Consortium, which reports that the typical boiler efficiency will be in the 75 to 85 percent range.[35] This yields further support to the value, since the midpoint is 80 percent, which agrees with code.

Savings Fraction, SF. The savings fraction is deemed to be 3 percent. In the deeming process, several sources were found that place savings between 2 and 6 percent.[36] [37] [38]

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[35] http://www.energysolutionscenter.org/boilerburner/Eff_Improve/Primer/Boiler_Introduction.asp. Accessed July 6, 2009.

[36] http://www.yorkland.net/counter.htm. Accessed July 7, 2009.

[39] These are presented in Table 4-6 below. Three percent was a previously deemed value, and based on these sources, three percent was deemed to be reasonable.

Table 4-6. Savings Percentage by Source

Source	Percent Savings
Yorkland Controls	1 to 5%
Removing Guesswork	3.1%
Enbridge Steam Saver	up to 5%
Industrial Controls	2 to 6%

Substituting the above deemed values into the savings equation yields the deemed savings value of 25 therms per boiler HP, as presented in Table 4-5.

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[37] Gary Cellucci, HPAC, Hydronics, *Removing Guesswork* September/October 2005 http://www.bizlink.com/HPAC_articles/September2005/38.pdf.

[38] Enbridge Steam Saver Program, Commercial/Institutional, https://portal-plumprod.cgc.enbridge.com/enbridge/files/comm_steam_saver.pdf.

[39] "Want Your Burner to be More Efficient and Reliable? Industrial Insights brochure by Industrial Controls." http://www.industrialcontrolsonline.com/pdf/Industrial%20Insights/ControlLinks%20Article.pdf. March 2007.

4.1.3 Boiler Tune-ups

Group: Boilers & Burners

Category: Boiler

Tech Code: 1.1300.430

Technology Description: Tune-up natural gas boilers to improve combustion efficiency.

Qualifying Equipment:

- The boiler must be fueled by natural gas and have a minimum output of 120MBh.
- The burner must be adjusted to improve combustion efficiency, and the service provider must perform pre- and post-service combustion efficiency tests.

Date Deeming Last Modified: November 2009

Date Deemed: May 2008

Summarized by: John Dendy

Table 4-7. Boiler Tune-up Measure

Tech Code	Measure Description	Deemed Savings (therms per year per input MBh)
1.1300.430	Boiler Tune-up - service buy-down	0.356

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

As a boiler operates over a period of time, its combustion efficiency can decrease due to fouling, controls maladjustment, or other issues. The efficiency can be improved by tuning up the boiler to return it to near optimal operating conditions. This efficiency gain saves natural gas.

Savings due to performing a boiler tune-up are described by the following equation. Savings are determined by applying a savings factor to an estimate of the boiler consumption prior to the tune-up. The energy savings for this measure are determined per input boiler capacity in thousand Btu per hour (MBh).

$$\frac{Therm\ Savings}{MBh\ Input} = BOF \times SF \times \frac{HDD \times 24}{(T_{Indoor} - T_{Outdoor}) \times Eff_{Pre-TuneUp} \times 100}$$

where:

- *BOF = Boiler oversize factor, deemed 77 percent*
- *SF = Savings Factor, deemed 1.6 percent*
- *$Eff_{Pre-TuneUp}$ = Efficiency of the boiler prior to the tune-up, deemed 80 percent*

- T_{Indoor} = *Indoor design temp, assumed to be 65°F*
- $T_{Outdoor}$ = *Outdoor design temp, deemed -15°F*
- *HDD = Heating Degree Days for Wisconsin, deemed 7,699*
- *100 = conversion factor, MBh (thousand Btu per hour) per therm.*

Boiler Oversize Factor, BOF. The boiler oversize factor is an estimate of the percent of boiler capacity that represents building heat load at design conditions.

Savings Factor, SF. The savings factor is an estimate of the percent of annual gas consumption that is saved due to tuning up the boiler.[40]

Heating Degree Days, HDD. Heating Degree Days is the sum of the number of degrees that the average daily temperature is less than a base temperature over a given time period. For these calculations, HDD is the population-weighted statewide average normal annual HDD for Wisconsin.

Efficiency of the Boiler Prior to Tune-up, $Eff_{Pre\text{-}TuneUp}$. The efficiency of the boiler prior to tune-up is the assumed combustion efficiency of the boiler that will be serviced.

Indoor design temperature, T_{Indoor}. The indoor design temperature is the standard balance temperature used in system design calculations.

Outdoor design temperature, $T_{Outdoor}$. In system design calculations, the outdoor design temperature is the coldest temperature for which a heating system is designed to meet the heating load, disregarding any oversizing. For this calculation, we use a population-weighted average of outdoor design temperatures for Wisconsin.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The values used for each parameter in the deemed savings calculation are discussed below.

Boiler Oversize Factor, BOF. Most heating equipment is sized to provide more heat than is necessary under design conditions. The degree of oversize can vary based on many factors, including the system designer. Thus, when basing consumption estimates on design conditions, an oversize factor is introduced.

When this measure was deemed, it was agreed that some oversize factor was necessary. There were no sources found that provided reliable research into average oversize factor for boiler installations. Based on the experience of those involved, the design factor of 0.77 was chosen. This is equivalent to 30 percent over design, or 1/1.3.

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[40] Note that this savings factor is not the same thing as “efficiency improvement,” a parameter that would represent the difference between the efficiency before the tune up and the efficiency after. If the value were for efficiency improvement, the equation would take a different form.

Savings Factor, SF. The savings factor is deemed to be 1.6 percent. When the measure was deemed, two sources were found that reported actual savings due to boiler tune-ups. The Building Tune-up and Operations Program Evaluation, performed for the Energy Trust of Oregon, found that annual savings from boiler tune-ups were approximately one percent of the boiler's pre-service energy consumption.[41] Based on combustion tests of hundreds of steam boilers, the Enbridge Steam Saver Program found that "a regular boiler tune-up will save an average of 1.6 percent of the total fuel consumed by the average boiler plant."[42] The value of 1.6 percent was chosen to account for the higher energy savings that will be realized from process boilers, which are eligible for this measure.

Heating Degree Days, HDD. This calculation uses the program's standard population-weighted statewide average normal annual HDD value of 7,669. See Section 3.2 for a discussion of the development of this value.

Standard Boiler Efficiency, $Eff_{Pre\text{-}TuneUp}$. Standard boiler efficiency is deemed to be 80 percent. This is based on the Wisconsin Commercial Code. Also cited is an estimate by the Natural Gas Boiler Burner Consortium, which reports that the typical boiler efficiency will be in the 75 to 85 percent range.[43] This yields further support to the value, since the midpoint is 80 percent, which agrees with code.

Indoor Design Temperature, T_{Indoor}. The indoor design temperature is deemed to be 65°F, which is the standard balance temperature in HVAC design calculations.

Outdoor Design Temperature, $T_{Outdoor}$. The outdoor design temperature is deemed to be - 15°F. This is a population-weighted average for the state of Wisconsin. For a discussion of this value, refer to Section 3.4.

Substituting the above values into the savings equation yields the deemed savings value of 0.356 therm per thousand Btu per hour of boiler input capacity.

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[41] Linda Dethman and Rick Kunkle for Energy Trust of Oregon, Phil Degens, evaluation manager. *Final Report, Building Tune-Up and Operations Program Evaluation.* http://www.energytrust.org/library/reports/0705_BTO_ProgramEvaluation.pdf?link_programs_reports_lin1Page=2. Accessed July 7, 2009.

[42] *Enbridge Steam Saver Program, Commercial/Institutional,* https://portal-plumprod.cgc.enbridge.com/enbridge/files/comm_steam_saver.pdf. Accessed July 7, 2009.

[43] http://www.energysolutionscenter.org/boilerburner/Eff_Improve/Primer/Boiler_Introduction.asp. Accessed July 6, 2009.

4.1.4 Industrial Steam Trap Repair

Group: Boilers and Burners

Category: Steam Trap

Technology Description: Repair leaking steam trap, industrial only.

Qualifying Equipment:

- Must be an industrial steam system, not primarily used for space heating.
- Repaired traps must be leaking steam, not failed closed or plugged.
- Incentive is available once per year per system.
- Municipal steam systems do not qualify.

With a steam trap survey:

- Repairs should be performed within 9 months of steam trap survey completion.[44]
- A steam trap survey and repair log must be completed. Required information includes a trap ID tag Number, location description, nominal steam pressure, trap type, trap condition (functioning, failed not leaking, failed leaking), and orifice size. A survey form can be found on the Focus web site.[45]

Without a steam trap survey.

- If mass replacement of steam traps occurs without a survey, it is assumed that 30 percent of the replaced traps were leaking, and the incentive is paid for 30 percent of the replaced traps.

Date Deemed: May 2008

Summarized by: John Dendy

Table 4-8. Industrial Steam Trap Repair Measures

WISeerts Tech Code	Measure Description	Deemed Savings		
		kW	kWh	Therms
1.1412.390	Repair leaking steam trap, <50 psig steam (Industrial Only)	0	0	196
1.1414.390	Repair leaking steam trap, 50-125 psig steam (Industrial Only)	0	0	756
1.1416.390	Repair leaking steam trap, 126-225 psig steam (Industrial Only)	0	0	1,084
1.1418.390	Repair leaking steam trap, >225 psig steam (Industrial Only)	0	0	2,075

[44] The language used is “should,” rather than “must,” and it is a suggestion, not a requirement.

[45] http://www.focusonenergy.com/files/Document_Management_System/Business_Programs/steamtrapsurveyrepairlog_template.xls.

A. SAVINGS EQUATIONS AND PARAMETERS

A leaking steam trap allows steam to escape into the condensate line before it can be used. Therefore, the boiler must produce more steam than is required for the process it serves. Energy savings is realized by replacing a leaking trap, thereby saving the amount of energy that is being lost through the leak. Energy loss from a leaking steam trap is described by the following equation:

$$therm\ savings\ =\ d\left(\frac{lb}{hr}\right)\left(1{,}000\ \frac{Btu}{lb}\right)\left(\frac{1}{eff}\right)\times Hr\div 100{,}000$$

where:

- *d = derating factor, deemed 50 percent*
- *lb/hr = discharge rate of steam through the leaking trap, values in Table* 4-9
- *1000 Btu/lb = energy content of steam*
- *eff = combustion efficiency of boiler, deemed 80%*
- *Hr = annual hours of operation of boiler, deemed 4,567 hr/yr*
- *100,000 = conversion factor, Btu per therm.*

Derating factor, d. The discharge rate of steam through an orifice is determined by orifice size and steam pressure. However, the effective orifice size is often not equal to the actual orifice size when fully open. Traps can fail at 100 percent open or at any fraction thereof. The presence of condensate at the orifice also reduces the effective orifice size. Therefore, a derating factor is introduced to avoid over-estimating savings.

Discharge rate of steam, lb/hr. Discharge rate refers to the rate at which steam passes through a given orifice size from a given pressure to atmospheric pressure.

Boiler Efficiency, eff. For this calculation, boiler efficiency refers to the boiler's combustion efficiency.

Annual hours of operation, Hr. The annual hours of operation correspond to the number of hours that the boiler is on and the system is at design pressure.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Derating factor, d. According to the Department of Energy (DOE), "assuming a trap has failed with an orifice size equivalent to one-half its fully open condition is probably prudent."[46] Therefore, the derating factor is assumed to be 50 percent.

Discharge rate of steam, lb/hr. The DOE presents data from the Boiler Efficiency Institute that shows discharge rate for varying orifice sizes at various pressures,[47] shown in Table 4-9.[48]

Table 4-9. Steam Discharge Rate[49]

Trap Orifice Diameter (Inches)	Leaking Steam Trap Discharge Rate (lb/hr) Steam Pressure, psig			
	15	100	150	300
1/32	0.9	3.3	4.8	9.1
1/16	3.4	13.2	18.9	36.2
1/8	13.7	52.8	75.8	145.0
3/16	30.7	119.0	170.0	326.0
1/4	54.7	211.0	303.0	579.0
3/8	123.0	475.0	682.0	1,303.0

Boiler Efficiency, eff. Boiler efficiency is deemed to be 80 percent. This is based on the Wisconsin Commercial Code. Also cited is an estimate by the Natural Gas Boiler Burner Consortium, which reports that the typical boiler efficiency will be in the 75 to 85 percent range.[50] This yields further support to the value, since the midpoint is 80 percent, which agrees with code.

Annual hours of operation, Hr. The annual boiler operating hours are assumed to be equivalent to the annual operating hours of lighting in an industrial facility. When this

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[46] *Steam Trap Performance Assessment.* Federal Energy Management Program. DOE/EE-0193, July 1999, p.12. Available at: http://www1.eere.energy.gov/femp/pdfs/FTA_SteamTrap.pdf.

[47] *Steam Tip Sheet #1.* DOE Industrial technology Program, January 2006. Available at http://www1.eere.energy.gov/industry/bestpractices/pdfs/steam1_traps.pdf

[48] The source document indicates that the discharge rate values are for steam leaking through a re-entrant orifice with a coefficient of discharge of 0.72.

[49] The source for all values is as cited, except for the value for 300 psig steam through a 1/32" orifice. There is no value in the source document for that situation. The value entered here, 9.1 lb/hr, is calculated by linear regression of a plot of discharge rate versus steam pressure for the other 1/32" orifice size data points.

[50] http://www.energysolutionscenter.org/boilerburner/Eff_Improve/Primer/Boiler_Introduction.asp. Accessed July 6, 2009.

measure was deemed, the deemed standard lighting operating hours for the industrial sector was 4,567 hr/yr, and that is the value used in this calculation.[51]

Energy savings calculations are performed using the savings equation and each discharge rate value in Table 4-9. The results are presented in Table 4-10.

Table 4-10. Energy Loss by Orifice Size and Pressure

Trap Orifice Diameter (inches)	Energy lost per year through leaks (therms/yr)			
	Steam Pressure, psig			
	15	100	150	300
1/32	24	94	137	260
1/16	97	**378**	541	1,035
1/8	392	1,510	2,168	4,147
3/16	878	3,403	4,862	9,324
1/4	1,564	6,035	8,666	16,559
3/8	3,518	13,585	19,505	37,266

This yields energy savings for a number of pressure/orifice size combinations. However, the WISeerts database is limited in the number of variables it can accommodate. For this reason, savings are not based on the actual orifice size. Instead, assumptions are made about the distribution of orifice sizes, in order to determine average energy saved for each operating pressure across the spectrum of orifice sizes.

The deeming process documentation cites Enercheck Systems as a source that indicates that the average orifice size is 1/16”.[52] Market share values are set such that 1/16” is the most prevalent, with an equal percentage greater and lesser than 1/16”, as shown in Table 4-11. No source is cited for percentage allocated to each orifice size.

Table 4-11. Orifice Size Distribution

Trap Orifice Diameter (Inches)	Market Prevalence
1/32	25%
1/16	50%
1/8	19%
3/16	4%
1/4	2%
3/8	0%

The energy loss value for each orifice size at a given pressure is multiplied by its market share, and the results are summed to yield a weighted average energy loss for each pressure. Since industrial systems can operate at pressures other than those represented above, each of the pressures above is assumed to be a proxy for a certain

[51] The standard lighting operating hours for the industrial sector are now deemed as 4,745 hours per year, so using this new value and re-deeming this measure may be warranted.

[52] http://www.enerchecksystems.com/stemsurv.html.

pressure range. The average energy loss for each pressure and the pressure range to which that energy savings value is applied are presented in Table 4-12. These results are the deemed savings values presented in Table 4-8.

Table 4-12. Annual Energy Loss by Pressure

Steam Pressure, psig	Pressure Range to Which Savings Value Applies	Energy Loss (therms/yr)
15	< 50 psig	196
100	50 - 125 psig	756
150	126 - 225 psig	1,084
300	> 225 psig	2,075

4.1.5 Hot Water Boiler for Space Heating

Group: Boilers and Burners

Category: Boiler

Technology Description: Boiler, hot water, for space heating, (>300 and <=1,000 MBh input)

Qualifying Equipment:

- Must have thermal efficiency of 85 percent or greater.[53]
- Must be capable of capacity modulation.
- Must be used for space heating (HVAC), not industrial uses or domestic hot water heating.
- Redundant or backup boilers do not qualify.

Date Deemed: November 2008

Summarized by: John Dendy

[53] For boilers of this size, efficiency is typically discussed in terms of thermal efficiency.

Table 4-13. Hot Water Boiler for Space Heating Measures[54]

WISeerts Tech Code	Measure Description	Deemed Savings		
		kW	kWh	Therms per MBh
1.2700.040	Boiler, hot water, for space heating (thermal efficiency 85.0%-85.9%)(>300, <=1000 MBh input)	0	0	1.430
1.2701.040	Boiler, hot water, for space heating (thermal efficiency 86.0%-86.9%)(>300, <=1000 MBh input)	0	0	1.671
1.2702.040	Boiler, hot water, for space heating (thermal efficiency 87.0%-87.9%)(>300, <=1000 MBh input)	0	0	1.906
1.2703.040	Boiler, hot water, for space heating (thermal efficiency 88.0%-88.9%)(>300, <=1000 MBh input)	0	0	2.135
1.2704.040	Boiler, hot water, for space heating (thermal efficiency 89.0%-89.9%)(>300, <=1000 MBh input)	0	0	2.360
1.2705.040	Boiler, hot water, for space heating (thermal efficiency 90.0%-90.9%)(>300, <=1000 MBh input)	0	0	2.579
1.2706.040	Boiler, hot water, for space heating (thermal efficiency 91.0%-91.9%)(>300, <=1000 MBh input)	0	0	2.794
1.2707.040	Boiler, hot water, for space heating (thermal efficiency 92.0%-92.9%)(>300, <=1000 MBh input)	0	0	3.004
1.2708.040	Boiler, hot water, for space heating (thermal efficiency 93.0%-93.9%)(>300, <=1000 MBh input)	0	0	3.210
1.2709.040	Boiler, hot water, for space heating (thermal efficiency 94.0%-94.9%)(>300, <=1000 MBh input)	0	0	3.411
1.2710.040	Boiler, hot water, for space heating (thermal efficiency 95.0%-95.9%)(>300, <=1000 MBh input)	0	0	3.608
1.2711.040	Boiler, hot water, for space heating (thermal efficiency 96.0%-96.9%)(>300, <=1000 MBh input)	0	0	3.801
1.2712.040	Boiler, hot water, for space heating (thermal efficiency 97.0%-97.9%)(>300, <=1000 MBh input)	0	0	3.990

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Therm savings for this measure result from installing a more efficient boiler than the market standard or code. Savings are calculated using the following equation:

$$Therm\ Savings = \left(\frac{C_q\ x\ BOF\ x\ HDD\ x\ 24}{\Delta T}\right) \times \left(\frac{1}{TE_b} - \frac{1}{TE_q}\right) \times \left(\frac{1}{100}\right)$$

where:

- *C_q = Input capacity of qualifying unit in thousand Btu per hour (MBh), from application*
- *BOF = Boiler oversize factor, deemed 77 percent*
- *HDD = heating degree days, deemed 7,699 °F-day*

[54] Deemed savings for this measure are per thousand Btu per hour input.

- *24 = conversion factor, hours per day*
- *ΔT = design temperature difference, deemed 80°F*
- *TE_b = thermal efficiency of baseline unit, deemed 8 percent*
- *TE_q = thermal efficiency of qualifying unit, from application*
- *100 = conversion factor, thousand Btu (MBtu) per therm.*

Input Capacity, C_q. Input capacity is the nominal maximum input capacity of the qualifying boiler in thousand Btu per hour.

Boiler Oversize Factor, BOF. The boiler oversize factor is an estimate of the percent of boiler capacity that represents building heat load at design conditions.

Heating Degree Days, HDD. Heating Degree Days is the sum of the number of degrees that the average daily temperature is less than a base temperature over a given time period. For these calculations, HDD is the population-weighted statewide average normal annual HDD for Wisconsin.

Design temperature difference, ΔT. The design temperature difference is equal to the indoor temperature minus the outside design temperature. The indoor temperature is represented by the base temperature used to determine HDD. The design temperature is the coldest temperature at which the heating equipment is designed to meet building heat loss, disregarding equipment oversizing. This calculation uses a population-weighted design temperature for the state of Wisconsin.

Thermal Efficiency, baseline, TE_b. Thermal efficiency is the amount of heat that is output by the heating equipment divided by the heat value of the fuel input. It includes combustion losses and losses through the boiler shell but not system losses. TE_b is the thermal efficiency of the baseline unit.

Thermal Efficiency, qualifying, TE_q. In this calculation, the thermal efficiency of the qualifying unit is determined from the application.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values and assumptions are used for each of the parameters discussed above:

Boiler Oversize Factor, BOF. Most heating equipment is sized to provide more heat than is necessary under design conditions. The degree of oversize can vary based on many factors, including the system designer. Thus, when basing consumption estimates on design conditions, an oversize factor is introduced.

When this measure was deemed, it was agreed that some oversize factor was necessary. There were no sources found that provided reliable research into average oversize factor for boiler installations. Based on the experience of those involved, the design factor of 0.77 was chosen. This is equivalent to 30 percent over design, or 1/1.3.

Heading Degree Days, HDD. A population-weighted value of 7,699 °F-day is used. This is based on a balance temperature of 65 °F, the industry standard. For a discussion of this value, please see Section 3.2.

Design temperature difference, ΔT. The design temperature difference is equal to the indoor temperature minus the outside design temperature. The indoor temperature is represented by the base temperature used to determine HDD, or 65°F. The design temperature is a population-weighted design temperature for the state of Wisconsin, deemed -15°F. For a discussion of the development of this value, see Section 3.4.

Thermal Efficiency, baseline, TE_b. The baseline thermal efficiency is given as 80 percent, a previously deemed value. Previous deeming appears to be based on the code efficiency for hot water boilers less than 300 MBh, whereas this measure is for boilers between 300 and 1000 MBh.[55]

Thermal Efficiency, qualifying, TE_q. The thermal efficiency of the qualifying unit is determined from the application, but is not exactly equal to the value on the application. Each measure is defined by a one percent range of qualifying efficiencies. TE_q in the savings calculation is the midpoint of this range, as provided in Table 4-14 below.

Table 4-14. Qualifying Thermal Efficiency Values by Measure

WISeerts Tech Code	Efficiency Range	TE_q (%)
1.2700.040	85.0 - 85.9%	85.5
1.2701.040	86.0 - 86.9%	86.5
1.2702.040	87.0 - 87.9%	87.5
1.2703.040	88.0 - 88.9%	88.5
1.2704.040	89.0 - 89.9%	89.5
1.2705.040	90.0 - 90.9%	90.5
1.2706.040	91.0 - 91.9%	91.5
1.2707.040	92.0 - 92.9%	92.5
1.2708.040	93.0 - 93.9%	93.5
1.2709.040	94.0 - 94.9%	94.5
1.2710.040	95.0 - 95.9%	95.5
1.2711.040	96.0 - 96.9%	96.5
1.2712.040	97.0 - 97.9%	97.5

Substituting the values above into the savings equation yields the savings estimates presented in Table 4-13. These values are multiplied by input capacity in thousand Btu/hr to yield actual therms saved.

There are no kWh or kW savings attributed to this technology.

[55] Current Wisconsin Code is based on the International Energy Conservation Code of 2006. For a boiler between 300 and 1,000 MBh, code is 75 percent thermal efficiency tested at minimum capacity.

4.1.6 Hot Water Boiler, High Efficiency Modulating

Group: Boilers and Burners

Category: Boiler

Technology Description: Boiler, hot water, high efficiency modulating, for space heating

Qualifying Equipment:

- Equipment must be >= 90 percent AFUE and have a sealed combustion unit.
- Must modulate firing rate.
- Must be used for space heating applications. Equipment serving process or other loads does not qualify.
- Must appear on the list of pre-qualified equipment, available on the Focus web site.[56] If a model meets other qualifying criteria and is not on the pre-qualified list, an Equipment Qualification Form[57] may be submitted to pre-qualify the equipment.
- Chimney liners must be installed if the boiler is replacing a naturally drafting unit that was vented through the same flue as a water heater.
- Flue closure protocol[58] must be followed where the chimney used by the replaced unit is no longer in use.

Date Deemed: May 2008

Summarized by: John Dendy

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56 http://www.focusonenergy.com/files/Document_Management_System/Residential_Programs/prequalifiedequipment_productlist.pdf.

57 http://www.focusonenergy.com/files/Document_Management_System/Business_Programs/hvacequipment_qualificationform.pdf.

58 http://www.focusonenergy.com/files/Document_Management_System/Residential_Programs/flueclosure_protocol.pdf.

Table 4-15. High Efficiency Modulating Hot Water Boiler Measures

WISeerts Tech Code	Measure Description	Deemed Savings		
		kW	kWh	Therms per MBh
1.2790.040	Boiler, hot water, high efficiency modulating, for space heating (AFUE >= 90%)	0	0	3.108
1.2791.040	Boiler, hot water, high efficiency modulating, for space heating (AFUE >= 90%)(175 - 300 MBh)	0	0	3.108

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Therm savings for this measure result from installing a more efficient boiler than the market standard or code. Savings are calculated using the following equation:

$$Therm\ Savings\ = \left(\frac{C_q\ x\ BOF\ x\ HDD\ x\ 24}{\Delta T}\right) \times \left(\frac{1}{AFUE_b} - \frac{1}{AFUE_q}\right) \times \left(\frac{1}{100}\right)$$

where:

- *C_q = Input capacity of qualifying unit in thousand Btu per hour (MBh), from application*
- *BOF = Boiler oversize factor, deemed 77 percent*
- *HDD = heating degree days, deemed 7,699 °F-day*
- *24 = conversion factor, hours per day*
- *ΔT = design temperature difference, deemed 80 °F*
- *$AFUE_b$ = Annual Fuel Utilization Efficiency of baseline unit, deemed 8 percent*
- *$AFUE_q$ = Annual Fuel Utilization Efficiency of qualifying unit, deemed 9 percent*
- *100 = conversion factor, thousand Btu (MBtu) per therms.*

Input Capacity, C_q. Input capacity is the nominal maximum input capacity of the qualifying boiler in thousand Btu per hour.

Boiler Oversize Factor, BOF. The boiler oversize factor is an estimate of the percent of boiler capacity that represents building heat load at design conditions.

Heating Degree Days, HDD. Heating Degree Days is the sum of the number of degrees that the average daily temperature is less than a base temperature over a given time period. For these calculations, HDD is the population-weighted statewide average normal annual HDD for Wisconsin.

Design temperature difference, ΔT. The design temperature difference is equal to the indoor temperature minus the outside design temperature. The indoor temperature is represented by the base temperature used to determine HDD. The design temperature is the coldest temperature at which the heating equipment is designed to meet building heat loss, disregarding equipment oversizing. .

Baseline AFUE, $AFUE_b$. Annual Fuel Utilization Efficiency is a measure of annual efficiency and is determined by a lab test defined by the U.S. Department of Energy.[59] *$AFUE_b$* in this calculation is an estimate of the lowest AFUE available to a consumer replacing a boiler.

Qualifying AFUE, $AFUE_q$. This is an estimate of the lowest AFUE available to a consumer replacing a boiler with a boiler that qualifies for the incentive.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values and assumptions are used for each of the parameters discussed above:

Boiler Oversize Factor, BOF. Most heating equipment is sized to provide more heat than is necessary under design conditions. The degree of oversize can vary based on many factors, including the system designer. Thus, when basing consumption estimates on design conditions, an oversize factor is introduced.

When this measure was deemed, it was agreed that some oversize factor was necessary. There were no sources found that provided reliable research into average oversize factor for boiler installations. Based on the experience of those involved, the design factor of 0.77 was chosen. This is equivalent to 30 percent over design, or 1/1.3.

Heating Degree Days, HDD. A population-weighted value of 7,699 °F-day is used. This is based on a balance temperature of 65 °F, the industry standard. For a discussion of this value, please see Section 3.2.

Design temperature difference, ΔT. The design temperature difference is equal to the indoor temperature minus the outside design temperature. The indoor temperature is represented by the base temperature used to determine HDD, or 65°F. The design temperature is a population-weighted design temperature for the state of Wisconsin, deemed -15°F. For a discussion of the development of this value, see Section 3.4.

Baseline AFUE, $AFUE_b$. The baseline efficiency used in the calculation is the code value of 80 percent.

Qualifying AFUE, $AFUE_q$. The qualifying AFUE is deemed at 93 percent. Qualifying boilers must be greater than 90 percent AFUE. Deeming documentation indicates that the GAMA database[60] was reviewed for qualifying equipment, and only three boilers

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[59] Title 10, Code of Federal Regulations, Part 430, *Energy Conservation Program for Consumer Products*.

[60] GAMA has merged with AHRI. Their current boiler database may be found at: http://cafs.ahrinet.org/gama_cafs/sdpsearch/search.jsp?table=Boiler.

were found with an efficiency of less than 93 percent. These were determined to be outliers, and 93 percent was chosen as the deemed value.[61]

Substituting the values above into the savings equation yields the constant multiplier of 3.108 therm per thousand Btu input shown in Table 4-13. The boiler input from the application is multiplied by 3.108 to calculate therm savings.

There are no kWh or kW savings attributed to this technology.

[61] Discussion of this value is available in the memo entitled “Spring ’08 Deemed Savings Review (Step 4)”.

4.1.7 Boiler Reset/Cutout Control

Group: Boilers & Burners

Category: Controls

Tech Code: 1.3801.085

Technology Description: Outside Air Temperature Boiler Reset/Cutout Control, per MBh.

Qualifying Equipment:

- The incentive is intended for retrofit projects. New boilers equipped with these controls are not eligible. New boilers not equipped with these controls are eligible for retrofit.
- System must have an outdoor air temperature sensor in a shaded location on the north side of the building.
- System must be set such that the minimum temperature is less than 10°F above the boiler manufacturer's recommended minimum return temperature, unless unusual circumstances require a higher setting.
- For controls on multiple boilers to qualify, the 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.

Date Deemed: November 2009

Summarized by: John Dendy

Table 4-16. Boiler Reset/Cutout Control Measure

WISeerts Tech Code	Measure Description	Deemed Savings		
		kW	kWh	Therms per MBh
1.3801.085	Outside Air Temperature Boiler Reset/Cutout Control, per MBh	0	0	1.674

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Outside air temperature boiler reset and cutout controls are separate control schemes using a single piece of control equipment. The reset control adjusts the delivery temperature of system water based on the outside air temperature. The warmer the outside air temperature, the lower the temperature of the supply water needs to be to meet the heat load of the building. Reducing the temperature of supply water reduces heat losses through the boiler shell and in the distribution system. The cutout control shuts the boiler down when outside temperature is greater than a set point. This prevents heating when the need for it is marginal and can reduce simultaneous heating and cooling.

Savings due to installing and operating a boiler reset/cutout control are described by the following equation. Savings are determined by applying a savings factor to an estimate of the boiler consumption prior to the installation of the controls. The energy savings for this measure are determined per input boiler capacity in thousand Btu per hour (MBh).

$$\frac{Therm\ Savings}{MBh\ Input} = BOF \times SF \times \frac{HDD \times 24}{(T_{Indoor} - T_{Outdoor}) \times Eff \times 100}$$

where:

- *BOF = Boiler oversize factor, deemed 77%*
- *SF = Savings Factor, deemed 8%*
- *Eff = Combustion efficiency of the boiler, deemed 85%*
- T_{Indoor} = *Indoor design temp, deemed 65°F*
- $T_{Outdoor}$ = *Outdoor design temp, deemed -15°F*
- *HDD = Heating Degree Days for Wisconsin, deemed 7,699*
- *24 = conversion factor, hours per day*
- *100 = conversion factor, MBh (thousand Btu per hour) per therm.*

Boiler Oversize Factor, BOF. The boiler oversize factor is an estimate of the percent of boiler capacity that represents building heat load at design conditions.

Savings Factor, SF. The savings factor is an estimate of the percent of annual gas consumption that is saved due to installing reset/cutout controls on the boiler.

Efficiency of the Boiler, Eff. The efficiency of the boiler is the assumed combustion efficiency of the boiler on which the controls are installed.

Indoor design temperature, T_{Indoor}. The indoor temperature is represented by the base temperature used to determine HDD.

Outdoor design temperature, $T_{Outdoor}$.The outdoor design temperature is the coldest temperature for which a heating system is designed to meet the heating load, disregarding any over sizing. This calculation uses a population-weighted design temperature for the state of Wisconsin

Heating Degree Days, HDD. Heating Degree Days is the sum of the number of degrees that the average daily temperature is less than a base temperature over a given time period. For these calculations, HDD is the population-weighted statewide average normal annual HDD for Wisconsin.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The values used for each parameter in the deemed savings calculation are discussed below.

Boiler Oversize Factor, BOF. Most heating equipment is sized to provide more heat than is necessary under design conditions. The degree of oversize can vary based on many factors, including the system designer. Thus, when basing consumption estimates on design conditions, an oversize factor is introduced.

When this measure was deemed, it was agreed that some oversize factor was necessary. There were no sources found that provided reliable research into average oversize factor for boiler installations. Based on the experience of those involved, the design factor of 0.77 was chosen. This is equivalent to 30 percent over design, or 1/1.3.

Savings Factor, SF. The savings factor is deemed to be 8 percent. This is based on a variety of sources.[62] [63] [64] [65] The savings ranges reported in each source are presented in Table 4-17 below. Based on these sources, the program and evaluators agreed that 8 percent is reasonable.

Table 4-17. Percent Savings Ranges from Cited Sources

Source	Percent Savings Range
Minneapolis Energy Office	10–20%
Wisconsin Small Multifamily	7.3%
Home Energy Magazine	10–25%
Taco	5–30%

Efficiency of the boiler, Eff. Boiler efficiency is deemed to be 85 percent. This is described in deeming documents to be a “guestimate” between Wisconsin code, which is 80 percent, and the highest efficiency available.[66]

Indoor design temperature, T_{Indoor}. The indoor design temperature is represented by the base temperature used to determine HDD, or 65°F.

Outdoor design temperature, $T_{Outdoor}$. The outdoor design temperature is a population-weighted design temperature for the state of Wisconsin, deemed -15°F. For a discussion of the development of this value, see Section 3.4.

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[62] Hewett, Martha, and George Peterson. “Measured Energy Savings from Outdoor Resets in Modern, Hydronically Heated Apartment Buildings,” Minneapolis Energy Office, 1984. http://www.mncee.org/pdf/tech_pubs/84-2.pdf

[63] Ewing, Glenna, et al. “Effectiveness of Boiler Control Retrofits on Small Multifamily Buildings in Wisconsin,” Proceedings of the American Council for an Energy Efficient Economy, Vol. 2, pp. 51-56.

[64] Lobenstein, Mary Sue, and Martha Hewett. "The Best Boiler and Water Heating Retrofits." Home Energy Magazine Online, September / October 1995. *Resets and Cutouts* and Table 2. http://www.homeenergy.org/archive/hem.dis.anl.gov/eehem/95/950909.html

[65] “Taco Radiant Made Easy Application Guide: Outdoor Boiler Reset.” http://www.taco-hvac.com/uploads/FileLibrary/OM01.pdf (accessed 9 Feb 2009)

[66] The deeming spreadsheet also indicates that 85 percent is the deemed efficiency for the Boiler Tune Up measure. However, the assumed boiler efficiency for that measure has been changed to 80 percent.

Heating Degree Days, HDD. A population-weighted value of 7,699 °F-day is used. This is based on a balance temperature of 65 °F, the industry standard. For a discussion of this value, please see Section 3.2.

Substituting the values above into the savings equation yields the constant multiplier of 1.674 therm per thousand Btu input shown in Table 4-16. The boiler input from the application is multiplied by 1.674 to calculate therm savings.

4.2 FOOD SERVICE

The Food Service section contains the technologies outlined in Table 4-18.

Table 4-18. Deemed Savings Manual Entries, Food Service

Group Description	Manual Entry
Food Service	Fryers
	Steamers
	Hot Food Holding Cabinet
	Ovens
	Griddles
	Refrigerators and Freezers
	Ice Machines
	Dishwashers

4.2.1 Fryers

Group: Food Service

Category: Fryer

Technology Description: Fryer, Electric or Gas, ENERGY STAR or High Efficiency

Qualifying Equipment: Whether ENERGY STAR or High Efficiency Large Vat, fryers must appear on the list of qualifying equipment on the Focus on Energy web site.[67]

Date Deemed: April 2007

Summarized by: John Dendy

Table 4-19. Fryer Measures

Measure Description	Deemed Savings (per frypot)		
	kW	kWh	Therms
Fryer, Electric, ENERGY STAR	0.2000	983	0
Fryer, Gas, ENERGY STAR	0	0	396
Fryer, Large Vat, Electric, High Efficiency	0.4000	1,789	0
Fryer, Large Vat, Gas, High Efficiency	0	0	577

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Energy savings result from installing a more efficient unit than the standard efficiency on the market and depend on the type of unit installed. Unit types include ENERGY STAR electric, ENERGY STAR gas, high efficiency large vat electric, and high efficiency large vat gas.

Savings estimates are based on savings equations and assumptions provided to Pacific Gas and Electric by the Food Service Technology Center and shared with Focus through the Consortium on Energy Efficiency. Fryer performance is determined by applying ASTM F1361-05, the Standard Test Method for the Performance of Open Deep Fat Fryers. The savings estimates are reported per frypot, and must be multiplied by the number of frypots to yield savings for the fryer.

For electric fryers, kW savings are not determined by a savings equation. Rather, they are reported based on metered data.

The energy consumption equation for electric fryers (kWh) and gas fryers (Btu) is of the same form, with only the units of the variables changed. The form of the equation shows

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[67] ENERGY STAR units: http://www.energystar.gov/ia/products/prod_lists/Fryers_prod_list.pdf.

Large Vat units: http://www.focusonenergy.com/files/Document_Management_System/Business_Programs/largevatfryers_productlist.pdf.

that energy consumption of a fryer is equal to the sum of energy used for cooking, energy used at idle, and energy used to preheat.

The equation for the daily energy consumption of a fryer is:

$$E_{Day} = \frac{LB_{Food} \times E_{Food}}{Efficiency} + IdleRate \times (OpHrs - \frac{LB_{Food}}{PC} - \frac{T_{PreHt}}{60}) + E_{PreHt}$$

where:

- *E_{Day} = daily energy consumption per frypot (kWh or Btu), calculated*
- *LB_{Food} = pounds of food cooked per day (lb/day), deemed 100 lb/day for ENERGY STAR and 125 lb/day for large vat*
- *E_{Food} = ASTM Energy to Food, deemed 0.167 kWh/lb or 570 Btu/lb*
- *Efficiency = ASTM Heavy Load Cooking Energy Efficiency (%), deemed by fryer type*[68]
- *IdleRate = Idle Energy Rate (kW or Btu/hr), deemed by fryer type*[68]
- *OpHrs = operating hours per day (hr), deemed 12 hr/day*
- *PC = Production Capacity (lb/hr), deemed by fryer type*[68]
- *T_{PreHt} = Preheat Time (min), deemed 15 minutes*
- *60 = minute to hour conversion*
- *E_{PreHt} = Preheat Energy (kWh or Btu), deemed by fryer type.*[68]

Pounds of Food Cooked per Day, LB_{Food}. This is an estimate of the average pounds of food cooked per day by fryer type.

Energy to Food, E_{Food}. Energy to Food is the amount of energy absorbed by the food during cooking per pound of food.

Efficiency. Efficiency for this calculation is the ASTM Heavy Load Cooking Energy Efficiency, and represents the ratio of the energy absorbed by food during cooking (E_{Food}) to total energy consumed during cooking (%).

Idle Energy Rate, IdleRate. Idle energy rate is the amount of power drawn by the fryer when on but not cooking (kW or Btu/hr).

Operating Hours, OpHrs. Operating hours refers to the number of hours that the fryer is on per day, whether cooking or at idle.

[68] Values deemed by fryer type are presented in Table 4-21, Table 4-23, Table 4-25, and Table 4-27.

Production Capacity, PC. Production capacity is the amount of food that a given fryer can cook per hour, as determined by ASTM methods.

Preheat Time, T_{PreHt}. Preheat time is the amount of time it takes a fryer to reach operating temperature after being turned on.

Preheat Energy, E_{PreHt}. Preheat Energy is the amount of energy the fryer consumes daily to reach operating temperature (*kWh or Btu).*

In order to estimate annual savings, the consumption of the baseline and qualifying units are calculated using the above equation, and the latter is subtracted from the former. The resulting daily savings value is multiplied by operating days per year to yield annual savings.

$$Annual\ Savings = (E_{Day,B} - E_{Day,Q})\ x\ OpDay$$

where:

- $E_{Day,B}$ = *Daily energy use of a baseline unit, kWh or Btu*
- $E_{Day,Q}$ = *Daily energy use of a qualifying unit, kWh or Btu*
- *OpDay = number of operating days per year, deemed 365 days.*

For electric fryers, the units on daily consumptions and energy savings are kWh. For gas fryers, the daily consumption in Btu is divided by 100,000 to convert to therms.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

Below is a discussion of each parameter and its basis. Following that discussion, the values for each parameter are presented in table format by fryer type.

ASTM Parameters. ASTM parameters are those that were determined by FSTC by applying ASTM F1361-05, the Standard Test Method for the Performance of Deep Fat Fryers. Among these are Energy to Food, Heavy Load Cooking Efficiency, Idle Energy Rate, Production Capacity, and Preheat Energy.

All ASTM parameter values are thought to be averages of the values for fryers tested by FSTC,[69] besides the Heavy Load Cooking Efficiency of the qualifying fryers. The Heavy Load Cooking Efficiency of qualifying fryers is actually the minimum qualifying value for each measure. These minimum qualifying values of 50 percent for gas fryers and 80 percent for electric fryers are used as the efficiencies of the qualifying fryers in the savings calculations.

Pound of Food per Day (LB_{Food}) and Operating Hours (OpHr). When the measure was deemed, a definitive source could not be found for these values. However, during the

[69] The deeming calculation spreadsheet states "Measure data for savings calculations have been developed based on average equipment characteristics for customer participants for the Food Service Equipment program."

deeming process, several sources were cited for these values for ENERGY STAR Fryers, including:

- The FSTC website uses 12 hr/day and 100 lb/day.
- The FSTC has a presentation that estimates 16 hr/day and 125 lb/day.
- CEE has a paper that uses 12 hr/day and 100 lb/day.
- The ENERGY STAR Calculator uses 12 hr/day and 125 lb/day.

Based on these sources, the values of 12 hr/day and 125 lb/day were chosen for ENERGY STAR fryers. For large vat fryers, 12 hr/day and 150 lb/day are assumed.

Operating Days (OpDay). The calculation assumes that the fryers operate 365 days/yr.

Preheat Time. A preheat time of 15 minutes is used in the savings equation for each fryer. Since the value is consistent across all fryer types, it appears to be assumed rather than measured.

Values used in the savings equations and the resulting energy consumptions and measure savings are presented below. Certain values discussed above are consistent for all fryers. These are operating time and preheat time parameters, shown in Table 4-20.

Table 4-20. Operating Time Parameters

Parameter	Value
Preheat Time (min)	15
Operating Hours/Day	12
Operating Days/Year	365

Other values vary by fryer type, and are presented in the tables below. The kW savings are reportedly from metering studies conducted by the Food Service Technology Center. A more specific citation is not available.[70]

i. Electric ENERGY STAR Fryer

Parameter values for electric ENERGY STAR fryers are presented in Table 4-21, with resulting savings values in Table 4-22.

[70] If kW values were metered while the unit was firing, using these metered values to determine kW savings assumes that the unit is firing throughout the peak period.

Table 4-21. Parameter Values for Electric ENERGY STAR Fryers

Parameter	Baseline Model	Energy Efficient Model
Preheat Energy (kWh)	2.3	1.7
Idle Energy Rate (kW)	1.05	1
Efficiency (%)	75%	80%
Production Capacity (lbs/hr)	65	70
ASTM Energy to Food (kWh/lb)	0.167	0.167
Pounds of Food Cooked per Day	125	125

Table 4-22. Consumptions and Savings Values, Electric ENERGY STAR Fryers

Model	kW	kWh
Baseline	3.1	14,765
Energy Efficient	2.9	13,782
Savings	**0.2**	**983**

ii. Electric High Efficiency Large Vat Fryer

Parameter values for electric large vat fryers appear in Table 4-23, and resulting kWh savings and metered kW savings appear in Table 4-24.

Table 4-23. Parameter Values for Electric High Efficiency Large Vat Fryers

Parameter	Baseline Model	Energy Efficient Model
Preheat Energy (kWh)	2.5	2.1
Idle Energy Rate (kW)	1.35	1.1
Efficiency (%)	75%	80%
Production Capacity (lbs/hr)	100	110
ASTM Energy to Food (kWh/lb)	0.167	0.167
Pounds of Food Cooked per Day	150	150

Table 4-24. Deemed Savings Values, High Efficiency Electric Large Vat Fryers

Model	kW	kWh
Baseline	4.1	18,154
Energy Efficient	3.7	16,366
Savings	**0.4**	**1,789**

iii. ENERGY STAR Gas Fryer

For gas fryers, deemed savings are determined using the same savings equation as electric units. Annual energy savings in Btu are converted to therms by dividing by 100,000. For ENERGY STAR Gas Fryers, the parameter values are reported in Table 4-25 and results are reported in Table 4-26.

Table 4-25. Parameter Values for Gas ENERGY STAR Units

Parameter	Baseline Model	Energy Efficient Model
Preheat Energy (Btu)	16,000	15,500
Idle Energy Rate (Btu/hr)	14,000	9,000
Cooking-Energy Efficiency (%)	35%	50%
Production Capacity (lbs/hr)	60	65
ASTM Energy to Food (Btu/lb)	570	570
Pounds of Food Cooked per Day	125	125

Table 4-26. Consumptions and Deemed Savings Value, Gas ENERGY STAR Fryer

Model	Btu/day	therm/yr
Baseline	354,905	1,295
Energy Efficient	246,442	900
Savings	**108,462**	**396**

iv. Energy Efficient Large Vat Gas Fryer

Parameter values and results for large vat gas fryers are reported in Table 4-27 and Table 4-28 below.

Table 4-27. Parameter Values for Energy Efficient Large Vat Fryer

Parameter	Baseline Model	Energy Efficient Model
Preheat Energy (Btu)	21,000	16,500
Idle Energy Rate (Btu/hr)	20,000	12,000
Cooking-Energy Efficiency (%)	35%	50%
Production Capacity (lbs/hr)	100	110
ASTM Energy to Food (Btu/lb)	570	570
Pounds of Food Cooked per Day	150	150

Table 4-28. Consumptions and Deemed Savings Value, Large Vat Gas Fryer

Model	Btu/day	therm/yr
Baseline	470,286	1,717
Energy Efficient	312,136	1,139
Savings	**158,149**	**577**

4.2.2 Steamers

Group: Food Service

Category: Steamer

Technology Description: ENERGY STAR Steamer, Electric or Gas

Qualifying Equipment: Steamer must appear on the list of qualifying equipment on the Focus on Energy web site.[71]

Date Deeming Last Modified: May 2008[72]

Date Deemed: April 2007

Summarized by: John Dendy

Table 4-29. Steamer Measures

WISeerts Tech Code	Measure Description	Deemed Savings			Date Deemed
		kW	kWh	Therms	
14.2103.395	Steamer, Electric, 3 pan - ENERGY STAR	2.500	11,188	0	Apr-07
14.2104.395	Steamer, Electric, 4 pan - ENERGY STAR	2.500	12,459	0	Apr-07
14.2105.395	Steamer, Electric, 5 pan - ENERGY STAR	2.500	13,831	0	Apr-07
14.2106.395	Steamer, Electric, 6 pan - ENERGY STAR	2.500	15,170	0	Apr-07
14.2206.395	Steamer, Gas, 6 pan - ENERGY STAR	0	0	2,084	Apr-07
14.2107.395	Steamer, Gas, 5 pan - ENERGY STAR	0	0	1,900	May-08

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Energy savings result from installing a more efficient unit than the standard efficiency on the market and depend on the type of unit installed. Unit types include 3, 4, 5, and 6 pan electric steamers and 5 and 6 pan gas steamers.

Savings estimates are based on savings equations and assumptions provided to Pacific Gas and Electric by the Food Service Technology Center and shared with Focus through the Consortium on Energy Efficiency. Steamer performance was determined by FSTC according to ASTM F1484, the Standard Test Method for Performance of Steam Cookers.

[71] http://www.energystar.gov/ia/products/prod_lists/Steamers_prod_list.pdf.

[72] Five pan gas steamer deemed May 2008. All other measures deemed April 2007.

Electric and six-pan gas steamers are deemed according to an equation that follows the form found in other cooking equipment measures. Five pan gas steamers were deemed at a different time and using a different method.

i. Electric Steamers and Six Pan Gas Steamers

kW savings for electric steamers are not determined using a savings equation. Rather, they are reported based on metered data.

The energy consumption equation for electric steamers (kWh) and gas steamers (Btu) is of the same form, with only the units of the variables changed. The form of the equation shows that energy consumption of a steamer is equal to the sum of cooking, idle, residual, and preheat energy.

The equation for the daily energy consumption of a steamer is:

$$E_{Day} = \frac{LB_{Food} \times E_{Food}}{Efficiency} + \left((IdleRate + ResidualRate) \times (OpHrs - \frac{LB_{Food}}{PC} - \frac{T_{PreHt}}{60}) \right) + E_{PreHt}$$

where:

- *E_{Day} = daily energy consumption (kWh or Btu), calculated*
- *LB_{Food} = pounds of food cooked per day (lb/day), deemed 100 lb/day*
- *E_{Food} = ASTM Energy to Food (kWh/lb or Btu/lb), deemed 0.038 kWh/lb for electric and 105 Btu/lb for gas*
- *Efficiency = ASTM Heavy Load Cooking Energy Efficiency (%), deemed by steamer type, values in Table 4-30 and Table 4-32*
- *IdleRate = Idle Energy Rate (kW or Btu/hr), values in Table 4-30 and Table 4-32*
- *ResidualRate = Residual Energy Rate (kW or Btu/hr), values in Table 4-30 and Table 4-32*
- *OpHrs = operating hours per day (hr), deemed 12 hours*
- *PC = Production Capacity (lb/hr), values in Table 4-30 and Table 4-32*
- *T_{PreHt} = Preheat Time (min), deemed 15 minutes*
- *60 = minute to hour conversion*
- *E_{PreHt} = Preheat Energy (kWh or Btu), values in Table 4-30 and Table 4-32.*

Pounds of Food Cooked per Day, LB_{Food}. This is an estimate of the average pounds of food steamed per day.

Energy to Food, E_{Food}. Energy to Food is the amount of energy absorbed by the food during cooking, per pound of food.

Efficiency. Efficiency for this calculation is the ASTM Heavy Load Cooking Energy Efficiency, and represents the ratio of the energy absorbed by food during cooking (E_{Food}) to total energy consumed during cooking.

Idle Energy Rate, IdleRate. Idle Energy Rate is the energy rate consumed by the steamer when on but not cooking and not set to "constant steam" (see below).

Residual Energy Rate, ResidualRate. Steamers have a "constant steam" setting that keeps the steamer operating at maximum input even when it is not cooking. The setting is controlled by the operator. Residual Energy Rate is the average rate at which energy is consumed by the steamer when not cooking and set to "constant steam."[73]

Operating Hours, OpHrs. Operating hours refers to the number of hours that the steamer is on per day, whether cooking or at idle.

Production Capacity, PC. Production capacity is the amount of food that a given steamer can cook per hour.

Preheat Time, T_{PreHt}. Preheat time is the amount of time it takes a steamer to reach operating temperature when turned on.

Preheat Energy, E_{PreHt}. Preheat Energy is the amount of energy the steamer consumes daily to reach operating temperature (*kWh or Btu).*

In order to estimate annual savings, the consumption of the baseline and qualifying units are calculated using the above equation, and the latter is subtracted from the former. The resulting daily savings value is multiplied by operating days per year to yield annual savings.

$$Annual\ Savings = (E_{Day,B} - E_{Day,Q})\ x\ OpDay$$

where:

- *$E_{Day,B}$ = Daily energy use of baseline unit, kWh or Btu*
- *$E_{Day,Q}$ = Daily energy use of qualifying unit, kWh or Btu*
- *OpDay = number of operating days per year, deemed 365 days.*

For electric steamers, the units on daily consumptions and energy savings are kWh. For gas steamers, the result in Btu is divided by 100,000 to convert to therms.

ii. Five Pan Gas Steamers

Five pan gas steamers were deemed at a different time and by a different method than other steamers. Presumably, a set of test data and assumptions for 5-pan steamers was

[73] Per David Zabrowski of the FSTC, in-kitchen monitoring was used to determine the percentage of time that the steamer is in "constant steam" mode, and that percentage is included in the values used.

not available from the Food Service Technology Center. Therefore, the program looked to previously deemed steamers for a savings relationship to determine 5-pan gas steamer savings by ratio.

Many of the variables that govern energy savings for steamers are not linear with respect to number of pans. Among these are residual energy rate, idle energy rate, and preheat time. Therefore, a 5/6 fraction cannot be used to adjust gas 6-pan energy savings to gas 5-pan energy savings.

However, gas and electric steamers are physically and thermally similar, and energy losses are mainly due to size difference. This means that a better ratio to use to predict gas 5-pan energy savings from 6-pan is the relationship between deemed energy savings of 5- and 6-pan electric steamers. Five pan gas steamer energy savings are deemed using this ratio.

$$\textit{Five Pan Gas Savings} = \textit{Six Pan Gas Savings } x \left(\frac{\textit{Five Pan Electric Savings}}{\textit{Six Pan Electric Savings}} \right)$$

All savings values in the above equation refer to savings that are already deemed.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

i. Electric Steamers and Six Pan Gas Steamers

ASTM Parameters. Values for ASTM parameters for baseline and energy efficient cases were determined by FSTC according to ASTM F1484, the Standard Test Method for Performance of Steam Cookers. These parameters include Energy to Food, Heavy Load Cooking Efficiency, Idle Energy Rate, Residual Energy Rate, Production Capacity, and Preheat Energy. It is not known which specific steamer models were tested, but the values used for each parameter are thought to be averages of tested models.[74]

One of the ASTM parameter values is not based on an average of tested steamers. The Heavy Load Cooking Efficiency of qualifying steamers is actually the minimum qualifying value for each measure. These minimum qualifying values of 38 percent for gas steamers and 50 percent for electric steamers are used as the efficiencies of the qualifying steamers in the savings calculations.

Values used for all ASTM parameters are presented in the tables below.

Pound of Food per Day (LB_{Food}). The calculation assumes that 100 lb/day of food are steamed by each steamer type. No source is given for this value.

Operating Days (OpDay). The calculation assumes that the steamers operate 365 days/yr.

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[74] The deeming calculation spreadsheet states “Measure data for savings calculations have been developed based on average equipment characteristics for customer participants for the Food Service Equipment program.”

Preheat Time. A preheat time of 15 minutes is used in the savings equation for each steamer.

Values used in the savings equations and the resulting consumptions and savings are presented below for electric and six pan gas steamers.

Table 4-30. Electric Steamers, Assumptions that are Constant with Respect to Number of Pans

Parameter	Baseline Model	Energy Efficient Model
Preheat Time (min)	15	15
Preheat Energy (kWh)	1.5	1.5
Cooking-Energy Efficiency (%)	26%	50%
Operating Hours/Day	12	12
Operating Days/Year	365	365
Pounds of Food Cooked per Day	100	100
ASTM Energy to Food (kWh/lb)	0.0308	0.0308
Residual Energy Rate (kW)	1.91	0.12
Pounds of Food Cooked per Day	100	100

Table 4-31. Electric Steamers, Assumptions that Vary with Number of Pans

Number of Pans	Parameter	Baseline Model	Energy Efficient Model
3	Idle Energy Rate (kW)	1	0.4
	Production Capacity (lb/h)	70	50
4	Idle Energy Rate (kW)	1.325	0.53
	Production Capacity (lb/h)	87	67
5	Idle Energy Rate (kW)	1.675	0.67
	Production Capacity (lb/h)	103	83
6	Idle Energy Rate (kW)	2	0.8
	Production Capacity (lb/h)	120	100

Using the above values, daily kWh consumptions for both baseline and energy efficient models are calculated, and the difference between these is multiplied by annual operating days to yield deemed savings values in Table 4-29.

kW savings are 2.5 kW for all electric steamers, as shown in Table 4-29. These values are reportedly based on metering studies conducted by the Food Service Technology Center. A more specific citation is not available.[75]

[75] If kW values were metered while the unit was firing, using these metered values to determine kW savings assumes that the unit is firing throughout the peak period.

Table 4-32. Assumptions for 6-pan Gas Steamers

Parameter	Base Model	Energy Efficient Model
Pan Capacity	6	6
Preheat Time (min)	15	15
Preheat Energy (Btu)	18,000	9,000
Idle Energy Rate (Btu/h)	16,000	12,500
Cooking-Energy Efficiency (%)	0.15	0.38
Production Capacity (lb/h)	140	120
Operating Hours/Day	12	12
Operating Days/Year	365	365
ASTM Energy to Food (Btu/lb)	105	105
Residual Energy Rate (Btu/hr)	45,080	1,658
Pounds of Food Cooked per Day	100	100

Using the above values, daily Btu consumptions for both baseline and energy efficient models are calculated, and the difference between them is multiplied by annual operating days to yield deemed savings in Btu. That result is divided by 100,000 to convert deemed savings estimates to the therm values in Table 4-29.

ii. Five Pan Gas Steamers

The ratio of deemed energy savings between 5- and 6-pan electric steamers is (13,831 kWh/ 15,170 kWh), or 91.17 percent. Multiplying 6-pan gas steamer deemed savings of 2,084 therm by this percentage yields 1,900 therms, the deemed savings value for 5-pan gas steamers.

4.2.3 Hot Food Holding Cabinet

Group: Food Service

Category: Hot Holding Cabinet

Technology Description: ENERGY STAR Hot Food Holding Cabinet

Qualifying Equipment:

- Must appear on the list of qualifying equipment on the Focus web site.[76]

Date Deemed: October 2006

Summarized by: John Dendy

Table 4-33. Hot Food Holding Cabinet Measure

WISeerts Tech Code	Measure Description	Deemed Savings		
		kW	kWh	Therms
14.3000.225	Hot Food Holding Cabinet - ENERGY STAR	0.6375	4,654	0

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Savings result from installing an ENERGY STAR hot food holding cabinet rather than a standard efficiency model. ENERGY STAR holding cabinets are required to consume less than 40 W per cubic foot of storage space. Efficiency gains are largely due to better insulation, and may also include a better door design and closure.

The savings equations are not explicit in the deeming documentation. The kW savings are based on empirical results rather than engineering calculations. The kWh savings appear to be calculated from the kW savings value using the following equation:

$$kWh\ Savings = \frac{kW\ Savings}{DDF} \times Hr \times Day$$

where:

- *kW Savings = deemed kW savings, 0.638 kW*
- *DDF = demand diversity factor, deemed 0.6*
- *Hr = Operating hours per day, deemed 12 hr*
- *Day = operating days, 365 day.*

[76] http://www.energystar.gov/ia/products/prod_lists/HFHC_prod_list.pdf.

kW Savings. kW savings is the deemed value for peak demand savings, or the average kW saved during the peak period.

Demand Diversity Factor, DDF. The demand diversity factor is the average fraction of full load kW at which the cabinet operates during the peak period.

Operating hours, Hr. This is the estimated daily operating hours of the hot food holding cabinet.

Operating Days, Day. This is the annual number of operating days of the cabinet.

The kWh savings equation was not found in any program documentation or spreadsheets. The program documentation does contain the source of the kW savings value, as well as the values for DDF and operating hours per day. The savings equation was determined by arranging the variables such that the deemed kWh savings value was produced.[77]

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values were assumed for the calculation input parameters:

kW Savings. kW savings is based on values reported by Itron in a 2005 report for We Energies.[78] The values presented in that report were obtained from the California Express Efficiency Program and are based on equipment size. The program uses savings values for ¾ size cabinets to represent the population of units covered by this measure. The ¾ size values below are taken from Table 4-2 in the Itron report; Focus takes the average of the savings for the two unit types to obtain a kW savings value of 0.6375 kW.

Table 4-34. Hot Food Holding Cabinet kW Savings

Equipment Description	Base Demand (kW)	Energy Efficient Demand (kW)	Savings (kW)
3/4 Size Cabinet <=0.6 kW	1.125	0.6	0.525
3/4 Size Cabinet <=0.4 kW	1.125	0.375	0.75
Average			**0.6375**

Demand Diversity Factor, DDF. The demand diversity factor is the average fraction of full load kW at which the cabinet operates during the peak period. Focus uses a DDF value of 0.6. The source of this value is not known.

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[77] There may be an error in the equation. If the values for kW Savings are full load, then in order to obtain kWh savings, kW Savings should be multiplied by DDF and operating hours. If kW savings are average partial load, then it is correct to divide by DDF to get full load kW, but then the hours values should be an estimate of equivalent full load operating hours, rather than actual operating hours.

[78] *Development of Deemed Savings for the Commercial Prescriptive Rebate Program.* We Energies Energy Efficiency Procurement Plan, March 28, 2005.

Operating hours, Hr. The deemed operating hours per day is 12 hr. The source of this value is not known.

Operating days, Day. The value of operating days was determined to be 365 days in this analysis. This was found through reverse-calculation, not reported in the documentation.

Substituting the above values into the kWh Savings equation yields the deemed savings estimate of 4,654 kWh.[79]

[79] While this is presented as if the kWh Savings value is calculated from the equation, the equation was actually determined from the documented deemed values. The deemed savings documentation does not include a savings calculation.

4.2.4 Ovens

Group: Food Service

Category: Ovens

Technology Description: Gas or Electric Convection, Rack Type, or Combination Ovens

Qualifying Equipment: Oven must appear on the list for Convection,[80] Rack Type,[81] or Combination[82] ovens on the Focus on Energy web site.

Date Deeming Last Modified: November 2009[83]

Date Deemed: April 2007

Summarized by: John Dendy

Table 4-35. Oven Measures

WISeerts Tech Code	Measure Description	Deemed Savings		
		kW	kWh	Therms
14.3101.290	Oven, Convection, Electric, ENERGY STAR, per cavity	0.500	1,879	0
14.3102.290	Oven, Convection, Gas, ENERGY STAR, per cavity	0	0	306
14.3112.290	Oven, Rack Type, Gas, Single Compartment, High Efficiency	0	0	1,034
14.3122.290	Oven, Rack Type, Gas, Double Compartment, High Efficiency	0	0	2,113
14.3131.290	Oven, Combination Type, Electric, High Efficiency	4.200	18,432	0
14.3132.290	Oven, Combination Type, Gas, High Efficiency	0	0	403

80 http://www.focusonenergy.com/files/Document_Management_System/Business_Programs/convectionovens_productlist.pdf.

81 http://www.focusonenergy.com/files/Document_Management_System/Business_Programs/rackovens_productlist.pdf.

82 http://www.focusonenergy.com/files/Document_Management_System/Business_Programs/combinationovens_productlist.pdf.

83 Convection oven measures were modified in November 2009. The measure definition was changed from “high efficiency” to “ENERGY STAR,” and the savings estimates were revised based on ENERGY STAR qualifications and assumptions.

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Energy savings result from installing a more efficient unit than the standard efficiency on the market and depend on the type of unit installed. Unit types include gas and electric ENERGY STAR convection ovens, gas and electric high efficiency combination ovens, and single and double compartment high efficiency gas rack type ovens.

Savings estimates are based on savings equations and assumptions provided to Pacific Gas and Electric by the Food Service Technology Center and shared with Focus through the Consortium on Energy Efficiency. Oven performance was determined by FSTC according to ASTM test methods for each oven type.

For electric ovens, kW savings are not determined by a savings equation. Rather, they are reported based on metered data.

The savings equation for electric ovens (kWh) and gas ovens (Btu) is of the same form, with only the units of the variables changed. The form of the equation shows that energy consumption of an oven is equal to the sum of energy used for cooking, idle, and preheating.

$$E_{Day} = \frac{LB_{Food} \times E_{Food}}{Efficiency} + IdleRate \times \left(OpHrs - \frac{LB_{Food}}{PC} - \frac{T_{PreHt}}{60}\right) + E_{PreHt}$$

where:

- E_{Day} = *daily energy consumption (kWh or Btu), calculated*
- LB_{Food} = *pounds of food cooked per day (lb), values in Table 4-36, Table 4-38, or Table 4-40*
- E_{Food} = *ASTM Energy to Food (kWh/lb or Btu/lb), values in Table 4-36, Table 4-38, or Table 4-40*
- *Efficiency = ASTM Heavy Load Cooking Energy Efficiency (%), values in Table 4-36, Table 4-38, or Table 4-40*
- *IdleRate = Idle Energy Rate (kW or Btu/hr), values in Table 4-36, Table 4-38, or Table 4-40*
- *OpHrs = operating hours per day (hr), deemed 12 hr*
- *PC = Production Capacity (lb/hr), values in Table 4-36, Table 4-38, or Table 4-40*
- T_{PreHt} = *Preheat Time (min), deemed 15 minutes*
- *60 = minute to hour conversion*
- E_{PreHt} = *Preheat Energy (kWh or Btu), values in Table 4-36, Table 4-38, or Table 4-40.*

Pounds of Food Cooked per Day, LB_{Food}. This is an estimate of the average pounds of food cooked per day by each oven type.

Energy to Food, E_{Food}. Energy to Food is the amount of energy absorbed by the food during cooking (kWh/lb or Btu/lb).

Efficiency. Efficiency for this calculation is the ASTM Heavy Load Cooking Energy Efficiency, and represents the ratio of the energy absorbed by food during cooking (E_{Food}) to total energy consumed during cooking (%).

Idle Energy Rate, IdleRate. Idle energy rate is the amount of power drawn by the oven when on but not cooking (kW or Btu/hr).

Operating Hours, OpHrs. Operating hours refers to the number of hours that the oven is on per day, whether cooking or at idle.

Production Capacity, PC. Production capacity is the amount of food that a given oven can cook per hour.

Preheat Time, T_{PreHt}. Preheat time is the amount of time it takes an oven to reach operating temperature after being turned on.

Preheat Energy, E_{PreHt}. Preheat Energy is the amount of energy the oven consumes daily to reach operating temperature (*kWh or Btu).*

In order to estimate annual savings, the consumption of the baseline and qualifying units are calculated using the above equation, and the latter is subtracted from the former. The resulting daily savings value is multiplied by operating days per year to yield annual savings.

$$Annual\ Savings\ =\ (E_{Day,B}\ -\ E_{Day,Q})\ x\ OpDay$$

where:

- $E_{Day,B}$ = *Daily energy use of baseline unit, kWh or Btu*
- $E_{Day,Q}$ = *Daily energy use of qualifying unit, kWh or Btu*
- *OpDay = number of operating days per year, deemed 365 days/yr.*

For electric ovens, the units of daily consumptions and energy savings are kWh. For gas ovens, the result Btu is divided by 100,000 to convert to therms.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

ASTM Variables. Values for ASTM variables for baseline and energy efficient cases were determined by FSTC according to the applicable ASTM standard test method, and provided to the program when these measures were deemed.[84] These variables include Energy to Food, Heavy Load Cooking Efficiency, Idle Energy Rate, Residual Energy

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[84] It is not known which oven models were tested to produce the values. The test method that applies to each oven type is discussed by oven type below.

Rate, Production Capacity, and Preheat Energy. The values used for these variables are presented in the tables below.

All ASTM parameter values are thought to be averages of the values for ovens tested by FSTC,[85] besides the Heavy Load Cooking Efficiency of the qualifying ovens. The Heavy Load Cooking Efficiency of qualifying ovens is actually the minimum qualifying value for each measure. These minimum qualifying values are used as the efficiencies of the qualifying ovens in the savings calculations.[86]

Pound of Food per Day (LB_{Food}). The assumed value for pounds of food per day varies by oven type, as presented in tables below.

Operating Days (OpDay). The calculation assumes that the ovens operate 365 days/yr.

Preheat Time. A preheat time of 15 minutes is used in the savings equation for each oven.

kW Savings. kW savings are reportedly from metering studies conducted by the Food Service Technology Center.[87] A more specific citation is not available. These values are reported by oven type in tables below.

i. Convection Ovens

Convection ovens were tested according to ASTM F1496, the Standard Test Method for the Performance of Convection Ovens. Parameter values, consumptions, and savings estimates are shown in Table 4-36 and Table 4-37.

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[85] The deeming calculation spreadsheet states “Measure data for savings calculations have been developed based on average equipment characteristics for customer participants for the Food Service Equipment program.”

[86] For ENERGY STAR convection ovens, the qualifying efficiency value is the minimum ENERGY STAR qualifying efficiency of 44 percent. Idle cooking energy rates for convection ovens have also been updated based on the ENERGY STAR calculator assumptions, which are based on more recent FSTC tests.

[87] If kW values were metered while the unit was firing, using these metered values to determine kW savings assumes that the unit is firing throughout the peak period.

Table 4-36. Convection Oven Parameter Values

Oven Fuel	Parameter	Baseline Model	ENERGY STAR Model
Electric or Gas	Preheat Time (min)	15	15
	Production Capacity (lb/h)	70	80
	Operating Hours/Day	12	12
	Operating Days/Year	365	365
	Pounds of Food Cooked per Day	100	100
Electric	Preheat Energy (kWh)	1.5	1
	Idle Energy Rate (kW)	2.0	1.5
	Cooking Energy Efficiency (%)	65%	70%
	ASTM Energy to Food (kWh/lb)	0.0732	0.0732
Gas	Preheat Energy (Btu)	19,000	11,000
	Idle Energy Rate (Btu/h)	18,000	13,000
	Cooking-Energy Efficiency (%)	30%	44%
	ASTM Energy to Food (Btu/lb)	250	250

Table 4-37. Convection Oven Energy Consumptions and Savings

Model	Electric Oven		Gas Oven
	kW	kWh	therms
Baseline	2.8	12,193	1,052
ENERGY STAR	2.3	10,314	746
Savings	**0.5**	**1,879**	**306**

ii. Combination Ovens

Combination ovens were tested according to ASTM F1639-05, the Standard Test Method for Combination Ovens. Parameter values, consumptions, and savings estimates are presented in Table 4-38 and Table 4-39.

Table 4-38. Parameter Values for Combination Ovens

Fuel	Parameter	Baseline Model	Energy Efficient Model
Electric or Gas	Preheat Time (min)	15	15
	Operating Hours/Day	12	12
	Operating Days/Year	365	365
	Pounds of Food Cooked per Day	200	200
Electric	Preheat Energy (kWh)	3	1.5
	Idle Energy Rate (kW)	7.5	3
	Cooking-Energy Efficiency (%)	44%	60%
	ASTM Energy to Food (kWh/lb)	0.0732	0.0732
	Production Capacity (lb/h)	80	100
Gas	Preheat Energy (Btu)	18,000	13,000
	Idle Energy Rate (Btu/h)	28,000	17,000
	Cooking-Energy Efficiency (%)	35%	40%
	ASTM Energy to Food (Btu/lb)	250	250
	Production Capacity (lb/h)	80	120

Table 4-39. Combination Oven Consumptions and Savings

Model	Electric Oven		Gas Oven
	kW	kWh	therms
Baseline	8.8	38,561	1,532
Energy Efficient	4.6	20,130	1,129
Savings	**4.2**	**18,432**	**403**

iii. Rack Type Ovens

Rack Type ovens were tested according to ASTM F2093, the Standard Testing Method for Rack Type Ovens. Parameter values, consumptions, and savings estimates are presented in Table 4-40 and Table 4-41.

Table 4-40. Assumptions for Rack Type Ovens

Compartments	Parameter	Base Model	Energy Efficient Model
One or Two	Preheat Time (min)	20	20
	Operating Hours/Day	12	12
	Operating Days/Year	365	365
	ASTM Energy to Food (Btu/lb)	235	235
	Baking-Energy Efficiency (%)	30%	50%
One	Preheat Energy (Btu)	50,000	44,000
	Idle Energy Rate (Btu/h)	43,000	29,000
	Production Capacity (lb/h)	130	140
	Pounds of Food Cooked per Day	600	600
Two	Preheat Energy (Btu)	100,000	85,000
	Idle Energy Rate (Btu/h)	65,000	35,000
	Production Capacity (lb/h)	250	280
	Pounds of Food Cooked per Day	1,200	1,200

Table 4-41. Consumptions and Savings for Rack Type Ovens

Model	One Compartment	Two Compartments
Baseline (therms)	3,005	5,425
Energy Efficient (therms)	1,971	3,312
Savings (therms)	**1,034**	**2,113**

4.2.5 Griddles

Group: Food Service

Category: Griddle

Technology Description: High Efficiency Electric or Gas Griddle

Qualifying Equipment: Griddle must appear on the list of qualifying equipment on the Focus on Energy web site.[88]

Date Deeming Last Modified: November 2009

Date Deemed: April 2007

Summarized by: John Dendy

Table 4-42. Griddle Measures

WISeerts Tech Code	Measure Description	Deemed Savings		
		kW	kWh	Therms
14.3501.210	Griddle, Electric, ENERGY STAR, per linear foot	0.149	651	0
14.3502.210	Griddle, Gas, ENERGY STAR, per linear foot	0	0	62

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Energy savings result from installing a more efficient unit than the standard efficiency on the market. Savings estimates are based on savings equations and assumptions provided to Pacific Gas and Electric by the Food Service Technology Center and shared with Focus through the Consortium on Energy Efficiency.

For electric griddles, kW savings are not determined by a savings equation. Rather, they are reported based on metered data. All savings are per linear foot of griddle.

The equation for energy consumption for electric griddles and gas griddles is of the same form, with only the units of the variables changed. The form of the equation shows that energy consumption of a griddle is equal to the sum of energy used for cooking, idle, and preheating.

$$\frac{E_{Day}}{linear\ ft} = \frac{LB_{Food} \times E_{Food}}{Efficiency} + IdleRate \times (OpHrs - \frac{LB_{Food}}{PC} - \frac{T_{PreHt}}{60}) + E_{PreHt}$$

where:

- E_{Day} = *daily energy consumption (kWh or Btu), calculated*

88 http://www.focusonenergy.com/files/Document_Management_System/Business_Programs/griddles_productlist.pdf

- *LB_{Food} = pounds of food cooked per day per linear foot (lb/ft), values in Table 4-43 or Table 4-45*
- *E_{Food} = ASTM Energy to Food (kWh/lb or Btu/lb), values in Table 4-43 or Table 4-45*
- *Efficiency = ASTM Heavy Load Cooking Energy Efficiency (%), values in Table 4-43 or Table 4-45*
- *IdleRate = Idle Energy Rate per linear foot (kW/ft or Btu/hr/ft), values in Table 4-43 or Table 4-45*
- *OpHrs = operating hours per day (hr/day), deemed 12 hr/day*
- *PC = Production Capacity per linear foot (lb/hr/ft), values in Table 4-43 or Table 4-45*
- *T_{PreHt} = Preheat Time (min), deemed 15 minutes*
- *60 = minute to hour conversion*
- *E_{PreHt} = Preheat Energy per linear foot (kWh/ft or Btu/ft), values in Table 4-43 or Table 4-45.*

Pounds of Food Cooked per Day, LB_{Food}. This is an estimate of the average pounds of food cooked per day per linear foot (lb/ft).

Energy to Food, E_{Food}. Energy to Food is the amount of energy absorbed by the food during cooking (kWh/lb or Btu/lb).

Efficiency. Efficiency for this calculation is the ASTM Heavy Load Cooking Energy Efficiency, and represents the ratio of the energy absorbed by food during cooking (E_{Food}) to total energy consumed during cooking (%).

Idle Energy Rate, IdleRate. Idle energy rate is the amount of power drawn by the griddle when on but not cooking per linear foot (kW/ft or Btu/hr/ft).

Operating Hours, OpHrs. Operating hours refers to the number of hours that the griddle is on per day, whether cooking or at idle.

Production Capacity, PC. Production capacity is the amount of food that a given griddle can cook per hour per linear foot (lb/ft)

Preheat Time, T_{PreHt}. Preheat time is the amount of time it takes a griddle to reach operating temperature after being turned on.

Preheat Energy, E_{PreHt}. Preheat Energy is the amount of energy the griddle consumes daily to reach operating temperature per linear foot (*kWh/ft or Btu/ft).*

In order to estimate annual savings, the consumption of the baseline and qualifying units are calculated using the above equation, and the latter is subtracted from the former. The resulting daily savings value is multiplied by operating days per year to yield annual savings.

$$Annual\ Savings = (E_{Day,B} - E_{Day,Q})\ x\ OpDay$$

where:

- $E_{Day,B}$ = *Daily energy use of baseline unit per linear foot, kWh/ft or Btu/ft*
- $E_{Day,Q}$ = *Daily energy use of qualifying unit per linear foot, kWh/ft or Btu/ft*
- *OpDay = number of operating days per year, deemed 365 days.*

For electric griddles, the units on daily consumptions and energy savings are kWh. For gas griddles, the resulting value in Btu is divided by 100,000 to convert to therms.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

Many of the parameter values used in the savings estimate were determined by FSTC according to ASTM F1275, the Standard Test Method for Performance of Griddles.[89] These were originally prepared for PG&E and were provided to the program through the Consortium on Energy Efficient Kitchens when the measure was deemed in 2007. ENERGY STAR subsequently began qualifying griddles, and savings estimates have been updated to match ENERGY STAR data and criteria. All values are discussed below, and they are summarized in Table 4-43 for electric griddles and Table 4-45 for gas griddles.

Pounds of Food per Day, LB_{Food}. The deeming calculation assumes that 33.3 pounds of food are cooked per day per linear foot by gas and electric standard efficiency and ENERGY STAR griddles. When the measure was first deemed, the FSTC provided the assumption that 100 lb/hr were cooked per day by each griddle. The current deemed value is obtained by assuming that griddles are 3 feet long, and dividing 100 lb/hr by 3 ft.

Energy to Food, E_{Food}. Energy to Food is deemed to be 0.139 kWh/lb for electric griddles and 475 Btu/lb for gas griddles. These values are the original values provided by FSTC.

Efficiency. The deemed ASTM Heavy Load Cooking Energy Efficiency values used in this calculation are the values provided by FSTC. For baseline units, deemed values are 32 percent for gas griddles and 65 percent for electric griddles. For ENERGY STAR units, the deemed values of 38 percent for gas griddles and 70 percent for electric griddles are also the minimum ENERGY STAR qualifying efficiencies.[90]

Idle Energy Rate, IdleRate. The deemed idle energy rates for baseline models are 6,333 Btu/hr/ft for gas griddles and 0.83 kW/ft for electric models. These are based on FSTC-provided values of 19,000 Btu/hr for gas griddles and 2.5 kW. The FSTC-provided values are divided by an assumed griddle length of 3 feet to yield the deemed values.

For ENERGY STAR units, idle energy rate is based on the ENERGY STAR qualifying requirements of 2,650 Btu/hr/ft^2 for gas units and 0.355 kW/ft^2 for electric units.[90] The

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[89] It is not known which griddle models were tested to produce the values.

[90] http://www.energystar.gov/index.cfm?c=griddles.pr_crit_comm_griddles.

griddles are assumed to be 2 feet deep, which is reported in deeming documents to be the most common depth, based on an FSTC tech assessment study.[91] In order to obtain deeming values per linear foot, the ENERGY STAR qualifying requirements per square foot are multiplied the assumed depth of 2 feet. This yields deemed energy idle rates of 5,300 Btu/hr/ft for gas griddles and 0.71 kW//ft for electric griddles.

Operating Days (OpDay). The calculation assumes that the griddles operate 365 days/yr.

Production Capacity, PC. For baseline griddles, the deemed Production Capacity values are 13.3 lb/hr/ft for gas griddles and 12.7 lb/hr/ft for electric griddles. These are based on default values provided in the FSTC's life cycle cost calculator.[92] The FSTC values are divided by an assumed griddle length of 3 feet to convert from pounds per hour to pounds per hour per linear foot.[93]

For ENERGY STAR griddles, deemed values are 16.3 lb/hr/ft for gas griddles and 17.5 lb/hr/ft for electric griddles. These values are the calculated averages from the ENERGY STAR Commercial Griddles Qualified Product List.[94] The average of the values on this list are divided by the assumed griddle length of 3 feet to yield the Production Capacity values per linear foot.

Preheat Time, T_{PreHt}. Preheat time is the amount of time it takes a griddle to reach operating temperature after being turned on.

Preheat Energy, E_{PreHt}. Preheat Energy is the amount of energy the griddle consumes daily to reach operating temperature per linear foot (*kWh/ft or Btu/ft).*

The values discussed above are summarized in Table 4-43 and Table 4-45. These values are substituted into the savings equation to yield the savings values reported in Table 4-44 and Table 4-46.

kW savings are not based on the savings equation. Rather, they are reportedly from metering studies conducted by the FSTC.[95] A more specific citation is not available. These values are reported by griddle type in the tables below.

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[91] No further information is available about this source.

[92] Gas griddles: http://www.fishnick.com/saveenergy/tools/calculators/ggridcalc.php. Electric griddles: http://www.fishnick.com/saveenergy/tools/calculators/egridcalc.php.

[93] As of this writing, default values in the FSTC life cycle cost calculators are 35 lb/hr for gas griddles and 35 lb/hr for electric griddles, which when divided by 3 feet yield values of 11.7 lb/hr/ft for gas and 12.3 lb/hr/ft for electric.

[94] http://www.energystar.gov/ia/products/prod_lists/comm_griddles_prod_list.xls.

[95] We assume that these data for kW were metered while the unit or units were firing. The peak period kW savings are defined as the average kW from 1 to 4 pm, Monday through Friday, June through August. So, using these metered kW values tacitly assumes that the unit is firing throughout the peak period.

All parameter values, consumptions, and savings are presented in the tables below.

Table 4-43. Parameter Values for Electric Griddles

Parameter	Baseline Model	ENERGY STAR Model
Preheat Time (min)	15	15
Preheat Energy (kWh/ft)	1.33	0.67
Idle Energy Rate (kW/ft)	0.83	0.71
Cooking-Energy Efficiency (%)	65%	70%
Production Capacity (lb/h/ft)	12.7	17.5
Operating Hours/Day	12	12
Operating Days/Year	365	365
Pounds of Food per Day (lb/day/ft)	33.3	33.3
ASTM Energy to Food (kWh/lb)	0.139	0.139

Table 4-44. Electric Griddle Consumption and Savings

Model	kW per linear ft	kWh per linear ft
Baseline	1.338	5,862
ENERGY STAR	1.190	5,211
Savings	**0.149**	**651**

Table 4-45. Parameter Values for Gas Griddles

Parameter	Baseline Model	ENERGY STAR Model
Preheat Time (min)	15	15
Preheat Energy (Btu/ft)	7,000	5,000
Idle Energy Rate (Btu/h/ft)	6,333	5,300
Cooking-Energy Efficiency (%)	32%	38%
Production Capacity (lb/h/ft)	13.3	16.3
Operating Hours/Day	12	12
Operating Days/Year	365	365
Pounds of Food per Day (lb/day/ft)	33.3	33.3
ASTM Energy to Food (Btu/lb)	475	475

Table 4-46. Gas Griddle Consumptions and Savings

Model	Therms
Baseline	420
ENERGY STAR	358
Savings	**62**

4.2.6 Refrigerators and Freezers

Group: Food Service

Category: Refrigerator / Freezer, Commercial

Technology Description: Commercial Refrigerators and Freezers, ENERGY STAR, Solid or Glass Door

Qualifying Equipment:

- Must have vertical configuration.
- Must meet ENERGY STAR qualifications.

Date Deemed: November 2009

Summarized by: John Dendy

Table 4-47. Refrigerator/Freezer Measures

WISeerts Tech Code	Measure Description	Deemed Savings		
		kW	kWh	Therms
14.4240.340	Freezer, Glass Door, < 15 cu ft, ENERGY STAR	0.1831	1,604	0
14.4241.340	Freezer, Glass Door, 15-29 cu ft, ENERGY STAR	0.2284	2,001	0
14.4242.340	Freezer, Glass Door, 30-49 cu ft, ENERGY STAR	0.5333	4,672	0
14.4243.340	Freezer, Glass Door, 50+ cu ft, ENERGY STAR	0.8725	7,643	0
14.4244.340	Freezer, Solid Door, < 15 cu ft, ENERGY STAR	0.0573	502	0
14.4245.340	Freezer, Solid Door, 15-29 cu ft, ENERGY STAR	0.0992	869	0
14.4246.340	Freezer, Solid Door, 30-49 cu ft, ENERGY STAR	0.2407	2,109	0
14.4247.340	Freezer, Solid Door, 50+ cu ft, ENERGY STAR	0.4773	4,181	0
14.4248.340	Refrigerator, Glass Door, < 15 cu ft, ENERGY STAR	0.0823	721	0
14.4249.340	Refrigerator, Glass Door, 15-29 cu ft, ENERGY STAR	0.0767	672	0
14.4250.340	Refrigerator, Glass Door, 30-49 cu ft, ENERGY STAR	0.0890	780	0
14.4251.340	Refrigerator, Glass Door, 50+ cu ft, ENERGY STAR	0.1049	919	0
14.4252.340	Refrigerator, Solid Door, < 15 cu ft, ENERGY STAR	0.0300	263	0
14.4253.340	Refrigerator, Solid Door, 15-29 cu ft, ENERGY STAR	0.0584	512	0
14.4254.340	Refrigerator, Solid Door, 30-49 cu ft, ENERGY STAR	0.0983	861	0
14.4255.340	Refrigerator, Solid Door, 50+ cu ft, ENERGY STAR	0.1390	1,218	0

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Energy savings result from installing a more efficient unit than the standard efficiency on the market. An energy efficient refrigerator or freezer is defined as one that meets ENERGY STAR version 2.0 requirements.[96] Savings for commercial refrigeration vary according to whether the unit is a refrigerator or freezer, whether it has a solid or glass

[96] ENERGY STAR Version 2.0 is based on the Consortium for Energy Efficiency (CEE) Tier 2 standards, and replaces ENERGY STAR version 1.0, which was based on CEE Tier 1 standards.

door, and by unit size. Therefore, the savings estimates are broken down into 16 measures according to these categories.

The basic savings equations for all refrigeration types and efficiencies are:

$$kWh\ Savings = \left(kWh_b - kWh_q\right) x\ Days$$

$$kW\ Savings = \frac{kWh\ Savings}{HR}$$

where:

- *kWh_b = daily baseline unit consumption, expressions in Table 4-48*
- *kWh_q = daily qualifying unit consumption, expressions in Table 4-48*
- *Days = annual days of operation, deemed 365*
- *HR = annual hours of operation, deemed 8,760.*

Baseline consumption, kWh_b. Baseline consumption is an expression of the daily kWh consumption of a conventional refrigeration unit in terms of the inside volume of the unit *(V)*.

Qualifying consumption, kWh_q. Qualifying unit consumption is an expression of the daily consumption of the ENERGY STAR unit. The expressions are defined by ENERGY STAR, and are dependent on the inside volume of the unit *(V).*

Operating Days, Days. This is the assumed annual operating days of the unit.

Operating hours, HR. This is the assumed annual operating hours of the unit.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

Expressions for baseline and qualifying consumptions as a function of unit volume are provided in Table 4-48. These expressions are substituted into the kWh savings equation to yield the annual savings expression for each unit type.

Table 4-48. Consumption and Savings Expressions

Unit Type	Door Type	Size (ft^3)	Daily Baseline Consumption	Daily Qualifying Consumption	Daily Savings (kWh/day)
Freezer	Glass	< 15	0.75 V + 4.10	0.607V + 0.893	0.143V + 3.207
		15-29	0.75 V + 4.10	0.733V - 1.000	0.017V + 5.1
		30-49	0.75 V + 4.10	0.250V + 13.500	0.5V - 9.4
		50+	0.75 V + 4.10	0.450V + 3.500	0.3V + 0.6
	Solid	< 15	0.4V + 1.38	0.250V + 1.25	0.15V + 0.13
		15-29	0.4V + 1.38	0.4V - 1.00	2.38
		30-49	0.4V + 1.38	0.163V + 6.125	0.237V - 4.745
		50+	0.4V + 1.38	0.158V + 6.333	0.242V - 4.953
Refrigerator	Glass	< 15	0.12 V + 3.34	0.118V + 1.382	0.002V + 1.958
		15-29	0.12 V + 3.34	0.140V + 1.050	-0.02V + 2.29
		30-49	0.12 V + 3.34	0.088V + 2.625	0.032V + 0.715
		50+	0.12 V + 3.34	0.110V + 1.500	0.01V + 1.84
	Solid	< 15	0.10V + 2.04	0.089V + 1.411	0.011V + 0.629
		15-29	0.10V + 2.04	0.037V + 2.2	0.063V - 0.016
		30-49	0.10V + 2.04	0.056V + 1.635	0.044V + 0.405
		50+	0.10V + 2.04	0.06V + 1.416	0.04V + 0.624

Baseline consumption, kWh_b. The baseline for all of these measures is the Energy Policy Act of 2005. [97] The expression is in terms of refrigeration unit inside volume in cubic feet.

Qualifying consumption, kWh_q. The expressions for the consumption of qualifying measures are defined by ENERGY STAR. These expressions reflect the maximum consumption allowed for a unit to qualify for ENERGY STAR.

Volume, V. The volume used in the savings expressions in Table 4-48 for each size category is the average of the unit volumes within each category that appear on the list of qualifying units for ENERGY STAR version 1.0.[98] Deemed volumes for each size category are presented in Table 4-49.

Table 4-49. Average Volume by Size Category

Size Range (ft^3)	Average Size (ft^3)
< 15	8.3
15-29	22.5
30-49	44.4
50+	67.8

[97] Energy Policy Act of 2005 (Congressional Bill H.R. 6, section 136 (d), p. 47 http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=109_cong_bills&docid=f:h6enr.txt.pdf.

[98] http://www.energystar.gov/index.cfm?fuseaction=refrig.display_products_excel. This version of ENERGY STAR expires on December 31, 2009.

Hours and Days. Almost all refrigerators and freezers are assumed to operate continuously, which is 8,760 hours per year or 365 days per year.

Substituting the above volumes in to the savings expressions yields daily savings values, which are multiplied by operating days to yield the annual savings presented in Table 4-47. Dividing these values by operating hours yields the kW savings in Table 4-47.

4.2.7 Ice Machines

Group: Food Service

Category: Ice Machine

Technology Description: Ice Machines, ENERGY STAR

Qualifying Equipment:

- Unit must meet ENERGY STAR qualifying requirements.
- Applies only to air-cooled cube ice machines. Equipment producing nugget or flake ice is excluded.

Date Deeming Last Modified: November 2009

Date Previously Deemed: October 2006

Summarized by: John Dendy

Table 4-50. Ice Machine Measures

Tech Code	Measure Description	Savings per Ice Machine	
		kW Savings	kWh Savings
14.5320.235	Ice Machine, ENERGY STAR, ice-making head, <300 lb/day	0.0598	524
14.5321.235	Ice Machine, ENERGY STAR, ice-making head, >=1000 lb/day	0.1364	1,195
14.5323.235	Ice Machine, ENERGY STAR, ice-making head, 300-449 lb/day	0.0598	524
14.5324.235	Ice Machine, ENERGY STAR, ice-making head, 450-499 lb/day	0.1364	1,195
14.5325.235	Ice Machine, ENERGY STAR, ice-making head, 500-999 lb/day	0.1364	1,195
14.5326.235	Ice Machine, ENERGY STAR, remote-condensing w/ remote compressor, >=1000 lb/day	0.1440	1,261
14.5328.235	Ice Machine, ENERGY STAR, remote-condensing w/ remote compressor, 300-499 lb/day	0.0985	863
14.5329.235	Ice Machine, ENERGY STAR, remote-condensing w/ remote compressor, 500-933 lb/day	0.0985	863
14.5330.235	Ice Machine, ENERGY STAR, remote-condensing w/ remote compressor, 934-999 lb/day	0.1440	1,261
14.5331.235	Ice Machine, ENERGY STAR, remote-condensing w/o remote compressor, >=1000 lb/day	0.1599	1,401
14.5333.235	Ice Machine, ENERGY STAR, remote-condensing w/o remote compressor, 300-499 lb/day	0.0978	856
14.5334.235	Ice Machine, ENERGY STAR, remote-condensing w/o remote compressor, 500-999 lb/day	0.0978	856
14.5335.235	Ice Machine, ENERGY STAR, self-contained, <175 lb/day	0.0290	254
14.5336.235	Ice Machine, ENERGY STAR, self-contained, 175 - 299 lb/day	0.0326	286
14.5337.235	Ice Machine, ENERGY STAR, self-contained, 300 - 499 lb/day	0.0326	286
14.5338.235	Ice Machine, ENERGY STAR, self-contained, 500 - 999 lb/day	0.0326	286

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Savings result from installing an ice machine that is more efficient than the standard model available on the market. The efficient model is defined as one that is ENERGY STAR qualified. Savings depend on the style of ice maker and its capacity. ENERGY STAR defines four different styles with two size categories each, which would suggest 8 measures. However, because the program's capacity definitions are not dependent on ice machine style and do not correspond to the ENERGY STAR capacity categories, there are 16 measures.

The savings equations are:

$$kWh\ Savings = DC \times \frac{H}{100} \times \left(kWh_{b/100} - kWh_{q/100}\right)\ x\ Days$$

$$kW\ Savings = \frac{kWh\ Savings}{HR}$$

where:

- *DC = average duty cycle of an ice machine, deemed 50 percent*
- *H = average harvest rate of ice machine, lb/hr, values in Table 4-53*
- *100 = conversion factor, pounds of ice per day per hundred pounds of ice per day*
- *$kWh_{b/100}$ = baseline unit consumption per 100 lb of ice produced, expressions in Table 4-52*
- *$kWh_{q/100}$ = qualifying unit consumption per 100 lb of ice produced, expressions in Table 4-52*
- *Days = Annual days of operation, deemed 365*
- *HR = hours of operation, deemed 8,760.*

Duty Cycle, DC. Duty cycle is the average percent of time the ice machine produces ice.

Harvest Rate, H. Harvest rate is the average capacity of an ice machine in pounds per hour. It represents the maximum production rate of the machine.

Baseline consumption per 100 lb ice, $kWh_{b/100}$. Baseline consumption per 100 lb of ice is an expression of the consumption of a conventional ice maker. The expressions are in terms of the harvest rate *(H*) in pounds per hour, and are defined by Environmental Policy Act of 2005.[99]

[99] Energy Policy Act of 2005 (Congressional Bill H.R. 6, section 136 (d), p. 47 http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=109_cong_bills&docid=f:h6enr.txt.pdf.

Qualifying consumption per 100 lb ice, $kWh_{q/100}$. Qualifying unit consumption per 100 lb of ice is an expression of the daily consumption of the ENERGY STAR unit. The expressions are in terms of harvest rate of the unit *(H)* in pounds per hour, and are defined by the ENERGY STAR program.

Operating Days, days. This is the assumed annual operating days of the unit.

Operating hours, HR. This is the assumed annual operating hours of the unit.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

Duty Cycle, DC. The average ice machine does not produce ice continuously. Duty cycle converts harvest rate, which is an expression for maximum production capacity in pounds per day, to an estimate of the actual amount of ice produced in pounds per day. The average Duty Cycle of an ice machine is deemed to be 50 percent. This value is based on two sources. The 1996 ADL Report estimates an average duty cycle of 50 percent.[100] A FSTC metering study of 8 ice machines found an average duty cycle of 56.8 percent.[101] The assumed annual duty cycle of 50 percent is the more conservative estimate.

Harvest Rate, H. As stated above, Harvest Rate is the rated capacity of a given ice machine. In this calculation, the values used for Harvest Rate are the average of the unit harvest rates within each size category that appear on the list of qualifying units for ENERGY STAR version 1.0.[102] The average is calculated for each style of ice machine and size range as defined by ENERGY STAR. [103] Harvest Rate values for each machine style and capacity are shown in Table 4-53.

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[100] Arthur D. Little, Inc. Energy Savings Potential for Commercial Refrigeration Equipment - Final Report. 1996.

[101] "A Field Study to Characterize Water and Energy Use of Commercial Ice Machines and Quantify Saving Potential", Food Service Technology Center, December 2007, p. 24. http://www.fishnick.com/publications/appliancereports/special.

[102] http://www.energystar.gov/ia/products/prod_lists/ice_machines_prod_list.xls . This version of ENERGY STAR expires on December 31, 2009. The ENERGY STAR list does not distinguish remote condensing units with remote compressors from remote condensing units without remote compressors. The CEE Tier 2 list does provide this distinction, so the two lists were compared to determine which ENERGY STAR qualifying units are with and which are without remote compressors.

[103] The ENERGY STAR list does not distinguish remote condensing units with remote compressors from remote condensing units without remote compressors. The CEE Tier 2 list does provide this distinction, so the two lists were compared to determine which ENERGY STAR qualifying units are with and which are without remote compressors.

Table 4-51. Average Harvest Rate by Size Category

Style	Harvest Rate Range (lb/day)	Average Harvest Rate (lb/day)
Ice-making Head	< 450	325
	>= 450	1,025
Remote-condensing with Remote Compressor	< 934	668
	>= 934	1,379
Remote Condensing without Remote Compressor	< 1,000	703
	>= 1,000	1,928
Self-contained	< 175	128
	>= 175	227

Baseline consumption per 100 lb ice, $kWh_{b/100}$. The baseline consumption for all of these measures is the maximum consumption allowed by the Energy Policy Act of 2005.[99] The expressions are in terms of harvest rate in pounds per day, and are provided in Table 4-52.

Qualifying consumption per 100 lb ice, $kWh_{q/100}$. The expressions for the consumption of qualifying measures are the maximum daily qualifying consumption defined by ENERGY STAR. These expressions reflect the maximum consumption allowed for a unit to qualify for ENERGY STAR, and are provided in Table 4-52.

Table 4-52. Consumption and Savings Expressions

Style	Harvest Rate (lb/day)	Daily Baseline Consumption per 110 lb Ice	Daily Qualifying Consumption per 100 lb Ice	Daily Savings per 100 lb Ice
Ice-making Head	< 450	10.26 - 0.0086 H	9.23 - 0.0077 H	1.03 - 0.0009 H
	>= 450	6.89 - 0.0011 H	6.20 - 0.0010 H	0.69 - 0.0001 H
Remote-condensing with Remote Compressor	< 934	8.85 - 0.0038 H	8.05 - 0.0035 H	0.8 - 0.0003 H
	>= 934	5.3	4.82	0.48
Remote Condensing without Remote Compressor	< 1,000	8.85 - 0.0038 H	8.05 - 0.0035 H	0.8 - 0.0003 H
	>= 1,000	5.10	4.64	0.46
Self-contained	< 175	18.0 - 0.0469 H	16.7 - 0.0436 H	1.3 - 0.0033 H
	>= 175	9.8	9.11	0.69

Hours and Days. Almost all refrigerators and freezers are assumed to operate continuously, which is 8,760 hours per year or 365 days per year.

Substituting the average harvest rates in Table 4-53 into the savings expression in Table 4-52 yields the difference in consumption per 100 lb of ice produced by the baseline and qualifying units. Substituting that value and other parameters into the savings equation yields the deemed savings values for each ENERGY STAR size category for each ice machine style. Each of these savings values applies to two program size categories, as shown in Table 4-50. Dividing these values by operating hours yields the kW savings in Table 4-50.

4.2.8 Dishwashers

Group: Food Service

Category: Dishwasher, ENERGY STAR

Technology Description: ENERGY STAR Dishwashers, High or Low Temperature, Electric or Gas Water Heater and Electric or Gas Booster Heater.

Qualifying Equipment:

- Equipment must appear on the list of qualifying ENERGY STAR equipment on the Focus web site.[104]
- Flight type machines do not qualify.

Date Deemed: May 2008

Summarized by: John Dendy

Table 4-53. ENERGY STAR Dishwasher Measures

WISeerts Tech Code	Measure Description	Deemed Savings		
		kW	kWh	Therms
14.5400.120	Dishwasher, ENERGY STAR, High Temp, Electric Heat, Electric Booster, Door Type	1.5450	13,530	0
14.5401.120	Dishwasher, ENERGY STAR, High Temp, Electric Heat, Electric Booster, Multi Tank Conveyor	3.7270	32,650	0
14.5402.120	Dishwasher, ENERGY STAR, High Temp, Electric Heat, Electric Booster, Single Tank Conveyor	2.0320	17,800	0
14.5403.120	Dishwasher, ENERGY STAR, High Temp, Electric Heat, Electric Booster, Under Counter	0.8150	7,140	0
14.5404.120	Dishwasher, ENERGY STAR, High Temp, Gas Heat, Electric Booster, Door Type	0.5750	5,040	334
14.5405.120	Dishwasher, ENERGY STAR, High Temp, Gas Heat, Electric Booster, Multi Tank Conveyor	1.3550	11,870	818
14.5406.120	Dishwasher, ENERGY STAR, High Temp, Gas Heat, Electric Booster, Single Tank Conveyor	0.8170	7,160	419
14.5407.120	Dishwasher, ENERGY STAR, High Temp, Gas Heat, Electric Booster, Under Counter	0.2970	2,600	179
14.5408.120	Dishwasher, ENERGY STAR, High Temp, Gas Heat, Gas Booster, Door Type	0.0220	190	525
14.5409.120	Dishwasher, ENERGY STAR, High Temp, Gas Heat, Gas Booster, Multi Tank Conveyor	0.0000	0	1285
14.5410.120	Dishwasher, ENERGY STAR, High Temp, Gas Heat, Gas Booster, Single Tank Conveyor	0.1230	1,080	658
14.5411.120	Dishwasher, ENERGY STAR, High Temp, Gas Heat, Gas Booster, Under Counter	0.0000	0	281

[104] http://www.energystar.gov/ia/products/prod_lists/comm_dishwashers_prod_list.pdf.

WISeerts Tech Code	Measure Description	Deemed Savings		
		kW	kWh	Therms
14.5413.120	Dishwasher, ENERGY STAR, Low Temp, Electric Heat, Door Type	1.3240	11,600	0
14.5414.120	Dishwasher, ENERGY STAR, Low Temp, Electric Heat, Multi Tank Conveyor	1.9060	16,700	0
14.5416.120	Dishwasher, ENERGY STAR, Low Temp, Electric Heat, Single Tank Conveyor	1.2420	10,880	0
14.5417.120	Dishwasher, ENERGY STAR, Low Temp, Electric Heat, Under Counter	0.1320	1,160	0
14.5419.120	Dishwasher, ENERGY STAR, Low Temp, Gas Heat, Door Type	0.0000	0	457
14.5420.120	Dishwasher, ENERGY STAR, Low Temp, Gas Heat, Multi Tank Conveyor	0.0000	0	657
14.5422.120	Dishwasher, ENERGY STAR, Low Temp, Gas Heat, Single Tank Conveyor	0.0000	0	428
14.5423.120	Dishwasher, ENERGY STAR, Low Temp, Gas Heat, Under Counter	0.0000	0	46

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Savings result from installing an ENERGY STAR qualified unit rather than a standard efficiency unit. ENERGY STAR dishwashers save energy primarily by reducing the amount of water used, which reduces the energy consumed to heat that water.

The type and quantity of energy conserved by these measures depends on several factors, including the style of dishwasher, the temperature of the water used by the dishwasher, and whether the water heated for the dishwasher is heated by electricity, gas, or both.

Dishwasher types include under counter, door type, single tank conveyor, and multi-tank conveyor. Each of these units uses a different amount of water.

The temperature to which the water is heated is based on whether the unit operates at high temperature or low temperature. Both high and low temperature dishwashers use domestic hot water from the primary water heater (DHW), and high temperature units also have a booster heater to further increase water temperature.

Whether units save electricity, gas, or both depends on the fuel used by the primary water heater and by the booster heater for high temperature units. Low temperature units include gas and electric DHW's without booster heaters. High temperature combinations include:

- Electric DHW with electric booster
- Gas DHW with gas booster
- Gas DHW with electric booster.

The above differences in dishwasher type, temperature, and fuel account for and define the number of measures included in this technology, presented in Table 4-53. The energy consumption of the baseline and ENERGY STAR model covered by each measure can be defined as:

$$E = E_{DHW} + E_{boost} + E_{idle}$$

where:

- *E = annual energy consumption, baseline or qualifying*
- *E_{DHW} = annual energy consumption for dishwashing of the primary water heater, baseline or qualifying*
- *E_{boost} = annual energy consumption of the booster heater, baseline or qualifying*
- *E_{idle} = annual energy consumption of dishwasher at idle, baseline or qualifying.*

The energy consumption of the baseline and ENERGY STAR dishwashers are calculated using the above equation. Then, savings are calculated by subtracting the consumption of the ENERGY STAR unit from the baseline unit. kW savings, when applicable, are calculated by dividing kWh savings by 8,760 hours per year. The equations used to calculate each term in the consumption equation above are discussed in the following sections.

i. Water heating energy consumptions, E_{DHW} and E_{boost}

The energy used to heat water for dishwashing can be calculated using the sensible heat equation, which determines the heat required to raise the temperature of a given amount of water a given number of degrees. For this measure, the equation is adapted for the parameters specific to dishwashing. The energy consumption equations of electric and gas water heaters and booster heaters are defined as follows:

$$E_{DHW,g} = \frac{RPD \times GPR \times Days \times d \times c_p \times \Delta T_{dhw}}{EFF_g \times 100{,}000}$$

$$E_{boost,g} = \frac{RPD \times GPR \times Days \times d \times c_p \times \Delta T_{boost}}{EFF_g \times 100{,}000}$$

$$E_{DHW,e} = \frac{RPD \times GPR \times Days \times d \times c_p \times \Delta T_{dhw}}{EFF_e \times 3{,}413}$$

$$E_{boost,e} = \frac{RPD \times GPR \times Days \times d \times c_p \times \Delta T_{boost}}{EFF_e \times 3{,}413}$$

where:

- $E_{DHW,g}$ = *Energy consumed by gas primary water heater for dishwashing, therms*
- $E_{boost,g}$ = *Energy consumed by gas booster water heater, therms*
- $E_{DHW,e}$ = *energy consumed by electric primary water heater for dishwashing, kWh*
- $E_{boost,e}$ = *energy consumed by electric booster water heater, kWh*
- *RPD = racks of dishes per day, deemed by dishwasher type, values in Table 4-54 and Table 4-55*
- *GPR = gallons of water per rack, deemed by dishwasher type and efficiency, values in Table 4-54 and Table 4-55*
- *Days = operating days per year, deemed 360 days/yr*
- *d = density of water, deemed 8.2 lb/gal*[105]
- c_p = *specific heat of water, 1 Btu/lb-°F*
- ΔT_{DHW} = *temperature rise at primary water heater, deemed 70 °F*
- ΔT_{boost} = *temperature rise at booster heater, deemed 40 °F*
- EFF_g = *efficiency of gas water heaters, deemed 85 percent*
- EFF_e = *efficiency of electric water heater, deemed 98 percent*
- *100,000 = number of Btu per therm*
- *3,413 = number of Btu per kWh*

Racks per day, RPD. Commercial dishwashers contain racks to hold dishes. RPD is the average number of racks washed each day, and varies by dishwasher type.

Gallons per Rack, GPR. Commercial dishwashers use a certain amount of water for each rack washed. GPR is the average gallons per rack used by a particular dishwasher type and efficiency.

Days. This is the number of days per year the dishwasher operates.

Temperature rise at primary water heater, ΔT_{dhw}. Water used by a commercial dishwasher is first heated from the temperature at which it arrives at the building to the outlet temperature of the primary domestic water heater (DHW). The average DHW outlet temperature minus the average DHW inlet temperature is the temperature rise at the primary water heater.

[105] This is the deemed value, calculated in the deeming spreadsheet by dividing 61.4 by 7.48. A more accurate value for the density of water is 8.33 lb/gal.

Temperature rise at booster heater, ΔT_{boost}. For high temperature dishwashers, domestic hot water is further heated to the operating temperature of the dishwasher. ΔT_{boost} is the temperature at which high temperature units operate minus the outlet temperature of the primary water heater.

Efficiency of gas water heater, EFF_g. The sensible heat equation calculates the amount of energy necessary to achieve a certain temperature rise for a certain amount of water. This value must be divided by water heater efficiency to calculate the amount of energy input to achieve that result. The efficiency of a gas water heater is an estimate of the amount of heat energy delivered to the water divided by the amount of energy input.

Efficiency of electric water heater, EFF_e. This is an estimate of the amount of energy delivered to water by an electric water heater divided by the energy input to that water heater.

ii. Idle Energy Consumption, E_{idle}

The energy consumption of a dishwasher includes not only that to heat water, but also electric energy consumed at idle. Idle energy consumption is defined by the following equations:

$$E_{idle} = kW_{idle} \times \left(HPD - \frac{MPR \ x \ RPD}{60} \right) \times Day$$

where:[106]

- *E_{idle} = annual energy consumption of dishwasher at idle, kWh*
- *kW_{idle} = power draw of dishwasher when idle, kW*
- *HPD = hours per day the dishwasher operates, deemed 12 hours*
- *MPR = time to wash one rack of dishes, min/rack*
- *60 = minutes per hour.*

Idle Consumption, E_{idle}. The dishwasher consumes energy when it is on but not washing dishes. The Idle Consumption is the annual energy consumed by the dishwasher when it is on and inactive.

Idle Power, kW_{idle}. The amount of power the dishwasher draws while at idle, kW.

Hours per day, HPD. This is the daily operating hours of the dishwasher.

Minutes per Rack, MPR. This is the amount of time in minutes that it takes a given dishwasher to wash one rack of dishes.

[106] Note that the parenthetical expression in the idle consumption equation is simply an expression of the hours per day the dishwasher is at idle.

The above equations and parameters apply to both baseline and ENERGY STAR models.

For baseline and efficient models of all dishwasher temperatures and types, energy consumptions are calculated by using the applicable equations and summing the results. Then energy savings are determined by using the basic savings equation of baseline consumption minus qualifying consumption.

B. VALUES AND ASSUMPTIONS

Almost all of the values for the parameters above are taken from the ENERGY STAR calculator for commercial dishwashers.[107] Only efficiencies and daily operating hours are modified from the ENERGY STAR values.

i. Water Heating Energy

Racks per day, RPD. Racks per day values are provided by ENERGY STAR based on dishwasher type. Under counter models are assumed to wash 75 racks per day and door type are assumed to wash 280. These are cited by ENERGY STAR as being based on a 2007 FSTC report. Single- and multi-rack conveyors are assumed to wash 400 and 600 racks, respectively. The source given by ENERGY STAR for this value is “assumption” and no further information is available.

Gallons per Rack, GPR. Gallons per rack values vary based on machine type, efficiency, and operating temperature. For ENERGY STAR models, GPR is the specification that defines the qualification as ENERGY STAR. For qualifying units, the gallons per rack for each dishwasher type and temperature is assumed to be this maximum qualifying GPR value. For the conventional units, GPR is cited to be based on a 2007 Lawrence Berkeley National Labs report. Gallons per rack values for each dishwasher type, temperature, and efficiency are reported in Table 4-54 and Table 4-55.

Days. All dishwashers are assumed to operate 360 days per year, which is the assumption of the ENERGY STAR Calculator.

Temperature rise at primary water heater, ΔT_{dhw}. Temperature rise at the primary DHW is assumed to be 70 °F, which is the assumption of the ENERGY STAR calculator. The source for this value is not known.

Temperature rise at booster heater, ΔT_{boost}. Temperature rise at the booster heater is assumed to be 40 °F, which is the assumption of the ENERGY STAR calculator. The source for this value is not known.

Efficiency of gas water heater, EFF_g. The efficiency of a gas water heater, whether the primary DHW or the booster heater, is assumed to be 85 percent. This value was

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107 http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorCommercialDishwasher.xls.

introduced to yield a more conservative savings estimate than the ENERGY STAR assumption of 80 percent. The source of the ENERGY STAR value is not known.

Efficiency of electric water heater, EFF_e. The efficiency of an electric water heater, whether the primary DHW or the booster heater, is assumed to be 98 percent. This value was introduced to yields a more conservative savings than the ENERGY STAR assumption of 95 percent. The source of the ENERGY STAR value is not known.

Values for the parameters that vary by dishwasher type and the resulting energy consumptions are presented in Table 4-54 and Table 4-55 by dishwasher type.

Table 4-54. Low Temperature Parameters and Water Heating Consumptions

Parameter or Result	Under Counter		Door Type		Single Tank Conveyor		Multi-tank Conveyor	
	Base Model	Energy Efficient Model	Base Model	Energy Efficient Model	Base Model	Energy Efficient Model	Base Model	Energy Efficient Model
Racks per Day	75	75	280	280	400	400	600	600
Low Temperature Gallons per Rack	1.95	1.70	1.85	1.18	1.23	0.79	0.99	0.54
High Temperature Gallons per Rack	1.98	1	1.44	0.95	1.13	0.7	1.1	0.54
Gas DHW consumption (therm)	356	310	1,261	804	1,197	769	1,446	788
Electric DHW consumption (kWh)	9,045	7,885	32,036	20,434	30,428	19,543	36,736	20,038

Table 4-55. High Temperature Values and Water Heating Consumptions

Parameter or Result	Under Counter		Door Type		Single Tank Conveyor		Multi-tank Conveyor	
	Base Model	Energy Efficient Model	Base Model	Energy Efficient Model	Base Model	Energy Efficient Model	Base Model	Energy Efficient Model
Racks per Day	75	75	280	280	400	400	600	600
Gallons per Rack	1.98	1	1.44	0.95	1.13	0.7	1.1	0.54
Gas DHW consumption (therm)	361	183	981	647	1,100	681	1,606	788
Gas booster consumption (therm)	207	104	561	370	629	389	918	451

Parameter or Result	Under Counter		Door Type		Single Tank Conveyor		Multi-tank Conveyor	
	Base Model	Energy Efficient Model	Base Model	Energy Efficient Model	Base Model	Energy Efficient Model	Base Model	Energy Efficient Model
Electric DHW consumption (kWh)	9,184	4,638	24,936	16,451	27,954	17,317	40,818	20,038
Electric booster consumption (kWh)	5,248	2,651	14,249	9,400	15,974	9,895	23,324	11,450

When input in the equations described above, these consumptions yield the savings values presented in the savings summary section in Table 4-57.

ii. Idle Energy Consumption

For all but two dishwasher types, the parameters that govern idle energy consumption are the same for the baseline and ENERGY STAR models. Therefore, idle energy consumption has no effect on energy savings for these dishwasher types. The exceptions are the high temperature door type and single-tank conveyor dishwashers.

The high temperature door type ENERGY STAR and baseline dishwashers have the same values for all parameters except minutes per rack. The different minutes per rack values yield different daily operating times, which yield different daily idle times. This means that idle energy consumptions are different for the base and efficient cases.

For high temperature single-tank conveyor models, all parameters have the same values except idle power draw. Different idle power draw values for these models yield different idle energy consumptions for the base and efficient cases.

Idle Power, kW_{idle}. Idle power draw values are cited in the ENERGY STAR calculator based on data from a 2007 FSTC report. For high temperature door type dishwashers, the value for both base and efficient cases is 0.58 kW. For high temperature single-tank conveyor models, the value is 2.3 kW for the base case and 2.0 kW for the efficient case.

Hours per day, HPD. Operating hours are deemed at 12 hr per day, which yields more conservative savings than the ENERGY STAR value of 16 hr per day.

Minutes per rack, MPR. Minutes per rack values are reported by ENERGY STAR based on a 2007 LBNL report. According to the ENERGY STAR calculator, the minutes per rack value for high temperature door type dishwashers is 1.4 for the baseline model and 1.6 for the ENERGY STAR Model. For single-tank conveyor dishwashers, the value for the base and efficient cases is 0.3 minutes per rack.

Substituting the above values into the idle energy equation yields the annual idle energy consumptions and savings values presented in Table 4-56.

Table 4-56. Idle Energy Consumptions and Savings

Dishwasher Type	Idle Consumption		
	Base Model	Energy Efficient Model	Idle Energy Savings
High Temperature Door Type	1,141	947	194
High Temperature Single-tank Conveyor	8,280	7,200	1,080

iii. Savings Summary and kW Savings

Table 4-54 and Table 4-55 show water heating energy consumptions for baseline and energy efficient water heaters and booster water heaters for low and high temperature units. Energy efficient energy consumption is subtracted from the baseline energy consumption for each water heater and dishwasher type and is reported in Table 4-57 below. Idle savings from Table 4-56 are also reported here.

Table 4-57. Savings Summary

Savings Type	Under Counter		Door Type		Single Tank Conveyor		Multi-tank Conveyor	
	Low Temp	High Temp	Low Temp	High Temp	Low Temp	High Temp	Low Temp	High Temp
Gas DHW savings (therm)	46	179	457	334	428	419	657	818
Gas booster savings (therm)	0	102	0	191	0	239	0	467
Electric DHW savings (kWh)	1,160	4,546	11,602	8,485	10,885	10,637	16,698	20,780
Electric booster savings (kWh)	0	2,597	0	4,849	0	6,078	0	11,874
Idle savings (kWh)	0	0	0	194	0	1,080	0	0

For each measure in Table 4-53, the applicable savings values from Table 4-57 are summed to calculate total therm and kWh savings for the measure. The values for kWh savings are rounded to the nearest ten kWh to result in the values reported in Table 4-53.

The rounded kWh savings values are divided by 8,760 hours per year to determine the kW savings values in Table 4-53.[108]

[108] Note that this assumes that the dishwasher's annual consumption is averaged over a 24-hour period, which is not consistent with the assumption that dishwashers operate 12 hours per day.

4.3 PLUG LOADS

The Plug Loads section contains the technologies outlined in Table 4-58.

Table 4-58. Deemed Savings Manual Entries, Plug Loads

Group Description	Manual Entry
Plug Loads	ENERGY STAR Vending Machines
	Vending Machine Controls, Cold Beverage Machine
	Snack Machine Vending Miser Controller
	Beverage Cooler Controls
	Engine Block Heater Timer

4.3.1 ENERGY STAR Vending Machines

Group: Plug Loads

Category: Vending Machine

Technology Description: Vending Machine, ENERGY STAR, Cold Beverage (either Software Activated or Not Software Activated)

Qualifying Equipment: Machine must be ENERGY STAR qualified. A list of qualifying models can be found on the ENERGY STAR web site.[109]

Date Deemed: May 2008

Summarized by: John Dendy

Table 4-59. ENERGY STAR Vending Machine Measures

WISeerts Tech Code	Measure Description	Deemed Savings		
		kW	kWh	Therms
17.0500.465	Vending Machine, ENERGY STAR, Cold Beverage, Not Software Activated	0	1,754	0
17.0501.465	Vending Machine, ENERGY STAR, Cold Beverage, Software Activated	0	2,231	0

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Energy savings result from installing a vending machine that is more efficient than the standard machine on the market. Savings result from a more efficient compressor, fan motors, and lighting systems. ENERGY STAR-qualified units also have a low power mode option that allows the machine to be placed in low-energy lighting and/or low-energy refrigeration states during times of inactivity. Machines that are software activated have greater energy savings than those that are not.

There are no kW savings associated with these measures, because savings are largely based on occupancy sensors, and the peak period is typically a time of high occupancy.[110]

kWh savings for this measure are simply the consumption of the baseline unit minus the consumption of the qualifying unit.

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[109] www.energystar.gov/ia/products/prod_lists/vending_machines_prod_list.pdf.

[110] The estimate of 0 kW savings neglects any savings associated with the compressor, insulation, and reduced display wattage.

$$kWh\ Savings = kWh_b - kWh_q$$

where:

- kWh_b = *annual consumption, baseline unit, values in Table 4-60*
- kWh_q = *annual consumption, qualifying unit, values in Table 4-60.*

Annual consumptions, kWh_b and kWh_q. These values represent the average annual energy consumption for baseline and qualifying units, respectively. The values for kWh_q depend on whether the qualifying unit is software controlled or not.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The energy consumption of baseline and qualifying units is based on the ENERGY STAR Calculator, including its associated assumptions.

Annual consumptions, kWh_b and kWh_q. The ENERGY STAR calculator provides annual energy consumptions for a conventional unit, a non-software-activated ENERGY STAR unit, and a software-activated ENERGY STAR unit. These values are cited by ENERGY STAR as being based on a 2007 study by Lawrence Berkeley National Laboratory. A more specific citation is not available.

The consumptions reported by ENERGY STAR are based on the machine capacity defined by the number of cans it holds. The capacity categories are < 500, 500, 600, 700, 800, and > 800 cans. The program uses the consumption values for the 500 can capacity machine in the calculation. This is referred to as a "previously deemed value." The consumptions for 500 can machines are reported in Table 4-60.

Table 4-60. Energy Consumption and Savings Values

	Annual Energy Consumption, kWh		
Vending Machine Type	**Conventional Unit**	**ENERGY STAR Qualified Unit**	**kWh Savings**
Software Activated	3,916	1,685	2,231
Not Software Activated	3,916	2,162	1,754

4.3.2 Vending Machine Controls, Cold Beverage Machine

Group: Plug Loads

Category: Controls

Technology Description: Vending Machine Controls, on cold beverage machine

Qualifying Equipment:

- Measures 17.0510 and 17.0515 are for occupancy-based controls. For these measures, controls must include a passive infrared occupancy sensor to turn off fluorescent lights and compressor when surrounding area is unoccupied for 15 minutes or longer. Control should periodically power up machine at regular intervals to maintain product temperature and provide compressor protection.
- Measure 17.0517 is for sales-based controls. ENERGY STAR qualified cold beverage machines do not qualify for this measure.
- Control for refrigerated vending machines is for machines containing only non-perishable bottled and canned beverages.

Date Deemed: September 2006

Summarized by: John Dendy

Table 4-61. Cold Beverage Machine Controls Measures

WISeerts Tech Code	Measure Description	Deemed Savings		
		kW	kWh	Therms
17.0510.465	Vending Machine Controls, occupancy based, on cold beverage machine	0	1,633	0
17.0515.465	Vending Machine Controls, occupancy based, on cold beverage machine, direct install	0	1,633	0
17.0517.465	Vending Machine Controls, sales based, on cold beverage machine	0	1,243	0

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Occupancy-based vending machine controls save energy when installed on refrigerated vending machines by turning off the display lights and the compressor when the surrounding area is unoccupied. Machines are turned off when a passive infrared occupancy sensor registers no occupancy for 15 minutes. Sales-based vending machine controls use a sales-based logic algorithm to turn off the compressor based on sales data, but leaves the display lighting and card reader on.

There are no kW savings deemed for these measures. The kWh savings associated with this technology are based on the unit being off during times of low traffic, and times of low traffic generally occur at times other than during the peak period.

Savings are governed by the following equations:

$$kWh\ savings = kWh_b \times \%\ savings$$

where:

- *kWh_b = baseline annual energy consumption, deemed 3,550 kWh*
- *% savings = average savings percentage due to installing controls, deemed 46 percent for occupancy sensor controls and 35% for sales based controls.*

Baseline energy consumption, kWh_b. Baseline energy consumption is an estimate of the annual energy consumed by a typical refrigerated vending machine without occupancy sensor controls.

Percent savings, % savings. Percent savings refers to the average percent savings realized by installing the control on a vending machine.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

Baseline energy consumption, kWh_b. Baseline energy consumption is deemed as 3,550 kWh per year. This value is based on three sources: a Texas A&M campus study,[111] a study in two Michigan public schools,[112] and the ENERGY STAR calculator.[113] The average consumption found in each study is presented in Table 4-62.

Table 4-62. Average Cold Beverage Energy Consumption by Source

Source	Average Consumption (kWh)
Texas A&M Study	3,546
Michigan Schools Study	3,586
ENERGY STAR Calculator	3,619

The deemed value of 3,550 kWh is not an average of the three values above. Rather, it is taken as a typical value and is on the conservative end of the range presented.

Percent savings, % savings. Percent Savings is deemed to be 46 percent for occupancy sensor controls and 35 percent for sales based controls. The 46 percent value is the average savings value claimed by the manufacturer of VendingMiser™, a control manufactured by USA Technologies that meets the requirements of the measure.[114]

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[111] Ritter, John and Joel Hugghins. Vending Machine Energy Consumption and VendingMiser Evaluation. October 31, 2000. http://repositories.tamu.edu/bitstream/handle/1969.1/2006/ESL-TR-00-11-01.pdf?sequence=1.

[112] Michigan Department of Labor and Economic Growth, Energy Office case study 05-0042. http://www.michigan.gov/documents/CIS_EO_Vending_Machine_05-0042_155715_7.pdf.

[113] http://www.energystar.gov/index.cfm?c=vending_machines.pr_proc_vendingmachines.

[114] http://www.usatech.com/energy_management/downloads/USATech_snackmiser.pdf.

There is no specific source cited on the USA Technologies web site for this specific value, but it does provide a technical paper showing energy savings metered over a 24-hour period for a cold beverage vending machine.[115] This study reports 48.2 percent savings for the tested unit, but this corresponds to a period when the area around the machine was unoccupied. The report states that actual savings for a machine in an area with traffic would be lower.

However, deeming documents cite three sources to support the deemed value. The Texas A&M study found savings for machines in appropriate locations to be between 48 and 65 percent. The Michigan study found savings to be in the range of 39 to 80 percent. An E-Source review found studies with savings in the range of 6 to 77 percent.[116] The average of the savings for machines in appropriate locations (greater than 20 percent savings) from this study was found to be 49 percent.

The deemed value of 35 percent for the sales based control is also based on a claim by USA Technologies. Deeming documents report 35 percent to be the average or typical savings percentage, but the product web site claims savings of “up to 35 percent.”[117]

Multiplying the baseline consumption value of 3,550 kWh by the appropriate percent savings values above yield the kWh saving values presented in Table 4-61.

[115] Vending Machine Energy Efficiency Device Engineering and Test Report. Prepared for Bayview Technologies by Foster-Miller, Inc., June 1, 2000.

[116] E-Source document ER-00-12. Speiser, Tertia and Kirsten Cabanas-Holmen. “Scaling Back Vending Machine Energy Use with VendingMiser.”

[117] http://www.usatech.com/energy_management/downloads/USATech_vm2iq.pdf.

4.3.3 Snack Machine Vending Miser Controller

Group: Plug Loads

Category: Controls

Technology Description: Snack Machine – Install Vending Miser Control

Qualifying Equipment:

- Controls must include a passive infrared occupancy sensor to turn off fluorescent lights when the surrounding area is unoccupied for 15 minutes or longer.

Date Deemed: April 2007

Summarized by: John Dendy

Table 4-63. Snack Machine Vending Miser Measure

WISeerts Tech Code	Measure Description	Deemed Savings		
		kW	kWh	Therms
17.0520.085	Snack Machine – Install VendingMiser Controller	0	343	0

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Vending Miser controls save energy by turning off display lights on unrefrigerated machines. Machines are turned off when a passive infrared occupancy sensor registers no occupancy for 15 minutes.

There are no kW savings deemed for this measure. kWh savings associated with this technology are based on the unit being off during times of low traffic, and times of low traffic generally occur at times other than during the peak period.

Savings are governed by the following equations:

$$kWh\ savings = kW_b \ x\ HR\ \ x\ \%\ savings$$

where:

- *kW_b = baseline power of an unrefrigerated snack machine, deemed 0.085 kW*
- *HR = annual operating hours of a vending machine, deemed 8,760*
- *% savings = average savings percentage, deemed 46 percent.*

Baseline power, kW_b. Baseline power is that of a typical unrefrigerated snack machine.

Percent savings, % savings. Percent Savings refers to the average percent savings realized by installing a Vending Miser on a typical vending machine.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

Values for baseline power and percent savings in the above equation are based on manufacturer data provided by USA Technologies, makers of VendingMiser™, SnackMiser™, and other similar products. These products meet the program's qualifications for the measure.

Values are taken from a graph titled "Typical Savings Generated with SnackMiser", taken from the USA Technologies web site.[118] Values from the web site are reported in Table 4-64.

Table 4-64. Assumptions for VendingMiser Savings Equation

Standard Snack Machine with Lamps	Assumption
Typical Power Rating per Snack Machine (Watts)	85
% Savings for Low Traffic Areas	56%
% Savings for Mean Traffic Areas	46%
% Savings for High Traffic Areas	36%
Average % Savings	**46%**

Baseline power, kW_b. Baseline power is that of a typical unrefrigerated snack machine, 85 W. This value is also based on data from the USA Technologies web site. No further source is provided.

Percent savings, % savings. The percent savings value is that reported in the manufacturer's data for mean traffic areas. There is no source cited on the USA Technologies web site for this value. Note that the value for mean traffic areas is the mean of the high traffic and low traffic percentages. So, from its name and value, it appears that percent savings for a mean traffic area was not itself measured, but is the mean of measured values for high and low traffic areas. This is supposed but not known because there is no source given for the values.

It is also not known what kind of vending machine was used in measuring the savings values. The same savings percentage values are reported for refrigerated and unrefrigerated vending machines.

The USA Technologies web site does provide a technical paper showing energy savings metered over a 24-hour period for a cold beverage vending machine.[119] This study reports 48.2 percent savings for the tested unit, but this corresponds to a period when the area around the machine was unoccupied. The report states that actual savings for a machine in an area with traffic would be lower.

Hours, H. Most vending machines are plugged in year round, so operating hours are set at 8,760 hr.

[118] http://www.usatech.com/energy_management/downloads/USATech_snackmiser.pdf.

[119] Vending Machine Energy Efficiency Device Engineering and Test Report. Prepared for Bayview Technologies by Foster-Miller, Inc., June 1, 2000.

Substituting the 0.085 kW, 8,760 hr, and 46 percent savings into the kWh savings equation yields the deemed savings value of 343 kWh.

4.3.4 Beverage Cooler Controls

Group: Plug Loads

Category: Controls

Technology Description: Beverage Cooler Controls

Qualifying Equipment:

- Controls may be applied to self-contained commercial merchandising beverage coolers only.
- Coolers must have see-through doors, may or may not have interior lighting, and must have net capacity ≥ 8 cubic feet.
- Controls must include a passive infrared occupancy sensor to turn off lights and compressor when surrounding area is unoccupied for preset length of time.
- Control should periodically power up machine at intervals to maintain product temperature and provide compressor protection.
- For coolers containing non-perishable beverages only.

Date Deeming Last Modified: November 2009

Summarized by: John Dendy

Table 4-65. Cold Beverage Machine Controls Measures

WISeerts Tech Code	Measure Description	Deemed Savings		
		kW	kWh	Therms
17.0525.085	Beverage Cooler Controls	0	1,209	0

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Occupancy-based beverage cooler controls save energy by turning off the cooler when the surrounding area is unoccupied. Machines are turned off when a passive infrared occupancy sensor registers no occupancy for a pre-set time.

There are no kW savings deemed for these measures. kWh savings associated with this technology are based on the unit being off during times of low traffic, and times of low traffic generally occur at times other than during the peak period.

Savings are governed by the following equations:

$$kWh\ savings = kW_b \times 8{,}760 \times \%\ savings$$

where:

- *kW_b = power of a typical beverage cooler, deemed 0.460 kW*

- *% savings = average savings percentage due to installing controls, deemed 30 percent*
- *8,760 = number of hours in a year.*

Baseline power, kW_b. Baseline power is an estimate of the average power demand of a typical beverage cooler without occupancy sensor controls.

Percent savings, % savings. Percent savings refers to the average percent of kWh consumption realized by installing the occupancy sensor control on beverage cooler.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

Baseline power, kW_b. Baseline power is deemed 0.460 kW. This value is taken from the USA Technologies website.[120] USA Technologies manufactures the CoolerMiser, which meets the qualifications of this measure. No further source is provided for this value.

Percent savings, % savings. Percent savings is deemed to be 30 percent. This value is also based on information on the USA Technologies website.[1] It represents the manufacturer's claimed savings for a cooler in a mean-traffic area. No further source is given for this value.

Substituting the above values into the savings equation yields the deemed savings value presented in Table 4-65.

[120] http://www.usatech.com/energy_management/downloads/USATech_coolermiser.pdf.

4.3.5 Engine Block Heater Timer

Group: Plug Loads

Category: Controls

Technology Description: Engine Block Heater Timer, Ag Only

Qualifying Equipment:

- This incentive is available for the Agriculture Sector only.
- Timers are purchased by the program, and the incentive is not available to the general public.
- Timers do not allow heaters to operate if the ambient temperature is above 39°F.

Date Deeming Last Modified: November 2009

Summarized by: John Dendy

Table 4-66. Engine Block Heater Timer Measure

WISeerts Tech Code	Measure Description	Deemed Savings		
		kW	kWh	therms
17.1500.085	Engine Block Heater Timer (Ag Only)	0	576	0

A. SAVINGS BASIS, EQUATIONS AND PARAMETERS

Engine block heater timers save energy by reducing the time that engine block heaters operate. Typically, block heaters are plugged in throughout the night. Using timers allows the heater to come on at a preset time in the night, rather than being on throughout the night. The timers covered by this measure also have a thermostat that does not allow the block heater to operate if the ambient temperature is greater than 39°F. They also have a control that allows the user to reduce this maximum temperature to a value less than 39°F.

There are no kW savings for this measure, since engine block heaters are not in use during the peak period. kWh savings are calculated using the following equation:

$$kWh\ Savings = \frac{P \times hours \times days \times UF}{1{,}000}$$

where:

- *P = average power of engine block heater, deemed 1,000 W*
- *hours = reduction in hours block heater is used per night, deemed 8 hr*
- *days = number of operating days per year, deemed 90 days*

- *UF = usage fraction, deemed 0.8*
- *1,000 = conversion factor, watts per kilowatt.*

Power of Block Heater, P. The power of the block heater is the assumed average power of the block heater plugged in to the timer.

Reduction in Operating Hours, hours. In this calculation, *hours* refers to the assumed daily reduction in operating hours resulting from using the timer.

Operating Days, days. Days refers to the assumed number of operating days of the heater/timer combination in a year.

Usage Fraction, UF. The usage fraction is the assumed fraction of the block heaters that will be used properly by the customer.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values are used for each of the parameters defined above:

Power of Block Heater, P. The average block heater power is deemed to be 1,000 W. This is described as a medium sized heater in the deeming spreadsheet. According to a program fact sheet, typical heater sizes are 400 to 2,000 W.[121] There is not a more specific citation for this value.

Reduction in Operating Hours, hours. The reduction in operating hours is deemed to be 8 hours per night that the heater operates. This is based on the assumption that a heater without a timer will operate for 10 hours per night, 8 p.m. to 6 a.m., and that a heater with a timer will operate for 2 hours. There are no secondary sources cited for these values.

Operating Days, days. The heater is deemed to operate 90 days per year. This is based on operating for the three coldest months, December, January, and February. There is no secondary source cited for this assumption.

Usage Fraction, UF. It is assumed that 80 percent of the heaters provided by the program will be used properly. This reflects the reality that not all timers provided will be used or used correctly. There is no secondary source cited for this assumption.

Substituting the above values into the savings equation yields the deemed savings value of 576 kWh per year.

121 http://www.focusonenergy.com/files/Document_Management_System/Business_Programs/engineblockheaters_factsheet.pdf.

4.4 REFRIGERATION

The Refrigeration section contains the technologies outlined in Table 4-67.

Table 4-67. Deemed Savings Manual Entries, Refrigeration

Group Description	Manual Entry
Refrigeration	Commercial Refrigeration Tune-up, Non-self-contained
	Commercial Refrigeration Tune-up, Self-contained
	Anti-sweat Heater Control
	Freezer and Refrigerated Case Doors
	ECM/PSC Motor in Refrigerated/Freezer Case
	ECM Motor in Walk-in Coolers and Freezers
	Night Curtains on Open Coolers

4.4.1 Commercial Refrigeration Tune-up, Non-Self-Contained

Group: Refrigeration

Category: Tune Up / Repair / Commissioning

Technology Description: Commercial refrigeration equipment tune-up for a non-self-contained cooler or freezer

Qualifying Equipment:

- Incentive is available for the tune-up of commercial-grade refrigeration equipment with the intention of reducing electricity consumption.
- Non-self-contained low- and medium- temperature refrigeration systems are eligible.[122] Walk-in coolers and walk-in freezers which do not have self-contained refrigeration systems are also eligible.
- Warehouse-type systems do not qualify for the incentive.
- Incentive is available every 2 years.
- Refrigeration service must include all applicable items on the Refrigeration Tune-up Checklist.[123]

Date Deemed: November 2009

Summarized by: John Dendy

Table 4-68. Refrigeration, Tune Up Measures, Not Self-contained

WISeerts Tech Code	Measure Description	Deemed Savings, per ton	
		kW	kWh
3.0906.430	Commercial refrigeration equipment tune-up, not self-contained reach-in or walk-in, medium-temp, per ton	0.099	537
3.0908.430	Commercial refrigeration equipment tune-up, not self-contained reach-in or walk-in, low-temp, per ton	0.191	1,338

[122] Self-contained equipment is also eligible, but deemed savings are calculated using a different method, so these are discussed elsewhere.

[123] This measure was not active at the time this entry was written; therefore the Refrigeration Tune-up Checklist was not available online.

A. SAVINGS BASIS, EQUATIONS AND PARAMETERS

Refrigeration that is cleaned and maintained uses less energy than refrigeration that is not cleaned and maintained. Energy savings are calculated per ton of cooling by applying a savings fraction to estimates of refrigeration energy consumption per ton of cooling. Savings equations are as follows:

$$\frac{kW\ Savings}{ton} = \frac{12}{EER} \times SF$$

$$\frac{kWh\ Savings}{ton} = \frac{kW\ Savings}{ton} \times DC \times 8{,}760$$

where:

- *EER = Energy efficiency ratio of the compressor, deemed 8.5 for coolers and 4.4 for freezers*
- *SF =Savings fraction, deemed 7 percent*
- *12 = Conversion factor based on definition of EER, converts EER to kW/ton*
- *DC = Duty cycle, deemed 0.62 for coolers and 0.80 for freezers*
- *8,760 = Number of hours in a year.*

Energy Efficiency Ratio, EER. EER is a measure of refrigeration efficiency equal to the rated cooling output of the compressor in thousand Btu per hour divided by the rated electrical input in kilowatts. In this calculation, it is an estimate of the EER of the compressor of the average cooler and freezer that will be tuned up under this measure.

Savings fraction, SF. Savings fraction is the fraction of power or energy consumption that is saved per year by performing a refrigeration tune-up.

Duty Cycle, DC. Duty cycle is the average fraction of time that the compressor operates.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

Energy efficiency ratio of the compressor, EER. The EER of a cooler is deemed 8.5 and the EER of a freezer is deemed 4.4. These values are based on those used by Arthur D. Little in a report for the U.S. Department of Energy.[124] The report uses coefficient of performance (COP) values of 2.5 for coolers and 1.3 for freezers. These are converted to EER values by multiplying by the conversion factor of 3.412. The COP values cited are for a semihermetic reciprocating compressor, which is stated to be a typical compressor on a non-self-contained refrigeration system in a supermarket.

[124] Arthur D. Little, Inc. Energy Savings Potential for Commercial Refrigeration Equipment - Final Report. 1996.

Savings fraction, SF. The savings fraction is deemed to be 7 percent. This is based on several studies or estimates, as shown in Table 4-69.[125] [126] [127]

Table 4-69. Percent Savings by Source

Source	Percentage Savings
Xcel	5–10%
Food Market Institute	5–25%
Xenergy	5%
NEEA	6–20%

Based on the above sources, a savings percentage of 7 percent was chosen. Deeming documents indicate that this value was thought to be conservative, but not overly conservative, since it is near but not identical to the lower limit of the cited ranges.

Duty Cycle, DC. The duty cycle of the average cooler compressor is deemed to be 0.62 and that of the average freezer compressor is deemed to be 0.8. These are based on the average of two sources. A report by Wisconsin Electric Power Company states that the average duty cycle for refrigeration compressors is 75 percent for low temperature and 69 percent for medium temperature.[128] An Arthur D. Little report for the Alliance for Responsible Atmospheric Policy uses 85 percent for low temperature and 55 percent for medium temperature.[129] The deemed value of 0.62 for coolers is the average of the two medium temperature values, 69 and 55 percent. The deemed value for freezers is the average of 75 percent and 85 percent, or 0.8.

Substituting the above values into the savings equation yields the savings estimates presented in Table 4-68.

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[125] Specific sources are not available for the Xcel Energy and Food Market Institute values.

[126] Documentation of Energy Efficiency Potential Estimates. Prepared by Kema-Xenergy for San Diego Gas and Electric Company, March 25, 2003. Measure 508, page CEX-7.

[127] Northwest Energy Efficiency Alliance. BetterBricks Grocery Initiative: MPER #3. February 15, 2008.

[128] Wisconsin Electric Power Company. *Energy Efficient Supermarket Refrigeration*. September 29, 1993. Page 52, 53.

[129] The Alliance for Responsible Atmospheric Policy. *A. D. Little Report.* Section 8.2. http://www.arap.org/adlittle/8.html.

4.4.2 Commercial Refrigeration Tune-up, Self-Contained

Group: Refrigeration

Category: Tune-up / Repair / Commissioning

Technology Description: Commercial refrigeration equipment tune-up for cooler or freezer

Qualifying Equipment:

- Incentive is available for the tune-up of commercial-grade refrigeration equipment with the intention of reducing electricity consumption.
- Self-contained commercial freezers and coolers are eligible.[130]
- Incentive is available every 2 years.
- Refrigeration service must include all applicable items on the Refrigeration Tune-up Checklist.[131]

Date Deemed: November 2009

Summarized by: John Dendy

Table 4-70. Commercial Refrigeration Tune-up Measures, Self-Contained

WISeerts Tech Code	Measure Description	Deemed Savings, per hp	
		kW	kWh
3.0907.430	Commercial refrigeration equipment tune-up, self-contained cooler, per hp	0.1048	569
3.0909.430	Commercial refrigeration equipment tune-up, self-contained freezer, per hp	0.0877	614

A. SAVINGS BASIS, EQUATIONS AND PARAMETERS

Refrigeration that is cleaned and maintained uses less energy than refrigeration that is not cleaned and maintained. Energy savings are calculated per compressor horsepower by applying a savings fraction to estimates of refrigeration energy consumption per compressor horsepower. Consumption and savings equations are as follows:

$$\frac{kW\ Savings}{HP} = SF \times kW_{perHP}$$

[130] Non-self-contained equipment is also eligible, but deemed savings are calculated using a different method, so these are discussed elsewhere.

[131] This measure was not active at the time this entry was written; therefore the Refrigeration Tune-up Checklist was not available online.

$$\frac{kWh\ Savings}{HP} = SF \times kWh_{perHP}$$

where:

- kW_{perHP} = *kW per compressor HP, values in Table 4-71 and Table 4-72*
- kWh_{perHP} =*kWh per compressor HP, values in Table 4-71 and Table 4-72*
- *SF = Savings fraction, deemed 7 percent.*

kW per compressor HP, kW_{perHP}*.* kW per compressor HP is the average kW demand of a compressor per nominal compressor horsepower.

kWh per compressor HP, kW_{perHP}*.* kWh per compressor HP is the average kWh consumed by a compressor per nominal compressor horsepower.

Savings fraction, SF. Savings fraction is the average fraction of power or energy consumption that is saved per year by performing a refrigeration tune-up.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

kW per compressor HP, kW_{perHP}*.* kW per compressor HP is calculated based on an analysis of manufacturer data from True Manufacturing for 28 refrigerator and 25 freezer compressors. It is calculated for each compressor using the following equation:

$$kW_{perHP} = \frac{V \times A \times PF}{1{,}000 \times HP}$$

where:

- *V = Volts, from manufacturer data*
- *A = Amps, from manufacturer data*
- *PF = Power factor, deemed 0.6*
- *1,000 = Conversion factor, watts per kW*
- *HP = Nominal horsepower of the unit.*

All values are taken from True Manufacturing product data besides the assumed power factor. Deeming documents state that the power factor of a compressor is typically between 0.5 and 0.7, but no source is given for this estimate.[132]

[132] Power factor is the ratio of real power, the ability of a system to do work, to apparent power, the product of current and voltage. The difference in real and apparent power for some devices is due to the amperage and voltage being out of phase.

Then for each compressor size tier (¼, ½, ¾, and 1 HP), the average kW_{perHP} is calculated. These values are provided in Table 4-71 for refrigerators and Table 4-72 for freezers.

Table 4-71. Average Refrigerator Compressor Demand and Consumption per HP

Size Tier	kW per HP	kWh per HP	Weight
1/4 hp	1.6503	8,963	40%
1/2 hp	1.3832	7,512	40%
3/4 hp	1.3800	7,495	10%
1 hp	1.4582	7,920	10%
Average	**1.4972**	**8,132**	**100%**

Table 4-72. Average Feezer Compressor Demand and Consumption per HP

Size Tier	kW per HP	kWh per HP	Weight
1/4 hp	1.3111	9,188	20%
1/2 hp	1.3984	9,800	10%
3/4 hp	1.1776	8,253	40%
1 hp	1.2637	8,856	30%
Average	**1.2522**	**8,776**	**100%**

The calculated values for each size tier are then averaged using the weights shown in the tables. These weights are not based upon actual market share; rather, they are based on the number of compressors for which data is available in each category. These values are further rounded to the nearest ten percent. So, for example, six of the 25 freezer compressors in the analysis, or 24 percent, are ¼ hp. This is rounded to 20 percent, as shown on the first line of Table 4-72.

The weighted average kW_{perHP} value in Table 4-71 is the deemed value for refrigerators and the one in Table 4-72 is the deemed value for freezers.

kWh per compressor HP, kWh_{perHP}. kWh per compressor HP for each compressor is calculated from kW_{perHP} according to the following equation:

$$kWh_{perHP} = kW_{perHP} \times DC \times 8{,}760$$

where:

- *kW_{perHP} = kilowatts per compressor HP, values in Table 4-71 and Table 4-72*
- *DC = Duty cycle of the compressor, 62% for refrigerators and 80% for freezers*
- *8,760 = number of hours in a year*

The duty cycle values of 62 percent for refrigerators and 80 percent for freezers are based on the average of two sources. A report by Wisconsin Electric Power Company provides that the average duty cycle for refrigeration compressors is 75 percent for low temperature and 69 percent for medium temperature.[133] An Arthur D. Little report for the Alliance for Responsible Atmospheric Policy uses 85 percent for low temperature and 55 percent for medium temperature.[134] The deemed value of 62 percent for coolers is the average of the two medium temperature values, 69 and 55 percent. The deemed value for freezers is the average of 75 percent and 85 percent, or 80 percent.

Thus, kWh per compressor HP is calculated for each compressor, the results in each size tier are averaged, and the values for each size tier are weighted according to the number of compressors in each category. The deemed values for kWh_{perHP} are as reported in the bottom row of Table 4-71 for refrigerators and in Table 4-72 for freezers.

Savings fraction, SF. The savings fraction is deemed to be 7 percent. This is based on several studies or estimates.[135] [136] [137]

Table 4-73. Percent Savings by Source

Source	Percentage Savings
Xcel	5-10%
Food Market Institute	5-25%
Xenergy	5%
NEEA	6-20%

Based on the above sources, a savings percentage of 7 percent was chosen. Deeming documents indicate that this value was thought to be conservative, but not overly conservative, since it is near but not identical to the lower limit of the cited ranges.

Substituting the deemed values for savings fraction, kW per HP, and kWh per HP into the savings equations yields the deemed kW and kWh savings values per compressor HP provided in Table 4-70.

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[133] Wisconsin Electric Power Company. *Energy Efficient Supermarket Refrigeration*. September 29, 1993. Page 52, 53.

[134] The Alliance for Responsible Atmospheric Policy. *A. D. Little Report.* Section 8.2. http://www.arap.org/adlittle/8.html.

[135] Specific sources are not available for the Xcel Energy and Food Market Institute values.

[136] Documentation of Energy Efficiency Potential Estimates. Prepared by Kema-Xenergy for San Diego Gas and Electric Company, March 25, 2003. Measure 508, page CEX-7.

[137] Northwest Energy Efficiency Alliance. BetterBricks Grocery Initiative: MPER #3. February 15, 2008.

4.4.3 Anti-sweat Heater Control

Group: Refrigeration

Category: Controls

Technology Description: Automatic controls for anti-sweat heaters in cooler and freezer cases.

Qualifying Equipment:

- Install equipment that senses the relative humidity in the air outside of the display case and reduces or turns off the glass door (if applicable) and frame anti-sweat heaters at low humidity conditions.
- Equipment must control heaters on frame and mullion in all instances. If the door is equipped with a heater then it must also be controlled.

Date Deeming Last Modified: May 2008

Summarized by: Josh Venden

Table 4-74. Anti-sweat Heater Controls Measures

WISeerts Tech Code	Measure Description	Deemed Savings	
		kW	kWh
3.1197.085	Anti-sweat heater controls, on freezer case with low-heat door	0.0220	1,431
3.1198.085	Anti-sweat heater controls, on freezer case with no-heat door	0.0090	575
3.1199.085	Anti-sweat heater controls, on freezer case with standard door	0.0310	2,060
3.1200.085	Anti-sweat heater controls, on refrigerated case with standard door	0.0360	1,339
3.1201.085	Anti-sweat heater controls, on refrigerated case with low-heat or no-heat doors	0.0200	740

A. SAVINGS BASIS, EQUATIONS AND PARAMETERS

Anti-sweat heater (ASH) controls sense the humidity outside of refrigeration units and turn off anti-sweat heaters during periods of low humidity. Without controls, anti-sweat heaters run continuously whether they are necessary or not. Qualifying controls turn off all heaters including mullion heaters on cases with no door glass or frame heaters. By controlling all heaters, savings are still possible with no-heat doors.

Savings are realized in two ways. Primary energy savings result from the reduction in electric energy when the heaters are off. Secondary savings result from the reduced cooling load on the refrigeration unit when the heaters are off.

kW and kWh savings for coolers and freezers are described by the following equations.[138]

Coolers:

$$kW_{Cooler}\ Savings = kW_{CoolerBase} \times CHP_{off} \times (1 + R_H)$$

$$kWh_{Cooler}\ Savings = kW_{CoolerBase} \times 8{,}760 \times CHA_{off} \times (1 + R_H)$$

Freezers:

$$kW_{Freezer}\ Savings = kW_{FreezerBase} \times FHP_{off} \times (1 + R_H)$$

$$kWh_{Freezer}\ Savings = kW_{FreezerBase} \times 8{,}760 \times FHA_{off} \times (1 + R_H)$$

where:

- *$kW_{CoolerBase}$ = power consumption of cooler case ASH without controls, deemed by door heater type, values in Table 4-75.*
- *$kW_{FreezerBase}$ = power consumption of freezer case ASH without controls, deemed by door heater type, values in Table 4-75.*
- *CHP_{off} = percent of time cooler case ASH with controls will be off during the peak period, deemed 20 percent.*
- *CHA_{off} = percent of time cooler case ASH with controls will be off annually, deemed 85 percent.*
- *FHP_{off} = percent of time freezer case ASH with controls will be off during the peak period, deemed 10 percent.*
- *FHA_{off} = percent of time freezer case ASH with controls will be off annually, deemed 75 percent.*
- *R_H = residual heat fraction, deemed 0.65*
- *8,760 = number of hours per year.*

Baseline Energy Demand, $kW_{CoolerBase}$, $kW_{FreezerBase}$. These values are estimates of the baseline electric demand for typical freezer and cooler anti-sweat heaters in the Wisconsin market. Values are based on whether the door heaters are standard, low-heat, or no-heat.

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[138] There appears to be an error in the calculation. The reduction in heat load in the equations as deemed and presented neglects the efficiency of the refrigeration unit. For these equations to be accurate, the term R_H should be divided by the COP of the refrigerated units. In the low- and no-heat door measures, COP values are deemed to be 1.3 for freezers and 2.5 for coolers.

Peak Percent Off, CHP_{off}, and FHP_{off}, Peak Percent Off is an estimate of the percent of time the heater in a cooler or freezer is not in use because of the control installation during the peak period.

Annual Percent Off, CHA_{off}, and $FHA_{off.}$. Annual Percent Off is an estimate of the overall percent of time the heater in a cooler or freezer is not in use because of the control installation.

Residual Heat Fraction, $R_{H.}$ Residual Heat is the estimated percentage of the heat produced by the heaters that remains in the freezer or cooler case and must be removed by the refrigeration unit.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Baseline Demand, $kW_{CoolerBase}$ and $kW_{FreezerBase}$,. Baseline demand values of uncontrolled anti-sweat heaters are based on manufacturer data for standard, low-heat, and no-heat doors. Most values are based on averages for several manufacturers, as discussed in Section 4.4.4 of this report. The baseline value for a cooler with standard doors, however, is equal to and appears to be based on the value for a Zero Zone freezer with a low heat Anthony door. Values are presented in Table 4-75.[139]

Percent Off, CHP_{off}, CHA_{off}, FHP_{off}, $FHA_{off.}$ It is assumed for this savings calculation that a cooler ASH will be off 85 percent of the time annually (CHA_{off}) and a freezer ASH will be off 75 percent of the time annually (FHA_{off}). During the peak period, it is assumed that a cooler ASH will be off 20 percent of the time (CHP_{off}), and freezer ASH will be off 10 percent of the time (FHP_{off}). These estimates were provided by Bob Savage at Door Miser.

Residual Heat, $R_{H.}$ The residual heat fraction is deemed 0.65. The source of this value is not known, but a deeming memo states that it was determined by evaluators. This value is greater than the 50 percent value originally proposed by the program.

Table 4-75 shows all of the parameter values and the resulting kW and kWh savings. For freezers and coolers with standard doors, these are the deemed values shown in Table 4-74. Coolers with low heat and no-heat doors are further combined into a single measure. This is done by weighting the values for low and no-heat doors according to an assumed market share. It is assumed that low heat doors make up 75 percent of these installations, and no-heat doors make up the remaining 25 percent. Weighting the kW

[139] Note that the baseline values for freezers presented here are one watt lower than those cited in 4.4.4b, though they are based on the same data. This is due to what appears to be a data entry error in the value for freezers with standard doors, which is entered as 0.190 kW rather than 0.191 kW. The actual spreadsheet calculation uses this value as a base and calculates the values for freezers with low and no-heat doors by subtracting the difference between these and the standard door. This effectively reduces these values by one W as well.

and kWh savings values accordingly yields the deemed savings values of 0.0200 kW and 740 kWh.

Table 4-75. Parameter Values and Savings by Unit and Door Type

Unit Type	Door Type	kW Baseline	Peak Percent Off	Annual Percent Off	Residual Heat Fraction	kW Savings	kWh Savings
Freezer	Standard	0.190	0.1	0.75	0.65	0.031	2,060
	Low Heat	0.132	0.1	0.75	0.65	0.022	1,431
	No Heat	0.053	0.1	0.75	0.65	0.009	575
Cooler	Standard	0.109	0.2	0.85	0.65	0.036	1,339
	Low Heat	0.063	0.2	0.85	0.65	0.021	774
	No Heat	0.052	0.2	0.85	0.65	0.017	639

4.4.4 Freezer and Refrigerated Case Doors

Group: Refrigeration

Category: Case Doors

Technology Description: Freezer and cooler case door anti-sweat heaters (ASH).

Qualifying Equipment:

- For refrigerated case applications, only no-heat doors qualify; low-heat doors are not eligible.
- Both no-heat and low-heat doors qualify if used on freezer cases.

Date Deemed: May 2008

Summarized by: Josh Venden

Table 4-76. Freezer and Refrigerated Case Door Measures

WISeerts Tech Code	Measure Description	Deemed Savings	
		kW	kWh
3.1220.510	Case door, freezer, low heat	0.0870	762
3.1221.510	Case door, freezer, no heat	0.2060	1,800
3.1225.510	Case door, refrigerated, no heat	0.0140	121

A. SAVINGS BASIS, EQUATIONS AND PARAMETERS

Anti-sweat heaters minimize condensation or sweating on cooler and freezer doors. Energy consumption can be reduced by using doors with lower wattage heaters or without heaters (no-heat doors). Energy savings are realized in two ways. Primary energy savings result from the reduction in electric energy used by the heater. Secondary savings result from the reduced cooling load on the refrigeration unit with low-heat or no-heat type doors. This cooling load reduction is based on the primary savings, the amount of door heat that remains in the case, and the efficiency of the refrigeration unit.

The kW and kWh savings for this measure are defined using the following equations. Note that the kW savings equation accounts for both primary and secondary heat load energy savings. The units are assumed to run continuously, so annual kWh savings is calculated by multiplying kW savings by the number of hours in a year.

$$kW\ Savings = \left(kW_{Baseline} - kW_{Qualifying}\right) \times \left(1 + \frac{R_H}{COP}\right)$$

$$kWh\ Savings = kW\ Savings \times 8{,}760$$

where:

- $kW_{Baseline}$ = *energy demand of baseline case door heaters, values in Table 4-77.*
- $kW_{Qualifying}$ = *energy demand of qualifying case door heaters, values in Table 4-77*
- R_H = *residual heat fraction, deemed 0.65*
- *COP = coefficient of performance, deemed 2.5 for coolers and 1.3 for freezers*
- *8,760 = number of hours in a year.*

Baseline Demand, $kW_{Baseline}$. Baseline energy demand represents the average electric energy demand of baseline door heaters. The baseline for a cooler case is a low-heat door. The baseline for a freezer case is a standard heat door.

Qualifying Demand, $kW_{Qualifying}$. Qualifying energy demand represents the average electric energy demand of low-heat (freezers only) or no-heat case doors.

Residual Heat Fraction, R_H. Residual Heat is the estimated percentage of the heat produced by the heaters that remains in the freezer or cooler case and must be removed by the refrigeration unit.

Coefficient of Performance, COP. The coefficient of performance is a measure of the efficiency of a refrigerated or freezer case, and is equal to the ratio of the heat removed from the cooler or freezer to the amount of energy consumed by the refrigeration system. In this case, it represents the average COP of cooler or freezer compressors.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

Baseline Demand, $kW_{Baseline}$. Baseline demand for both coolers and freezers is taken from manufacturer data for Zero Zone reach-in refrigeration.[140] Deeming documents report that Zero Zone has a high market share in Wisconsin. For coolers, the base case is the low heat door. The deemed baseline of 0.063 kW is the demand reported for the Anthony 101 Low-energy door, which is the only low-energy door option for Zero Zone coolers. For freezers, the base case is a standard door. Zero Zone provides two options for standard freezer doors: Anthony 101 and Gemtron Polar. Demand for the Anthony is reported as 0.190 kW, and for Gemtron, 0.192 kW. The deemed baseline value for freezers is 0.191 kW, the average of these.[141] [142]

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[140] Zero Zone cooler data: http://www.zero-zone.com/files/RVCC30%20&%20RVCC30BB%20Spec%20Sheet%2010-02-06.pdf.

Zero Zone freezer data: http://www.zero-zone.com/files/1.%20RVZC30%20&%20RVZC30BB%20Spec%20Sheet%203-22-07.pdf

[141] In the calculation spreadsheet, the value of 0.190 kW is entered in the main table, rather than 0.191 kW. However, the differences between baseline and qualifying kW is calculated based on 0.191 kW, so savings values are correctly based on this average of 0.191 kW.

Qualifying Demand, $kW_{Qualifying}$. Qualifying demand values are based on data from Zero Zone and Hussmann,[143] another refrigeration manufacturer. For coolers, the qualifying case is a no-heat door, and the qualifying demand is 0.053 kW. This is the average of values presented for Hussman and two options for Zero Zone – Anthony doors and Gemtron doors. For freezers, both low-heat and no-heat doors qualify. The qualifying demand for low heat freezer doors is 0.133 kW, which again is the average of Hussman, Zero Zone/Anthony, and Zero Zone/Gemtron. The qualifying demand for the no-heat door is that reported for Hussmann, 0.054 kW.

Coefficient of Performance, COP. Deemed values for COP are 2.5 for coolers and 1.3 for freezers. These are the default values taken from the U.S. Department of Energy publication "Energy Savings Potential for Commercial Refrigeration Equipment."[144]

Residual Heat Fraction, R_H. The residual heat fraction is deemed 0.65. The source of this value is not known, but a deeming memo states that it was determined by evaluators. This value is greater than the 50 percent value originally proposed by the program.

Substituting the above values into the savings equations yields the kW and kWh savings values reported in Table 4-77 below.

Table 4-77. Parameter Values and Deemed Savings

Unit and Door Type	Baseline kW	Qualifying kW	Residual Heat Fraction	COP	kW savings	kWh Savings
Freezer, Low-Heat	0.191	0.133	0.65	1.3	0.087	762
Freezer, No-Heat	0.191	0.054	0.65	1.3	0.206	1,800
Cooler, No-Heat	0.063	0.052	0.65	2.5	0.014	121

142 The current Zero Zone reach-in freezer cut sheet shows the demand for the Anthony 101 standard door to be 0.186 kW, not 0.190 kW. It is possible that the data has been updated since this measure was deemed. Using the updated value, the average of the Anthony and Gemtron doors would be 0.189 W rather than 0.191 W using the original value.

143 Cut sheet for Hussmann products not currently available.

144 U.S. DOE Publication #46230-00, "Energy Savings Potential for Commercial Refrigeration Equipment", 1996, Arthur C. Little, Inc.

4.4.5 ECM/PSC Motor In Refrigerated/Freezer Case

Group: Refrigeration

Category: Motor

Technology Description: Electronically Commutated (ECM) or Permanent Split Capacitor (PSC) motor replacing shaded-pole motor in refrigerated/freezer case.

Qualifying Equipment:

- Incentives are available for ECM (electronically commutated motor) and PSC (permanent split capacitor) fan motor retrofits in existing refrigerated display cases and for new installations.
- New PSC motors must replace shaded pole (S-P) motors.
- New ECM motors may replace either S-P motors or PSC motors.

Date Deemed: May 2008

Summarized by: Josh Venden

Table 4-78. Refrigeration Motor Measures

WISeerts Tech Code	Measure Description	Deemed Savings		
		kW	kWh	Therms
3.1410.270	ECM (electronically commutated) motor replacing shaded-pole motor in refrig/freezer case	0.1030	904	0
3.1420.270	PSC (permanent split capacitor) motor replacing shaded-pole motor in refrig/freezer case	0.0820	715	0

A. SAVINGS BASIS, EQUATIONS AND PARAMETERS

The shaded-pole (SP) fan motor is the traditional standard for refrigeration. This style of motor is inefficient and generates an excessive amount of heat that the refrigeration system must overcome to maintain adequate cooling in freezer or refrigerator cases. ECM (electronically commutated motor) and PSC (permanent split capacitor) motors are more efficient.

The savings realized by installing more efficient motors are two-fold. Primary energy savings are realized by the reduction in electric energy used by the motor. Additional savings are incurred due to the lower heat produced by the more efficient motors, reducing the cooling load on the refrigeration unit.

The electric demand associated with a motor in a refrigerated unit is defined by the following equation:

$$kW = \frac{W_{motor}}{1{,}000} \times \left(LF + \frac{1}{eff \times COP} \right)$$[145]

where:

- W_{motor} = *Wattage of motor, deemed 135 W for SP, 85 for PSC, and 55 for ECM*
- *LF = Load Factor, deemed 0.9*
- *eff = Efficiency at which motor heat is removed, deemed 80 percent*
- *COP = Coefficient of performance of compressor, deemed 1.3 for freezers and 2.5 for coolers*
- *1,000 = Conversion factor, watts per kilowatt.*

Wattage of motor, W_{motor}. Motor wattage is the nominal rated power of each motor type, SP, PSC, or ECM.

Load Factor, LF. Load factor is the assumed average load on the motor.[146]

Efficiency of heat removal, eff. This is the assumed efficiency of the cooler or freezer at removing the heat generated by the motor.[147]

Coefficient of performance, COP. COP is a measure of refrigeration efficiency. The COP of a compressor is the rate of net heat removal divided by the energy input into the compressor.

The kW savings for this measure are determined by first calculating the electric consumption of each motor and refrigeration unit combination (electric and heat impacts). Then, the consumption of the replacement case is subtracted from that of the existing or baseline case to determine savings.

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[145] The first part of the parenthetical expression represents the primary electric demand of the motor, and the second part represents the heat removal demand.

[146] Note that the load factor in the savings calculation is applied only to the primary electric demand, and is not applied to the heat removal demand. This appears to be an error, since a motor at 90 percent of its rated power would produce 90 percent of the heat.

[147] As used in the calculation, this factor effectively reduces the COP of the compressor. It may be introduced to convert the COP of the compressor to that of the refrigeration system as a whole, including evaporator and condenser fans. However, other deemed refrigeration calculations assume that not all of the heat generated in a refrigerated case remains in the case to be removed by the unit. If it is introduced as a fraction of motor heat that contributes to cooling load, then it should be in the numerator of the savings equation, rather than denominator.

The kWh savings are calculated by multiplying the kW savings by 8,760, the estimated annual operating hours. The estimate assumes that the units operate 24 hours per day, 365 days per year.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Wattage of motor, Wmotor. SP motors are deemed to be 135 W, PSC are deemed to be 85 W, and ECM are deemed to be 55 W. These values are taken from the California Standard Performance Contract summary.

Load Factor, LF. The average load factor is assumed to be 0.9 for all motors. No source is given for this value, but it reflects the reality that motors do not typically operate at 100 percent of rated power.

Efficiency of heat removal, eff. This factor is deemed at 0.8. The source of and rationale for introducing this parameter is not known.

Coefficient of performance, COP. The COP values used for this analysis are 1.3 for freezers and 2.5 for coolers. These are default values taken from a U.S. Department of Energy Publication.[148]

The following table provides parameter values that vary by motor type and installation application and the resulting energy demand for Shaded-Pole, PSC and ECM motors in freezers and coolers.

Table 4-79. Energy Demand by Motor Type and Installation

	SP		PSC		ECM	
Parameter or Result	**Freezer**	**Cooler**	**Freezer**	**Cooler**	**Freezer**	**Cooler**
Motor Watts	135	135	85	85	55	55
COP	2.5	1.3	2.5	1.3	2.5	1.3
kW Consumption	0.251	0.189	0.158	0.119	0.102	0.077

Savings for each replacement scenario are calculated by subtracting the consumption of the replacement unit from that of the replaced. The savings values for each replacement scenario are presented in Table 4-80. Using these values directly would generate six savings estimates: one for freezers and one for coolers for each of the three replacement scenarios.

[148] US DOE Publication #46230-00, “Energy Savings Potential for Commercial Refrigeration Equipment”, 1996, Arthur C. Little, Inc.

However, the program further combines the values to limit the number of deemed measures. In order to do this, savings values are averaged according to the following assumptions:

- Replacements are assumed to occur in equal proportions of freezers and coolers. The savings values for freezers and coolers are averaged to produce and average savings value for each replacement scenario.
- ECM motors are assumed to replace SP motors twice as often as they replace PSC motors. A weighted average of savings value for ECM replacement motors is calculated according to this distribution.

The average savings of 0.082 kW for PSC motor installation is reported in the top row of Table 4-80 below, and the weighted average savings of 0.103 kW for ECM motor installations is reported in the bottom row. These values are equal to the deemed kW savings values reported in Table 4-78.

Table 4-80. kW Savings by Replacement Scenario

Replacement Scenario	kW Savings		
	Freezer	Cooler	Average
PSC Replacing SP	0.093	0.070	0.082
ECM Replacing PSC	0.056	0.042	0.049
ECM Replacing SP	0.149	0.112	0.131
Weighted Average ECM Replacement	**-**	**-**	**0.103**

These deemed kW savings values are then multiplied by 8,760 operating hours per year to yield the deemed kWh savings reported in Table 4-78.

4.4.6 ECM Motors in Walk-in Coolers or Freezers

Group: Refrigeration

Category: Motor

Technology Description: Electronically Commutated (ECM) motor replacing shaded-pole motor in refrigerated/freezer case.

Qualifying Equipment:

- Incentives are available for electronically commutated motors (ECMs) replacing shaded pole (SP) motors or permanent split capacitor (PSC) motors on existing walk-in freezer and cooler evaporator fans.
- Incentive does not apply to condenser fan motors.
- Incentive not available for equipment in *new* walk-in freezers or coolers.

Date Deemed: November 2009

Summarized by: John Dendy

Table 4-81. ECM in Walk-in Coolers and Freezers Measures

WISeerts Tech Code	Measure Description	Deemed Savings	
		kW	kWh
3.1430.270	ECM evaporator fan motor replacing shaded-pole motor, <1/20 hp, in walk-in cooler	0.1113	935
3.1431.270	ECM (electronically commutated) evaporator fan motor replacing shaded-pole motor, >=1/20 hp, <1hp, in walk-in cooler	0.2422	2,033
3.1432.270	ECM (electronically commutated) evaporator fan motor replacing PSC motor, >=1/10 hp, <1 hp, in walk-in cooler	0.0697	585
3.1440.270	ECM (electronically commutated) evaporator fan motor replacing shaded-pole motor, <1/20 hp, in walk-in freezer	0.1411	1,184
3.1441.270	ECM (electronically commutated) evaporator fan motor replacing shaded-pole motor, >=1/20 hp, <1hp, in walk-in freezer	0.3068	2,576
3.1442.270	ECM (electronically commutated) evaporator fan motor replacing PSC motor, >=1/10 hp, <1 hp, in walk-in freezer	0.0882	741

A. SAVINGS BASIS, EQUATIONS AND PARAMETERS

ECM motors are more efficient than shaded pole (SP) or permanent split capacitor (PSC) motors, meaning they can produce an equal amount of output horsepower with less energy input.

The savings realized by installing more efficient motors are two-fold. Primary energy savings are realized by the reduction in electric energy used by the motor. Additional savings are incurred due to the lower heat produced by the more efficient motors, reducing the cooling load on the refrigeration unit.

The electric savings associated with a motor in a refrigerated unit are defined by the following equations:

$$kW\ Savings = \Delta kW_{motor} \times \left(1 + \frac{3.412}{EER}\right)$$

$$kWh\ Savings = kW\ Savings \times HR$$

where:

- *ΔkW_{motor} = difference in motor demand, values in Table 4-83, Table 4-84, and Table 4-85*
- *EER = Energy Efficiency Ratio of compressor, deemed 4.4 for freezers and 8.5 for coolers*
- *3.412 = conversion factor, Btu per watt-hour*
- *HR = annual operating hours of the evaporator fan, deemed 8,395 hr.*

Difference in motor demand, ΔkW_{motor}. The difference in motor demand is the difference between the kW demand of the ECM motor and the kW demand of the SP or PSC motor.

Energy Efficiency Ratio, EER. EER is a measure of refrigeration efficiency. The EER of a compressor is its rated cooling output in thousands of Btus per hour divided by its rated electrical input in kW.

Operating hours, HR. Operating hours is the annual operating hours of the evaporator fan.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Difference in motor demand, ΔkW_{motor}. The difference in motor demand is found by subtracting the demand of the replacement ECM motor from that of the SP or PSC motor replaced. Motor wattages by nominal motor output horsepower are taken from an EPRI report.[149] Motor wattages are provided in Table 4-82.

[149] *Assessment of Refrigerated Display Cases,* EPRI, May 1994. For motor sizes and types for which the EPRI report does not provide data, the wattage is interpolated or extrapolated from values provided.

Table 4-82. Motor Demand by Motor Horsepower and Type

HP	ECM (kW)	PSC (kW)	SP (kW)
1/40	0.027	-	0.090
1/30	0.033	-	0.110
1/25	0.039	-	0.127
1/20	0.049	0.068	0.175
1/15	0.065	0.090	0.207
1/10	0.098	0.136	0.349
1/6	0.155	0.202	-
1/3	0.304	0.370	-
1/2	0.450	0.530	-

Energy Efficiency Ratio, EER. Compressor EER is deemed as 8.5 for coolers and 4.4 for freezers. This is based on a 1996 report by Arthur D. Little.[150] The EER values are for a Copeland Discus semihermetic reciprocating compressor, which the report offered as representative of a typical installation in a supermarket.

Operating hours, HR. Operating hours are deemed as 8,395 hours per year. This value is based on the assumption that the fans are off one hour per day during defrost. The deemed value is equal to 8,760 hours per year multiplied by a ratio of 23 hr/24 hr.

The change in motor kW is calculated using the values in Table 4-82. Savings are then calculated for coolers and freezers for each nominal motor horsepower by substituting ΔkW into the savings equation using the deemed EER value for each. Then, savings values for each measure are calculated based on a weighted average of savings values within its motor type and motor size category. The source of the weighting fractions is not known. The kW savings for ECM motors replacing PSC motors in coolers and freezers is presented in Table 4-83.

Table 4-83. kW Savings, PSC Replacement

HP	Delta kW	Cooler Savings (kW)	Freezer Savings (kW)	Weight Fraction
1/20	0.019	0.027	0.034	0.10
1/15	0.025	0.035	0.044	0.10
1/10	0.038	0.053	0.067	0.30
1/6	0.047	0.066	0.083	0.10
1/3	0.066	0.092	0.117	0.20
1/2	0.080	0.112	0.142	0.20
Weighted Average		**0.0697**	**0.0882**	**1.00**

The kW savings for ECM motors replacing SP motors are divided into two measure categories based on motor size. Savings for replacing SP motors less than 1/20 HP are presented in Table 4-84. For those between 1/20 and 1 HP, savings are presented in Table 4-85.

[150] Arthur D. Little, Inc. Energy Savings Potential for Commercial Refrigeration Equipment - Final Report. 1996.

Table 4-84. kW Savings for SP Replacements, <1/20 HP

HP	Delta kW	Cooler Savings (kW)	Freezer Savings (kW)	Weight Fraction
1/40	0.063	0.088	0.112	0.20
1/30	0.077	0.108	0.137	0.30
1/25	0.088	0.123	0.155	0.50
Weighted Average		**0.1113**	**0.1411**	**1.00**

Table 4-85. kW Savings for SP Replacements, 1/20 – 1 HP

HP	Delta kW	Cooler Savings (kW)	Freezer Savings (kW)	Weight Fraction
1/40	0.063	0.088	0.112	0.20
1/30	0.077	0.108	0.137	0.30
1/25	0.088	0.123	0.155	0.50
Weighted Average		**0.1113**	**0.1411**	**1.00**

The deemed kW savings values in the above tables are multiplied by 8,395 operating hours per year to yield the deemed kWh savings values presented in Table 4-81.

4.4.7 Night Curtains on Open Coolers

Group: Refrigeration

Category: Refrigerated Case Door

Technology Description: Night Curtains for Open Coolers

Qualifying Equipment:

- Applies to professionally installed, "permanent," low emissivity (reflective) night curtain products only.
- Linear foot measurement is the side-to-side (not top to bottom) measured width of all installed night curtains.

Date Deeming Last Modified: November 2008

Summarized by: Josh Venden

Table 4-86. Night Curtains on Open Cooler Measure

WISeerts Tech Code	Measure Description	Deemed Savings (per foot)		
		kW	kWh	Therms
3.2401.510	Night Curtains for Open Coolers, per linear foot	0	156	0

A. SAVINGS BASIS, EQUATIONS AND PARAMETERS

Night curtains are used on open refrigerated cases (open coolers) to reduce heat transfer between the air inside of the case and the air outside of the case. The technology adds a barrier over the open face of the case for use during closed hours. When curtains are in use, the heat transfer by convection and radiation is reduced, thereby reducing the cooling load on the refrigeration system.

There are no kW savings associated with this technology, since night curtains are not used during the peak period. kWh savings are described by the following equation:

$$kWh = \left(\frac{Load_{NC}}{12{,}000}\right) \times \left(\frac{12}{3.413}\right) \times COP \times Percent_{Savings} \times 8{,}760$$

where:

- *$Load_{NC}$ = Average refrigeration load without curtains, deemed 1,500 Btu per linear foot.*
- *COP = Coefficient of Performance for refrigerated cases, deemed 2.2.*
- *$Percent_{Savings}$ = Assumed reduction in compressor energy consumption when using night curtains, deemed 9 percent.*
- *12,000 = number of BTU in one ton of refrigeration capacity.*

- $\frac{12}{3.413}$ *= conversion factor for converting COP to kW/ton.*
- *8,760 = number of hours in one year.*

Refrigeration Load without Night Curtains, $Load_{NC}$. Refrigeration Load is the average compressor load per linear foot for multi-deck open case refrigerated coolers without night curtains.

Coefficient of Performance, COP. The coefficient of performance is a measure of the efficiency of the refrigeration system and is equal to the ratio of net heat removal to the total energy input.

Percent Savings. Percent savings applies to the reduction in compressor energy consumption when using night curtains.

B. VALUES, ASSUMPTIONS AND CALCULATIONS

The deemed savings estimate is based on secondary research that provides estimates for the cooling load of refrigerated cases without curtains, the average COP of compressors in such cases, and a value for percent savings due to installing and using curtains.

The following values were assumed for the calculation input parameters:

Refrigeration Load without Night Curtains, $Load_{NC}$. The average refrigeration load is assumed to be 1,500 BTU/hr per linear foot based on a report by Davis Energy Group.[151]

Percent Savings. Percent savings is deemed at 9 percent based on a study by Southern California Edison that found the average reduction in compressor consumption to be 9 percent when using night curtains.[152]

Coefficient of Performance, COP. The coefficient of performance was assumed to be 2.2 for this savings calculation. This value is presented as “previously deemed” and the source of the value is unknown.

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[151] Davis Energy Group. *Analysis of Standards Options for Open Case Refrigerators and Freezers.*

[152] Southern California Edison. Display Case Shield Reduces Supermarket Energy Use.

http://www.sce.com/RebatesandSavings/LargeBusiness/Commercial/SupermarketDisplayCaseShields/ Refer to the summary table on page iii of the executive summary of the detailed report.

Total savings are equal to the assumed reduction in compressor energy consumption when using night curtains. Table 4-87 below shows the original energy consumption without night curtains and the assumed reduction in compressor energy consumption when using night curtains. The result in kWh per linear foot is equal to the deemed kWh savings value presented in Table 4-86.

Table 4-87. Baseline Cooler Consumption and Savings

	kWh per linear foot
Open Case Cooler without Night Curtains	1,734
9% Reduction with Night Curtains	156

4.5 HVAC

The HVAC section contains the technologies outlined in Table 4-88.

Table 4-88. Deemed Savings Manual Entries, HVAC

Group Description	Manual Entry
HVAC	Agricultural Exhaust Fans
	HVAC Steam Traps
	Furnace
	A/C Split System < 65MBh
	Packaged Terminal Units
	Guest Room Energy Management Controls
	Rooftop A/C

4.5.1 Agricultural Exhaust Fans[153]

Group: HVAC

Category: Fans

Technology Description: High efficiency agricultural exhaust fans.

Qualifying Equipment:

- Measure is limited for use by the agriculture sector only.
- Intended for barn exhaust propeller type fans.
- Ventilation fans must have a minimum rating of 21 CFM/W at 0.00 inches H_2O static pressure, 20 CFM/W at 0.05 inches H_2O static pressure, or be approved by Focus on Energy prior to sale.
- Fans must be rated through the Bioenvironmental and Structural Systems Laboratory (BESS Lab) or Air Movement and Control Association International laboratory (AMCA Lab).

Date Deeming Last Modified: November 2009

Date Previously Deemed: May 2008

Summarized by: Dale Tutaj

Table 4-89. High Efficiency Agricultural Exhaust Fans Measures and Savings

Tech Code	Measure Description	Deemed Savings		
		kW	kWh	Therms
4.0736.150	Ventilation Fans, High Efficiency - 36"	0.2061	700	0
4.0742.150	Ventilation Fans, High Efficiency - 42"	0.2399	815	0
4.0748.150	Ventilation Fans, High Efficiency - 48"	0.2737	930	0
4.0750.150	Ventilation Fans, High Efficiency - 50"	0.3053	1,037	0
4.0751.150	Ventilation Fans, High Efficiency - 51"	0.3053	1,037	0
4.0752.150	Ventilation Fans, High Efficiency - 52"	0.3053	1,037	0
4.0754.150	Ventilation Fans, High Efficiency - 54"	0.3053	1,037	0
4.0755.150	Ventilation Fans, High Efficiency - 55"	0.3053	1,037	0
4.0760.150	Ventilation Fans, High Efficiency - 60"	0.3053	1,037	0
4.0772.150	Ventilation Fans, High Efficiency - 72"	0.3053	1,037	0

[153] These measures were formerly called “High Efficiency Ventilation Fans.” The name has been changed to distinguish these measures from a measure the program has introduced for high efficiency agriculture circulation fans.

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

High efficiency exhaust fans replace existing, less efficient exhaust fans. High efficiency fans are able to move an equivalent amount of air with less power. Fan efficiency is a function of all of the components of fan design including fan motors, fan blades, fan drive, housing, shutters, guards, and other accessories.

Savings due ventilation fan installations are described by the following equations:

$$kW_{Savings} = (kW_b - kW_q)(1-TR) + (kW_T)(TR)$$

$$kW_{Savings} = [(kW_b - kW_q)(1-TR) + (kW_T)(TR)](Hours)$$

where:

- Hours = annual fan runtime, deemed 3,397 hours/year
- kW_b = baseline fan power, values in Table 4-94
- kW_q = qualifying fan power, values in Table 4-94
- kW_T = fan power savings due to size transition, values in Table 4-96
- TR = transition rate, values in Table 4-96.

Annual Runtime, Hours. Annual Runtime represents the hours per year that the average fan will operate.

Fan Power, Baseline, kW_b Baseline fan power represents the power drawn by the average replaced fan in kilowatts.

Fan Power, Qualifying, kW_q. Qualifying fan power represents the power drawn by the average high efficiency fan in kilowatts.

Size Transition Power Savings, kW_T. Size Transition Power Savings is the overall reduction in fan power resulting from increasing fan size and reducing the number of fans. A lesser number of large fans more efficiently moves the equivalent amount of air as a greater number of smaller fans.

Transition Rate, TR. Transition Rate is the percent of projects in which many smaller existing fans are replaced with fewer larger fans.

It should be noted that 42" fans do not follow this calculation method, but are given kW and kWh savings values which are an average between 36" and 48" fans.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

Annual Runtime, Hours. Annual Runtime is deemed to be 3,397 hours per year. This value is a weighted average runtime based on the percentage of fans that operate in various barn types at various temperatures. The exhaust fans are typically installed in one of the three barn types, and fans in each barn type are operated for different amounts of time. The barn types and operating conditions are as follows:

- **Free stall barn:** Free stall barns are open or partially enclosed structures. Often a long wall of curtains can be dropped to allow for natural ventilation, though some fan use is required year round. It is standard practice to set 10 percent of fans run to continuously, while 40 percent run during moderate temperatures and 100 percent run during the hottest weather[154].
- **Stall barn:** A stall barn typically has three fans controlled manually and by thermostats. It is assumed that one fan operates at "cold" temperatures, two at "moderate" temperatures, and all three at "hot" temperatures. It is assumed that daily operating hours are 18 hours/day. Deeming documents report that this is based on observed practice.
- **Cross-ventilated barn:** Cross-ventilated barns are enclosed free stall barns that use banks of fans to move air across the width of the barn (not length). They operate similarly to stall barns, with some fans operating continuously.

When initially deemed, the annual runtimes were based on the assumption that 10 percent of fans run in cold weather, 40 percent in moderate weather, and 100 percent in hot weather. For this assumption, cold weather is defined as <50 °F, moderate is 50 to 70 °F, and hot is defined as ≥ 70 °F. A source for this industry recommendation was not provided. TMY2 data was used to determine the number of hours in each weather bin category.[155] These data are summarized in Table 4-90.

Table 4-90. Industry-recommended Fan Operation and TMY2 Data

Bin Category	Definition	Hours	Percentage of Fans Operating
Cold	<50°F	4,577	10%
Moderate	≥ 50°F	2,908	40%
Hot	≥ 70°F	1,275	100%

In a recent review of this measure, secondary sources were found that support these values. A Pacific Northwest Extension paper[156] and one appearing on

[154] It should be noted that 10 percent, 40 percent, and 100 percent of fans run during “cold,” “moderate,” and “hot” temperatures, respectively. In a previous round of deeming, there was confusion on this issue. The text of the spreadsheet and the memo suggested that 10 percent, 30 percent, and 60 percent of fans run during these periods, respectively. This was a misinterpretation of the calculations, which were correct. The 10 percent of fans running during “cold” temperatures will also run during “moderate” and “hot” temperatures, and the 30 percent of fans which come on during “moderate” temperatures will stay on during “hot” temperatures. All fans run during “hot” temperatures.

[155] The location used to generate the TMY2 data is not known.

[156] Moore, Oregon State University. *Pacific Northwest Extension Publication,* “Basic Ventilation Considerations for Livestock or Poultry Housing,” Reprinted June 1993.

milkproduction.com[157] provide ventilation requirements for livestock barns for winter, mild, and summer weather.[158] The ventilation requirements in cubic feet per minute (CFM) can be converted to the percent of maximum airflow by dividing the winter and moderate weather airflow values by the summer values. The CFM requirements and calculated percent of airflow values for each source are presented in Table 4-91 along with the existing assumptions for percent of fans operating.

Table 4-91. Minimum Ventilation Needs and Percent of Airflow

Weather Period	Improving Mechanical Ventilation in Dairy Barns		Basic Ventilation Considerations for Livestock and Poultry		Deemed Percent of Fans Running
	Ventilation Rate (CFM/Cow)	Percent of Air Flow	Ventilation Rate (CFM/Cow)	Percent of Air Flow	
Winter Weather	50	10%	50	11%	10%
Mild Weather	170	34%	170	36%	40%
Summer Weather	500	100%	470	100%	100%

Note that each source provides values that are very close to the deemed assumptions in the rightmost column. These assumptions apply to free-stall barns and cross-ventilated barns. However, since stall barns typically have only three fans, these percentages do not make sense. It is impossible for 10 percent of a three-fan system to be operating. For stall barns, it is assumed that one fan operates in cold weather, two in mild weather, and three in hot weather. Table 4-92 shows the bin hours, percent of fans operating, and operating assumptions for each barn type. The hours for each temperature bin are weighted by the percent of fans operating at those temperatures to determine the average weighted hours.

Table 4-92. Dairy Facility Type Weighted Hours and Assumptions

Dairy Facility Type	Bin Category	Hours	Percent of Fans Operating	Weighted Hours	Assumptions
Stall Barn	Cold and warmer	6,570	33%	4,009	Assumes one fan, 18hours per day
	Moderate and warmer	4,183	33%		Assumes one fan added at 50°F or higher
	Hot	1,275	33%		Assumes one fan added at 70°F or higher
Free Stall /Cross-ventilated Barns	Cold	4,577	10%	2,896	Industry recommended values
	Moderate	2,908	40%		Industry recommended values
	Hot	1,275	100%		Industry recommended values

In order to generate a single annual runtime value, these hours of operation are further weighted based on the market share of each barn type, as shown in Table 4-93. No source is provided for these values, so they are thought to be based on the experience

[157] Chastain, milkproduction.com. "Improving Mechanical Ventilation in Dairy Barns," December 19, 2006, section of website containing article: http://www.milkproduction.com/Library/Articles/Improving_mechanical_ventilation.htm.

[158] The definitions of what constitutes winter, moderate, and summer weather are not provided for the secondary sources.

of program staff. The resulting weighted average of 3,397 hours per year is the deemed annual runtime value.

Table 4-93. Dairy Facility Type Market Share and Average Weighted Hours

Dairy Facility Type	Market Share of Fan Sales	Weighted Hours
Stall Barns	45%	4,009
Free Stall Barns	50%	2,896
Cross Ventilated Barns	5%	2,896
Average Weighted Runtime		**3,397**

Baseline and Qualifying Fan Power, kW_b and kW_q. Baseline and qualifying fan power is based on data provided by the BESS lab performance test data for more than 600 fans.[159] Each test is recorded by manufacturer, nominal fan diameter, cone use, shutter type, and whether the motor is single phase or three-phase.[160] Fans are tested for airflow and ventilating efficiency ratio (VER) at 0.05 and 0.10 inches H_2O static pressure testing conditions. The following equation is used to calculate motor input power:

$$MotorInputkW = \frac{Airflow}{(1{,}000)(VER)}$$

where:

- *Motor Input kW = Motor input power, kilowatts*
- *Airflow = rated fan airflow, CFM*
- *VER = ventilating efficiency ratio, CFM/watt*
- *1,000 = conversion factor, watts per kilowatt.*

The calculation is done using the VER as measured at the 0.10 inches H_2O static pressure test condition. This is based on information on the BESS website that states that 0.10 inches H_2O is representative of typical operating pressures.[161] The value is further supported by an article entitled "Selecting Rated Ventilation Fans" which offers 0.10 or 0.125 inches as the proper design condition.[162]

A VER of 20 CFM per watt is used as the cut-off between high efficiency and normal fans. This is supported by a University of Wisconsin Extension Energy Conservation Article, which provides 20 CFM/W as the recommended high efficiency VER for 36" and

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[159] BESS data downloaded on 7/7/09 from http://bess.illinois.edu/searchResults2.asp.

[160] This analysis used only the single-phase motor dataset. Future updates should consider including the three-phase test results as well.

[161] Section of website that contains this information: http://www.bess.illinois.edu/selcrit.html. Website accessed July 7, 2009.

[162] Wheeler, Agricultural and Biological Engineering, University of Pennsylvania State University. "Selecting Rated Ventilation Fans."

48" fans.[163] Using the BESS data, the average fan input power is calculated for fans with VER greater and lesser than 20 CFM/W. The average of those with VER less than 20 CFM/W represent the baseline fan power and the average of those with VER greater than 20 CFM/W represent the qualifying fan power. The deemed baseline and qualifying fan power values for 36", 48", and ≥ 50" fans are provided in Table 4-94. For the 42" fan measure, the averages of the 36" and 48" kW values are the deemed kW values.

Table 4-94. Qualifying and Baseline Fan kW

Fan Size	kW_q (VER ≥ 20 CFM/W)	kW_b (VER < 20 CFM/W)
36 inch	0.53	0.73
48 inch	1.06	1.30
50 inch+	1.17	1.49

Transition Rate, TR. Transition Rate is deemed to be 25 percent, meaning that it is assumed that one quarter of these measures include replacing a greater number of smaller fans with fewer larger fans. The basis of this value is not known, and is likely based on the experience of program staff.[164]

Size Transition Power Savings, kW_T. Size Transition Power Savings are calculated by the following equation:

$$kW_T = (kW_{b,smaller})(FanRatio) - kW_{q,Larger}$$

where:

- $kW_{b,Smaller}$ *= fan power of the smaller baseline fan, kilowatt*
- $kW_{q,\ Larger}$ *= fan power of the larger qualifying fan kilowatt*
- *Fan Ratio = ratio of the number of baseline fans with smaller diameters needed to create the same airflow as one qualifying fan with larger fan diameter, dimensionless.*

This equation reflects the reality that the smaller fans being replaced are of baseline efficiency and the larger fans being installed are of qualifying efficiency. It is applied to three transition scenarios—36" to 48", 36" to 50+", and 48" to 50+". The fan ratio for each transition scenario is calculated by dividing the average CFM provided by the qualifying larger fans divided by that of the baseline smaller fans. The values used for each replacement scenario and the resulting Size Transition Power Savings are shown in Table 4-95.

[163] Sanford, University of Wisconsin-Extension. *Energy Conservation in Agriculture*, "Ventilation and Cooling Systems for Animal Housing," 2003.

[164] A recent review of this measure suggests that the program collect data on the application that can be used to better determine this value.

Table 4-95. Deemed Transition Power Savings Parameters

Transition	Description	$kW_{b, Smaller}$	$kW_{q, Larger}$	Fan Ratio	kW Savings
T1	from 36" to 48"	0.73	1.06	1.94	0.37
T2	from 36" to 50+"	0.73	1.17	2.22	0.25
T3	from 48" to 50+"	1.30	1.17	1.11	0.28

Since 36” fans are the smallest replacement fan size category, no transition to larger fans or associated transition savings occurs under this measure. The kW_T value for transition T1 above is the deemed value for the 48” fan measure. For the 50+” fan measures, the average of the kW_T values for transition T2 and T3 is the deemed kW_T value. These are reported in Table 4-96.

Table 4-96. Deemed Transition Power Savings and Transition Rates

Fan Size (dia.)	Transition	kW_T	TR
36 inch	N/A	N/A	N/A
48 inch	T1	0.37	25%
50 inch+	Average of T2 & T3	0.27	25%

Substituting the values for each parameter into the savings equation yields the kW and kWh savings reported in Table 4-89.

4.5.2 HVAC Steam Traps

Group: HVAC

Category: Steam Trap

Technology Description: Repair leaking steam trap, building space conditioning system

Tech Code: 4.1000.390

Qualifying Equipment:

- Boiler must be used for space heating, not process applications.
- Repaired traps must be leaking steam, not failed closed or plugged.
- Incentive is available once per year per system.
- Municipal steam systems do not qualify.

With a steam trap survey:

- Repairs should be performed within 9 months of steam trap survey completion.[165]
- A steam trap survey and repair log must be completed. Required information includes a trap ID tag Number, location description, nominal steam pressure, trap type, trap condition (functioning, failed not leaking, failed leaking), and orifice size. A survey form can be found on the Focus web site.[166]

Without a steam trap survey:

- If mass replacement of steam traps occurs without a survey, it is assumed that 30 percent of the replaced traps were leaking, and the incentive is paid for 30 percent of the replaced traps.

Date Deeming Last Modified: December 2009

Date Deemed: May 2008

Summarized by: John Dendy

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[165] The language used is "should," rather than "must," and it is a suggestion, not a requirement.

[166]http://www.focusonenergy.com/files/Document_Management_System/Business_Programs/steamtrapsurveyrepairlog_template.xls.

Table 4-97. HVAC Steam Trap Repair Measure

Tech Code	Measure Description	Deemed Savings (therms per year)
4.1000.390	Repair leaking steam trap, building space conditioning system	910

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Steam traps that fail in the open position allow steam to escape into the condensate lines before the available heat energy can be used for space heating, wasting the energy used to make the steam. By replacing or repairing traps that have failed in the open position, the wasted heat energy can be conserved.

The therms saved by repairing a leaking trap are equal to the therms lost through the leaking trap. The general equation for therm savings through a leaking steam trap is:

$$therm\ savings = Loss\ Rate \times Energy\ Content \times \left(\frac{1}{eff}\right) \times Hr \div 100{,}000$$

where:

- *Loss Rate = discharge rate of steam through the leaking orifice that is 50% of the fully opened orifice, values in Table 4-100, lb/hr*
- *Energy Content = energy content of steam, values in Table 4-99*
- *eff = combustion efficiency of boiler, deemed 80%*
- *Hr = annual hours of trap operation, deemed 2,310 hr for thermostatic traps and 4,972 hr for float and thermostatic traps*
- *100,000 = conversion factor, Btu per therm.*

Derating factor, DF. The derating factor adjusts the maximum trap orifice size to account for partial trap closures or condensate in the orifice, which affects the discharge rate of the steam. The effective orifice size is often not equal to the actual orifice size when fully open. Traps can fail at 100 percent open or at any fraction thereof. The derating factor is measured in percent.

Discharge Rate of Steam, Loss Rate. Discharge rate refers to the rate that steam passes through a given orifice size from a given system pressure to atmospheric pressure. In this calculation, the loss rate includes a derating factor to account for steam traps that fail partially open.

Boiler Efficiency, eff. Boiler efficiency refers to the boiler's combustion efficiency in percent.

Annual hours of operation, Hr. The annual hours of operation correspond to the number of hours per year that the steam trap is exposed to steam. This varies based on the location of the steam trap in the system. Since different types of steam traps are used at different locations within the system, operating hours may also be based on steam trap type.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

Savings for this measure are calculated by first calculating what therm savings would be for a range of orifice sizes, steam pressures, and trap types. Then market share assumptions are used to calculate an average savings across all orifice sizes, steam pressures, and trap types.

i. Parameter Values

Hours of Operation. Hours of operation are deemed to be 2,310 hours for thermostatic traps and 4,972 hours for F&T traps. The values are different because the two trap types are typically installed in different locations in the steam system, and their location determines under what conditions they are exposed to steam.

Hours of operation are calculated assuming that the boiler will operate only on days when the high temperature is below 65 ºF. This accounts for the fact that most commercial, industrial, school, and government buildings have a high internal heat load due to electronic equipment, lighting, and people. These loads help heat the building when the outdoor air temperature is below the internal set point temperature until cooler weather persists. Based on TMY2 data, the average number of days when the high temperature is below 65 ºF is 226 days.

The operating hours for thermostatic traps are controlled by steam system valves upstream from the thermostatic traps. These valves close when the system is not calling for heat. Leakage will only occur when these upstream valves are open. Operating hours of a thermostatic trap are calculated using the equivalent full load hours of a space heating boiler and the following equations:

$$EFLH = \frac{HDD \times 24}{T_{Indoor} - T_{Outdoor}}$$

$$OH = \frac{EFLH}{Boiler\ Operating\ Days}$$

where:

- *EFLH = Equivalent full load operating hours of the boiler, hr/yr*
- *HDD = Heating degree days for Wisconsin, 7,699 degrees F-day*[167]
- *T_{Indoor} = Indoor design temp, assumed to be 65 degrees F*[168]
- *$T_{Outdoor}$ = Outdoor design temp, deemed to be -15 degrees F*[169]

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[167] This HDD value is discussed in Section 3.2.

[168] This is the standard balance temperature in HVAC calculations.

[169] This value is discussed in Section 3.4.

- *OH = Thermostatic Steam Trap Operating Hours per heating day*
- *Boiler Operating Days = 226 days, cited above*
- *24 = conversion factor, hours per day.*

Using the above equations results in 2,310 hours per year for EFLH and 10.2 operating hours per day for a thermostatic steam trap. EFLH can be used to estimate the operating hours of a thermostatic steam trap because the thermostatic steam trap is only exposed to steam when a particular zone is calling for heat, and when it does, it is either on or off. Thus, for any given zone containing a thermostatic steam trap, all operating hours are *full load* operating hours.

The operating hours for F&T traps are based on the hours when the boiler is actually producing steam because these traps generally are not down stream from control valves. During the heating season, the boiler will generally produce steam 24 hours a day. It is possible that the boiler may only operate for partial days in the early and late heating seasons. Therefore, it is assumed that the boilers (and therefore F&T traps) will operate 22 hours per day.[170] Based on 226 days per year, F&T traps will operate 4,972 hours per year. Table 4-98 provides a summary of deemed steam trap operating hours.

Table 4-98. Annual Steam Trap Operating Hours Estimates

Trap Type	Hours
Thermostatic	2,310
Float and Thermostatic	4,972

Boiler Efficiency. Boiler efficiency is deemed to be 80 percent. According to the Natural Gas Boiler Burner Consortium, the typical boiler efficiency will be in the 75 to 85 percent range. The midpoint of that range, 80 percent, agrees with Wisconsin code. Therefore, 80 percent is chosen as the deemed boiler efficiency value.

Energy Content. The latent heat content of steam varies based on the pressure of the steam system. This measure covers low pressure HVAC systems only, which typically operate between five and fifteen pounds per square inch. Latent heat values by steam pressure are taken from steam tables and presented in Table 4-99.

Table 4-99. Energy Content of Steam by Pressure

Steam Pressure (psig)	Latent Heat (Btu/lb)
5	960.1
10	952.1
15	945.3

[170] No specific source is given for this value.

Discharge Rate. The steam leakage rate is dependent on the system pressure and the size of the leaking orifice. Discharge rate is calculated by Grashof's equation,[171] which is:

$$\dot{Q} = (0.7)(0.0165)(3{,}600)(A)\left(p^{0.97}\right)$$

where:

- $\dot{Q}$ = *the flow rate of steam, lb/hr*
- *0.7 = the coefficient of discharge for the hole, dimensionless*
- *A = the area of the hole, in^2*
- *p = pressure inside the line, psia.*

The discharge rates calculated using this equation represent discharge from a fully open, unobstructed orifice. However, according to a federal technology alert,[172] traps can fail open anywhere from one to 100 percent. Also, the presence of condensate at the orifice can reduce discharge rate. The report recommends applying a derating factor of 50 percent to the discharge rate. Discharge rates including the 50 percent derating factor through common orifice sizes are presented in Table 4-100.

Table 4-100. Discharge Rate by Steam Pressure and Orifice Size, Including Derating Factor

	Discharge Rate (lb/hr)		
	Steam Pressure, psig		
Orifice Size	5	10	15
7/32"	14.3	17.7	21.2
1/4"	18.7	23.2	27.6
5/16"	29.2	36.2	43.2

ii. Market Share Data and Calculations

The above parameter values are then used to calculate therm savings for each trap type, steam pressure, and orifice size. Weighted average therm savings are calculated according using market share estimates. All market share estimates are taken from interviews with Tim Thuemling, a steam trap service provider.[173]

[171] Ashley Prins, "Steam Trap Monitoring: Adding Value by Cutting Waste," Mechanical Engineering the Magazine of ASME, edited by Executive Editor Harry Hutchinson, February 2009.

[172] Discharge rates are calculated for these particular orifice sizes based on market share data, presented below.

[173] Phone interview with Tim Thuemling, July 6, 2009, at 11:00 AM. http://www.thuemling.com/. Accessed July 6, 2009. Mr. Thuemling was originally interviewed in 2005. The 2009 interview confirmed that data provided in 2005 was still accurate, and provided some additional information.

According to Mr. Thuemling, the market prevalence of each orifice size by trap type and of each steam pressure are as presented in Table 4-101, Table 4-102, and Table 4-103.

Table 4-101. Thermostatic Steam Trap Prevalence

Orifice Size	Prevalence
7/32"	5%
1/4"	5%
5/16"	90%

Table 4-102. F&T Steam Trap Prevalence

Orifice Size	Prevalence
7/32"	48%
1/4"	47%
5/16"	5%

Table 4-103. Steam System Pressure Prevalence

Pressure (psig)	Prevalence
5	45%
10	45%
15	10%

These data are used to calculate the weighted average therm savings per year for each trap type. For thermostatic traps, Table 4-104 shows the therms saved for each orifice size at 5, 10, and 15 psig and the weighted average savings for each pressure. These results are then weighted by the prevalence of each operating pressure, as shown in Table 4-105. The average energy savings from a thermostatic steam valve are calculated to be 889 therms per year.

Table 4-104. Therms Savings per Year by Repairing Leaking Thermostatic Steam Traps

		Therms Saved per Year		
		Steam Pressure, psig		
Orifice Size	Prevalence	5	10	15
7/32"	5%	396	488	578
1/4"	5%	517	637	755
5/16"	90%	808	995	1,179
Weighted average	**100%**	**773**	**952**	**1,128**

Table 4-105. Therms Savings per Year, Thermostatic Steam Traps Across System Pressures

Steam Pressure	Prevalence	Therm Savings
5	45%	773
10	45%	952
15	10%	1,128
Weighted average	100%	889

The same process is repeated for F&T steam traps. The results of the calculations for F&T traps by orifice size are shown in Table 4-106. Those results were weighted by steam system pressure as seen in Table 4-107. The average energy savings from repairing an F&T steam valve are calculated to be 1,172 therms per year.

Table 4-106. Therms Savings per Year by Repairing Leaking F&T Steam Traps

Orifice Size	Prevalence	Therms Saved per Year Steam Pressure, psig		
		5	10	15
7/32"	48%	852	1,049	1,244
1/4"	47%	1,113	1,371	1,624
5/16"	5%	1,739	2,142	2,538
Weighted average	**100%**	**1,019**	**1,255**	**1,487**

Table 4-107. Therms Savings per Year, F&T Steam Traps Across System Pressures

Steam Pressure	Prevalence	Therm Savings
5	45%	1,019
10	45%	1,255
15	10%	1,487
Weighted average	**100%**	**1,172**

In order to combine the average savings for thermostatic and F&T steam traps into a single deemed value, the market share of each steam trap must be known. Again, Mr. Thueling provided this information, reporting that 90 percent of steam traps are thermostatic and 10 percent are F&T. In addition, he reported that 90 percent of thermostatic traps fail open (leaking) and 66 percent of F&T traps fail open. Since the measure is for replacement of a leaking steam trap, the applicable weighting percentage is not the percent of traps, but the percent of traps that fail open. Therefore, this percentage is calculated, as shown in shown in Table 4-108. The final savings calculation assumes that 92 percent of leaking traps are thermostatic and 8 percent are F&T.

Table 4-108. Trap Type Weighting Factors

Trap Type	Population Percentage	Rate that Fail Open	Population Percentage that Fail Open	Weight
Thermostatic	90%	90%	81%	92%
F&T	10%	66%	7%	8%

Finally, these weighting factors are used to calculated the average therms saved by the measure, using the following equation:

$$Deemed\ Therm\ Savings = Wt_{Thermostatic} \times Therms_{Thermostatic} + Wt_{F\&T} \times Therms_{F\&T}$$

where:

- *$Wt_{Thermostatic}$ = Weight of population of failed open traps that are thermostatic, deemed 92%*
- *$Wt_{F\&T}$ = Weight of population of failed open traps that are F&T, deemed 8%*
- *$Therms_{Thermostatic}$ = weighted average therms saved annually for thermostatic steam traps, 889 therms per year*
- *$Therms_{F\&T}$ = weighted average therms saved annually for thermostatic steam traps, 1,172 therms per year.*

This calculation yields a deemed savings value of 910 therms, as reported in Table 4-97.

4.5.3 Furnace

Group: Furnace

Category: Furnace

Technology Description: Furnace, with ECM fan motor, for space heating

Qualifying Equipment:

- Equipment must be ≥90% Annual Fuel Utilization Efficiency (AFUE) rating and have a sealed combustion unit.
- Furnaces must automatically vary output by using a variable speed (not two-speed or multi-speed) blower motor (ECM/brushless DC motor) and have at least two firing stages. Air handlers are not eligible.
- Furnace incentives are only available for equipment used in space heating applications. Equipment serving process or other loads does not qualify.
- Equipment must appear on the list of pre-qualified models on the Focus web site.[174]

Date Deemed: May 2008

Summarized by: Josh Venden

174 http://www.focusonenergy.com/files/Document_Management_System/Residential_Programs/prequalifiedequipment_productlist.pdf.

Table 4-109. Furnace Measures

WISeerts Tech Code	Measure Description	Deemed Savings kW	kWh	Therms
4.1697.190	Furnace, with ECM fan motor, for space heating (AFUE >= 90%), 54.675 - 60.749 MBh	0	592	182
4.1698.190	Furnace, with ECM fan motor, for space heating (AFUE >= 90%), 60.750 - 67.499 MBh	0	658	203
4.1699.190	Furnace, with ECM fan motor, for space heating (AFUE >= 90%), 67.5 - 74.9 MBh	0	731	225
4.1701.190	Furnace, with ECM fan motor, for space heating (AFUE >= 90%), 75.0 - 82.5 MBh	0	808	249
4.1702.190	Furnace, with ECM fan motor, for space heating (AFUE >= 90%), 82.5 - 90.75 MBh	0	889	274
4.1703.190	Furnace, with ECM fan motor, for space heating (AFUE >= 90%), 90.76 - 99.82 MBh	0	978	301
4.1704.190	Furnace, with ECM fan motor, for space heating (AFUE >= 90%), 99.83 - 109.8 MBh	0	1,076	331
4.1705.190	Furnace, with ECM fan motor, for space heating (AFUE >= 90%), 109.9 - 120.7 MBh	0	1,184	364
4.1706.190	Furnace, with ECM fan motor, for space heating (AFUE >= 90%), 120.8 - 132.9 MBh	0	1,302	401
4.1707.190	Furnace, with ECM fan motor, for space heating (AFUE >= 90%), 133.0 - 146.1 MBh	0	1,432	441
4.1708.190	Furnace, with ECM fan motor, for space heating (AFUE >= 90%), 146.2 - 160.8 MBh	0	1,575	485

A. SAVINGS BASIS, EQUATIONS AND PARAMETERS

High efficiency furnaces use less fuel than standard furnaces to produce the same amount of heat, yielding therm savings. High efficiency furnaces also make use of more efficient ECM fan motors, yielding kWh savings. There are no kW savings associated with this measure, since furnaces used for space heat do not operate during the peak period.

Therm savings are calculated by finding the difference in energy consumptions between standard efficiency furnaces and high efficiency furnaces. Electric savings are estimated by multiplying the consumption of the efficient furnace in therms by a kWh/therm savings factor.

Annual savings are described by the following equations:

$$therm\ Savings = \left(\frac{80\% \times BTU}{\Delta T}\right) \times \left(\frac{1}{AFUE_{standard}} - \frac{1}{AFUE_{eff}}\right) \times HDD \times \left(\frac{1}{100{,}000}\right) \times 24$$

$$kWh\ Savings = (kWh/therm) \times \left(\frac{80\% \times BTU}{\Delta T}\right) \times \left(\frac{1}{AFUE_{eff}}\right) \times HDD \times \left(\frac{1}{100{,}000}\right) \times 24$$

where:

- *BTU = output capacity of furnace, values in Table 4-110.*

- *ΔT = heating design temperature difference, deemed 80 ºF.*
- *$AFUE_{standard}$= efficiency rating of standard efficiency furnace, deemed 78 percent.*
- *$AFUE_{eff}$= efficiency rating of high efficiency furnace, deemed 90 percent.*
- *HDD = number of heating degree days, deemed 7,699.*
- *80% = percent of furnace output capacity assumed to represent building heating load.*[175]
- *100,000 = conversion factor, Btu per therm*
- *24 = number of hours in 1 day.*
- *kWh/therm = high efficiency electric savings factor, deemed 0.5 kWh/therm.*

Output Capacity, BTU. Output capacity is the maximum amount of heat the furnace is designed to deliver, in Btu/hr.

Heating Design Temperature Difference, ΔT. The design temperature difference is equal to the indoor temperature minus the outside design temperature. The indoor temperature is represented by the base temperature used to determine HDD. The design temperature is the coldest temperature at which the heating equipment is designed to meet building heat loss, disregarding equipment oversizing.

Furnace Efficiencies, $AFUE_{standard}$ and $AFUE_{eff}$. These variables refer to the Annual Fuel Utilization Efficiency (AFUE) of the standard and high efficiency furnaces, respectively.

Heating Degree Days, HDD. Heating Degree Days is the sum of the number of degrees that the average daily temperature is less than a base temperature over a given time period. For these calculations, HDD is the population-weighted statewide average normal annual HDD for Wisconsin.

High Efficiency Electric Savings Factor, kWh/therm. The high efficiency electric savings factor is an estimate of the kWh savings realized per therm of input capacity due to the ECM fan motor.

B. VALUES, ASSUMPTIONS AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Output Capacity, BTU. Each deemed furnace measure is defined by a range of furnace output capacities in Btu/hr. The midpoint of each range is used in the savings calculation for all furnaces with output capacities in that range.

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[175] Furnace burners are often over-sized for the building heating load as they are packaged with air handlers that are typically sized for building cooling loads. For this savings calculation, the actual building heating load was assumed to be 80 percent of the furnace output capacity.

Heating Design Temperature Difference, ΔT. The indoor temperature is the base temperature, 65 ºF. The outdoor temperature used in this analysis is -15 ºF. This is based on a population weighted average for the state of Wisconsin, and is discussed in Section 3.4 of this report. The resulting ΔT is 80 ºF.

Furnace Efficiencies, $AFUE_{standard}$. The AFUE of the standard efficiency furnace is deemed to be 78 percent. This is equal to the minimum efficiency required by code.

Furnace Efficiencies, $AFUE_{eff}$. The AFUE of the high efficiency furnace is deemed to be 90 percent. This is equal to the qualifying efficiency for this measure and provides a conservative estimate of energy savings.

Heating Degree Days, HDD. The average annual normal heating degree days for Wisconsin are 7,699. The calculation used to determine this value is discussed in Section 3.2 above of this report.

High Efficiency Electric Savings Factor, kWh/therm. The high efficiency electric savings factor is deemed at 0.5 kWh per therm input capacity. This is based on field studies conducted by the Energy Center of Wisconsin as presented in the trade publication *Wisconsin Perspective.*[176] The article presents findings that show that in heating mode, an ECM motor consumes about half the energy of a standard motor: 0.5 kWh/therm rather than 1 kWh/therm, yielding savings of 0.5 kWh/therm. These studies were done in the residential market and were determined to be applicable to these measures because the furnaces covered by the measures are small, residential-sized furnaces.

Table 4-110 shows the output ranges for each furnace measure, the mid-point output capacity range used in the savings calculation, the annual energy consumption in therms for standard and high efficiency furnaces, and the resulting therm savings. Annual kWh savings for high efficiency furnaces are shown. Savings values are equal to the deemed savings presented in Table 4-109.

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[176] Source: Pigg, Scott. “Variable-speed Furnaces Come of Age.” November/December 2004. Wisconsin Perspective, pp. 38-42. Brookfield, Wis.

Table 4-110. Furnace Energy Consumption and Savings

Furnace Output Capacity Range (MBh)	Midpoint Output Capacity (Btu/h)	Standard Furnace Consumption (therm)	High Efficiency Furnace Consumption (therm)	Annual Therm Savings (therm)	kWh Savings
54.675 - 60.749	57,712	1,367	1,185	182	592
60.750 - 67.499	64,125	1,519	1,317	203	658
67.500 - 74.900	71,250	1,688	1,463	225	731
75.000 - 82.500	78,750	1,866	1,617	249	808
82.500 - 90.750	86,626	2,052	1,778	274	889
90.760 - 99.820	95,288	2,257	1,956	301	978
99.830 - 109.800	104,817	2,483	2,152	331	1,076
109.900 - 120.700	115,298	2,731	2,367	364	1,184
120.800 - 132.900	126,828	3,004	2,604	401	1,302
133.000 - 146.100	139,511	3,305	2,864	441	1,432
146.200 - 160.800	153,462	3,635	3,151	485	1,575

4.5.4 A/C Split System < 65MBh

Group: HVAC

Category: Rooftop Unit/Split System A/C

Technology Description: A/C Split System < 65MBh, SEER 14, 15, 16, or greater.

Qualifying Equipment:

- 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.[177]
- Both the condenser and evaporator coils must be replaced. Refrigerant line diameters must meet manufacturer specifications.
- Mini-split / ductless systems and air-source heat pumps that meet these efficiencies also qualify.

Date Deemed: October 2006

Summarized by: Josh Venden

Table 4-111. A/C Split System <65MBTU/hr Measures

WISeerts Tech Code	Measure Description	Deemed Savings		
		kW	kWh	Therms
4.3530.365	A/C Split System < 65 MBh SEER 14	0.4810	255	0
4.3540.365	A/C Split System < 65 MBh SEER 15	0.7090	387	0
4.3550.365	A/C Split System < 65 MBh SEER 16 or greater	0.9090	502	0

A. SAVINGS BASIS, EQUATIONS AND PARAMETERS

A split-system air conditioner has a compressor and condenser located outside of the building and an evaporator mounted inside in an air handler or blower inside the building. 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 refrigerant charge and airflow (RCA). Proper adjustment of the RCA results in more efficient

[177] www.ahridirectory.org.

operation. Installation by a qualified contractor and regular servicing are required to maintain proper RCA.

Savings are described by the following equations:

$$kW = ton \times \left(\frac{12}{SEER_{qualifying}} - \frac{12}{SEER_{baseline}} \right) + RCA_{kW}$$

$$kWh = ton \times \left(\frac{CDD \times 24}{\Delta T} \right) \times \left(\frac{12}{SEER_{qualifying}} - \frac{12}{SEER_{baseline}} \right) + RCA_{kWh}$$

where:

- *$SEER_{qualifying}$ = seasonal energy efficiency ratio of the qualifying unit, deemed 14, 15, or 16, depending on measure.*
- *$SEER_{baseline}$ = seasonal energy efficiency ratio of the baseline unit, deemed 13.*
- *ton = Cooling capacity of the air conditioner in tons, deemed 4 tons.*
- *CDD = number of Cooling Degree Days, deemed 535.*
- *12 = conversion factor based on the definition of EER, converts EER to kW/ton*
- *24 = number of hours in a day.*
- *ΔT = design temperature difference, deemed 22.3 ºF.*
- *RCA_{kW} = kW savings for properly adjusted RCA, deemed 0.217 kW.*
- *RCA_{kWh} = kWh savings for properly adjusted RCA, deemed 103 kWh.*

Seasonal Energy Efficiency Ratios, $SEER_{baseline}$ and $SEER_{qualifying}$. SEER is a rating of air conditioner efficiency calculated by dividing the BTU of cooling output during a typical cooling season by the total electric energy input in watt-hours during the same period. In this calculation, $SEER_{baseline}$ is a single value based on code and $SEER_{qualifying}$ varies by measure.

Cooling Capacity, ton. The cooling capacity of an air conditioner is the amount of heat that can be removed by the unit. One ton of cooling is equivalent to 12,000 BTU/hr. In this calculation, it represents the assumed average cooling capacity of an air conditioner installed using this measure.

Cooling Degree Days, CDD. Cooling Degree Days is the sum of the number of degrees that the average daily temperature is greater than a base temperature over a given time period. In this calculation, CDD is a population-weighted statewide average normal annual CDD for Wisconsin.

Design Temperature Difference, ΔT. The design temperature difference is the difference between the outdoor design temperature and indoor temperature. The indoor temperature is represented by the base temperature used to determine CDD. The outdoor design temperature is the warmest temperature at which the cooling equipment is designed to meet the cooling load, disregarding equipment over sizing.

Refrigerant Charge and Airflow, RCA_{kW} and RCA_{kWh}. These are the kW and kWh savings resulting from achieving proper RCA.

B. VALUES, ASSUMPTIONS AND CALCULATIONS

The following values were assumed for the calculation input parameters:

$SEER_{baseline.}$ The SEER value assumed for the baseline unit is 13. This is reported in the deeming spreadsheet to based on 2005 EPACT or other federal code.[178]

$SEER_{qualifying}$. The SEER value for each measure is assumed to be the lowest qualifying SEER value covered by that measure. So, SEER 14 is assumed for units between SEER 14 and 15, SEER 15 is assumed for those between 15 and 16, and SEER 16 is assumed for those greater than or equal to 16.

Cooling Capacity, ton. The savings calculation approximates the cooling capacity of each unit installed under this measure by calculating the average cooling capacity of units covered by the measure. For Split-Systems less than 65 MBTU/hr the sizes range from 18,000 BTU/hr to 65,000 BTU/hr and the average output capacity is approximately 41,500 BTU/hr. This is equivalent to 3.5 tons. For the calculation, this value is rounded up to an assumed size of 4 tons.

ΔT, Design Temperature Difference. The design temperature difference is equal to the indoor temperature minus the outside design temperature. The indoor temperature is represented by the base temperature used to calculate CDD, or 65°F. The outdoor temperature used in this analysis is 87.3 ºF. This is based on an average of state code design temperatures for 6 major cities in Wisconsin, and is discussed in Section 3.5 above of this report. The resulting ΔT is 22.3 ºF.

CDD, Cooling Degree Day). The population weighted 30 yr average Cooling Degree Days in Wisconsin is 535.[179] The calculation used to determine this value is discussed in Section 3.3 of this report.

RCA_{kW} and RCA_{kWh}, Refrigerant Charge and Airflow Savings. For this analysis, deemed RCA savings values of 0.217 kW and 103 kWh were assumed for all SEER ratings. No specific source is given for these values in the deeming calculation. Further investigation is necessary to verify the source of these values.

Using the values presented above, demand and consumption are calculated for 4-ton units with a SEER of 13, 14, 15, and 16. SEER 13 is the baseline unit. Savings resulting from installing a unit with greater SEER are presented below in Table 4-112. These are the savings associated only with the efficiency improvement, disregarding RCA savings.

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[178] A more specific citation is not available.

[179] Source: 2005 Wisconsin Energy Statistics, Wisconsin Department of Energy.

Table 4-112. Annual Energy Consumption and Savings for Efficiency Improvement

SEER Rating	Energy Consumption		Efficiency Savings	
	kW	kWh	kW	kWh
13 (baseline)	3.692	2,130	n/a	n/a
14	3.429	1,978	0.264	152
15	3.200	1,846	0.492	284
16 and greater	3.000	1,731	0.692	399

Total savings are equal to the sum of the energy savings due to efficiency improvement shown above and the RCA savings. The following table shows the efficiency savings, RCA savings and total savings by SEER rating. The total savings are equal to the deemed savings shown in Table 4-111.

Table 4-113. Total Savings by SEER Rating

SEER Rating	Efficiency Savings		RCA Savings		Total Savings	
	kW	kWh	kW	kWh	kW	kWh
14	0.2637	152	0.217	103	0.4807	255
15	0.4923	284	0.217	103	0.7093	387
16 and greater	0.6923	399	0.217	103	0.9093	502

4.5.5 Packaged Terminal Units

Group: HVAC

Category: Packaged Terminal Units

Technology Description: Packaged Terminal Air Conditioners and Packaged Terminal Heat Pumps, new or retrofit

Qualifying Equipment:

- Window air conditioners are not eligible.
- Packaged Terminal Heat Pumps (PTHP) must meet both heating and cooling specifications.
- Packaged Terminal Air-Conditioner (PTAC) and PTHP eligibility is based on information in the Air-Conditioning, Heating and Refrigeration Institute (AHRI) database.[180]

Date Deemed: May 2008

Summarized by: Josh Venden

Table 4-114. Packaged Terminal A/C and Heat Pump Measures

WISeerts Tech Code	Measure Description	Deemed Savings		
		kW	kWh	Therms
4.3805.295	PTAC, <8000 Btuh, >=12.1 EER, Retrofit Application	0.1188	105	0
4.3806.295	PTAC, <8000 Btuh, >=12.1 EER, New Construction	0.0478	42	0
4.3810.295	PTAC, 8000 - 9999 Btuh, >=11.5 EER, Retrofit Application	0.1052	93	0
4.3811.295	PTAC, 8000 - 9999 Btuh, >=11.5 EER, New Construction	0.0549	49	0
4.3815.295	PTAC, 10000-12999 Btuh, >=10.9 EER, Retrofit Application	0.2083	185	0
4.3816.295	PTAC, 10000-12999 Btuh, >=10.9 EER, New Construction	0.0719	64	0
4.3820.295	PTAC, >=13000 Btuh, >=9.8 EER, Retrofit Application	0.2770	246	0
4.3821.295	PTAC, >=13000 Btuh, >=9.8 EER, New Construction	0.0657	58	0
4.3822.295	PTHP, <8000 Btuh, >=12.1 EER, Retrofit Application	0.0710	1,652	0
4.3823.295	PTHP, <8000 Btuh, >=12.1 EER, New Construction	0.0641	1,646	0
4.3824.295	PTHP, 8000 - 9999 Btuh, >=11.5 EER, Retrofit Application	0.1307	2,098	0
4.3825.295	PTHP, 8000 - 9999 Btuh, >=11.5 EER, New Construction	0.0582	2,033	0
4.3826.295	PTHP, 10000-12999 Btuh, >=10.9 EER, Retrofit Application	0.2408	2,847	0
4.3827.295	PTHP, 10000-12999 Btuh, >=10.9 EER, New Construction	0.0989	2,722	0
4.3830.295	PTHP, >=13000 Btuh, >=9.8 EER, Retrofit Application	0.2853	3,471	0
4.3831.295	PTHP, >=13000 Btuh, >=9.8 EER, New Construction	0.0863	3,294	0

[180] www.ahridirectory.org

A. SAVINGS BASIS, EQUATIONS AND PARAMETERS

Packaged Terminal Air-Conditioners (PTAC) and Packaged Terminal Heat Pumps (PTHP) are self-contained air conditioning and heating units like those typically found in hotel rooms and apartment buildings. Many are designed to be installed through a wall with vents and heat sinks both inside and outside of the building.

Cooling energy savings result from installing PTAC's or PTHP's with a minimum Energy Efficiency Ratio (EER) that is greater than a standard unit on the market. Measures are categorized by nominal system capacity, minimum EER, and application (new or retrofit).

Heating energy savings for PTHP's result from replacing electric resistance heat with a more efficient heat pump for part of the annual heating load. PTHP's heat buildings by using the refrigeration process in reverse. The heat pump operates when the outside temperature is warm enough to allow the heat pump to extract heat from the outside air to heat the inside space. Backup electric resistance heaters operate only when the outside temperature is too low for the heat pump to meet the heating load.

Total annual energy savings are the sum of cooling savings and heating savings, when applicable.

i. COOLING MODE SAVINGS

Cooling savings for PTAC's and PTHP's are calculated by finding the difference between the energy consumption of baseline and qualifying equipment. Savings for cooling mode PTAC's and PTHP's are described by the following equations:

$$kW = ton * \left(\frac{12}{EER_{baseline}} - \frac{12}{EER_{qualifying}} \right) * DC$$

$$kWh = ton * \left(\frac{12}{EER_{baseline}} - \frac{12}{EER_{qualifying}} \right) * \left(\frac{CDD * 24}{\Delta T_C} \right)$$

where:

- *$EER_{qualifying}$ = energy efficiency ratio of the qualifying unit, values in Table 4-117*
- *$EER_{baseline}$ = energy efficiency ratio of the baseline unit, values in Table 4-117*
- *ton = Cooling capacity of the air-conditioner in tons, values in Table 4-118*
- *CDD = number of Cooling Degree Days, deemed 535*
- *ΔT_C = cooling design temperature difference, deemed 22.3 ºF*
- *DC = Duty Cycle of PTAC or PTHP, deemed 65 percent*
- *24 = number of hours in a day.*
- *12 = conversion factor based on the definition of EER, converts EER to kW/ton*

Energy Efficiency Ratios, $EER_{baseline}$ and $EER_{qualifying}$. EER is a rating of air conditioner efficiency calculated by dividing the cooling output in thousand Btu per hour by the rated electrical input in kW. In this calculation, $EER_{baseline}$ is the minimum EER required by Wisconsin code, which is based on whether the unit is installed in new construction or as a retrofit. $EER_{qualifying}$ is the average EER of the installed unit.

Cooling Capacity, ton. The cooling capacity of an air conditioner is the amount of heat that can be removed by the unit. In this calculation, it represents the average cooling capacity of an air conditioner installed under each measure.

Cooling Degree Days, CDD. Cooling Degree Days is the sum of the number of degrees that the average daily temperature is greater than a base temperature over a given time period. In this calculation, CDD is a population-weighted statewide average normal annual CDD for Wisconsin.

Cooling Design Temperature Difference, ΔT_C. The cooling design temperature difference is the difference between the outdoor cooling design temperature and indoor temperature. The indoor temperature is represented by the base temperature used to determine CDD. The design temperature is the warmest temperature at which the cooling equipment is designed to meet the cooling load, disregarding equipment over sizing.

Duty Cycle, DC. Duty Cycle is the fraction of time during the peak period that the air conditioner compressor is operating.

ii. HEATING MODE SAVINGS (PTHP only)

Heating savings result from replacing electric resistance heaters with the more efficient heat pump for part of the heating load. Electric resistance heaters still operate when conditions are such that the heat pump cannot meet the heating load.

Total heating savings for PTHP's are described by the following equation:

$$kWh = \left(\frac{HC \times HDD \times 24}{\Delta T_H \times 3{,}413} \right) - \left(\left(\frac{HC \times HDD \times 24}{\Delta T_H \times 3{,}413} \right) \times \left(BU\% + \frac{(1 - BU\%)}{COP} \right) \right)$$

where:

- *HC = heating capacity in BTU/hr*
- *HDD = number of Heating Degree Days, deemed 7,699*
- *ΔT_H = design temperature difference for heating, deemed 85 ºF.*
- *COP = Coefficient of Performance for heat pump, values in Table 4-117*
- *24 = number of hours in a day*
- *BU% = percent of heating load that is provided by backup resistance heaters, calculated 44.8 percent.*
- *3,413 = conversion factor, Btu per kWh*

Heating Capacity, HC. The Heating Capacity is the average rated capacity of all installed units expressed in terms of BTU/hr.

Heating Degree Days, HDD. Heating Degree Days is the sum of the number of degrees that the average daily temperature is less than a base temperature over a given time period. For these calculations, HDD is the population-weighted statewide average normal annual HDD for Wisconsin.

Heating Design Temperature Difference, ΔT_H. The design temperature difference is the difference between the outdoor heating design temperature and a base temperature.[181]

Backup Percent, BU%. The backup percent is the fraction of the heating load that the heat pump cannot meet by extracting heat energy from the outside air. It is the fraction of the heating load that is met by resistance heat.

Coefficient of Performance, COP. The coefficient of performance is a measure of the efficiency of a heat pump and is equal the ratio of the amount of heat energy provided to the building or room to the amount of energy consumed by the heat pump. In this calculation, COP is based on minimum state code, which is different for new construction and retrofit installations.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

Several parameters used in these savings calculations are based on data obtained from the Air-conditioning, Heating, and Refrigeration Institute (AHRI) database. AHRI provides data for capacity and efficiency for PTAC's and PTHP's on the market. Parameter values that are determined from this data in the savings calculation include the EER of qualifying PTAC's, the cooling capacity of PTAC's, and the design load (heating capacity) of PTHP's. Each of these and all other parameter values are discussed below.

$EER_{baseline}$. Baseline energy efficiency is based on the Wisconsin Energy Code that went into effect March 2008. This portion of the code is equivalent to IECC 2006. Code EER values are different for new construction and retrofit applications, and are listed based on unit capacity where capacity is in Btu per hour. The code expressions are shown in Table 4-115.

Table 4-115. Baseline EER Expressions

Installation	Baseline EER
PTAC New Construction	12.5 - (0.213 x Capacity/1000)
PTAC Retrofit	10.9 - (0.213 x Capacity/1000)
PTHP New Construction	12.3 - (0.213 x Capacity/1000)
PTHP Retrofit	10.8 - (0.213 x Capacity/1000)

[181] The base temperature for the heating calculation is 70 ºF, based on an assumed standard thermostat set-point temperature. No specific source was given for this number.

For some of the measures, the baseline EER calculated according to code is actually lower than the minimum EER available on the market, according to AHRI data. For these measures, the calculated baseline efficiency was replaced with the minimum available on the market. Baseline EER values appear in Table 4-117. The values for which the minimum market value is used rather than the calculated value appear in bold.

$EER_{qualifying}$. The qualifying EER value for each measure is the average of AHRI data for qualifying units within each nominal system capacity category. Values appear in Table 4-117.

Coefficient of Performance, COP. The COP for each PTHP measure is based on the Wisconsin Energy Code that went into effect March 2008. This portion of the code is equivalent to IECC 2006. COP equations are different for new construction and retrofit applications, and are based on capacity where capacity has units of Btu per hour. Expressions for COP are shown in Table 4-116, with values reported in Table 4-117.

Table 4-116. COP Expressions

Installation	Baseline COP
PTHP New Construction	3.2 - (0.026 * Capacity/1000)
PTHP Retrofit	2.9 - (0.026 * Capacity/1000)

Again, values that appear in bold are based on lowest available COP on the market according to AHRI data, rather than the calculated value based on code.

Table 4-117. Baseline and Qualifying EER and COP

Equipment Category	Baseline		Average Qualifying	
	EER	COP	EER	COP
PTAC, <8000 Btuh, >=12.1 EER Retrofit Application	**9.40**	n/a	12.40	n/a
PTAC, <8000 Btuh, >=12.1 EER New Construction	10.99	n/a	12.40	n/a
PTAC, 8000 - 9999 Btuh, >=11.5 EER Retrofit Application	**9.70**	n/a	11.75	n/a
PTAC, 8000 - 9999 Btuh, >=11.5 EER New Construction	10.58	n/a	11.75	n/a
PTAC, 10000-12999 Btuh, >=10.9 EER Retrofit Application	**8.50**	n/a	11.20	n/a
PTAC, 10000-12999 Btuh, >=10.9 EER New Construction	10.09	n/a	11.20	n/a
PTAC, >=13000 Btuh, >=9.8 EER Retrofit Application	7.76	n/a	10.00	n/a
PTAC, >=13000 Btuh, >=9.8 EER New Construction	9.36	n/a	10.00	n/a
PTHP, <8000 Btuh, >=12.1 EER Retrofit Application	**10.60**	**3.10**	12.63	3.57
PTHP, <8000 Btuh, >=12.1 EER New Construction	10.77	**3.10**	12.63	3.57
PTHP, 8000 - 9999 Btuh, >=11.5 EER Retrofit Application	**9.20**	**2.70**	11.58	3.29
PTHP, 8000 - 9999 Btuh, >=11.5 EER New Construction	10.38	2.99	11.58	3.29
PTHP, 10000-12999 Btuh, >=10.9 EER Retrofit Application	8.29	2.62	11.20	3.28

Equipment Category	Baseline		Average Qualifying	
	EER	COP	EER	COP
PTHP, 10000-12999 Btuh, >=10.9 EER New Construction	9.79	2.92	11.20	3.28
PTHP, >=13000 Btuh, >=9.8 EER Retrofit Application	7.71	2.55	10.06	3.16
PTHP, >=13000 Btuh, >=9.8 EER New Construction	9.21	2.85	10.06	3.16

Duty Cycle, DC. Not all of the units will be on during peak conditions due to compressor cycling and some rooms being unoccupied with thermostats set back. A duty cycle of 65 percent was included to account for this. No specific source was given for this percent reduction in peak load operation.

Cooling Capacity, ton. The average cooling capacity for all installed units is estimated by calculating the average cooling capacity of some of the units in the AHRI database within each size range.[182] The average cooling capacity values used in the savings equation are shown in Table 4-118.

Heating Capacity, HC. The average heating design load for all installed units is estimated by calculating the average heating design load of some of the units in the AHRI database within each size range.[183] Average heating capacities assumed for this savings calculation are shown in Table 4-118.

Table 4-118. Average Cooling and Heating Capacities

Equipment Category	Average Cooling Capacity (tons)	Average Heating Capacity (BTU/hr)
PTAC, <8000 Btuh, >=12.1 EER	0.592	n/a
PTAC, 8000 - 9999 Btuh, >=11.5 EER	0.75	n/a
PTAC, 10000-12999 Btuh, >=10.9 EER	0.942	n/a
PTAC, >=13000 Btuh, >=9.8 EER	1.229	n/a
PTHP, <8000 Btuh, >=12.1 EER	0.6	6,274
PTHP, 8000 - 9999 Btuh, >=11.5 EER	0.75	8,093
PTHP, 10000-12999 Btuh, >=10.9 EER	0.983	10,770
PTHP, >=13000 Btuh, >=9.8 EER	1.208	13,381

[182] In the case of PTACs, the average capacity used is the simple average of the maximum and minimum unit capacities in each size range, not the average of all of the units in the range. For PTHP's, the average used appear to be neither the average of the maximum and minimum values in the range, nor the average of all capacities in the range. Deeming documentation refers to using a sample of AHRI data, but the sample used is not known.

[183] Like some cooling capacities, the heating design load average value does not appear to be a straight average of all AHRI equipment, nor an average of the minimum and maximum values. The average values used are very close to these other averages, and may be based on a subset of the AHRI population provided in the savings calculation spreadsheet.

Cooling Degree Days, CDD. This calculation uses the program's population-weighted statewide average normal annual CDD value of 535. This value is discussed in Section 3.3 of this report.

Heating Degree Days, HDD. This calculation uses the program's standard population-weighted statewide average normal annual HDD value of 7,669. See Section 3.2 for a discussion of the development of this value.

Cooling Design Temperature Difference, ΔT_C. The cooling design temperature difference is the difference between the outdoor cooling design temperature and indoor temperature. The indoor temperature is the same as the base temperature for HDD calculations, 65 ºF. The outdoor temperature used in this analysis is 87.3 ºF. As discussed in Section 3.5 of this report, this is based on an average of state code design temperatures for 6 major cities in Wisconsin. The resulting ΔT_C is 22.3 ºF.

Heating Design Temperature Difference, ΔT_H. The indoor temperature in this calculation is based on the assumed thermostat set-point temperature of 70 ºF.[184] The outdoor temperature used in this analysis is -15 ºF. As discussed in Section 3.4 of this report, this is based on a population weighted average for the state of Wisconsin. The resulting ΔT_H is 85 ºF.

Backup Percent, BU%. The backup percent was determined through a temperature bin analysis that calculates the heat energy required to meet the heating load and the heat energy a heat pump can produce at varying outside temperatures.[185] The total annual heating load was calculated as 16,617,620 BTU. The amount of heat the average heat pump is able to provide was calculated as 9,178,442 BTU, or 55.2 percent of the total. This means that backup heating must run 44.8 percent of the time during the heating season.

i. Cooling Savings

Using the cooling savings equation and values above, cooling savings are calculated for each measure. Cooling savings appear in Table 4-119.

Table 4-119. Cooling Savings by Measure

Measure Description	Cooling Savings	
	kW	kWh
PTAC, <8000 Btuh, >=12.1 EER, Retrofit Application	0.1188	105
PTAC, <8000 Btuh, >=12.1 EER, New Construction	0.0478	42
PTAC, 8000 - 9999 Btuh, >=11.5 EER, Retrofit Application	0.1052	93
PTAC, 8000 - 9999 Btuh, >=11.5 EER, New Construction	0.0549	49
PTAC, 10000-12999 Btuh, >=10.9 EER, Retrofit Application	0.2083	185
PTAC, 10000-12999 Btuh, >=10.9 EER, New Construction	0.0719	64

[184] Note that this 70 °F value is different than the base temperature of 65 °F used in the HDD value calculation.

[185] The back up heating percentage supporting calculation is based on 2004 ASHRAE Handbook – HVAC Systems and Equipment and 1980 Systems, ASHRAE Handbook and Product Directory.

Measure Description	Cooling Savings	
	kW	kWh
PTAC, >=13000 Btuh, >=9.8 EER, Retrofit Application	0.2770	246
PTAC, >=13000 Btuh, >=9.8 EER, New Construction	0.0657	58
PTHP, <8000 Btuh, >=12.1 EER, Retrofit Application	0.0710	63
PTHP, <8000 Btuh, >=12.1 EER, New Construction	0.0641	57
PTHP, 8000 - 9999 Btuh, >=11.5 EER, Retrofit Application	0.1307	116
PTHP, 8000 - 9999 Btuh, >=11.5 EER, New Construction	0.0582	52
PTHP, 10000-12999 Btuh, >=10.9 EER, Retrofit Application	0.2408	214
PTHP, 10000-12999 Btuh, >=10.9 EER, New Construction	0.0989	88
PTHP, >=13000 Btuh, >=9.8 EER, Retrofit Application	0.2853	253
PTHP, >=13000 Btuh, >=9.8 EER, New Construction	0.0863	77

ii. Heating Savings

The baseline case for heating savings is 100 percent electric resistance heat. The qualifying case is a PTHP, for which part of the heat load is met by the heat pump, and the remainder is met by electric resistance heat. The difference between these consumptions is equal to heating savings. The following table shows baseline consumption and that of a PTHP, which is the sum of heat pump consumption and backup electric resistance heat consumption. The PTHP heating consumption is subtracted from the baseline consumption to yield heating savings.

Table 4-120. Heating Consumptions and Savings

Equipment Category	Baseline Consumption (kWh)	PTHP Consumption			Heating Savings (kWh)
		Heat Pump (kWh)	Backup Resistance Heater (kWh)	Total Heating Consumption (kWh)	
1/2 ton, >=12.1 EER	3,996	618	1,789	2,407	1,589
3/4 ton, >=11.5 EER	5,155	865	2,308	3,173	1,982
1 ton, >=10.9 EER	6,860	1,155	3,071	4,226	2,634
1 1/4 ton, >=9.8 EER	8,523	1,490	3,815	5,305	3,218

The total measure savings shown in Table 26 above are found by adding the cooling savings in Table 4-119 and heating savings in Table 4-120.

4.5.6 Guest Room Energy Management Controls

Group: HVAC

Category: Controls

Technology Description: Guest Room Energy Management Controls

Qualifying Equipment:

- Must be installed at a lodging business.
- New Guest Room Control installations only. Re-built or used equipment does not qualify.
- The incentive is for occupancy-based guest room energy management controls.
- Occupancy control may be key-activated or sensed due to motion or body heat and must control the HVAC system serving the room. “Front Desk Only” controls are not included in this incentive offering.
- The deemed calculation is only for rooms conditioned by PTAC units with electric resistance heat. Incentives are available for controls on other types of units, but the savings from these are calculated using another method.

Date Deemed: April 2007

Summarized by: Josh Venden

Table 4-121. Guest Room Energy Management Measures

WISeerts Tech Code	Measure Description	Deemed Savings		
		kW	kWh	Therms
4.5000.085	Guest Room Energy Management Controls - Electric heat PTAC systems only	0.1000	1,507	0

A. SAVINGS BASIS, EQUATIONS AND PARAMETERS

Guest room energy management controls use sensors to determine when a room is unoccupied and adjust the HVAC system operations accordingly. When guests return, the system readjusts to meet guest comfort requirements. In short, guest room energy management controls reduce the energy wasted by heating and cooling unoccupied rooms. Savings values are per room controlled.

The kW savings for this measure are based on metering, rather than on a savings equation.

The kWh savings are equal to the sum of heating and cooling energy consumption multiplied by a savings factor, and are described by the following equation:

$$kWh = \left(\frac{DL \times OLF \times HDD \times 24 \times HCF}{\Delta T_H \times 3{,}413} + \left(\frac{DL \times OLF \times CDD \times 24}{\Delta T_c \times 12{,}000} \times \frac{12}{EER} \right) \right) \times GREM$$

where:

- *DL = design load in BTU/hr*
- *HDD = number of heating degree days, deemed 7,501*
- *CDD = number of cooling degree days, deemed 582*
- *ΔT_H = design temperature difference for heating, deemed 76 ºF*
- *ΔT_C = design temperature difference for cooling, deemed 17 ºF*
- *HCF = Heating Correction Factor, deemed 0.75*
- *OLF = Oversized factor for design load, deemed 85 percent*
- *EER = Energy efficiency ratio for air conditioner*
- *12,000 = conversion factor, Btu per ton*
- *12 = conversion factor based on the definition of EER, converts EER to kW/ton*
- *GREM = percent reduction in energy consumption due to use of Guest Room Energy Management, deemed 30 percent*
- *24 = number of hours in a day.*
- *3,413 = conversion factor, BTU per kWh.*

Design Load, DL. Design load in this calculation refers to the nominal unit cooling capacity in tons.

Oversized Loading Factor, OLF. OLF is a correction factor that accounts for over-sized equipment.

Energy Efficiency Ratio, EER. EER is a rating of air conditioner efficiency equivalent to the cooling output in Btu per hour divided by the rated electrical input of the unit in kW.

Heating Degree Days, HDD. Heating Degree Days is the sum of the number of degrees that the average daily temperature is less than a base temperature over a given time period. For this calculation, HDD is the statewide average normal annual HDD for Wisconsin.

Cooling Degree Days, CDD. Cooling Degree Days is the sum of the number of degrees that the average daily temperature is greater than a base temperature over a given time period. In this calculation, CDD is represents the average normal annual CDD for Wisconsin..

Heating Design Temperature Difference, ΔT_H. The heating design temperature difference is the difference between the outdoor heating design temperature and a base temperature.

Cooling Design Temperature Difference, ΔT_C. The cooling design temperature difference is the difference between the outdoor cooling design temperature and a base temperature.

Heating Correction Factor, HCF. Heating correction factor is not defined in the deemed savings documentation. It appears to be a factor that estimates the unit heating capacity based on the unit cooling capacity.

Energy Reduction Factor, GREM. The energy reduction factor is the average reduction in total energy consumption realized by using Guest Room Energy Management controls.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The deemed savings estimate starts with a calculation of the energy savings for three common unit capacities—9,000, 12,000, and 15,000 Btu/hr units. Then, the final savings estimate is calculated based on a weighted average of savings values, according to the market share of the different unit sizes. Market share percentages are 80 percent for ¾ ton units, 15 percent for 1 ton units and 5 percent for 1 ¼ ton units. No specific source is given for the market share percentages.

The following values were assumed for the calculation input parameters:

Design Load, DL. The savings calculation accounts for three common sizes of PTAC units used in the guest rooms of hotels— 9,000, 12,000, and 15,000 Btu/hr.

Oversized Loading Factor, OLF. The oversized loading factor is deemed to be 85 percent. This reflects the reality that most heating and cooling units are oversized for their application. No specific source is given for this value.

Energy Efficiency Ratio, EER. Energy Efficiency Ratios are provided for the three common unit capacities considered in this calculation. EER's are 9.7 for 9,000 Btu/hr units, 9.35 for 12,000 Btu/hr units and 9 for 15,000 Btu/hr units. No specific source is given for these values.

CDD (Cooling Degree Days). The average annual Cooling Degree Days in Wisconsin used in this calculation was 582. No specific source was given for this value.[186]

HDD (Heating Degree Days). The average annual Heating Degree Days in Wisconsin used in this calculation was 7,501. No specific source was given for this value.[187]

Cooling Design Temperature Difference, ΔT_C. The balance temperature chosen for this calculation is 70 ºF. The outdoor temperature used in this analysis is 87 ºF. The resulting ΔT_C is 17 ºF. No specific source was given for these values.

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[186] This value is greater than the value of 535 CDD used in other deemed savings calculations.

[187] Note that this value is less than the value of 7,699 HDD used in other deemed savings calculations.

Heating Design Temperature Difference, ΔT_H. The balance temperature chosen for this calculation is 70 ºF. The outdoor temperature used in this analysis is -6 ºF. The resulting ΔT_H is 76 ºF. No specific source was given for these values.

Heating Correction Factor, HCF. The heating correction factor is assumed to be 0.75 for this calculation.[188] No specific source given for this correction factor, but from the form of the equation it appears to be the ratio of heating capacity to cooling capacity.

Cooling Correction Factor, CCF. Cooling correction factor is assumed to be 1.0 for this calculation. No specific source given for this correction factor.

Energy Reduction Factor, GREM. For this calculation the reduction in energy consumption when using Guest Room Energy Management controls is assumed to be 30 percent. The deemed savings documentation reports that this value is based on previous installations and measurement & verification results, but no other specific source is provided.

Table 4-122 shows the EER, market share, and energy consumption values for the three unit capacities typically installed in hotel guest rooms. Deemed kWh savings for the measure are equal to a weighted average of these savings values based on the market shares given for each unit. This weighted average is the deemed kWh savings value shown in Table 4-121.

Table 4-122. Guest Room Heating and Cooling Calculation Input Parameters

			Annual Energy Consumption (kWh)			
Capacity (Btu/H)	EER	Market Share	Cooling	Heating	Total	Savings (kWh)
9,000	9.7	80%	648	3,982	4,630	1,389
12,000	9.35	15%	896	5,309	6,206	1,862
15,000	9	5%	1,164	6,637	7,801	2,340
					Weighted Average Savings	1507

In addition to these kWh savings, kW savings per guest room are deemed 0.1 kW. This is reported to be based on a Focus on Energy Measurement & Verification study done at a hotel in Fond du Lac, Wisconsin.

[188] The savings calculation spreadsheet refers to this term as “correction factor”, and uses 0.75 for heating and 1.0 for cooling. Since the cooling correction factor is 1.0, it has no effect on the calculation, and so was eliminated from the savings equation in this discussion. Also, for the same reasons, we surmise that the 0.75 heating factor is the assumed ratio of heating capacity to cooling capacity.

4.5.7 Rooftop A/C

Group: HVAC

Category: Rooftop Unit/Split System A/C

Technology Description: Rooftop Air Conditioners

Qualifying Equipment:

- Equipment must meet the nominal efficiency level based on the size category. Bonus incentives are granted for equipment exceeding the minimum required efficiency.
- Eligibility is based on information in the AHRI database[189] or manufacturer specification if >= 240 MBh.

Date Deemed: May 2008

Summarized by: Josh Venden

Table 4-123. Rooftop A/C Measures

WISeerts Tech Code	Measure Description	Deemed Savings (per ton)		
		kW	kWh	Therms
4.5110.365	Rooftop A/C, <65 MBh, EER = 11.6	0.0220	16	0
4.5111.365	Rooftop A/C, <65 MBh, EER = 11.7	0.0290	21	0
4.5112.365	Rooftop A/C, <65 MBh, EER = 11.8	0.0360	26	0
4.5113.365	Rooftop A/C, <65 MBh, EER = 11.9	0.0423	31	0
4.5114.365	Rooftop A/C, <65 MBh, EER = 12.0	0.0496	36	0
4.5115.365	Rooftop A/C, <65 MBh, EER = 12.1	0.0562	41	0
4.5116.365	Rooftop A/C, <65 MBh, EER = 12.2	0.0627	45	0
4.5117.365	Rooftop A/C, <65 MBh, EER = 12.3	0.0691	50	0
4.5118.365	Rooftop A/C, <65 MBh, EER = 12.4	0.0753	54	0
4.5119.365	Rooftop A/C, <65 MBh, EER = 12.5	0.0816	59	0
4.5120.365	Rooftop A/C, <65 MBh, EER = 12.6	0.0877	63	0
4.5121.365	Rooftop A/C, <65 MBh, EER = 12.7	0.0937	68	0
4.5122.365	Rooftop A/C, <65 MBh, EER = 12.8	0.0996	72	0
4.5123.365	Rooftop A/C, <65 MBh, EER = 12.9	0.1054	76	0
4.5124.365	Rooftop A/C, <65 MBh, EER = 13.0	0.1111	80	0
4.5125.365	Rooftop A/C, <65 MBh, EER = 13.1	0.1167	84	0
4.5126.365	Rooftop A/C, 65 to 134 MBh, EER = 11.5	0.0973	70	0
4.5127.365	Rooftop A/C, 65 to 134 MBh, EER = 11.6	0.1045	75	0
4.5128.365	Rooftop A/C, 65 to 134 MBh, EER = 11.7	0.1115	80	0
4.5129.365	Rooftop A/C, 65 to 134 MBh, EER = 11.8	0.1185	85	0
4.5130.365	Rooftop A/C, 65 to 134 MBh, EER = 11.9	0.1253	90	0
4.5131.365	Rooftop A/C, 65 to 134 MBh, EER = 12.0	0.1320	95	0

[189] www.ahridirectory.org.

WISeerts Tech Code	Measure Description	Deemed Savings (per ton)		
		kW	kWh	Therms
4.5132.365	Rooftop A/C, 65 to 134 MBh, EER = 12.1	0.1387	100	0
4.5133.365	Rooftop A/C, 65 to 134 MBh, EER = 12.2	0.1452	105	0
4.5134.365	Rooftop A/C, 65 to 134 MBh, EER = 12.3	0.1516	109	0
4.5135.365	Rooftop A/C, 65 to 134 MBh, EER = 12.4	0.1578	114	0
4.5136.365	Rooftop A/C, 65 to 134 MBh, EER = 12.5	0.1640	118	0
4.5137.365	Rooftop A/C, 65 to 134 MBh, EER = 12.6	0.1701	123	0
4.5138.365	Rooftop A/C, 65 to 134 MBh, EER = 12.7	0.1761	127	0
4.5139.365	Rooftop A/C, 65 to 134 MBh, EER = 12.8	0.1820	131	0
4.5140.365	Rooftop A/C, 65 to 134 MBh, EER = 12.9	0.1879	135	0
4.5141.365	Rooftop A/C, 65 to 134 MBh, EER = 13.0	0.1936	140	0
4.5142.365	Rooftop A/C, 65 to 134 MBh, EER = 13.1	0.1992	144	0
4.5143.365	Rooftop A/C, 65 to 134 MBh, EER = 13.2	0.2048	148	0
4.5144.365	Rooftop A/C, 135 to 239 MBh, EER = 11.5	0.1549	112	0
4.5145.365	Rooftop A/C, 135 to 239 MBh, EER = 11.6	0.1621	117	0
4.5146.365	Rooftop A/C, 135 to 239 MBh, EER = 11.7	0.1692	122	0
4.5147.365	Rooftop A/C, 135 to 239 MBh, EER = 11.8	0.1761	127	0
4.5148.365	Rooftop A/C, 135 to 239 MBh, EER = 11.9	0.1830	132	0
4.5149.365	Rooftop A/C, 135 to 239 MBh, EER = 12.0	0.1897	137	0
4.5150.365	Rooftop A/C, 135 to 239 MBh, EER = 12.1	0.1963	142	0
4.5151.365	Rooftop A/C, 135 to 239 MBh, EER = 12.2	0.2028	146	0
4.5152.365	Rooftop A/C, 135 to 239 MBh, EER = 12.3	0.2092	151	0
4.5153.365	Rooftop A/C, 135 to 239 MBh, EER = 12.4	0.2155	155	0
4.5154.365	Rooftop A/C, 135 to 239 MBh, EER = 12.5	0.2217	160	0
4.5155.365	Rooftop A/C, 135 to 239 MBh, EER = 12.6	0.2278	164	0
4.5156.365	Rooftop A/C, 135 to 239 MBh, EER = 12.7	0.2338	169	0
4.5157.365	Rooftop A/C, 135 to 239 MBh, EER = 12.8	0.2397	173	0
4.5158.365	Rooftop A/C, 135 to 239 MBh, EER = 12.9	0.2455	177	0
4.5159.365	Rooftop A/C, 135 to 239 MBh, EER = 13.0	0.2512	181	0
4.5160.365	Rooftop A/C, 240 to 759 MBh, EER = 10.5	0.0962	69	0
4.5161.365	Rooftop A/C, 240 to 759 MBh, EER = 10.6	0.1049	76	0
4.5162.365	Rooftop A/C, 240 to 759 MBh, EER = 10.7	0.1133	82	0
4.5163.365	Rooftop A/C, 240 to 759 MBh, EER = 10.8	0.1216	88	0
4.5164.365	Rooftop A/C, 240 to 759 MBh, EER = 10.9	0.1298	94	0
4.5165.365	Rooftop A/C, 240 to 759 MBh, EER = 11.0	0.1378	99	0
4.5166.365	Rooftop A/C, 240 to 759 MBh, EER = 11.1	0.1457	105	0
4.5167.365	Rooftop A/C, 240 to 759 MBh, EER = 11.2	0.1534	111	0
4.5168.365	Rooftop A/C, 240 to 759 MBh, EER = 11.3	0.1610	116	0
4.5169.365	Rooftop A/C, 240 to 759 MBh, EER = 11.4	0.1684	121	0
4.5170.365	Rooftop A/C, 240 to 759 MBh, EER = 11.5	0.1757	127	0
4.5171.365	Rooftop A/C, 240 to 759 MBh, EER = 11.6	0.1829	132	0
4.5172.365	Rooftop A/C, 240 to 759 MBh, EER = 11.7	0.1900	137	0
4.5173.365	Rooftop A/C, 240 to 759 MBh, EER = 11.8	0.1970	142	0
4.5174.365	Rooftop A/C, 240 to 759 MBh, EER = 11.9	0.2038	147	0
4.5175.365	Rooftop A/C, 240 to 759 MBh, EER = 12.0	0.2105	152	0

A. SAVINGS BASIS, EQUATIONS AND PARAMETERS

Energy savings result from the installation of a rooftop unit that has a higher efficiency than the standard found on the market. Savings are expressed per ton of cooling, with tons of cooling taken from the incentive application.

Total savings per ton of cooling are described by the following equations:

$$kW\ Savings\ per\ ton = \left(\frac{12}{EER_{baseline}} - \frac{12}{EER_{qualifying}} \right) \times DC$$

$$kWh\ Savings\ per\ ton = \left(\frac{12}{EER_{baseline}} - \frac{12}{EER_{qualifying}} \right) \times \left(\frac{CDD \times 24}{\Delta T} \right)$$

where:

- *$EER_{qualifying}$ = energy efficiency ratio of the qualifying unit, defined by measure, values in Table 4-125.*
- *$EER_{baseline}$ = energy efficiency ratio of baseline equipment, values in Table 4-124.*
- *12 = conversion factor, kW/ton per EER*
- *CDD = number of Cooling Degree Days, deemed 535.*
- *ΔT = cooling design temperature difference, deemed 22.3 ºF.*
- *DC = peak period duty cycle of rooftop units, deemed 80 percent.*
- *24 = number of hours in a day.*

Energy Efficiency Ratios, $EER_{baseline}$ and $EER_{qualifying}$. EER is a rating of air conditioner efficiency equivalent to the cooling output in thousand Btu per hour divided by the rated electrical input in kW. In this calculation, *$EER_{baseline}$* is the minimum EER required by Wisconsin code. The $EER_{qualifying}$ value varies by unit size and is defined in each measure.

Cooling Degree Days, *CDD.* Cooling Degree Days is the sum of the number of degrees that the average daily temperature is greater than a base temperature over a given time period. In this calculation, CDD is a population-weighted statewide average normal annual CDD for Wisconsin.

Cooling Design Temperature Difference, ΔT. The cooling design temperature difference is the difference between the outdoor design temperature and indoor temperature. The indoor temperature is represented by the base temperature used to determine CDD. The design temperature is the warmest temperature at which the cooling equipment is designed to meet the cooling load, disregarding equipment over sizing.

Duty Cycle, DC. Duty Cycle is the fraction of the time during the peak period that the air conditioner compressor is operating.

B. VALUES, ASSUMPTIONS AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Baseline Energy Efficiency Ratio, $EER_{baseline.}$ Baseline energy efficiency is based on the Wisconsin Energy Code that went into effect in March of 2008. This portion of the code is equivalent to IECC 2006 for units of 65 MBtuh or greater. The Wisconsin code efficiency for units less than 65 MBtuh is higher than the IECC standard. Table 4-124 shows the baseline EER for the four different size categories covered by this measure.

Table 4-124. Baseline EER for Rooftop A/C by Size Category

Equipment Capacity (MBtu/hr)	Baseline EER
< 65	11.3
65 to 134	10.3
135 to 239	9.7
240 to 759	9.5

Qualifying Energy Efficiency Ratio, $EER_{qualifying.}$ The qualifying EER value varies by unit size and is defined in each measure. The value used in the calculation is the value listed in the measure definition.

Cooling Design Temperature Difference, ΔT. The cooling design temperature difference is equal to the indoor temperature minus the outside design temperature. The indoor temperature is represented by the base temperature used to calculate CDD, or 65°F. The outdoor temperature used in this analysis is 87.3 ºF. This is based on an average of state code design temperatures for 6 major cities in Wisconsin, and is discussed in Section 3.5 of this report. The resulting ΔT is 22.3 ºF.

CDD (Cooling Degree Days). This calculation uses the program's population-weighted statewide average normal annual CDD value of 535. This value is discussed in Section 3.3 of this report.

DC (Duty Cycle). This calculation assumes that the air conditioner compressor is operating for 80 percent of the time during the peak period. This value is reported to be based on a PG&E Advice Filing. A more specific reference is not provided.

Table 4-125 shows the kW/ton for baseline and qualifying units and the difference between these values The difference is equal to the parenthetical expression in the savings equations. Substituting this difference and other parameter values into the savings equations yields the deemed kW/ton and kWh/ton savings values found in Table 4-123. These results are multiplied by the capacity of the installed unit from the application (in tons) to yield actual kW and kWh savings.

Table 4-125. Baseline and Qualifying kW/ton

Equipment	Baseline (kW/ton)	Qualifying (kW/ton)	Difference (kW/ton)
Rooftop A/C, <65 MBh, EER = 11.6	1.0619	1.0345	0.0275
Rooftop A/C, <65 MBh, EER = 11.7	1.0619	1.0256	0.0363
Rooftop A/C, <65 MBh, EER = 11.8	1.0619	1.0169	0.0450
Rooftop A/C, <65 MBh, EER = 11.9	1.0619	1.0084	0.0535
Rooftop A/C, <65 MBh, EER = 12.0	1.0619	1.0000	0.0619
Rooftop A/C, <65 MBh, EER = 12.1	1.0619	0.9917	0.0702
Rooftop A/C, <65 MBh, EER = 12.2	1.0619	0.9836	0.0783
Rooftop A/C, <65 MBh, EER = 12.3	1.0619	0.9756	0.0863
Rooftop A/C, <65 MBh, EER = 12.4	1.0619	0.9677	0.0942
Rooftop A/C, <65 MBh, EER = 12.5	1.0619	0.9600	0.1019
Rooftop A/C, <65 MBh, EER = 12.6	1.0619	0.9524	0.1096
Rooftop A/C, <65 MBh, EER = 12.7	1.0619	0.9449	0.1171
Rooftop A/C, <65 MBh, EER = 12.8	1.0619	0.9375	0.1244
Rooftop A/C, <65 MBh, EER = 12.9	1.0619	0.9302	0.1317
Rooftop A/C, <65 MBh, EER = 13.0	1.0619	0.9231	0.1389
Rooftop A/C, <65 MBh, EER = 13.1	1.0619	0.9160	0.1459
Rooftop A/C, 65 to 134 MBh, EER = 11.5	1.1650	1.0435	0.1216
Rooftop A/C, 65 to 134 MBh, EER = 11.6	1.1650	1.0345	0.1306
Rooftop A/C, 65 to 134 MBh, EER = 11.7	1.1650	1.0256	0.1394
Rooftop A/C, 65 to 134 MBh, EER = 11.8	1.1650	1.0169	0.1481
Rooftop A/C, 65 to 134 MBh, EER = 11.9	1.1650	1.0084	0.1566
Rooftop A/C, 65 to 134 MBh, EER = 12.0	1.1650	1.0000	0.1650
Rooftop A/C, 65 to 134 MBh, EER = 12.1	1.1650	0.9917	0.1733
Rooftop A/C, 65 to 134 MBh, EER = 12.2	1.1650	0.9836	0.1814
Rooftop A/C, 65 to 134 MBh, EER = 12.3	1.1650	0.9756	0.1894
Rooftop A/C, 65 to 134 MBh, EER = 12.4	1.1650	0.9677	0.1973
Rooftop A/C, 65 to 134 MBh, EER = 12.5	1.1650	0.9600	0.2050
Rooftop A/C, 65 to 134 MBh, EER = 12.6	1.1650	0.9524	0.2127
Rooftop A/C, 65 to 134 MBh, EER = 12.7	1.1650	0.9449	0.2202
Rooftop A/C, 65 to 134 MBh, EER = 12.8	1.1650	0.9375	0.2275
Rooftop A/C, 65 to 134 MBh, EER = 12.9	1.1650	0.9302	0.2348
Rooftop A/C, 65 to 134 MBh, EER = 13.0	1.1650	0.9231	0.2420
Rooftop A/C, 65 to 134 MBh, EER = 13.1	1.1650	0.9160	0.2490
Rooftop A/C, 65 to 134 MBh, EER = 13.2	1.1650	0.9091	0.2560
Rooftop A/C, 135 to 239 MBh, EER = 11.5	1.2371	1.0435	0.1936
Rooftop A/C, 135 to 239 MBh, EER = 11.6	1.2371	1.0345	0.2026
Rooftop A/C, 135 to 239 MBh, EER = 11.7	1.2371	1.0256	0.2115
Rooftop A/C, 135 to 239 MBh, EER = 11.8	1.2371	1.0169	0.2202
Rooftop A/C, 135 to 239 MBh, EER = 11.9	1.2371	1.0084	0.2287
Rooftop A/C, 135 to 239 MBh, EER = 12.0	1.2371	1.0000	0.2371
Rooftop A/C, 135 to 239 MBh, EER = 12.1	1.2371	0.9917	0.2454
Rooftop A/C, 135 to 239 MBh, EER = 12.2	1.2371	0.9836	0.2535
Rooftop A/C, 135 to 239 MBh, EER = 12.3	1.2371	0.9756	0.2615
Rooftop A/C, 135 to 239 MBh, EER = 12.4	1.2371	0.9677	0.2694
Rooftop A/C, 135 to 239 MBh, EER = 12.5	1.2371	0.9600	0.2771
Rooftop A/C, 135 to 239 MBh, EER = 12.6	1.2371	0.9524	0.2847
Rooftop A/C, 135 to 239 MBh, EER = 12.7	1.2371	0.9449	0.2922

Equipment	Baseline (kW/ton)	Qualifying (kW/ton)	Difference (kW/ton)
Rooftop A/C, 135 to 239 MBh, EER = 12.8	1.2371	0.9375	0.2996
Rooftop A/C, 135 to 239 MBh, EER = 12.9	1.2371	0.9302	0.3069
Rooftop A/C, 135 to 239 MBh, EER = 13.0	1.2371	0.9231	0.3140
Rooftop A/C, 240 to 759 MBh, EER = 10.5	1.2632	1.1429	0.1203
Rooftop A/C, 240 to 759 MBh, EER = 10.6	1.2632	1.1321	0.1311
Rooftop A/C, 240 to 759 MBh, EER = 10.7	1.2632	1.1215	0.1417
Rooftop A/C, 240 to 759 MBh, EER = 10.8	1.2632	1.1111	0.1520
Rooftop A/C, 240 to 759 MBh, EER = 10.9	1.2632	1.1009	0.1622
Rooftop A/C, 240 to 759 MBh, EER = 11.0	1.2632	1.0909	0.1722
Rooftop A/C, 240 to 759 MBh, EER = 11.1	1.2632	1.0811	0.1821
Rooftop A/C, 240 to 759 MBh, EER = 11.2	1.2632	1.0714	0.1917
Rooftop A/C, 240 to 759 MBh, EER = 11.3	1.2632	1.0619	0.2012
Rooftop A/C, 240 to 759 MBh, EER = 11.4	1.2632	1.0526	0.2105
Rooftop A/C, 240 to 759 MBh, EER = 11.5	1.2632	1.0435	0.2197
Rooftop A/C, 240 to 759 MBh, EER = 11.6	1.2632	1.0345	0.2287
Rooftop A/C, 240 to 759 MBh, EER = 11.7	1.2632	1.0256	0.2375
Rooftop A/C, 240 to 759 MBh, EER = 11.8	1.2632	1.0169	0.2462
Rooftop A/C, 240 to 759 MBh, EER = 11.9	1.2632	1.0084	0.2548
Rooftop A/C, 240 to 759 MBh, EER = 12.0	1.2632	1.0000	0.2632

4.6 PROCESS

The Process section contains one technology, outlined in Table 4-126.

Table 4-126. Deemed Savings Manual Entry, Process

Group Description	Manual Entry
Process	Extraction Plate for Repulper Motor

4.6.1 Extraction Plate

Group: Process

Category: Specialty Pulp & Paper

Technology Description: Extraction Plate for Repulper Rotor

Qualifying Equipment:

- This incentive is available for the installation of an energy efficient extraction plate in an installation that is **not** under machine application.

Date Deemed: May 2008

Summarized by: Josh Venden

Table 4-127. Extractor Plate for Repulper Rotor Measure

WISeerts Tech Code	Measure Description	Deemed Savings		
		kW	kWh	Therms
5.2010.360	Extraction plate for repulper rotor	0	0	0

A. SAVINGS BASIS, EQUATIONS AND PARAMETERS

Paper mills use a considerable amount of energy re-constituting dried pulp bales, the raw materials for paper production, by using a repulper rotor and extraction plate. Actual energy savings are realized through the use of a more efficient repulper rotor.

The Focus on Energy program does not claim any energy savings for installation of extractor plates because they do not save energy. However, installing an extractor plate is necessary before installing an energy efficient repulper rotor in specific applications; therefore, the program offers a prescriptive incentive for this measure.

4.7 DOMESTIC HOT WATER

The Domestic Hot Water (DHW) section contains the technologies outlined in Table 4-128.

Table 4-128. Deemed Savings Manual Entries, DHW

Group Description	Manual Entry
Domestic Hot Water	Showerhead
	Aeration
	Pre-rinse Sprayer

4.7.1 Showerheads

Group: Domestic Hot Water

Category: Showerheads

Technology Description: Low-flow Showerhead

Qualifying Equipment:

- Showerheads with a flow rate ≤ 1.75 gallons per minute.

Date Deemed: November 2008

Summarized by: Josh Venden

Table 4-129. Showerhead Measures

WISeerts Tech Code	Measure Description	Deemed Savings		
		kW	kWh	Therms
6.0498.380	Showerhead, <=1.75gpm, natural gas - direct install (S&G Only)	0	0	86
6.0499.380	Showerhead, <=1.75gpm, electric - direct install (S&G Only)	0	2,148	0
6.0500.380	Showerhead, <=1.75gpm, natural gas - direct install (Commercial Only)	0	0	27
6.0510.380	Showerhead, <=1.75gpm, electric - direct install (Commercial Only)	0	682	0

A. SAVINGS BASIS, EQUATIONS AND PARAMETERS

Savings result from replacing standard showerheads with newer low-flow showerheads. This reduces hot water consumption, which reduces the amount of energy used to heat water. Savings are determined using the sensible heat equation and the difference in the annual gallons of water consumed. kWh savings are realized for electric water heaters and therm savings are realized for gas water heaters.

For natural gas water heaters, the savings equation is:

$$Therm\ Savings = (GPM_{old} - GPM_{new}) \times HPY \times 60 \times \left(\frac{\Delta T \times 8.33 \times C_{water}}{eff_{gas} \times 100{,}000} \right)$$

For electric water heaters, the savings equation is:

$$kWh\ Savings = (GPM_{old} - GPM_{new}) \times HPY \times 60 \times \left(\frac{\Delta T \times 8.33 \times C_{water}}{eff_{electric} \times 3{,}413} \right)$$

where:

- *GPM_{old} = volumetric flow rate of old higher-flow showerhead in gallons per minute, deemed 3.115 gpm.*

- *GPM_{new} = volumetric flow rate of new low-flow showerhead in gallons per minute, deemed 1.75 gpm.*
- *HPY = annual operating hours per showerhead, deemed 149.33 hours/yr for the Schools and Government sector and 47.45 hours/yr for the Commercial sector.*
- *ΔT = temperature difference between water entering the water heater and the blended water temperature at use, deemed 60 ºF.*
- *C_{water} = Specific heat of water, 1 Btu/lb_m-°F*
- *eff_{gas} = system efficiency with natural gas water heater, deemed 71 percent.*
- *$eff_{electric}$ = system efficiency with electric water heater, deemed 83 percent.*
- *60 = number of minutes in one hour.*
- *8.33 = density of water in pounds per gallon.*
- *100,000 = conversion factor, Btu per therm.*
- *3,413 = conversion factor, Btu per kWh.*

Gallons per Minute, GPM_{old} and GPM_{new}. These variables refer to the nominal volumetric flow rates of the existing showerheads and the new low-flow showerheads, respectively.

Annual Hours of Operation, HPY. Annual hours of operation is the average hours of use per showerhead per year and is assumed to be the same for both the old and new case.

Temperature Difference, ΔT. In this calculation, the temperature difference used is the difference between the temperature of the water entering the water heater and that of the water at the shower head.

Water Heater Efficiency, eff_{gas} and $eff_{electric}$. In this calculation, the efficiency is that of the water heater delivery system, including distribution losses. System efficiencies are determined in part by whether the water heater is gas or electric.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

Flow rate of existing showerhead, GPM_{old}. The flow rate assumed for the standard, existing showerhead is 3.115 gpm. This is based on a weighted average of flow rates taken from the 2003 ASHRAE Applications Handbook for different showerhead sizes. Flow rates are reported as 2.5 gpm for small showerheads, 4.5 gpm for medium, and 6 gpm for large.[190] To determine the average flow rate, the calculation assumes that 73 percent of shower heads are small, 22 percent are medium, and 5 percent are large. No source is cited for these weighting factors.

Flow rate of replacement showerhead, GPM_{new} Qualifying shower heads must have a flow rate of less than or equal to 1.75 gpm. This maximum allowable flow rate is used in the savings calculations.

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[190] 2003 ASHRAE Applications Handbook, p. 49.15.

Annual Hours of Operation, HPY. The annual hours of operation are calculated based on assumed values for shower duration, operating days, and showers per day per showerhead. Values are deemed based on sector. The Schools and Government value is based on assumptions for dormitories, and the Commercial value is based on assumptions for motels.[191] The assumed values for these variables are reported inTable 4-130.

Table 4-130. Shower Use Assumptions by Installation

Parameter	Dormitory	Motel
Days per year	224	237
Minutes per shower	8	8
Showers per day	5	1.5
Hours of Operation	149.33	47.45

The average shower is assumed to be 8 minutes long based on two sources. The Alliance for Water Efficiency offers that the average shower length is 8.2 minutes, and *Residential End Uses of Water* reports 8 minutes per shower.[192]

For dormitories, it is assumed that each showerhead is used five times per day for two sixteen week semesters. These values yield an Annual Hours of Operation value of 149.33 for dormitories. This value is used for the Schools and Government sector.

For motels, it is assumed that the average occupancy rate is 65 percent, yielding 237 occupied days per year.[193] It is further assumed that the average number of people per room is 1.5. Several sources are cited in deeming documentation for this value.[194] Taken together, the annual hours of operation for showers in motels is 47.45 hours per year. This value is used for the Commercial sector.

Temperature Difference, ΔT. The assumed supply water temperature is 50 ºF. This is based on typical average ground water temperature in Wisconsin.[195] The average water

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[191] This does not mean that the measures are limited to dormitories and motels. Rather, these installations are used to represent all installations in their sector.

[192] Mayer et al. http://www.osti.gov/bridge/servlets/purl/862083-6hqkCN/862083.PDF.

[193] Hotel Online Special Report: "Even As U.S. Hotel Occupancy Rates Decline, Average Daily Room Rates Rise." 9/2/1998 http://www.hotel-online.com/News/PressReleases1998_3rd/Sept98_PriceWaterhouse.html.

[194] http://www.hotelexecutive.com/bus_rev/pub/002/448.asp. http://www.hrm.uh.edu/docs/lpmi%20archives/1999.05.htm.

http://cd1.edb.hkedcity.net/cd/pshe/edtt2/public_html/cgi-bin/encyc.asp?word=D.

[195] Interview with Manus McDevitt, P.E. Principal (ground source heat pump system designer). Sustainable Engineering Group, LLC. Madison, WI. 2008.

temperature at the showerhead was assumed to be 110 ºF.[196] These assumptions result in the deemed temperature difference of 60 °F.

Water Heater Efficiency, eff_{gas} and $eff_{electric}$. The efficiency of natural gas and electric water heaters is based on average commercial water heater data taken from the Gas Appliance Manufacturers Association (GAMA).[197] Average efficiencies are calculated as 83.3 percent for gas water heaters and 98.1 percent for electric.

The efficiencies are further reduced by 15 percent to account for distribution losses. This value is based on a source that claims that home distribution efficiencies can be as low as 61 percent.[198] Deeming documentation indicates that 15 percent was chosen as a conservative and "more typical" estimate. Multiplying the average efficiencies by 85 percent yields the deemed system efficiencies of 71 percent for systems with gas water heaters and 83 percent for those with electric water heaters.

The following table shows values for the input parameters for the equations and the resulting energy savings, which are the same as those shown in Table 4-131.

Table 4-131. Input Parameters and Total Savings

Installation	Water Heater Type	Flow Rate Difference (gpm)	Annual Operating Hours	System Efficiency	Total Savings
Dormitory	Natural Gas	1.365	149.33	71%	86 therms
	Electric	1.365	149.33	83%	2,148 kWh
Motel	Natural Gas	1.365	47.45	71%	27 therms
	Electric	1.365	47.45	83%	682 kWh

196 2003 ASHRAE Applications Handbook. P 49.8, Table 2.

197 GAMA has merged with AHRI. Their current commercial water heater database may be found at: http://cafs.ahrinet.org/gama_cafs/sdpsearch/search.jsp?table=CWH.

198 "Studies indicate that hot water distribution efficiency can be as low as 61 percent for a typical home with piping in the attic." http://www.eere.energy.gov/buildings/building_america/rh_0704_home_improve.html.

4.7.2 Low Flow Faucet Aerators

Group: Domestic Hot Water

Category: Aeration

Technology Description: Low Flow Faucet Aerators

Qualifying Equipment:

- No specifications are made regarding qualifying equipment.

Date Deemed: November 2008

Summarized by: Josh Venden

Table 4-132. Low Flow Faucet Aerator Measures

WISeerts Tech Code	Measure Description	Deemed Savings		
		kW	kWh	Therms
6.0900.005	Low Flow Faucet Aerators, Direct Install, Natural Gas (Commercial Only)	0	0	8
6.0910.005	Low Flow Faucet Aerators, Direct Install, Electric (Commercial Only)	0	187	0
6.0913.005	Low Flow Faucet Aerators, Direct Install, Natural Gas (S&G Only)	0	0	36
6.0914.005	Low Flow Faucet Aerators, Direct Install, Electric (S&G Only)	0	885	0
6.0920.005	Low Flow Faucet Aerators, Direct Install, Natural Gas, Kitchen	0	0	202
6.0930.005	Low Flow Faucet Aerators, Direct Install, Electric, Kitchen	0	5,029	0

A. SAVINGS BASIS, EQUATIONS AND PARAMETERS

Faucet aerators reduce the flow rate of the water moving through the faucet. Savings are based on the reduction in energy consumed by the water heater due to the lower flow rate. Electric savings in kWh are realized for electric water heaters. Gas savings in therms are realized for natural gas water heaters.

Savings are calculated for 3 different installations – Commercial, School & Government (S&G) and Kitchen, and are equal to the difference in energy consumed by the water heater when using a regular flow aerator or no aerator versus a low-flow faucet aerator.

The savings equation for a natural gas water heater is:

$$therm\ Savings = (GPH_{old} - GPH_{new}) \times D \times \left(\frac{\Delta T \times 8.33 \times C_{water}}{eff_{gas} * 100{,}000} \right) \times\ days$$

The savings equation for an electric water heater is:

$$kWh\ Savings = (GPH_{old} - GPH_{new}) \times D \times \left(\frac{\Delta T \times 8.33 \times C_{water}}{eff_{electric} \times 3{,}413} \right) \times days$$

where:

- *GPH_{old} = hot water demand of a standard faucet in gallons per hour, deemed 15 gal/hr for S&G, 2 gal/hr for Commercial and 51 gal/hr for Kitchen.*
- *GPH_{new} = hot water demand of a low-flow faucet in gallons per hour, deemed 7.5 gal/hr for S&G, 1 gal/hr for Commericial and 30.6 gal/hr for Kitchen.*
- *D = number of daily faucet operating periods (1 hour per operating period), deemed 2 for S&G, 3 for Commercial and 3 for Kitchen.*
- *ΔT = Temperature difference between water entering and leaving the water heater, deemed 90 ºF.*
- *C_{water} = Specific heat of water, 1 BTU/lb-°F*
- *eff_{gas} = System efficiency of natural gas water heater, deemed 71 percent.*
- *$eff_{electric}$ = System efficiency of electric water heater, deemed 83 percent.*
- *8.33 = density of water, lb/gallon.*
- *100,000 = conversion factor, Btu per therm.*
- *3,413 = conversion factor, Btu per kWh*
- *days = annual operating days per year.*

Hot water demand of standard faucet, GPH_{old} The hot water demand of a standard faucet is the design demand of unblended hot water.

Hot water demand of low-flow faucet, GPH_{new}. The hot water demand of a low-flow faucet is the design demand of unblended hot water.

Number of daily faucet operating periods, D. The number of daily faucet operating periods are the assumed number of times per day the faucet is used. Each operating period is assumed to be one hour long.

Design Temperature Difference, ΔT. The design temperature difference is the temperature difference between the water entering the water heater and the water exiting the water heater.

Water Heater Efficiency, eff_{gas} and $eff_{electric}$. The efficiencies used in this calculation are an estimate of the average system efficiency of water heating systems using gas or electric water heaters. These efficiencies include delivery losses.

Annual Operating Days, days. Annual operating days is an estimate of the number of days that each installation requires the hot water demand values cited.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

Hot water demand of existing faucet, GPH_{old}. The unblended hot water demand assumed for non low-flow aerators is 15 gallons per hour for School & Government, 2 gallons per hour for Commercial, and 51 gallons per hour for Kitchen installations. The source of these values is the 2003 ASHRAE Applications Handbook.[199] The value used for Schools and Government is that given for lavatory basin use in a college dormitory. The Commercial value is that given for a lavatory basin in a motel. The Kitchen value is that given for a work sink in a commercial kitchen.

Gallons per hour of low-flow faucet, GPH_{new} The unblended hot water demand for low-flow aerators is based on the percent savings reported in 2003 ASHRAE Applications Handbook.[200] According to the Handbook, savings due to installing low-flow aerators are 50 percent for face and hand washing and 40 percent for food preparation. Applying 50 percent savings to existing School and Government and Commercial hot water demand values yields values of 7.5 gallons per hour for Schools and Government and 1 gallon per hour for Commercial. Applying 40 percent savings to the existing Kitchen hot water demand yields a value of 30.6 gallons per hour.

Daily Faucet Operating Periods, D. It is assumed that each period of operation is one hour in duration. Deemed values are two daily operating periods for Schools and Government and three for Commercial and Kitchen. The assumption of two daily operating periods for Schools and Government is based on one operating period in the morning and one at night. The assumption of three daily operating periods for Commercial is based on one morning, one evening and one night. The assumption of three operating periods for Kitchens is based on one operating period per meal. There is no source cited for these assumptions.

Design Temperature Difference, ΔT. The assumed supply water temperature is 50 ºF. This is based on typical average ground water temperature in Wisconsin.[201] The average unblended hot water temperature is assumed to be 140 ºF.[202] This yields a deemed value of 90°F for ΔT.

Water Heater Efficiency, eff_{gas} and $eff_{electric}$. The efficiency of natural gas and electric water heaters is based on average commercial water heater data taken from the Gas Appliance Manufacturers Association (GAMA).[203] Average efficiencies are calculated as 83.3 percent for gas water heaters and 98.1 percent for electric.

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[199] 2003 ASHRAE Applications Handbook. P 49.15, Table 8 and P 49.16, Table 10.

[200] 2003 ASHRAE Applications Handbook. P 49.9, Table 3.

[201] Interview with Manus McDevitt, P.E. Principal (ground source heat pump system designer). Sustainable Engineering Group, LLC. Madison, WI. 2008.

[202] 2003 ASHRAE Applications Handbook. P 49.15 – 49.16, Tables 8 and 10.

[203] GAMA has merged with AHRI. Their current commercial water heater database may be found at: http://cafs.ahrinet.org/gama_cafs/sdpsearch/search.jsp?table=CWH.

The efficiencies are further reduced by 15 percent to account for distribution losses. This value is based on a source that claims that home distribution efficiencies can be as low as 61 percent.[204] Deeming documentation indicates that 15 percent was chosen as a conservative and “more typical” estimate. Multiplying the average efficiencies by 85 percent yields the deemed system efficiencies of 71 percent for systems with gas water heaters and 83 percent for those with electric water heaters.

Annual operating days, days. For the Commercial measure, the annual operating days are based on an annual average motel occupancy rate of 65 percent, which yields a value of 237 occupied days.[205] For Schools and Government, the deemed value is 224 days based on an academic year of two 16-week semesters. For Kitchens, the value of 312 operating days is based on six operating days per week.

Table 4-133 shows the assumptions and parameters used to calculate the annual gallons of hot water saved by installation type.

Table 4-133. Gallons of Hot Water Saved Annually

	S&G	Commercial	Kitchen
Gallons per hour: non low-flow	15	2	51
Gallons per hour: low-flow	7.5	1	30.6
Daily Operating Periods	2	3	3
Annual Operating Days	224	237	312
Annual Gallons of Hot Water Saved	3,360	712	19,094

The following table shows the input parameters for the equations and the resulting energy savings, which are the same as those shown in Table 4-132.

Table 4-134. Key Input Parameters and Total Savings

Installation	Water Heater Type	Annual Water Saved (gal)	Water Heater Efficiency	Total Savings
S&G	Natural Gas	3,360	71	8 therms
	Electric	3,360	83	187 kWh
Commercial	Natural Gas	712	71	36 therms
	Electric	712	83	885 kWh
Kitchen	Natural Gas	19,094	71	202 therms
	Electric	19,094	83	5,029 kWh

[204] "Studies indicate that hot water distribution efficiency can be as low as 61 percent for a typical home with piping in the attic. http://www.eere.energy.gov/buildings/building_america/rh_0704_home_improve.html.

[205] This measure is not limited to motels, but values for motels are used for some assumptions, since many installations will be in motels and hotels. The source of 65 percent occupancy rate is: Hotel Online Special Report: "Even As U.S. Hotel Occupancy Rates Decline, Average Daily Room Rates Rise.” 9/2/1998 http://www.hotel-online.com/News/PressReleases1998_3rd/Sept98_PriceWaterhouse.html.

4.7.3 Pre-rinse Sprayers

Group: Domestic Hot Water

Category: Pre-rinse Sprayers

Technology Description: Low Flow Pre-rinse Sprayer

Qualifying Equipment:

- Qualifying sprayers are Fisher Ultra-spray 2949, T&S B-0107-C or others as indicated by the Food Service Technology Center under Federal Energy Management Program standards.
- Sales to federal or state facilities, including the UW System, are **not** eligible. County and municipal facilities **are** eligible.
- The pre-rinse sprayer must be installed in a business physically located in Wisconsin.
- Focus on Energy reserves the right to perform quality assurance to verify installations.

Date Deemed: April 2007

Summarized by: Josh Venden

Table 4-135. Pre-rinse Sprayer Measures

WISeerts Tech Code	Measure Description	Deemed Savings		
		kW	kWh	Therms
6.1001.315	Pre-rinse Sprayer, Low Flow, Natural Gas, commercial application	0.0000	0	42
6.1002.315	Pre-rinse Sprayer, Low Flow, Electric, commercial application	0.2180	957	0
6.1007.315	Pre-rinse Sprayer, Low Flow, Natural Gas - direct install	0.0000	0	42
6.1008.315	Pre-rinse Sprayer, Low Flow, Electric - direct install	0.2180	957	0

A. SAVINGS BASIS, EQUATIONS AND PARAMETERS

Low flow pre-rinse sprayers have a lower flow rate than standard pre-rinse sprayers. Savings are based on the reduction in energy consumed by the water heater due to the lower flow rate. Electric savings in kWh are realized for electric water heaters. Gas savings in therms are realized for natural gas water heaters.

For a natural gas water heater, the savings equation is:

$$Therm\ Savings = (GPM_{old} - GPM_{new}) \times H \times D \times 60 \times \left(\frac{\Delta T \times 8.33}{eff_g \times 100{,}000} \right)$$

For an electric water heater, the savings equation is:

$$kWh\ Savings = \left(GPM_{old} - GPM_{new}\right) \times H \times D \times 60 \times \left(\frac{\Delta T \times 8.33}{eff_e \times 3{,}413}\right)$$

where:

- *GPM_{old} = gallons per minute flow rate of old high-flow pre-rinse sprayer, value unknown.*
- *GPM_{new} = gallons per minute flow rate of new low-flow pre-rinse sprayer, value unknown.*
- *H = number of hours per day the sprayer is used, value unknown.*
- *D = number of days per year the sprayer is used, value unknown.*
- *ΔT = Temperature difference between water entering and leaving the water heater, value unknown.*
- *eff_g = Efficiency rating of gas water heater, value unknown.*
- *eff_e = Efficiency rating of electric water heater, value unknown.*
- *60 = number of minutes in one hour.*
- *8.33 = number of pounds weight in one gallon of water.*
- *100,000 = number of BTU in one therm.*
- *3,413 = number of BTU in one kWh.*

Gallons per Minute, GPM_{old} and GPM_{new}. Gallons per minute values are estimates of the average flow rate for high-flow and low-flow pre-rinse sprayers.

Hours of Operation, H. Hours of operation is the average number of hours per day the pre-rinse sprayer is in use.

*Days of Operation, D. Day*s of operation is the average number of days per year the pre-rinse sprayer is in use.

Temperature Difference, ΔT. The temperature difference is the difference between the water entering the water heater and the water supplied to the pre-rinse sprayer.

Efficiency, eff. This is the efficiency rating of the gas water heater. Further investigation is necessary to determine the value(s) assumed for water heater efficiency.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The available documentation does not provide enough information to define the values and assumptions used in deemed savings calculations. A spreadsheet is available with program data from 2003 and 2004, and the deemed savings calculation may be based on these data. It is possible that data in that spreadsheet could be used to reverse-engineer the savings estimate, thereby defining values for each parameter. However, an attempt at doing so did not yield a solution.

An April 2007 memo indicates that the program estimates were 2.1 kW and 6,255 kWh, and that evaluators recommended reducing these significantly to 0.218 kW and 957 kWh. Evaluators also provided the deemed savings value of 42 therms. These are the current deemed values.

Further investigation would be necessary to determine the values of all of the parameters in the savings estimate.

4.8 MOTORS

The Motors section contains one technology, outlined in Table 4-136.

Table 4-136. Deemed Savings Manual Entry, Motors

Group Description	Manual Entry
Motor	NEMA Premium Motors

4.8.1 NEMA Premium Motors

Group: Motors

Category: Motor

Technology Description: NEMA Premium Efficiency Motors, 1 hp–200 hp

Qualifying Equipment:

- Qualifying motors must be three phase, AC, 1–200 hp, open drip-proof (ODP) or totally enclosed fan-cooled (TEFC) units with nominal speeds of 1,200, 1,800 or 3,600 rpm.
- Motors with efficiencies equal to or greater than NEMA Premium Efficiency motors are eligible for incentives.
- Efficiencies are to be full-load, nominal efficiencies tested in accordance with IEEE Standard 112, Method B.
- Rebuilt/rewound equipment does not qualify.
- Redundant or backup units do not qualify.

Date Deeming Last Modified: November 2008

Summarized by: Josh Venden

Table 4-137. NEMA Premium Motor Measures

WISeerts Tech Code	Measure Description	Deemed Savings		
		kW	kWh	Therms
61.0111.270	Motor NEMA premium efficiency 1.0 hp	0.0177	= kw * hr/yr	0
61.0112.270	Motor NEMA premium efficiency 1.5 hp	0.0221	= kw * hr/yr	0
61.0113.270	Motor NEMA premium efficiency 2.0 hp	0.0291	= kw * hr/yr	0
61.0114.270	Motor NEMA premium efficiency 3.0 hp	0.0381	= kw * hr/yr	0
61.0115.270	Motor NEMA premium efficiency 5.0 hp	0.0546	= kw * hr/yr	0
61.0116.270	Motor NEMA premium efficiency 7.5 hp	0.0863	= kw * hr/yr	0
61.0117.270	Motor NEMA premium efficiency 10 hp	0.1075	= kw * hr/yr	0
61.0118.270	Motor NEMA premium efficiency 15 hp	0.1214	= kw * hr/yr	0
61.0119.270	Motor NEMA premium efficiency 20 hp	0.1926	= kw * hr/yr	0
61.0120.270	Motor NEMA premium efficiency 25 hp	0.1769	= kw * hr/yr	0
61.0121.270	Motor NEMA premium efficiency 30 hp	0.2025	= kw * hr/yr	0
61.0122.270	Motor NEMA premium efficiency 40 hp	0.2202	= kw * hr/yr	0
61.0123.270	Motor NEMA premium efficiency 50 hp	0.3470	= kw * hr/yr	0
61.0124.270	Motor NEMA premium efficiency 60 hp	0.3817	= kw * hr/yr	0
61.0125.270	Motor NEMA premium efficiency 75 hp	0.4056	= kw * hr/yr	0
61.0126.270	Motor NEMA premium efficiency 100 hp	0.4874	= kw * hr/yr	0
61.0127.270	Motor NEMA premium efficiency 125 hp	0.5385	= kw * hr/yr	0
61.0128.270	Motor NEMA premium efficiency 150 hp	0.5784	= kw * hr/yr	0
61.0129.270	Motor NEMA premium efficiency 200 hp	0.9505	= kw * hr/yr	0

A. SAVINGS BASIS, EQUATIONS AND PARAMETERS

Energy savings for this measure result from installing a NEMA Premium motor that is more efficient than the standard efficiency motor. Savings are equal to the difference in energy consumption between standard efficiency motors and higher efficiency NEMA Premium motors.

For any given motor horsepower, motor efficiencies vary by motor enclosure type and motor speed. Enclosure types include Open Drip Proof (ODP) and Totally Enclosed Fan Cooled (TEFC). Nominal motor speeds are 1,200, 1,800, and 3,600 rpm.

Savings for a particular motor replacement are described by the following equations:

$$kW = 0.764 \times hp \times EF \times LF$$

$$EF = \left(\frac{1}{EFF_{STD}} - \frac{1}{EFF_{NEMA}} \right)$$

$$kWh = kW \times HR$$

where:

- *hp = Horsepower rating of the motor, varies by measure*
- *EF = efficiency factor, calculated values in Table 4-138 and Table 4-139*
- *EFF_{STD} = efficiency of a standard motor, values in Table 4-138*
- *EFF_{NEMA} = efficiency of a NEMA premium motor, values in Table 4-138*
- *LF = Load factor, deemed 62 percent*
- *HR = Annual operating hours, from application*
- *0.764 = conversion factor, kW per horsepower.*

Horsepower, hp. Horsepower in this calculation is the nominal horsepower of the replacement motor.

Efficiency of a standard motor, EFF_{STD}. Standard motor efficiency is based on EPACT standard motor efficiency, and is reported by motor enclosure type and speed.

Efficiency of a NEMA premium motor, EFF_{NEMA}. Qualifying motor efficiency is based on NEMA premium motor efficiencies, reported by motor enclosure type and speed.

Efficiency Factor, EF. The efficiency factor is defined as the difference of the reciprocals of the standard and qualifying motor efficiencies.

Load Factor, LF. Load factor represents the average fraction of load at which the motor operates.

Annual operating hours, HR. Annual operating hours represents the time that the motor operates each year, in hours.

The first step in determining energy savings is to calculate the efficiency factor for each combination of motor horsepower, enclosure type, and speed. Then, the weighted average efficiency factor is determined across enclosure type and speed and used in the savings equation for each motor horsepower.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Horsepower, hp. The horsepower used in the savings calculation for each measure is the nominal horsepower of the motor being installed. Table 4-137 shows the motor horsepower rating covered by each measure.

Standard and Premium Motor Efficiencies, EFF_{STD} and EFF_{NEMA}. EPACT standard and NEMA premium motor efficiencies are reportedly taken from the CEE Premium-Efficiency Motors Initiative Efficiency Specifications.[206] Efficiency values are presented for ODP motors in Table 4-138 and for TEFC motors in Table 4-139.

Efficiency Factor, EF. The efficiency factor is calculated for each motor horsepower, enclosure type, and speed. These values are reported in Table 4-138 and Table 4-139.

Table 4-138. Open Drip-proof Motor Efficiency Comparison

Motor Size (hp)	1,200 rpm			1,800 rpm			3,600 rpm		
	EPACT Standard Efficiency	NEMA Premium Efficiency	EF	EPACT Standard Efficiency	NEMA Premium Efficiency	EF	EPACT Standard Efficiency	NEMA Premium Efficiency	EF
1.0	80.0%	82.5%	0.0379	82.5%	85.5%	0.0425	N/A	77.0%	N/A
1.5	84.0%	86.5%	0.0344	84.0%	86.5%	0.0344	82.5%	84.0%	0.0216
2.0	85.5%	87.5%	0.0267	84.0%	86.5%	0.0344	84.0%	85.5%	0.0209
3.0	86.5%	88.5%	0.0261	86.5%	89.5%	0.0388	84.0%	85.5%	0.0209
5.0	87.5%	89.5%	0.0255	87.5%	89.5%	0.0255	85.5%	86.5%	0.0135
7.5	88.5%	90.2%	0.0213	88.5%	91.0%	0.0310	87.5%	88.5%	0.0129
10	90.2%	91.7%	0.0181	89.5%	91.7%	0.0268	88.5%	89.5%	0.0126
15	90.2%	91.7%	0.0181	91.0%	93.0%	0.0236	89.5%	90.2%	0.0087
20	91.0%	92.4%	0.0167	91.0%	93.0%	0.0236	90.2%	91.0%	0.0097
25	91.7%	93.0%	0.0152	91.7%	93.6%	0.0221	91.0%	91.7%	0.0084
30	92.4%	93.6%	0.0139	92.4%	94.1%	0.0196	91.0%	91.7%	0.0084
40	93.0%	94.1%	0.0126	93.0%	94.1%	0.0126	91.7%	92.4%	0.0083
50	93.0%	94.1%	0.0126	93.0%	94.5%	0.0171	92.4%	93.0%	0.0070
60	93.6%	94.5%	0.0102	93.6%	95.0%	0.0157	93.0%	93.6%	0.0069
75	93.6%	94.5%	0.0102	94.1%	95.0%	0.0101	93.0%	93.6%	0.0069
100	94.1%	95.0%	0.0101	94.1%	95.4%	0.0145	93.0%	93.6%	0.0069
125	94.1%	95.0%	0.0101	94.5%	95.4%	0.0100	93.6%	94.1%	0.0057
150	94.5%	95.4%	0.0100	95.0%	95.8%	0.0088	93.6%	94.1%	0.0057
200	94.5%	95.4%	0.0100	95.0%	95.8%	0.0088	94.5%	95.0%	0.0056

[206] http://www.cee1.org/ind/motrs/CEE_NEMA.pdf

Table 4-139. Totally Enclosed, Fan Cooled Motor Efficiency Comparison

Motor Size (hp)	1,200 rpm			1,800 rpm			3,600 rpm		
	EPACT Standard Efficiency	NEMA Premium Efficiency	EF	EPACT Standard Efficiency	NEMA Premium Efficiency	EF	EPACT Standard Efficiency	NEMA Premium Efficiency	EF
1.0	80.0%	82.5%	0.0379	82.5%	85.5%	0.0425	75.5%	77.0%	0.0258
1.5	85.5%	87.5%	0.0267	84.0%	86.5%	0.0344	82.5%	84.0%	0.0216
2.0	86.5%	88.5%	0.0261	84.0%	86.5%	0.0344	84.0%	85.5%	0.0209
3.0	87.5%	89.5%	0.0255	87.5%	89.5%	0.0255	85.5%	86.5%	0.0135
5.0	87.5%	89.5%	0.0255	87.5%	89.5%	0.0255	87.5%	88.5%	0.0129
7.5	89.5%	91.0%	0.0184	89.5%	91.7%	0.0268	88.5%	89.5%	0.0126
10	89.5%	91.0%	0.0184	89.5%	91.7%	0.0268	89.5%	90.2%	0.0087
15	90.2%	91.7%	0.0181	91.0%	92.4%	0.0167	90.2%	91.0%	0.0097
20	90.2%	91.7%	0.0181	91.0%	93.0%	0.0236	90.2%	91.0%	0.0097
25	91.7%	93.0%	0.0152	92.4%	93.6%	0.0139	91.0%	91.7%	0.0084
30	91.7%	93.0%	0.0152	92.4%	93.6%	0.0139	91.0%	91.7%	0.0084
40	93.0%	94.1%	0.0126	93.0%	94.1%	0.0126	91.7%	92.4%	0.0083
50	93.0%	94.1%	0.0126	93.0%	94.5%	0.0171	92.4%	93.0%	0.0070
60	93.6%	94.5%	0.0102	93.6%	95.0%	0.0157	93.0%	93.6%	0.0069
75	93.6%	94.5%	0.0102	94.1%	95.4%	0.0145	93.0%	93.6%	0.0069
100	94.1%	95.0%	0.0101	94.5%	95.4%	0.0100	93.6%	94.1%	0.0057
125	94.1%	95.0%	0.0101	94.5%	95.4%	0.0100	94.5%	95.0%	0.0056
150	95.0%	95.8%	0.0088	95.0%	95.8%	0.0088	94.5%	95.0%	0.0056
200	95.0%	95.8%	0.0088	95.0%	96.2%	0.0131	95.0%	95.4%	0.0044

The efficiency factors for each motor enclosure type and speed are then weighted to produce an average efficiency factor for each motor horsepower. This is done using the relative proportions of 1,200 rpm, 1,800 rpm and 3,600 rpm motors for a given enclosure type and the relative proportions of open drip-proof (ODP) and totally enclosed, fan-cooled (TEFC) enclosures. These values are based on a 1992 New England Motor Baseline Study.[207] Table 4-140 shows the percentages of each motor type. These are the weighting factors applied to the efficiency factors.

Table 4-140. Relative Proportions of Motors

Motor Enclosure Type	RPM	Quantity	Percent	Percent Of All Motors
Open Drip-proof	1,200	1,422	10%	34%
	1,800	10,958	77%	
	3,600	1,941	14%	
Totally Enclosed, Fan-cooled	1,200	3,337	12%	66%
	1,800	20,325	72%	
	3,600	4,653	16%	

[207] Appendix "Baseline Summary of 1991 Motor Sales" of the 1992 New England Motor Baseline Study, Easton Consultants Data based on motor distribution in Maine, Connecticut, Rhode Island and New Hampshire. Equivalent data for Wisconsin was not available.

Table 4-141 shows the individual efficiency factors (taken from Table 4-138 and Table 4-139) and the weighted average efficiency factors determined using the percentages in Table 4-140. The overall efficiency factor (far right column) is what is used in the equation to calculate kW savings, producing the values in Table 4-137.

Table 4-141. Weighted Efficiency Factors

Motor Size (hp)	Open Drip-Proof				Totally Enclosed, Fan Cooled				Weighted Average EF
	1,200 rpm	1,800 rpm	3,600 rpm	Weighted Average	1,200 rpm	1,800 rpm	3,600 rpm	Weighted Average	
1.0	0.0379	0.0425	0.0000	0.0363	0.0379	0.0425	0.0258	0.0392	0.0382
1.5	0.0344	0.0344	0.0216	0.0327	0.0267	0.0344	0.0216	0.0314	0.0318
2.0	0.0267	0.0344	0.0209	0.0318	0.0261	0.0344	0.0209	0.0312	0.0314
3.0	0.0261	0.0388	0.0209	0.0351	0.0255	0.0255	0.0135	0.0236	0.0274
5.0	0.0255	0.0255	0.0135	0.0239	0.0255	0.0255	0.0129	0.0235	0.0236
7.5	0.0213	0.0310	0.0129	0.0276	0.0184	0.0268	0.0126	0.0235	0.0249
10	0.0181	0.0268	0.0126	0.0240	0.0184	0.0268	0.0087	0.0228	0.0232
15	0.0181	0.0236	0.0087	0.0211	0.0181	0.0167	0.0097	0.0157	0.0175
20	0.0167	0.0236	0.0097	0.0211	0.0181	0.0236	0.0097	0.0207	0.0208
25	0.0152	0.0221	0.0084	0.0196	0.0152	0.0139	0.0084	0.0131	0.0153
30	0.0139	0.0196	0.0084	0.0175	0.0152	0.0139	0.0084	0.0131	0.0146
40	0.0126	0.0126	0.0083	0.0120	0.0126	0.0126	0.0083	0.0119	0.0119
50	0.0126	0.0171	0.0070	0.0153	0.0126	0.0171	0.0070	0.0149	0.0150
60	0.0102	0.0157	0.0069	0.0140	0.0102	0.0157	0.0069	0.0136	0.0138
75	0.0102	0.0101	0.0069	0.0096	0.0102	0.0145	0.0069	0.0127	0.0117
100	0.0101	0.0145	0.0069	0.0130	0.0101	0.0100	0.0057	0.0093	0.0105
125	0.0101	0.0100	0.0057	0.0094	0.0101	0.0100	0.0056	0.0093	0.0093
150	0.0100	0.0088	0.0057	0.0085	0.0088	0.0088	0.0056	0.0083	0.0083
200	0.0100	0.0088	0.0056	0.0085	0.0088	0.0131	0.0044	0.0112	0.0103

Load Factor, LF. The load factor used in this calculation is 62 percent. It is the assumed manufacturing average part load used by the Department of Energy in the 1998 United States Industrial Electric Motor Systems Market Opportunities Assessment.[208]

Annual Operating Hours, HR. Annual operating hours are provided for each motor by the participant on the incentive application.

kW Savings for each measure are calculated by substituting the above values into the savings equation for each measure.[209] These deemed savings estimates are presented in Table 4-137. Annual operating hours from the application are multiplied by kW Savings to determine kWh Savings for the measure.

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[208] Source: "Motor Systems Inventory and Energy Use Details" 1998. United States Industrial Electric Motor Systems Market Opportunities Assessment. Burlington, MA. Pages A-3, A-9, A-15, A-21 and A-27.

[209] Note that this method assumes that the motor is operating throughout the peak period. If this assumption were not the case, a peak duty cycle value would be introduced into the savings estimate.

4.9 LIGHTING

The Lighting section contains the technologies outlined in Table 4-142.

Table 4-142. Deemed Savings Manual Entries, Lighting

Group Description	Manual Entry
Lighting	LED Exit Lighting
	Low Wattage CFLs
	High Wattage CFLs
	CFL Cold Cathode
	Occupancy Sensors -- Wall or Ceiling Mount
	High/Low Control for 320W PSMH
	Daylighting Controls
	4' T-8 Replacing 8' T-12 Fluorescent Lighting
	T8 Low Watt with CEE Ballast
	T8 Low Watt Relamp
	T8 High Lumen Lamp with Low Ballast Factor
	T5 2-Lamp Replacing 3-Lamp T8 or 4-Lamp T12
	LED Recessed Downlight
	Metal Halide Ceramic, Pulse Start, and Electronic Ballast Pulse Start
	LED Reach-in Refrigerated Case Lighting
	High Bay Fluorescent Replacing HID
	Occupancy Sensors for High Bay Fluorescent Fixtures
	T8 HP 2L Recessed Fixture Replacing 3L or 4L T8 or T12
	T12 Bounty

4.9.1 LED Exit Lighting

Group: Lighting

Category: Light Emitting Diode (LED)

Technology Description: LED Exit Lighting, early replacement only.

Qualifying Equipment:

- Existing signs must be incandescent or fluorescent.
- Replacement LED exit signs must meet ENERGY STAR V2 specifications.
- Incentive is only available for early replacement.
- Incentive applies to replacement of single exit signs.

Date Deeming Last Modified: April 2007

Summarized by: Peter McPhee

Table 4-143. LED Exit Lighting Early Replacement

WISeerts Tech Code	Measure Description	Deemed Savings	
		kW	kWh
2.0200.260	LED Exit Lighting - for specially targeted early replacement only	0.0341	298

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Savings result from replacing incandescent or fluorescent exit signs with LED exit signs. LED exit signs use significantly less electricity than incandescent or fluorescent exit signs. The savings estimate assumes that both incandescent and fluorescent exit signs undergo early replacement rather than replacement at failure.

The average wattage of the replaced sign is determined by calculating a weighted average of fluorescent and incandescent sign wattages based on their relative prevalence. kW and kWh savings are determined by the following equations:

$$kW\ Savings = (W_e r_e + W_f r_f) - W_l$$

$$kWh\ Savings = (kW\ Savings)\ (H)$$

where:

- W_e = *average incandescent exit sign wattage, deemed 0.040 kW*
- W_f = *average fluorescent exit sign wattage, deemed 0.011 kW*
- r_e = *ratio of incandescent exit signs to all incandescent and fluorescent exit signs, deemed 0.9*

- *r_f = ratio of fluorescent exit signs to all incandescent and fluorescent exit signs, deemed 0.1*
- *W_l = average LED exit sign wattage, deemed 0.0029 kW*
- *H = operating hours, deemed 8,760 hours per year.*

Average exit sign wattages, W_e, W_f, and W_l. These variables refer to the average power used by incandescent, fluorescent, and LED exit signs respectively. While there are fixtures of varying wattages within each exit sign fixture type, the variation across fixture types is greater than the variation within a given type. Therefore, the savings equation uses estimates of the average power used by each sign type.

Ratio of incandescent exit signs to all incandescent and fluorescent exit signs, r_e. This represents the fraction of all incandescent and fluorescent exit signs that are incandescent.

Ratio of fluorescent exit signs to all incandescent and fluorescent exit signs, r_f. This represents the fraction of all incandescent and fluorescent exit signs that are fluorescent.

Operating hours, H. This is the annual operating hours of the existing and replacement exit signs.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Average existing incandescent exit sign wattage, W_e. The value of 40 W for the average incandescent exit sign is based on a 2004 finding of Lawrence Berkeley National Lab, as cited by ENERGY STAR.[210]

Average existing fluorescent exit sign wattage, W_f. The value of 11W for the average fluorescent exit sign is based on a citation by Alliant Energy.[211]

Ratio of incandescent exit signs to all incandescent and fluorescent exit signs, r_e. At the time of deeming, Dr. Peter Boyce, Professor Emeritus from the Rensselaer Polytechnic Institute and the expert on exit signage at their Lighting Research Center, estimated that 90 percent of eligible exit signs were incandescent.[212]

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[210] http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_Exit_Signs.xls. Deeming documents cite this value as being based on a LBNL finding, but the ENERGY STAR calculator at this web address does not. Instead, the 40 W values is labeled "average for available products."

[211] Alliant Energy. "Energy Efficiency: Lighting – LED Exit Signs." http://www.alliantenergy.com/stellent/groups/public/documents/pub/012387.pdf (accessed 25 February 2005)

[212] Electronic correspondence. 25 February 2005.

Ratio of fluorescent exit signs to all incandescent and fluorescent exit signs, r_f. Of exit signs under consideration, the portion that is not incandescent will be fluorescent. This value represents the remaining exit sign population according to Dr. Boyce's estimate. The weighting ratio of fluorescent signs is 10 percent.

Average LED exit sign wattage, W_p. All ENERGY STAR-qualified LED signs are listed on the ENERGY STAR website.[213] The average wattages at 120V and 277V were calculated at the time the measure was last deemed and averaged to give a value of 2.9 W.

Operating hours, H. Exit signs are always on. Therefore, the operating hours are 24 hours per day for 365 days per year, or 8,760 hours per year.

kW and kWh savings are calculated by substituting the above values into the savings equations, yielding the deemed savings reported in Table 4-8.

[213] ENERGY STAR. "Exit Signs: Product List." http://www.energystar.gov/index.cfm?c=exit_signs.pr_exit_signs (accessed 7 February 2005).

4.9.2 Low Wattage CFLs

Group: Lighting

Category: Fluorescent, Compact (CFL)

Technology Description:

- Screw-in compact fluorescent lamp rated 32 watts or less replacing an incandescent lamp rated ≤ 100W.
- Screw-in compact fluorescent reflector flood lamp rated 30 watts or less replacing an incandescent reflector flood lamp rated ≤100W.
- CFL fixture containing pin-based CFL lamps, replacing incandescent fixture.

Qualifying Equipment:

CFL ≤ 32 Watt and CFL reflector flood lamps:

- Lamps must be screw-in type.
- New lamps must replace existing lamps one-for-one.
- Lamps must be installed indoors.

CFL Fixture:

- Existing fixtures must be incandescent.
- Replacement lighting must be a permanently-wired new fixture.
- Fixtures must be designed solely for use with pin-based CFLs.

Date Deeming Last Modified: December 2009

Date Previously Deemed:

- CFL ≤ 32W and CFL fixture deemed March 2005.
- CFL Reflector Flood Lamp deemed May 2008.

Reviewed by: Jeremiah Robinson

Table 4-144. Low Watt CFL Measures, Deemed Savings

WISeerts Tech Code	Measure Description	Deemed Savings: Agriculture kW	Agriculture kWh	Commercial kW	Commercial kWh	Industrial kW	Industrial kWh	Schools/Gov't kW	Schools/Gov't kWh
2.0301.165	CFL <= 32 Watts, replacing incandescent	0.0373	136	0.0427	208	0.0429	264	0.0359	180
2.0302.165	CFL reflector flood lamps replacing incandescent reflector flood lamps	0.0327	120	0.0374	182	0.0376	232	0.0314	158
2.0303.165	CFL Direct Install, replacing incandescent, WPS Hometown Checkup	0.0373	136	0.0427	208	0.0429	264	0.0359	180
2.0400.165	CFL Fixture, replacing incandescent fixture	0.0373	136	0.0427	208	0.0429	264	0.0359	180

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

CFL lamps save energy when replacing incandescent lamps because they are able to produce the same light output with a lower input wattage. Savings due to replacing light fixtures are described by the following equations:

$$kW_{Savings} = \left(\frac{LtgWatts_{old} - LtgWatts_{new}}{1{,}000}\right)(CF)$$

$$kWh_{Savings} = \left(\frac{LtgWatts_{old} - LtgWatts_{new}}{1{,}000}\right)(Hours)$$

where:

- *Ltg. Watts$_{old}$ = lighting wattage of existing fixture, values in Table 4-149, watts*
- *Ltg. Watts$_{new}$ = lighting wattage of new fixture, values in Table 4-149, watts*
- *Hours = hours of use per year, values in Table 4-151, hr/yr*
- *CF = coincidence factor, values in Table 4-151, percent*
- *1,000 = conversion factor, watts per kilowatt.*

Existing Lamp Wattage, Ltg. Watts$_{old}$. The Existing Lamp Wattage is the total wattage of the incandescent lamp or fixture being replaced, in watts.

New Lamp Wattage, Ltg. Watts$_{new}$. The New Lamp Wattage is the total fixture wattage of the CFL lamp or fixture being installed, in watts.

Hours of Use, Hours. Hours of Use refers to the average annual operating hours of the light fixture and is measured in hours/year.

Coincidence Factor, CF. Coincidence Factor refers to the average percentage of total system wattage that is operating during the peak period and is measured in percent.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

Existing Wattage, Ltg. $Watts_{old}$, and New Wattage, Ltg. $Watts_{new}$. The values for Existing and New Wattage for the CFL ≤ 32 W, CFL Direct Install, and CFL Fixture measures are based a review of impact evaluation surveys. The data used is from the impact evaluations for FY04, FY06, and 18MCP, and is provided in Table 4-145 and summarized in Table 4-146. The overall average Existing and New Lamp Wattage values are the weighted averages of the data based on sample size. These are the deemed wattages for the CFL ≤ 32W measure, CFL Direct Install, and CFL Fixture measures.

Table 4-145. CFL and Incandescent Wattage Based on Survey Analysis[214]

Sector	Period	Sample	CFL Watts	Incandescent Watts	Delta Watts
Agriculture	18 MCP	36	20.5	79.4	59.0
Agriculture	FY04	25	19.2	70.0	50.8
Agriculture	FY06	8	19.3	71.3	52.0
Commercial	18 MCP	60	19.5	74.4	54.9
Commercial	FY04	23	20.0	71.1	51.1
Channel	FY06	101	20.2	77.5	57.3
Overall	18 MCP	96	19.9	76.5	56.6
Overall	FY04	48	19.6	70.6	50.9
Overall	FY06	109	20.2	77.1	57.0

Table 4-146. Summary of CFL Values from Survey Analysis

Sector	Sample	CFL Watts	Incandescent Watts	Delta Watts
Agriculture	69	19.9	75.1	54.7
Commercial	83	19.7	73.5	53.7
Channel	101	20.2	77.5	57.2
Overall	253	19.9	75.5	55.4

For the CFL Reflector Flood Lamp measure, the New Lamp Wattage is based on a review of the WISeerts database completed in July 2009. The results of the analysis are shown in Table 4-147. The number of lamps represented by the projects reviewed is shown in the column labeled Sample and the total number of lamps rebated is in the column labeled Total. The average of 17.5 W is the weighted average of the sector wattage values based on the percentage of total rebated lamps.

[214] Channel refers to the Commercial, Industrial, and Schools & Government sectors which were reported together in FY06.

Table 4-147. Percentage of Fixtures Installed by Each Measure

Sector	Sample	Total	Percent	Avgerage Watts
Agriculture	6	6	100%	15.0
Commercial	7,190	26,471	27%	18.4
Industrial	162	281	58%	14.4
Schools & Gov't	6,420	7,350	87%	14.4
Average	**13,778**	**34,108**	**40%**	**17.5**

The Existing Lamp wattage for the CFL Flood Lamp measure is calculated by multiplying the New Lamp Wattage for CFL Floods by the ratio between the Existing and New Lamp Wattages for the CFL ≤ 32W measure. Thus, 17.5 W is multiplied by the ratio of 75.7 to 20.0, or 3.8. This calculation, summarized in Table 4-148, yields a deemed Existing Lamp Wattage for the CFL Flood measure of 66.3 W. Deemed wattages for all low wattage CFL measures are reported in Table 4-149.

Table 4-148. Calculation for Existing Wattage from Reflector Flood Lamps

Measure	Category	Value
CFL ≤ 32W	New	20.0
	Existing	75.7
	Ratio	3.8
Reflector Flood	New	17.5
	Existing	66.3

Table 4-149. Deemed New and Existing Wattages by Measure

Measure Description	New Watts	Old Watts
CFL <= 32W, CFL Direct Install, CFL Fixture	20	75.7
CFL reflector flood lamps <=30W replacing incandescent reflector flood lamps <=100W	17.5	66.3

Hours of Use, Hours. For all but the Agriculture sector, Hours of Use for these measures are the standard hours of use values by sector, as discussed in Section 3.1 of this report. For the Agriculture sector, the hours of use value is based on an analysis of data generated by the three most recent rounds of impact evaluations.[215] The data used in the analysis and the resulting weighted average hours/year is provided in Table 4-150. The resulting value of 2,450 hours is the deemed Hours of Use value for the Agriculture sector. The deemed hours of use values for this measure are provided in Table 4-151.

[215] This analysis was also carried out for the Commercial sector. The value produced for the Commercial sector was similar to the standard hours of use for the sector, so the standard value is used.

Table 4-150. CFL and Incandescent Hours of Use Based on Survey Analysis[216]

Sector	Period	Sample	Hours/Year
Agriculture	18 MCP	36	2,902
Agriculture	FY06	8	2,327
Agriculture	FY04	25	1,856
Average		69	2,450

Table 4-151. Hours of Use and Coincidence Factor Values for CFL Measures

Sector	Hours/Year	Coincidence Factor
Agriculture	2,450	67%
Commercial	3,730	77%
Industrial	4,745	77%
Schools-Gov't	3,239	64%

Coincidence Factor, CF. The deemed values for coincidence factor for CFL measures are the standard lighting coincidence factor values, provided in

Table 4-151 and discussed in Section 3.1.

Substituting the above values into savings into the savings equations yields the savings values presented in Table 4-144.

[216] Channel refers to the Commercial, Industrial, and Schools & Government sectors which were reported together in FY06.

4.9.3 High Wattage CFLs

Group: Lighting

Category: Fluorescent, Compact (CFL)

Technology Description: Replacement of high wattage incandescent or metal halide bulbs with high wattage compact fluorescent lamps (CFL).

Qualifying Equipment:

- Existing lamps must be incandescent or metal halide.
- CFL bases for incandescent replacements must be medium Edison screw base.
- Incentive applies to replacement of single bulb.
- Existing and replacement bulbs must coincide with bulb type and wattages presented in Table 4-152.

Date Deeming Last Modified: December 2009

Date Previously Deemed: October 2006

Summarized by: Peter McPhee

Table 4-152. CFL High Wattage Replacement Measures

WISeerts Tech Code	Measure Description	Deemed Savings							
		Agriculture		Commercial		Industrial		Schools/Gov't	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.0301.165	CFL High Wattage 31-115 Watts, replacing incandescent	0.0903	331	0.1034	504	0.1040	641	0.0869	437
2.0302.165	CFL High Wattage 116-149 Watts, replacing metal halide	0.0670	470	0.0770	373	0.0770	475	0.0640	324
2.0303.165	CFL High Wattage 150-199 Watts, replacing metal halide	0.0972	681	0.1117	541	0.1117	688	0.0928	470

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Savings result from replacing incandescent or metal halide bulbs with high wattage CFLs. High wattage CFLs use less electricity than incandescent or metal halide lamps to produce an equivalent amount of light. The electric deemed savings for this measure per bulb are provided in Table 4-152 based on customer sector.

kW and kWh savings are determined using the following equations:

$$kW\ Savings = \frac{\left(P_e\text{-}P_p\right) \times CF}{1{,}000}$$

$$kWh\ Savings = \frac{(P_e - P_p) \times H}{1{,}000}$$

where:

- *P_e = existing lighting wattage, values in Table 4-153*
- *P_p = proposed replacement lighting wattage, values in Table 4-153*
- *CF = coincidence factor, values in Table 4-155*
- *H = annual operating hours, values in Table 4-155*
- *1,000 = conversion factor, watts per kilowatt.*

Lighting wattages, P_e and P_p. These variables refer to the average power used by the existing incandescent or metal halide lamps and the installed CFLs, respectively.

Coincidence Factor, CF. Coincidence Factor refers to the average percentage of total system wattage that is operating during the peak period and is measured in percent.

Annual operating hours, H. This refers to the average annual operating hours of the light fixture and is measured in hours/year.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Existing lighting wattage, P_e. The deemed values used are shown in Table 4-153. The source of these values is not known. We believe that the value of 200 W for a high wattage incandescent is an approximation of the average value weighted by market share of incandescents over 100 W. The wattage of existing metal halides which would be replaced by a 116–149 W CFL was deemed to be 205 W. The wattage of metal halides eligible for replacement by a 150–199 W CFL was deemed to be 295 W. We believe both of these values were chosen based on lumen equivalents of modern metal halides and CFLs.

Table 4-153. Deemed Lighting Technology Wattages

Existing Lighting Technology	Existing Wattage	Replacement CFL Description	Replacement CFL Wattage
Incandescent (>100 W)	200	31 - 115 W	65
Metal Halide	205	116 - 149 W	105
Metal Halide	295	150 - 199 W	150

Proposed replacement lighting wattage, P_p. The deemed values for the lighting replacements are also shown in Table 4-153. The source of the deemed replacement wattages of the CFLs are unknown, though we expect that they are derived from the wattage bins chosen.[217]

Coincidence factor, CF. This calculation uses the program's standard lighting coincidence factors, presented in Table 4-155. For a more complete discussion of deemed coincidence factors, refer to Section 3.1.

Annual operating hours, H. For all but measure 2.0301 for the Agriculture sector, this calculation uses the program's standard lighting operating hours. These values are developed and discussed in Section 3.1 and are provided in Table 4-155. For CFLs replacing incandescents in the Agriculture sector, the deemed hours of use value is based on an analysis of data generated by the three most recent rounds of impact evaluations.[218] The data used in the analysis and the resulting weighted average hours/year is provided in Table 4-154. The resulting value of 2,450 hours is the deemed annual operating hours value for measure 2.0301 for the Agriculture sector.

Table 4-154. Measure 2.0301 Agriculture Sector Hours of Use Based on Survey Analysis[219]

Sector	Period	Sample	Hours/Year
Agriculture	18 MCP	36	2,902
Agriculture	FY06	8	2,327
Agriculture	FY04	25	1,856
Average		**69**	**2,450**

The deemed hours of use and coincidence factor values for this measure (excluding hours of use for measure 2.0301 for Agriculture) are provided in Table 4-155.

Table 4-155. Hours of Use and Coincidence Factor Values for CFL Measures

Sector	Hours/Year	Coincidence Factor
Agriculture	2,450	67%
Commercial	3,730	77%
Industrial	4,745	77%
Schools-Gov't	3,239	64%

Substituting the above values into the kW and kWh savings equations yields the deemed savings presented in Table 4-152.

[217] The wattage value of 105 W for the CFLs in the 116–149 W range appears inconsistent with the other wattage values chosen. Because this wattage level is below the CFL rated wattage range, further investigation of this value may be warranted.

[218] This analysis was also carried out for the Commercial sector. The value produced for the Commercial sector was similar to the standard lighting hours of use for the sector, so the standard value is used.

[219] Channel refers to the Commercial, Industrial, and Schools & Government sectors, which were reported together in FY06.

4.9.4 Cold Cathode CFLs

Group: Lighting

Category: Cold Cathode

Technology Description: CFL Cold Cathode Screw-in, replacing incandescent.

Qualifying Equipment:

- Existing lamps must be incandescent and 100 W or less.
- Bulbs must be screw base.

Date Deeming Last Modified: December 2009

Date Previously Deemed: October 2006

Summarized by: Peter McPhee

Table 4-156. CFL Cold Cathode Replacement

WISeerts Tech Code	Measure Description	Deemed Savings							
		Agriculture		Commercial		Industrial		Schools/Gov't	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.0305.060	CFL Cold Cathode Screw-In, replacing incandescent	0.0141	51	0.0161	78	0.0162	100	0.0135	68

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Saving result from replacing incandescent bulbs with cold cathode CFLs. Cold cathode CFLs use less electricity than incandescent lamps to produce an equivalent amount of light. The per-unit electric deemed savings for this measure are provided in Table 4-156 and are based on customer sector.

kW and kWh savings are determined by the following equations:

$$kW\ Savings = \frac{(P_e\text{-}P_p) \times CF}{1{,}000}$$

$$kWh\ Savings = \frac{(P_e - P_p) \times H}{1{,}000}$$

where:

- *P_e = existing lighting wattage, deemed 25 W*
- *P_p = proposed lighting wattage, deemed 4 W*
- *CF = coincidence factor, values in Table 4-159*

- *H = annual operating hours, values in Table 4-159*
- *1,000 = conversion factor, watts per kilowatt.*

Lighting wattages, P_e and P_p. These variables refer to the average power used by the existing incandescent lamps and the proposed cold cathode CFLs, respectively.

Coincidence Factor, CF. Coincidence Factor refers to the average percentage of total system wattage that is operating during the peak period and is measured in percent.

Annual operating hours, H. This refers to the average annual operating hours of the light fixture and is measured in hours/year..

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values are assumed for the calculation input parameters:

Proposed and Existing lighting wattage, P_p and P_e. Lighting wattages are based on a PG&E presentation and specification sheets from the lighting manufacturer TCP. Wattages for these cold cathode lamps and the incandescent lamps they replace are presented in Table 4-157.

Table 4-157. Cold Cathode Lamp Equivalents

Representative Cold Cathode Lighting	Cold Cathode Watts	Incandescent Watts
PG&E Small sign size #1	3	15
PG&E Small sign size #2	5	20
TCP Small sign size #1	3	20
TCP Small sign size #2	5	30
Deemed Value	4	25

The proposed lighting wattage, P_p, is deemed to be 4 W, which is the average of the cold cathode CFL wattages in Table 4-157. The existing lighting wattage, P_e, is deemed to be 25 W. This is greater than the average of the incandescent wattages reported in Table 4-157. Thus, it seems that the value used for the existing wattage is weighted toward the higher wattage lamps.

Coincidence factor, CF. This calculation uses the program's standard lighting coincidence factors, presented in Table 4-159Table 4-181. For a more complete discussion of deemed coincidence factors, refer to Section 3.1.

Annual operating hours, H. This calculation uses the program's standard lighting operating hours for the Commercial, Industrial, and Schools and Government sectors. These values are developed and discussed in Section 3.1. For CFLs in the Agriculture sector, the deemed annual operating hours is different from other lighting technologies.

For the Agriculture sector, the hours of use value is based on an analysis of data generated by three rounds of impact evaluations.[220] The data used in the analysis and the resulting weighted average hours/year is provided in Table 4-158. The resulting value of 2,450 hours is the deemed Hours of Use value for the Agriculture sector.

Table 4-158. Agriculture CFL Hours of Use Based on Survey Analysis[221]

Sector	Period	Sample	Hours/Year
Agriculture	18 MCP	36	2,902
Agriculture	FY06	8	2,327
Agriculture	FY04	25	1,856
Average		**69**	**2,450**

The deemed hours of use values for this measure are provided in Table 4-159.

Table 4-159. Hours of Use and Coincidence Factor Values for CFL Measures

Sector	Hours/Year	Coincidence Factor
Agriculture	2,450	67%
Commercial	3,730	77%
Industrial	4,745	77%
Schools-Gov't	3,239	64%

Substituting the above values into the kW and kWh savings equations yields the deemed savings presented in Table 4-156.

[220] This analysis was also carried out for the Commercial sector. The value produced for the Commercial sector was similar to the standard lighting hours of use for the sector, so the standard value is used.

[221] Channel refers to the Commercial, Industrial, and Schools & Government sectors, which were reported together in FY06.

4.9.5 Occupancy Sensors – Wall or Ceiling Mount

Group: Lighting

Category: Occupancy Sensors – Wall or Ceiling Mount

Technology Description: Installation of wall or ceiling mounted occupancy sensors to control non-high bay lighting.

Qualifying Equipment:

- Occupancy sensors must be ultrasonic or passive infrared sensors.
- Sensors must control non-high bay fixture types and must be either wall mounted or ceiling mounted.
- Sensors may not be socket based or fixture mounted.
- Sensors must control lighting wattages shown in Table 4-160.
- Incentive applies to installation of a single sensor, which may control more than one fixture.

Date Deeming Last Modified: December 2009

Date Previously Deemed: October 2006

Summarized by: Peter McPhee

Table 4-160. Occupancy Sensor Installation Deemed Savings

WISeerts Tech Code	Measure Description	Deemed Savings							
		Agriculture		Commercial		Industrial		Schools/Gov't	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.0505.085	Occupancy Sensors - Wall Mount <= 200 Watts	0	289	0	229	0	292	0	199
2.0506.085	Occupancy Sensors - Wall Mount >= 201 Watts	0	674	0	535	0	681	0	465
2.0507.085	Occupancy Sensors - Ceiling Mount <= 500 Watts	0	674	0	535	0	681	0	465
2.0508.085	Occupancy Sensors - Ceiling Mount 501-1000 Watts	0	1,445	0	1,147	0	1,459	0	996
2.0509.085	Occupancy Sensors - Ceiling Mount >= 1001 Watts	0	2,311	0	1,835	0	2,335	0	1,594

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Deemed savings result from installing wall mounted or ceiling mounted occupancy sensors as lighting controls. Occupancy sensors can reduce the hours of operation for lighting systems and thereby reduce electricity consumption. The electric deemed savings for this measure per sensor are provided in Table 4-160 based on customer sector.

There are no deemed demand savings associated with installing occupancy sensors. When savings were deemed, it was reasoned that the program's peak hours are during a period of high occupancy, and thus lights controlled by occupancy sensors would be on.

kWh savings are determined using the following equation:

$$kWh\ Savings = \frac{F_S \times H \times P_L}{1{,}000}$$

where:

- *F_S = savings factor, deemed 41 percent*
- *H = annual operating hours, values in Table 4-162*
- *P_L = Controlled lighting wattage, values in Table 4-163*
- *1,000 = conversion factor, watts per kilowatt.*

Savings factor, F_S. The savings factor represents the percentage of operating time that is reduced for a lighting system through the installation of an occupancy sensor.

Annual operating hours, H. This is the average annual operating hours of the lighting system before installation of the occupancy sensor, deemed by sector.

Controlled lighting wattage, P_L. The controlled lighting wattage is the average power used by the lighting system controlled with the occupancy sensor.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Savings factor, F_S. A savings factor of 41 percent is used across all sectors for calculating kWh savings. The savings factor is derived from estimates made by the EPA and EPRI for different applications.[222] The applications and savings factor estimates are provided in Table 4-161. The deemed value of 41 percent is the average of the savings factors for the different applications. The savings factors for some applications do not have a distinct source but are estimated based on similar applications with similar usage patterns.

[222] The EPA values can be seen at http://www.esource.com/BEA/demo/BEA_esource/PA_10.html.

Table 4-161. Assumed Savings Factor

Application	Savings Factor		
	From EPA	From EPRI	Assumed
Private office	13–50%	25%	25%
Open office			20%
Classroom	40–46%		40%
Conference room	22–65%	35%	35%
Break room			35%
Restroom	30–65%	40%	40%
Corridor	30–80%		50%
Storage area	45–80%		50%
Hotel meeting room		65%	65%
Warehouse			50%
		Average	**41%**

Annual operating hours, H. This calculation uses the program's standard lighting operating hours, presented in Table 4-162 and discussed in Section 3.1.

Table 4-162. Lighting Operating Hours by Sector

Sector	Hours	CF
Agriculture	4,698	67%
Commercial	3,730	77%
Industrial	4,745	77%
Schools-Gov't	3,239	64%

Controlled lighting wattage, P_L. The wattage of the lighting system controlled by the occupancy sensor is binned into power ranges for both ceiling mounted and wall mounted occupancy sensors. Table 4-163 shows the controlled lighting wattage bins and the deemed values associated with the bins. For bins where a lower and upper bound exist, the average value is used as the deemed value. For open-ended bins, the method of choosing a single deemed value is unknown. The chosen values may be intended to reflect an assumed population weighting of fixture wattages in that range.

Table 4-163. Controlled Lighting Wattage

Lighting System Description	Lighting System Wattage
Wall Mount <200 W	150
Wall Mount 201+ W	350
Ceiling Mount <500 W	350
Ceiling Mount 501 to 1,000 W	750
Ceiling Mount 1,001+ W	1,200

Substituting the above values into the kWh savings equation yields the deemed savings reported in Table 4-160.

4.9.6 High/Low Control for 320 W PSMH

Group: Lighting

Category: Controls

Technology Description: High/low control for a 320 W pulse start metal halide (PSMH), per fixture controlled.

Qualifying Equipment:

- PSMH lamp must be indoors.
- Fixture must be mounted more than 15 feet above the floor.
- Occupancy sensor must control a PSMH rated 320 W.
- Fixture must be a permanently-wired ballast and lamp retrofit or complete new fixture.
- Incentive applies to the installation of an individual control.

Date Deeming Last Modified: December 2009

Date Previously Deemed: November 2008

Summarized by: Peter McPhee

Table 4-164. High/Low Control Installation Deemed Savings

WISeerts Tech Code	Measure Description	Deemed Savings							
		Agriculture		Commercial		Industrial		Schools/Gov't	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.0515.085	High / low control for 320W PSMH, per fixture controlled	0	540	0	429	0	546	0	256

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Deemed savings result from installing a high/low control on a 320 W pulse start metal halide (PSMH) fixture. High/Low controls can reduce the light output when a space is unoccupied or full light level is not needed, thereby reducing the electricity consumption of a lamp that would otherwise be operating at full output. The savings for this measure are provided in Table 4-164 based on customer sector.

The deemed kWh savings are calculated by multiplying the number of hours at the reduced lighting level by the difference in wattage between the high and low operating levels. The kWh savings are deemed by sector. There are no deemed kW savings associated with installing high/low controls for PSMH's. When savings were deemed, it was reasoned that the program's peak hours are during a period of high occupancy, and thus lights controlled by occupancy sensors would be on.

The kWh savings are determined using the following equation:

$$kWh\ Savings = F_D \times H \times (P_F - P_L)$$

where:

- F_D = *Dimmed time factor of high/low controls, values in Table 4-165*
- *H = Annual operating hours, values in Table 4-166*
- P_F = *Full output lighting wattage, deemed 0.368 kW*
- P_L = *Low output lighting wattage, deemed 0.184 kW.*

Dimmed time factor, F_D*.* The dimmed time factor represents the percentage of operating hours that a lighting fixture is dimmed from full output to low output resulting from the installation of the control.

Annual operating hours, H. This is the average annual operating hours of the PSMH fixtures at all outputs, deemed by sector.

Full output lighting wattage, P_F*.* This variable refers to the power used by the PSMH lighting fixture while providing full light output.

Low output lighting wattage, P_L*.* This refers to the power used by the fixture while providing reduced light output as a result of the control.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Dimmed time factor, F_D*.* The dimmed time factor values are shown in Table 4-165. The Agricultural, Commercial, and Industrial sectors' factor of 62.5 percent is based on a range of estimates made by the EPA that reflect the dimmed time factor for a warehouse or storage area.[223] The value used in the calculation is the midpoint of the range of estimates. The qualifying equipment in these sectors (installed more than 15 feet above the floor) are most commonly found in storage areas, warehouses, and garages. The usage patterns of these spaces are best reflected in the EPA space type "storage area."

The value of 43 percent used for the Schools and Government sector assumes that the majority of PSMH lighting is used in gymnasiums and auditoriums, and that these spaces have similar usage patterns to classrooms. The EPA study estimates classroom occupancy sensor savings of 40–46 percent. The deemed value of 43 percent is the midpoint of this range.

Table 4-165. Dimmed Time Factors by Sector

	Agriculture	Commercial	Industrial	Schools/Gov't
Dimmed Time Factor	62.5%	62.5%	62.5%	43.0%

[223] http://www.esource.com/BEA/demo/BEA_esource/PA_10.html.

Annual operating hours, H. This calculation uses the program's standard lighting operating hours, presented in Table 4-166 and discussed in Section 3.1.

Table 4-166. Lighting Operating Hours by Sector

Sector	Hours	CF
Agriculture	4,698	67%
Commercial	3,730	77%
Industrial	4,745	77%
Schools-Gov't	3,239	64%

Full output lighting wattage, P_F. The full output lighting wattage includes the power drawn by the lamp and the ballast. The exact method for determining the full wattage estimate of 368 W is not clear, though it appears to reflect a population of both electronic and magnetic ballasts.

Low output lighting wattage, P_L. The low output wattage is assumed to be one half of the full output wattage, or 184 W. The source for this value is unknown, but it is possible that it was taken from manufacturer specifications.

Substituting the above values into the kWh savings equation yields the values presented in Table 4-160.

4.9.7 Daylighting Controls

Group: Lighting

Category: Controls

Technology Description: Daylighting controls, automatic stepped or automatic dimming.

Qualifying Equipment:

- Controlled lighting must be T5, T5HO, or T8 fluorescent lighting.
- Control system must consist of daylighting sensor and lighting control.
- The control system must be located such that the fixture's lighting level will reduce to its lowest possible level on sunny summer afternoons.
- Savings apply per controlled kW.
- For automatic stepped controls, controlled lighting must have at least two illumination levels, plus off.
- For automatic dimming controls, lighting fixture must utilize dimmable ballasts.

Date Deeming Last Modified: December 2009

Date Previously Deemed: November 2008

Summarized by: Peter McPhee

Table 4-167. Daylighting Controls Deemed Savings

WISeerts Tech Code	Measure Description	Deemed Savings							
		Agriculture		Commercial		Industrial		Schools/Gov't	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.0520.085	Daylighting Controls - Automatic stepped, minimum 3 lighting levels (per kW controlled)	0.6700	1,879	0.7700	1,492	0.7700	1,482	0.6400	1,296
2.0530.085	Daylighting Controls - Automatic dimming ballasts (per kW controlled)	0.6030	1,879	0.6930	1,492	0.6930	1,482	0.5760	1,296

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Energy savings result from installing an automatic daylighting control system on T5, T5 High Output (HO), or T8 fluorescent lighting. Automatic daylighting controls can reduce the light output of a lighting system during times when there is sufficient infiltration of natural light, thereby reducing electricity consumption. Two daylighting controls are deemed: automatic stepped systems and automatic dimming ballasts. The deemed savings for these measures are provided in Table 4-167 based on customer sector.

These savings are deemed per controlled kW. The kW controlled is taken from the application and multiplied by the deemed savings values to yield kW and kWh savings. The deemed demand savings (per controlled kW) are calculated by multiplying a lighting reduction percentage by the coincidence factor. The deemed kWh savings (per controlled kW) are calculated by multiplying the existing lighting system's operating hours by a savings percentage.

kW and kWh savings per kW controlled are and determined using the following equations:

$$\frac{kW\ Savings}{kW\ Controlled} = F_{PR} \cdot CF$$

$$\frac{kWh\ Savings}{kW\ Controlled} = F_{DS} \cdot H$$

where:

- F_{PR} = *Peak reduction factor, values in Table 4-168*
- *CF = Coincidence factor, values in Table 4-169*
- F_{DS} = *Daylighting savings factor due to daylighting controls, deemed 40 percent*
- *H = Annual operating hours, values in Table 4-169.*

Peak Reduction Factor, F_{PR}*.* The peak reduction factor represents the percentage reduction in the lighting system wattage during peak hours as a result of the controls.

Coincidence Factor, CF. Coincidence Factor refers to the average percentage of total system wattage that is operating during the peak period and is measured in percent.

Daylighting savings factor, F_{DS}*.* The daylighting savings factor represents the percentage of kWh consumption that is saved through the proper installation of daylighting controls.

Annual operating hours, H. This represents the average annual operating hours of the existing lighting system, deemed by sector.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Peak Reduction Factor, F_{PR}*.* Peak reduction factor values are shown in Table 4-168. The values are independent of sector as they reflect the applied technology and not usage patterns. The automatic stepped controls were examined as part of a study conducted by the Energy Center of Wisconsin (ECW).[224] The study reported that, on a peak usage day, properly located stepped daylighting controls would reduce the lighting output to

[224] "Daylighting Technologies and Incentive Research", Energy Center of Wisconsin. Report for Focus on Energy. 30 November 2006.

zero, thereby reducing wattage by 100 percent. The report also examined automatic dimming ballasts under the same peak design day scenario and found that lighting levels would be reduced by 90 percent. This is consistent with most dimming ballasts, which reduce output to about 10 percent of full output levels.

Table 4-168. Peak Reduction Factors by Measure

Measure Description	Peak Reduction Factor
Daylighting Controls - Automatic stepped, minimum 3 lighting levels (per kW controlled)	100%
Daylighting Controls - Automatic dimming ballasts (per kW controlled)	90%

Daylighting savings factor, F_{DS}. The daylighting savings factor value of 40 percent is used across sectors and for both stepped and dimming controls. The value is taken from an ACEEE study that examined integrated daylight controls.[225]

Annual operating hours, H. This calculation uses the program's standard lighting operating hours, presented in Table 4-169 and discussed in Section 3.1.[226]

Coincidence factor, CF. These calculations use the program's standard lighting coincidence factors, presented in Table 4-169. For a more complete discussion of deemed coincidence factors, refer to Section 3.1.

Table 4-169. Annual Operating Hours and Coincidence Factors by Sector

Sector	Hours	CF
Agriculture	4,368	90%
Commercial	3,680	90%
Industrial	3,536	90%
Schools/Gov't	3,200	71%

Substituting the above values into the savings equations yields the deemed kW and kWh savings per kilowatt controlled, as presented in Table 4-167. These values are multiplied by the controlled lighting kW from the application to yield measure savings.

[225] "ACEEE's Emerging Technologies Report: Integrated Daylight Controls", 2006. This report is available at http://www.aceee.org/emertech/2006_LightingControls.pdf.

[226] Note that the hours of use values for the Agriculture and Industrial sectors are greater than the average number of daylight hours in a year, which is approximately 4,380 hours per year. When this measure was originally deemed, the Industrial sector hours were reduced by 4 hours per day, 5 days per week, 52 weeks per year, or 1,040 hours per year. This correction was left out when the measure was updated and should be reinstated during the next deeming round.

4.9.8 4' T-8 Replacing 8' T-12 Fluorescent Lighting

Group: Lighting

Category: Fluorescent, Linear

Technology Description: 4' 4-Lamp T-8 fluorescent light fixtures replacing 8' 2-Lamp T-12 fluorescent light fixtures in retrofit applications.

Qualifying Equipment:

- New construction projects are not included.
- Must be replacing existing 8' T-12 fixtures.
- T-8 lamps must be high-performance T-8 (≥ 3100 initial lumens with 24,000 hour lamp life at 3-hour rated start) and be on the *CEE High Performance T-8* list.
- T-8 ballasts must be ≤ 0.78 ballast factor or be an approved ballast on the *CEE High Performance T-8* list.
- Fixtures must be installed indoors.

Date Deeming Last Modified: December 2009

Date Previously Deemed: May 2008

Reviewed by: Jeremiah Robinson

Table 4-170. T-8 Replacing 8' T-12 Fluorescent Lighting Measures

Tech Code	Measure Description	Savings							
		Ag		Com		Ind		S-G	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.0810.170	T8 4L-4ft High Performance Replacing T12 2L-8 ft	0.0156	110	0.0179	87	0.018	111	0.015	75
2.0811.170	T8 4L-4ft High Performance Replacing T12HO/VHO 2L-8 ft	0.0797	560	0.0912	444	0.0918	565	0.0767	386

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

T-8 fluorescent light fixtures save energy when replacing T-12 fluorescent fixtures because they are able to produce the same light output with a lower wattage. Savings due to replacing light fixtures are described by the following equations:

$$kW_{Savings} = \left(\frac{LtgWatts_{old} - LtgWatts_{new}}{1{,}000} \right) (CF)$$

$$kWh_{Savings} = \left(\frac{LtgWatts_{old} - LtgWatts_{new}}{1{,}000} \right) (Hours)$$

where:

- *Ltg. $Watts_{old}$ = lighting wattage of existing fixture, values in Table 4-173, watts*
- *Ltg. $Watts_{new}$ = lighting wattage of new fixture, values in Table 4-176, watts*
- *Hours = hours of use per year, values in Table 4-177, hr/yr*
- *CF = coincidence factor, values in Table 4-177, percent*
- *1,000 = conversion factor, watts per kilowatt.*

Existing Lighting Fixture Wattage, Ltg. $Watts_{old}$. The Existing Lighting Fixture Wattage is the total fixture wattage of the old fixture being replaced, including lamps and ballast.

New Lighting Fixture Wattage, Ltg. $Watts_{new}$. The New Lighting Fixture Wattage is the total fixture wattage of the new fixture being installed, including lamps and ballast.

Hours of Use, Hours. Hours of Use refers to the average annual operating hours of the light fixture and is measured in hours/year.

Coincidence Factor, CF. Coincidence Factor refers to the average percentage of total system wattage that is operating during the peak period and is measured in percent.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

In this discussion, measure 2.0810.170 is referred to as the "standard T-12 replacement" and measure 2.0811.170 is referred to as the "high output T-12 replacement."

Existing Lighting Fixture Wattage, Ltg. $Watts_{old}$. The wattage of the existing fixtures are deemed as 123 W for standard T12 replacement and 226 W for high output T12 replacement. These are based on wattages provided in the California Standard Performance Contract.[227] The wattage for the standard T12 measure is based on the value reported for a fixture with an energy saving magnetic ballast. For the high output measure, the deemed value is based on two values from SPC, one for a high output (HO) fixture with an energy saving magnetic ballast, and one for a very high output (VHO) fixture with a standard magnetic ballast. The SPC values are reported in Table 4-171.

Table 4-171. SPC Wattages Selected

Fixture Type	Input Watts
T12	123
T12HO	207
T12VHO	380

[227] During deeming, these wattages were compared to those reported by Advance Atlas, and the values were similar.

The HO and VHO values are combined based on market share percentages developed from interviews with lighting representatives. The market shares reported by three lighting representatives and the average of these are shown in Table 4-172.

Table 4-172. Results of Conversations with Lighting Representatives

Interview	Location	Installed Fixtures	
		% VHO	% HO
Gene Scholler with Sylvania Lighting Services	Milwaukee	8%	92%
Neher Lightbulbs (sales representative)	Milwaukee	15%	85%
Brian with Gexpro Lightbulbs	Wauwatosa	10%	90%
	Average	**11%**	**89%**

The existing fixture wattage for the high output measure is determined by weighting the HO and VHO fixture wattages according to these average market share percentages, as shown in Table 4-173.

Table 4-173. Deemed Values for Existing Fixture Wattage

Fixture Type	SPC Wattage	Weighting	Measure	Deemed Wattage
T12	123	N/A	2.0180.170	123
T12HO	207	89%		
T12VHO	380	11%	2.0181.170	226

New Lighting Fixture Wattage, Ltg. Watts$_{new}$. New lighting fixture wattage is deemed to be 100 W for standard T12 replacement and 107 W for high output T12 replacement. These values are developed using data from CEE and from the WISeerts database. CEE data is used to calculate the average input wattage of qualifying fixture if the ballast factor were one. This is done by dividing the average fixture wattage by the average ballast factor. The average input wattages if the ballast factor were 1.0 are shown in Table 4-174.

Table 4-174. CEE Avg. Ballast Factor, Input Wattage, and Input Wattage at BF=1.0

Ballast Factor Category	Average Ballast Factor	Average Input Wattage	Average Input Wattage at Ballast Factor = 1.00
Low	0.76	95	125
Normal	0.88	108	123
High	1.16	145	124

The average ballast factor of replacement fixtures is found by averaging a sample from the WISeerts database. [228]

[228] A smaller sample is used for the standard T12 replacement than for the high output T12 replacement because the ballast factor values for this measure are very consistent.

Table 4-175. Average Ballast Factors from WISeerts

Measure	Projects Reviewed	Percentage of Total Projects	Average Ballast Factor
2.0810.170	8	22%	0.8
2.0811.170	26	46%	0.87

The deemed new fixture wattage values are then found by multiplying the average ballast factor as determined from WISeerts by the CEE input wattage with ballast factor equal to one. The wattage for the Low ballast factor category is used for the normal T12 replacement measure and that of Normal ballast factor category are used for the high output T12 measure. The results are shown in Table 4-176.

Table 4-176. Deemed Values for New Fixture Wattage

Ballast Factor Category	Ballast Factor	Input Watts at Ballast Factor = 1.00	Input Wattage
Low	0.8	125	100
Normal	0.87	123	107

i. Hours of Use & Coincidence Factor

The values for hours of use and coincidence factor are those used for most lighting measures, deemed by sector. These sector-specific values are shown in Table 4-177.

Table 4-177. Hours of Use and Coincidence Factor

Sector	Hours	CF
Agriculture	4,698	67%
Commercial	3,730	77%
Industrial	4,745	77%
Schools-Gov't	3,239	64%

Substituting the existing wattages from Table 4-173, new wattages from Table 4-176, and the hours of use and coincidence factors from Table 4-177 into the savings equations yields the deemed savings reported in Table 4-170.

4.9.9 T8 Low Watt with CEE Ballast

Group: Lighting

Category: Fluorescent, Linear

Technology Description: 4' T8 Low Wattage with CEE Ballast

Qualifying Equipment:

- Existing lamps must be standard T12 or T8 systems.
- Replacement lamps must be four foot 25 W, 28 W, or 30 W linear T8s or 29 W or 30 W U lamps.
- All replacement lamps must be paired with an approved ballast.[229]
- Incentive and savings apply to replacement of single fixture.
- Replacement bulbs must coincide with bulb type and wattages presented in Table 4-178.

Date Deeming Last Modified: December 2009

Date Previously Deemed: May 2008

Summarized by: Peter McPhee

Table 4-178. T8 Low Watt with CEE Ballast Measures

WISeerts Tech Code	Measure Description	Deemed Savings							
		Agriculture		Commercial		Industrial		Schools/Gov't	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.0821.170	T8 1L-4 ft Low Watt with CEE Ballast - 25 Watts	0.0080	56	0.0092	45	0.0092	57	0.0077	39
2.0822.170	T8 2L-4 ft Low Watt with CEE Ballast - 25 Watts	0.0143	101	0.0165	80	0.0165	102	0.0137	69
2.0823.170	T8 3L-4 ft Low Watt with CEE Ballast - 25 Watts	0.0242	170	0.0278	135	0.0278	172	0.0231	117
2.0824.170	T8 4L-4 ft Low Watt with CEE Ballast - 25 Watts	0.0297	208	0.0341	165	0.0341	210	0.0284	143
2.0831.170	T8 1L-4 ft Low Watt with CEE Ballast - 28 Watts	0.0072	50	0.0082	40	0.0082	51	0.0068	35
2.0832.170	T8 2L-4 ft Low Watt with CEE Ballast - 28 Watts	0.0103	72	0.0119	57	0.0119	73	0.0099	50
2.0833.170	T8 3L-4 ft Low Watt with CEE Ballast - 28 Watts	0.0184	129	0.0212	103	0.0212	130	0.0176	89
2.0834.170	T8 4L-4 ft Low Watt with CEE Ballast - 28 Watts	0.0216	151	0.0248	120	0.0248	153	0.0206	104

[229] Qualified ballasts can be found at www.focusonenergy.com/businesslighting.

WISeerts Tech Code	Measure Description	Deemed Savings							
		Agriculture		Commercial		Industrial		Schools/Gov't	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.0841.170	T8 1L-4 ft Low Watt with CEE Ballast - 30 Watts	0.0053	37	0.0060	29	0.0060	37	0.0050	25
2.0842.170	T8 2L-4 ft Low Watt with CEE Ballast - 30 Watts	0.0096	67	0.0110	53	0.0110	68	0.0091	46
2.0843.170	T8 3L-4 ft Low Watt with CEE Ballast - 30 Watts	0.0170	119	0.0196	95	0.0196	121	0.0163	82
2.0844.170	T8 4L-4 ft Low Watt with CEE Ballast - 30 Watts	0.0202	142	0.0232	112	0.0232	143	0.0193	98

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Savings result from replacing standard T12 or T8 fixtures with low watt T8s and CEE ballasts. Low watt T8s with CEE ballasts use less electricity to produce an equivalent amount of light than standard T12 or T8 fixtures. The electric deemed savings for this measure per fixture are provided in Table 4-178 based on customer sector.

kW and kWh savings are determined using the following equations:

$$kW\ Savings = \frac{(P_e - P_p) \times CF}{1{,}000}$$

$$kWh\ Savings = \frac{(P_e - P_p) \times H}{1{,}000}$$

where:

- *P_e = existing lighting wattage, values in Table 4-180*
- *P_p = proposed replacement lighting wattage, values in Table 4-180*
- *CF = coincidence factor, values in Table 4-181*
- *H = annual operating hours, values in Table 4-181*
- *1,000 = conversion factor, watts per kilowatt.*

Lighting wattages, P_e and P_p. These variables refer to the average power used by the existing T12 or T8 fixtures and the proposed low wattage T8s, respectively.

Coincidence Factor, CF. Coincidence Factor refers to the average percentage of total system wattage that is operating during the peak period and is measured in percent.

Annual operating hours, H. This refers to the average annual operating hours of the light fixture and is measured in hours/year.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Existing lighting wattage, P_e. The deemed values for the existing lighting wattages are based on the assumption that 20 percent of replaced fixtures are T12 and 80 percent are T8.[230] Values are taken from a 2005 ASHRAE publication[231] for T12 with an energy efficient magnetic ballast and for 32 W T8 with an electronic ballast. The ASHRAE values and their weighted averages are shown in Table 4-179.

Table 4-179. Existing Lighting Wattage Assumptions

Fixture Type	T12 Wattage	T8 Wattage	Weighted Average
1 Lamp - 4 feet	42	32	34
2 Lamp - 4 feet	72	60	62.4
3 Lamp - 4 feet	115	93	97.4
4 Lamp - 4 feet	144	120	124.8

Proposed replacement lighting wattage, P_p. The deemed replacement wattages of the low watt T8s are based on the average of wattages in manufacturer data from MaxLite, Sylvania, GE, Advance, and Philips. The deemed values for the lighting replacements are shown in Table 4-180, along with the appropriate existing wattage values for each measure, from above.

Table 4-180. Deemed Lighting Technology Wattages

Existing Lighting Technology	Existing Wattage	Replacement Lighting Technology	Replacement Wattage
T12 or T8 1L-4 ft Standard	34.0	T8 1L-4 ft Low Watt with CEE Ballast - 25 Watts	22.0
T12 or T8 2L-4 ft Standard	62.4	T8 2L-4 ft Low Watt with CEE Ballast - 25 Watts	41.0
T12 or T8 3L-4 ft Standard	97.4	T8 3L-4 ft Low Watt with CEE Ballast - 25 Watts	61.3
T12 or T8 4L-4 ft Standard	124.8	T8 4L-4 ft Low Watt with CEE Ballast - 25 Watts	80.5
T12 or T8 1L-4 ft Standard	34.0	T8 1L-4 ft Low Watt with CEE Ballast - 28 Watts	23.3
T12 or T8 2L-4 ft Standard	62.4	T8 2L-4 ft Low Watt with CEE Ballast - 28 Watts	47.0
T12 or T8 3L-4 ft Standard	97.4	T8 3L-4 ft Low Watt with CEE Ballast - 28 Watts	69.9
T12 or T8 4L-4 ft Standard	124.8	T8 4L-4 ft Low Watt with CEE Ballast - 28 Watts	92.6
T12 or T8 1L-4 ft Standard	34.0	T8 1L-4 ft Low Watt with CEE Ballast - 30 Watts	26.2

[230] This distribution is agreed upon between the program and evaluators. The percentage of T12 fixtures has been reduced over time to reflect their decreasing prevalence.

[231] ASHRAE Fundamentals, 2005.

Existing Lighting Technology	Existing Wattage	Replacement Lighting Technology	Replacement Wattage
T12 or T8 2L-4 ft Standard	62.4	T8 2L-4 ft Low Watt with CEE Ballast - 30 Watts	48.1
T12 or T8 3L-4 ft Standard	97.4	T8 3L-4 ft Low Watt with CEE Ballast - 30 Watts	72.0
T12 or T8 4L-4 ft Standard	124.8	T8 4L-4 ft Low Watt with CEE Ballast - 30 Watts	94.7

Coincidence factor, CF. This calculation uses the program's standard lighting coincidence factors, presented in Table 4-181. For a more complete discussion of deemed coincidence factors, refer to Section 3.1.

Annual operating hours, H. This calculation uses the program's standard lighting operating hours, presented in Table 4-181 and discussed in Section 3.1.

Table 4-181. Lighting Operating Hours and Coincidence Factors by Sector

Sector	Hours	CF
Agriculture	4,698	67%
Commercial	3,730	77%
Industrial	4,745	77%
Schools-Gov't	3,239	64%

Substituting the above values into the kW and kWh savings equations yields the deemed savings presented Table 4-178.

4.9.10 T8 Low Watt Relamp

Group: Lighting

Category: Fluorescent, Linear

Technology Description: T8 Low Watt Relamp

Qualifying Equipment:

- Existing lamps must be either four foot 32 W T8 lamps or eight foot 59 W T8 lamps.
- Replacement lamps must be four foot 25 W, 28 W, or 30 W linear T8s or eight foot 54 W linear T8s.
- Incentive and savings apply to installation of a single lamp.
- Replacement bulbs must coincide with bulb type and wattages presented in Table 4-182.

Date Deeming Last Modified: December 2009

Date Previously Deemed: April 2007

Summarized by: Peter McPhee

Table 4-182. T8 Low Watt Relamping Deemed Savings

WISeerts Tech Code	Measure Description	Deemed Savings							
		Agriculture		Commercial		Industrial		Schools/Gov't	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.0851.170	T8 Low Watt Relamp - 25 Watts	0.0059	41	0.0068	33	0.0068	42	0.0056	29
2.0852.170	T8 Low Watt Relamp - 28 Watts	0.0044	31	0.0051	25	0.0051	31	0.0042	21
2.0853.170	T8 Low Watt Relamp - 30 Watts	0.0031	22	0.0036	18	0.0036	22	0.0030	15
2.0856.170	T8 Low Watt Relamp 8 ft - 54 Watts	0.0034	23	0.0039	19	0.0039	24	0.0032	16

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Savings result from replacing four foot 32 W or eight foot 59 W T8 lamps with low watt T8 lamps. Low watt T8s use less electricity than the standard T8 fixtures to produce an equivalent amount of light. The electric deemed savings for this measure per lamp are provided in Table 4-182 based on customer sector.

kW and kWh savings are determined using the following equations:

$$kW\ Savings = \frac{\left(P_e\text{-}P_p\right) \times CF}{1{,}000}$$

$$kWh\ Savings = \frac{(P_e - P_p) \times H}{1{,}000}$$

where:

- *P_e = existing lighting wattage, values in Table 4-183*
- *P_p = proposed replacement lighting wattage, values in Table 4-183*
- *CF = coincidence factor, values in Table 4-185*
- *H = annual operating hours, values in Table 4-185*
- *1,000 = conversion factor, watts per kilowatt*

Lighting wattages, P_e and P_p. These variables refer to the average power used by the existing T8 lamps and the proposed low wattage T8s, respectively.

Coincidence factor, CF. The coincidence factor represents the fraction of lights operating during peak period and is deemed by sector.

Annual operating hours, H. This is the average annual operating hours of the existing and replacement lamps, deemed by sector.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Existing lighting wattage, P_e. The deemed values for existing lighting wattages are shown in Table 4-183. The assumed values are based on ASHRAE wattage estimates[232] for four foot fixtures of one to four lamps and eight foot fixtures of one or two lamps. These values are presented in Table 4-184. For each fixture type, the total fixture wattage is divided by the number of lamps to yield a value for watts per lamp. Then, these wattages are averaged for each lamp length to produce an average watts per lamp of 30.8 W for 4 foot and 59 W for 8 foot fixtures.

Table 4-183. Deemed Lighting Technology Wattages

Existing Technology	Existing Wattage	Replacement Technology	Replacement Wattage
4 ft 32W Standard T8	30.8	4 ft Low Watt T8 - 25W	22.0
4 ft 32W Standard T8	30.8	4 ft Low Watt T8 - 28W	24.2
4 ft 32W Standard T8	30.8	4 ft Low Watt T8 - 30W	26.1
8 ft 59W Standard T8	59.0	8 ft Low Watt T8 - 54W	54.0

[232] ASHRAE Fundamentals, 2005.

Table 4-184. Existing Lighting Wattage Assumptions

Lamp Length	Existing Lighting Wattage			
	Fixture Type	Fixture Wattage	Per Lamp Wattage	Average Wattage per Lamp
4 foot	1 Bulb - 4 foot 32W T8	32	32	30.8
	2 Bulb - 4 foot 32W T8	60	30	
	3 Bulb - 4 foot 32W T8	93	31	
	4 Bulb - 4 foot 32W T8	120	30	
8 foot	1 Bulb - 8 foot 59W T8	59	59	59.0
	2 Bulb - 8 foot 59W T8	118	59	

Proposed replacement lighting wattage, P_p. The deemed values for the replacement lighting wattage are also shown in Table 4-183. The deemed wattages of the low watt T8s are based on averages of manufacturer data from Advance, GE, MaxLite, Sylvania, and Universal for normal ballast factor T8s.

Coincidence factor, CF. This calculation uses the program's standard lighting coincidence factors, presented in Table 4-185 and discussed in Section 3.1.

Annual operating hours, H. This calculation uses the program's standard lighting operating hours, presented in Table 4-185 and discussed in Section 3.1.

Table 4-185. Lighting Operating Hours and Coincidence Factors by Sector

Sector	Hours	CF
Agriculture	4,698	67%
Commercial	3,730	77%
Industrial	4,745	77%
Schools-Gov't	3,239	64%

Substituting the above values into the kW and kWh savings equations yields the deemed savings presented in Table 4-182.

4.9.11 T8 High Lumen Lamp with Low Ballast Factor

Group: Lighting

Category: Fluorescent, Linear

Technology Description: T8 High Lumen with Low BF

Qualifying Equipment:

- Existing fixtures for retrofit must be standard T12 or T8 systems.
- Replacement lamps must be high performance four foot 32W linear T8s. Specifically, replacement lamps must be high lumen, long life F32T8s with at least 3,100 initial lumens and a 24,000 hour rated life.
- All replacement lamps must be from Focus' "CEE High Performance T8" list.[233]
- Replacement lamp ballast must be either a low ballast factor (BF) electronic ballast (≤0.78 BF) or an approved ballast from the "CEE High Performance T8" qualified product list.
- Incentive and savings apply to installation of single fixture.
- Incentive and savings available for both new construction and retrofit.
- Replacement fixtures must coincide with fixture types presented in Table 4-186.

Date Deeming Last Modified: December 2009

Date Previously Deemed: May 2008

Summarized by: Peter McPhee

Table 4-186. T8 High Lumen Lamp with Low BF Deemed Savings

WISeerts Tech Code	Measure Description	Deemed Savings							
		Agriculture		Commercial		Industrial		Schools/Gov't	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.0860.170	T8 1L-4 ft Hi Lumen Lamp with Low BF	0.0040	28	0.0046	22	0.0046	28	0.0038	19
2.0870.170	T8 2L-4 ft Hi Lumen Lamp with Low BF	0.0076	54	0.0088	43	0.0088	54	0.0073	37
2.0880.170	T8 3L-4 ft Hi Lumen Lamp with Low BF	0.0143	101	0.0165	80	0.0165	102	0.0137	69
2.0890.170	T8 4L-4 ft Hi Lumen Lamp with Low BF	0.0180	126	0.0206	100	0.0206	127	0.0172	87
2.0895.170	T8 1L-4 ft Hi Lumen Lamp with Low BF (New Construction)	0.0027	19	0.0031	15	0.0031	19	0.0026	13

[233] Qualified equipment can be found at www.focusonenergy.com/businesslighting.

WISeerts Tech Code	Measure Description	Deemed Savings							
		Agriculture		Commercial		Industrial		Schools/Gov't	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.0896.170	T8 2L-4 ft Hi Lumen Lamp with Low BF (New Construction)	0.0060	42	0.0069	34	0.0069	43	0.0058	29
2.0897.170	T8 3L-4 ft Hi Lumen Lamp with Low BF (New Construction)	0.0114	80	0.0131	63	0.0131	81	0.0109	55
2.0898.170	T8 4L-4 ft Hi Lumen Lamp with Low BF (New Construction)	0.0147	103	0.0169	82	0.0169	104	0.0141	71

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Savings are deemed for both new construction and retrofit installations. For new construction installations, deemed savings result from installing high lumen, low ballast factor (BF) T8s instead of standard T8s. For retrofit installations, savings result from replacing existing standard T12 or T8 fixtures with the high lumen, low BF T8s. High lumen T8s with low BFs use less electricity than standard T12 or T8 fixtures to produce an equivalent amount of light. The electric deemed savings for this measure per fixture are provided in Table 4-186 based on customer sector.

kW and kWh savings are determined using the following equations:

$$kW\ Savings = \frac{(P_e - P_p) \times CF}{1{,}000}$$

$$kWh\ Savings = \frac{(P_e - P_p) \times H}{1{,}000}$$

where:

- *P_e = existing or baseline lighting wattage, values in Table 4-188*
- *P_p = proposed installed lighting wattage, values in Table 4-188*
- *CF = coincidence factor, values in Table 4-189*
- *H = annual operating hours, values in Table 4-189*
- *1,000 = conversion factor, watts per kilowatt.*

Lighting wattages, P_e and P_p. These variables refer to the average power used by the existing T12 or T8 fixtures (retrofit installations) or the standard T8 fixtures (new construction installations) and the proposed high lumen T8s with low BF, respectively.

Coincidence Factor, CF. Coincidence Factor refers to the average percentage of total system wattage that is operating during the peak period and is measured in percent.

Annual operating hours, H. This refers to the average annual operating hours of the light fixture and is measured in hours/year.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Existing or baseline lighting wattage, P_e. These wattages are based on values provided by ASHRAE,[234] found in Table 4-187. For new construction installations, the deemed wattages are equal to those provided by ASHRAE for T8s.

For the retrofit case, the deemed wattage is based on an assumed linear fluorescent distribution of 20 percent T12 and 80 percent T8 .[235] The existing lighting wattage is calculated by weighting the ASHRAE wattages of T8s and T12s for each fixture type according to these percentages. For T12s, the value used is for energy saving lamps with energy saving magnetic ballasts. For T8s, the value used is for 32 W lamps with electronic ballasts.

Table 4-187. ASHRAE Lighting Wattages

Fixture Type	T12 Wattage	T8 Wattage	Weighted Average
1 Lamp - 4 feet	42	32	34
2 Lamp - 4 feet	72	60	62.4
3 Lamp - 4 feet	115	93	97.4
4 Lamp - 4 feet	144	120	124.8

Proposed installed lighting wattage, P_p. The deemed high lumen T8 wattages are based on averages (by the number of lamps per fixture) of technologies presented on the CEE qualified ballast product list[236] while excluding technologies with a "high" ballast factor or those with a "normal" ballast factor but high fixture wattages.[237] These values, along with the appropriate existing lighting wattages from above, are presented in Table 4-188.

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[234] ASHRAE Fundamentals, 2005.

[235] This distribution is agreed upon between the program and evaluators. The percentage of T12 fixtures has been reduced over time to reflect their decreasing prevalence.

[236] Available through Focus on Energy at http://www.focusonenergy.com/Incentives/Business/Lighting.aspx.

[237] For single lamp fixtures, "normal" BF fixtures with wattages above 34 W were excluded. For two lamp fixtures, those above 60 W were excluded. For three lamps, "normal" BF fixtures with wattages above 84 W were excluded. For four lamps, those above 108 W were excluded. These exclusions in the "normal" BF category are in addition to exclusions of all "high" BF fixtures for these calculations.

Table 4-188. Deemed Lighting Wattages

Existing Lighting Technology	Existing Wattage	Replacement Lighting Technology	Replacement Wattage
New Construction - Assuming Standard 1L-4 ft 32W T8 with Electronic Ballast Baseline	32.0	High Performance 1L-4 ft T8 (High Lumen Lamp with Low BF)	28.0
New Construction - Assuming Standard 2L-4 ft 32W T8 with Electronic Ballast Baseline	60.0	High Performance 2L-4 ft T8 (High Lumen Lamp with Low BF)	51.0
New Construction - Assuming Standard 3L-4 ft 32W T8 with Electronic Ballast Baseline	93.0	High Performance 3L-4 ft T8 (High Lumen Lamp with Low BF)	76.0
New Construction - Assuming Standard 4L-4 ft 32W T8 with Electronic Ballast Baseline	120.0	High Performance 4L-4 ft T8 (High Lumen Lamp with Low BF)	98.0
Retrofit - Replacing Standard 1L-4 ft T12 or T8	34.0	High Performance 1L-4 ft T8 (High Lumen Lamp with Low BF)	28.0
Retrofit - Replacing Standard 2L-4 ft T12 or T8	62.4	High Performance 2L-4 ft T8 (High Lumen Lamp with Low BF)	51.0
Retrofit - Replacing Standard 3L-4 ft T12 or T8	97.4	High Performance 3L-4 ft T8 (High Lumen Lamp with Low BF)	76.0
Retrofit - Replacing Standard 4L-4 ft T12 or T8	124.8	High Performance 4L-4 ft T8 (High Lumen Lamp with Low BF)	98.0

Coincidence factor, CF. This calculation uses the program's standard lighting coincidence factors, presented in Table 4-189 and discussed in Section 3.1.

Annual operating hours, H. This calculation uses the program's standard lighting operating hours, presented in Table 4-189 and discussed in Section 3.1.

Table 4-189. Lighting Operating Hours and Coincidence Factors by Sector

Sector	Hours	CF
Agriculture	4,698	67%
Commercial	3,730	77%
Industrial	4,745	77%
Schools-Gov't	3,239	64%

Substituting the above values into the kW and kWh savings equations yields the deemed savings presented in Table 4-186.

4.9.12 T5 2-Lamp Replacing 3-Lamp T8 or 4-Lamp T12

Group: Lighting

Category: Fluorescent, Linear

Technology Description: Replacement of a 3-Lamp T8 system or 4-Lamp T12 system with a recessed, indirect 2-Lamp T5 system.

Qualifying Equipment:

- Existing fixtures may be 3-Lamp or 4-Lamp F32T8 or F40T12.[238]
- Replacement lamps must be high efficiency, low glare 2'x4' recessed indirect F28T5 fixtures or retrofit modules with an efficiency of 80% or greater.
- Approved replacement lamps appear on Focus' approved product list.[239]
- Specular reflector kits are not eligible for this incentive.
- T5HO lamps are not eligible for this incentive.

Date Deeming Last Modified: December 2009

Date Previously Deemed: May 2008

Summarized by: Peter McPhee

Table 4-190. T5 2-Lamp Replacing T8 3-Lamp Deemed Savings[1]

WISeerts Tech Code	Measure Description	Deemed Savings							
		Agriculture		Commercial		Industrial		Schools/Gov't	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.0900.170	T5 2L - F28T5 Fixture, Recessed Indirect 2x4, replacing 3LT8 or 4LT12	0.0201	141	0.0231	112	0.0231	142	0.0192	97

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Deemed savings result from replacing standard 3-Lamp or 4-Lamp T8 or T12 fixtures with 2-Lamp T5 fixtures. T5 fixtures require a lower input wattage to produce an equivalent amount of light to that produced by T8 or T12 fixtures. The electric deemed savings for this measure per fixture are provided in Table 4-190 based on customer sector.

[238] The application is worded such that existing fixtures may be 3-Lamp T8, 4-Lamp T8, 3-Lamp T12, or 4-Lamp T12. The measure description is worded such that existing fixtures may be 3-Lamp T8 or 4-Lamp T12.

[239] Approved products can be found at www.focusonenergy.com/businesslighting.

kW and kWh savings are determined by the following equations:

$$kW\ Savings = \frac{(P_e - P_p) \times CF}{1{,}000}$$

$$kWh\ Savings = \frac{(P_e - P_p) \times H}{1{,}000}$$

where:

- *P_e = existing lighting wattage, deemed 93 W*
- *P_p = proposed replacement lighting wattage, deemed 63 W*
- *CF = coincidence factor, values in Table 4-191*
- *H = annual operating hours, values in Table 4-191*
- *1,000 = conversion factor, watts per kilowatt.*

Lighting wattages, P_e and P_p. These variables refer to the power used by the existing fixtures and the proposed 2-Lamp T5s, respectively.

Coincidence Factor, CF. Coincidence Factor refers to the average percentage of total system wattage that is operating during the peak period and is measured in percent.

Annual operating hours, H. This refers to the average annual operating hours of the light fixture and is measured in hours/year.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Existing lighting wattage, P_e. Existing lighting wattage is based on the wattage of a 3-Lamp fixture with 32 W T8s, and is deemed to be 93 W. This wattage is taken from a 2005 ASHRAE estimate for this fixture.[240] Note that this yields a conservative savings estimate, since the other fixture types that qualify for the incentive have a greater wattage.

Proposed replacement lighting wattage, P_p. The deemed wattage for the 2-Lamp T5 is 63 W. This wattage is taken from Advance Transformer's specifications for the ICN-2S28, a representative 2-Lamp T5 fixture.[241]

Coincidence factor, CF. This calculation uses the program's standard lighting coincidence factors, presented in Table 4-191 and discussed in Section 3.1.

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[240] ASHRAE Fundamentals, 2005.

[241] The Advance Transformer catalog can be accessed at http://www.advancetransformer.com/ecatalog/.

Annual operating hours, H. This calculation uses the program's standard lighting operating hours, presented in Table 4-191 and discussed in Section 3.1.

Table 4-191. Lighting Operating Hours and Coincidence Factors by Sector

Sector	Hours	CF
Agriculture	4,698	67%
Commercial	3,730	77%
Industrial	4,745	77%
Schools-Gov't	3,239	64%

Substituting the above values into the kW and kWh savings equations yields the deemed savings presented in Table 4-190.

4.9.13 LED Recessed Downlight

Group: Lighting

Category: LED Recessed Downlight

Technology Description: Replacement of 60W–100W incandescent with ENERGY STAR qualified LED recessed downlight ≤ 18W.

Qualifying Equipment:

- Existing lamps must be 60W-100W incandescent.
- Replacement LED downlight consists of a complete replacement luminaire unit including housing trim, reflector, lens, heat sink, driver, and light source.
- Replacement LED must appear on ENERGY STAR SSL qualified products list[242] or meet ENERGY STAR eligibility criteria.[243]
- Replacement LED downlight must be ≤ 18W.
- Incentive applies to replacement of single lamp and fixture.

Date Deeming Last Modified: December 2009

Date Previously Deemed: November 2008

Summarized by: Peter McPhee

Table 4-192. LED Recessed Downlight Replacement

WISeerts Tech Code	Measure Description	Deemed Savings							
		Agriculture		Commercial		Industrial		Schools/Gov't	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.0970.260	LED recessed downlight - ENERGY STAR qualified	0.0350	246	0.0403	195	0.0403	248	0.0335	169

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Energy savings result from replacing incandescent bulbs with LED recessed downlights. LEDs use less electricity than incandescent lamps to produce an equivalent amount of light. The electric deemed savings for this measure per bulb are provided in Table 4-192 based on customer sector.

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[242] http://www.energystar.gov/index.cfm?fuseaction=ssl.display_products_com_pdf

[243] http://www.energystar.gov/index.cfm?fuseaction=ssl.display_products_com_pdf

kW and kWh savings are determined by the following equations:

$$kW\ Savings = \frac{\left(P_e\text{-}P_p\right) \times CF}{1{,}000}$$

$$kWh\ Savings = \frac{(P_e - P_p) \times H}{1{,}000}$$

where:

- *P_e = existing lighting wattage, deemed 65 W*
- *P_p = replacement lighting wattage, deemed 12.7 W*
- *CF = coincidence factor, values in Table 4-193*
- *H = annual operating hours, , values in Table 4-193*
- *1,000 = conversion factor, watts per kilowatt.*

Lighting wattages, P_e and P_p. These variables refer to the average power used by the existing incandescent lamp and the proposed LED, respectively.

Coincidence Factor, CF. Coincidence Factor refers to the average percentage of total system wattage that is operating during the peak period and is measured in percent.

Annual operating hours, H. This refers to the average annual operating hours of the light fixture and is measured in hours/year.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Existing lighting wattage, P_e. The deemed value of the existing incandescent wattage is 65 W. The measure calls for the replacement of 60-100 W incandescent downlights. Most of the flood lights that will be replaced are expected to be 65 W or 75 W. The assumed value of 65 W is intended to be a conservative assumption of the wattage of incandescent downlights in the population eligible for replacement by the LED downlight.[244]

Proposed replacement lighting wattage, P_p. The deemed value for the LED recessed downlight replacement is 12.7 W. This value reflects the prevalence of two common LED downlights at the time of deeming. The Cree LR6 (12 W) and Cooper's Halo ML706830 (14.8 W) accounted for approximately 75 percent and 25 percent of eligible installed

[244] The chosen value of existing lighting wattage was discussed in a correspondence between WECC and KEMA in a memo dated 4 November 2008. The subject of the memo is "Fall '08 Deemed Savings Review." No specific sources are cited for the wattage values or prevalence of lamps in the population.

LED downlights, respectively.[245] The value of 12.7 W is a weighted average of the two LED downlights.

Coincidence factor, CF. This calculation uses the program's standard lighting coincidence factors, presented in Table 4-193 and discussed in Section 3.1.

Annual operating hours, H. This calculation uses the program's standard lighting operating hours, presented in Table 4-193 and discussed in Section 3.1.

Table 4-193. Lighting Operating Hours and Coincidence Factors by Sector

Sector	Hours	CF
Agriculture	4,698	67%
Commercial	3,730	77%
Industrial	4,745	77%
Schools-Gov't	3,239	64%

Substituting the above values into the kW and kWh savings equations yields that values presented in Table 4-192.

[245] The LED lighting wattage was also discussed in the WECC/KEMA memo dated 4 November 2008.

4.9.14 Metal Halide Ceramic, Pulse Start, and Electronic Ballast Pulse Start

Group: Lighting

Category: High Intensity Discharge (HID)

Technology Description: Replacement of incandescent, HID, or standard metal halide lamps with ceramic, pulse start, or electronic ballast pulse start metal halides.

Qualifying Equipment:

Ceramic Metal Halide (CMH) Measures:

- Existing fixtures or lamps must be incandescent.[246]
- Replacement fixtures or screw in lamps must be CMHs with wattages as shown in Table 4-194.[247]
- CMH fixtures or lamps may replace more than one incandescent.
- Total CMH wattage must be lower than existing total incandescent wattage.
- For measure 2.2110.220, incentive is for complete hardwired fixtures containing qualified CMH lamp and ballast.
- For measure 2.2115.220, incentive is for CMH reflector lamp with integrated ballast.

Pulse Start and Electronic Ballast Pulse Start Metal Halide Measures:

- Lighting systems must be for indoor applications only.
- Existing lighting technology must be standard HID or standard MH fixtures/components.
- Replacement technologies must coincide with technologies shown in Table 4-194.
- Replacement fixtures must be permanently-wired ballast and lamp retrofit or complete new fixture—screw in retrofit lamps do not qualify.
- Incentive is per fixture installed.

Date Deeming Last Modified: December 2009

[246] The 2.2115.220 measure description indicates that the existing incandescent bulb must be 75-90 W. However, the Focus on Energy incentive application shows that the replaced bulb may be from 70-100 W.

[247] The 2.2115.220 measure description states that the replacement CMH must be 25 W, while the Focus incentive application allows the CMH to be ≤25 W.

Date Previously Deemed:

- October 2006 (2.2110.220, 2.2150.220)
- April 2007 (2.2115.220)
- May 2008 (2.2155.220, 2.2170.220, 2.2171.220)

Summarized by: Peter McPhee

Table 4-194. CMH, PSMH, and Electronic Ballast PSMH Deemed Savings

WISeerts Tech Code	Measure Description	Deemed Savings							
		Agriculture		Commercial		Industrial		Schools/Gov't	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.2110.220	Metal Halide (MH) Ceramic 20-100 Watts - Replaces Incandescent	0.0874	613	0.1005	487	0.1005	619	0.0835	423
2.2115.220	Metal Halide (MH) Ceramic 25 Watts - Replaces 75-90 Watts Incandescent	0.0385	270	0.0443	214	0.0443	273	0.0368	186
2.2150.220	Metal Halide (MH), Pulse Start, 320W replacing 400W HID	0.0630	442	0.0724	351	0.0724	446	0.0602	304
2.2155.220	Metal Halide (MH), Pulse Start - 750W replacing 1000W MH	0.1910	1,339	0.2195	1,063	0.2195	1,352	0.1824	923
2.2170.220	Metal Halide (MH), Electronic Ballast Pulse Start - 250W replacing 400W HID	0.1213	850	0.1394	675	0.1394	859	0.1158	586
2.2171.220	Metal Halide (MH), Electronic Ballast Pulse Start - 320W replacing 400W HID	0.0764	536	0.0878	425	0.0878	541	0.0730	369

Savings Basis, Equations, and Parameters

Deemed savings result from replacing incandescent or standard HID/MH bulbs or fixtures with CMH, PSMH, or electronic ballast PSMH fixtures as shown in Table 4-194. The replacement metal halides use less electricity than incandescent or standard HID lamps to produce an equivalent amount of light. The electric deemed savings for these measures per fixture are provided in Table 4-194 based on customer sector.

kW and kWh savings are determined using the following equations:

$$kW\ Savings = \frac{\left(P_e - P_p\right) \times CF}{1{,}000}$$

$$kWh\ Savings = \frac{(P_e - P_p) \times H}{1{,}000}$$

where:

- *P_e = existing lighting wattage, values in Table 4-195*
- *P_p = proposed replacement lighting wattage, values in Table 4-195*
- *CF = coincidence factor, values in Table 4-196*
- *H = annual operating hours, values in Table 4-196*
- *1,000 = conversion factor, watts per kilowatt.*

Lighting wattages, P_e and P_p. These variables refer to the average power used by the existing incandescent or standard HID/MH lamps and the proposed efficient MHs, respectively.

Coincidence Factor, CF. Coincidence Factor refers to the average percentage of total system wattage that is operating during the peak period and is measured in percent.

Annual operating hours, H. This refers to the average annual operating hours of the light fixture and is measured in hours/year.

A. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Existing lighting wattage, P_e. The deemed values for existing lighting wattage used in the savings calculations are shown in Table 4-195. For incandescents being replaced by 20-100 W CMHs, the wattage of the incandescent is derived from the CMH wattage for lamps of equivalent light output. The CMH wattages are based on a select number of CMH lamps on the market, though the specific lamp technologies are not presented. The deemed incandescent wattage of 55 W reflects the average of the equivalent incandescent wattages.

For an incandescent (75–90 W) being replaced by a CMH (25 W), the existing incandescent wattage value of 82.5 W is a simple average of the incandescent range considered.

For the replacement of the rated 400 W standard HID with a rated 320 W PSMH, the source of the deemed value is unclear. However, both existing and proposed wattage values appear to utilize a ballast factor of 1.16. This value is used to determine the 400 W HID’s actual wattage of 465 W.

The existing wattage of the standard HID/MH lamps used in the remaining measures is derived from lighting technologies available through Advance Transformer.[248] The appropriate rated wattages of the standard HID/MH lamps that fit the measure descriptions were averaged to determine the deemed wattage values of existing lighting for measures 2.2155.220, 2.2170.220, and 2.2171.220.

Table 4-195. Deemed Existing and Replacement Wattages

Existing Technology	Existing Wattage	Replacement Technology	Replacement Wattage
Incandescent	185.5	CMH (20-100W)	55.0
Incandescent (75-90 W)	82.5	CMH (25W)	25.0
400W Standard HID	465.0	PSMH (320W)	371.0
1000W Standard MH	1,100.0	PSMH (750W)	815.0
400W Standard HID	459.0	Electronic Ballast PSMH (250W)	278.0
400W Standard HID	459.0	Electronic Ballast PSMH (320W)	345.0

Proposed replacement lighting wattage, P_p. The deemed values for the lighting replacements are also shown in Table 4-195. The 55 W deemed wattage for the 20-100 W range was based on an average of four CMH lamps in that size range, though the specific lamps and source of these values is unclear.

The deemed wattage value of the 25 W CMH is taken directly from the nameplate rating of the lamp. The measure itself refers to this replacement lamp wattage; therefore, no other lamp wattages were considered.

The source of the deemed wattage of the rated 320 W PSMH is also unknown, but appears to be based on the same ballast factor assumption (BF = 1.16) as the existing 400 W standard HID. Multiplying the 320 W rating by 1.16 yields the replacement fixture wattage of 371 W.

The 750 W PSMH and the electronic ballasted PSMH deemed wattages were taken from manufacturer data for these lamps as provided though the Advance Transformer catalog. The deemed values are averages of the actual wattage of the applicable lamps.

Coincidence factor, CF. This calculation uses the program's standard lighting coincidence factors, presented in Table 4-196 and discussed in Section 3.1.

Annual operating hours, H. This calculation uses the program's standard lighting operating hours, presented in Table 4-196 and discussed in Section 3.1.

Table 4-196. Lighting Operating Hours and Coincidence Factors by Sector

Sector	Hours	CF
Agriculture	4,698	67%

[248] The Advance Transformer catalog is available at http://www.advancetransformer.com/ecatalog/.

Commercial	3,730	77%
Industrial	4,745	77%
Schools-Gov't	3,239	64%

Substituting the above values into the kW and kWh savings equations yields the deemed savings presented in Table 4-194.

4.9.15 LED Reach-in Refrigerated Case Lighting

Group: Lighting

Category: LED Reach-in Refrigerated Case Lighting

Technology Description: Replacement of T8 or T12 fluorescent refrigerator and cooler lamps with LED lamps.

Qualifying Equipment:

- Existing lamps must be T8 or T12 fluorescent lamps.
- Replacement lamps must be LEDs.
- Incentives are available for both retrofits in existing refrigerated display cases and new installations.
- Retrofit projects must completely remove the existing fluorescent fixture end connectors and ballasts to qualify, though wiring may be reused.
- Incentive applies to LED upgrade on a per door basis.

Date Deeming Last Modified: November 2008

Summarized by: Peter McPhee

Table 4-197. LED Reach-in Refrigerated Case Lighting Deemed Savings

WISeerts Tech Code	Measure Description	Deemed Savings	
		kW	kWh
2.3100.260	LED Reach-In Refrigerated Case Lighting replaces T12 or T8	0.0455	398

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Savings result from replacing fluorescent T8 or T12 refrigerated case lighting fixtures with LEDs. LEDs use less electricity than fluorescent lamps to produce an equivalent amount of light and produce less heat than an equivalent fluorescent lamp, reducing the cooling load on the refrigeration system and the energy needed at the refrigerator compressor. The deemed savings for this measure are provided per door in Table 4-197.

The kW and kWh savings are determined using the following equations:

$$kW\ Savings = P_e - P_p + \left(\frac{P_e F_{FH} - P_p F_{LH}}{COP_{Cooling}} \right)$$

$$kWh\ Savings = \left(P_e - P_p + \left(\frac{P_e F_{FH} - P_p F_{LH}}{COP_{Cooling}} \right) \right) H$$

where:

- *P_e = existing fluorescent lighting wattage, deemed 0.0700 kW*
- *P_p = replacement LED lighting wattage, deemed 0.0363 kW*
- *F_{FH} = fluorescent lighting to heat factor, deemed 79 percent*
- *F_{LH} = LED lighting to heat factor, deemed 80 percent*
- *$COP_{Cooling}$ = coefficient of performance of refrigeration system, deemed 2.22*
- *H = annual operating hours, deemed 8,760.*

Lighting wattages, P_e and P_p. These variables refer to the average power used by the existing fluorescent fixtures and the replacement LEDs, respectively.

Lighting to heat factors, F_{FH} and F_{LH}. These factors refer to the fraction of energy consumed by the fluorescent or LED lighting that is converted into thermal energy instead of light. They include the effects of infrared radiation and heat transmitted through conduction and convection.[249]

Coefficient of performance of refrigeration system, $COP_{Cooling}$. The coefficient of performance is a measure of the efficiency of the refrigeration system and is equal to the ratio of net heat removal to the total energy input.

Annual operating hours, H. This refers to the average annual operating hours of the light fixture and is measured in hours/year.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Existing lighting wattage, P_e. The deemed value of the existing fluorescent wattage is 70 W per refrigerator door. The estimate represents the assumed base case technology of F58T8 fluorescent lamps with electronic ballasts. The deemed wattage value was taken from specifications for a standard refrigeration case utilizing the same existing lighting technology as provided by Zero-Zone, a Wisconsin based refrigeration supplier.[250]

Proposed replacement lighting wattage, P_p. The deemed value for the LED replacement lamp is 36.3 W per door. The estimate represents the power consumed by the LED case lighting for 60" refrigeration units. The deemed value is the average of three refrigerated case LED light fixtures, as provided by manufacturers' specifications.[251]

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[249] The calculation assumes that 100 percent of the thermal energy produced by the lights is removed by the refrigeration system.

[250]The Zero-zone products considered are the RVZC30 and RVZC30BB Reach-In Freezer Cases, as specified in the 6/06/06 catalogue. The current Zero-Zone catalogue can be found at http://www.zero-zone.com/products.asp.

[251] The GE RV30 series, the GE RDL Gen 2 series, and the Nualight Vantium Porto were included in the average. The GE products can be found at

Fluorescent lighting to heat factor, F_{FH}. The deemed value for the fluorescent lighting to heat factor is 79 percent. This value is taken from DOE EERE analysis that compares the power of white light sources.[252] The analysis states that 21 percent of the power to a fluorescent light is converted to light while the remainder (79%) is infrared radiation or direct heat.

LED lighting to heat factor, F_{LH}. The deemed value for the LED lighting to heat factor is 80 percent. This value is also taken from the DOE analysis.[252] The analysis states that 15-25 percent of an the power to an LED light is converted to light, while the remainder (75-85%) is converted directly to heat. The deemed value of 80 percent is the midpoint of the range of the DOE estimate.

Coefficient of performance of refrigeration system, $COP_{Cooling}$. The deemed value of the coefficient of performance for a refrigeration system is 2.22.[253] This value was previously used in the April 2007 deeming round, and its source is unknown. It is intended to represent the standard existing COP for a refrigeration system.

Annual operating hours, H. The deemed value of the annual operating hours is 8,760 hours, the number of hours in a year.[254]

Substituting the above values into the kW and kWh savings equations yields the deemed savings presented in Table 4-197.

http://www.lumination.com/literature/RDL_RV30_SpecGuide_WEB_082008.pdf and the Nualight product can be found at http://www.nualight.ie/datasheets/Technical_Specification_Datasheet_Vantium_Porto_05_08.pdf.

[252] Available at http://www1.eere.energy.gov/buildings/ssl/comparing_lights.html.

[253] Most refrigeration measures use a COP of 2.5 for coolers and 1.3 for freezers.

[254] Typically case lighting is operated 24 hours per day, 7 days per week to support stocking during closed hours.

4.9.16 High Bay Fluorescent Replacing HID

Group: Lighting

Category: Fluorescent, Linear

Technology Description: T-8 or T-5 linear fluorescent light fixtures replacing high bay HID light fixtures.

Qualifying Equipment:

- New fixtures must be replacing existing fixtures one-for-one, two-for-one, or in a consistent ratio which (adding fixture wattages together as appropriate) corresponds to the wattage requirements listed below.
- Fixtures must be installed indoors.
- Installed and removed fixture wattages must conform to the requirements shown in Table 4-198.

Table 4-198. Wattage Requirements for HID to Fluorescent Replacement

Tech. Code	Installed Wattage	Removed Wattage
2.5170.170	<155	250–399
2.5180.170	<365	400–999
2.5182.170	<250	400–999
2.5185.170	≤500	1,000+
2.5186.170	≤800	1,000+

Date Deeming Last Modified: December 2009

Date Deeming Last Modified: November 2008[255]

Reviewed by: Jeremiah Robinson

[255] 2.5182.170 added April 2007. 2.5185.170 added November 2008.

Table 4-199. High Bay Fluorescent Replacing HID Measures and Deemed Savings

Tech Code	Measure Description	Agriculture		Commercial		Industrial		Schools-Gov't	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.5170.170	T8 4 lamp or T5HO 2 lamp Replacing 250-399 W HID	0.101	709	0.1156	563	0.1163	716	0.0972	489
2.5180.170	T8 6 lamp or T5HO 4 lamp Replacing 400-999 W HID	0.1648	1,157	0.1886	919	0.1898	1,169	0.1586	798
2.5182.170	T8 8 lamp or T5HO 6 lamp Replacing 400-999 W HID	0.0693	486	0.0793	386	0.0798	491	0.0666	335
2.5185.170	T8/T5HO <= 500 Watts Replacing >=1000 W HID	0.4797	3,368	0.549	2,674	0.5523	3,402	0.4615	2,322
2.5186.170	T8 or T5HO <= 800W, Replacing >=1000 W HID	0.365	2,563	0.4178	2,035	0.4203	2,589	0.3512	1,767

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Linear fluorescent light fixtures save energy when replacing high bay HID light fixtures because they are able to produce the same light output with a lower input wattage.

Savings due to replacing light fixtures are described by the following equations:

$$kW_{Savings} = \left(\frac{LtgWatts_{old} - LtgWatts_{new}}{1{,}000} \right) (CF)$$

$$kWh_{Savings} = \left(\frac{LtgWatts_{old} - LtgWatts_{new}}{1{,}000} \right) (Hours)$$

where:

- *Ltg. Watts$_{old}$ = lighting wattage of existing fixture, values in Table 4-200, watts*
- *Ltg. Watts$_{new}$ = lighting wattage of new fixture, values in Table 4-201, watts*
- *Hours = hours of use per year, values in Table 4-202, hr/yr*
- *CF = coincidence factor, values in Table 4-202, percent*
- *1,000 = conversion factor, watts per kilowatt.*

Existing Lighting Fixture Wattage, Ltg. Watts$_{old}$. The existing lighting fixture wattage is the wattage of the fixture being replaced, including lamps and ballast.

New Lighting Fixture Wattage, Ltg. Watts$_{new}$. The new lighting fixture wattage is the wattage of the new fixture being installed, including lamps and ballast.

Hours of Use, Hours. Hours of Use refers to the average annual operating hours of the light fixture and is measured in hours/year.

Coincidence Factor, CF. Coincidence Factor refers to the average percentage of total system wattage that is operating during the peak period and is measured in percent.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

Existing Lighting Fixture Wattage, Ltg. Watts$_{old}$. Existing Lighting Fixture Wattage for these measures is based on wattage values from the California SPC[256] and data from WISeerts. The wattage of each replaced fixture type is taken from the SPC. Then the percentage of that fixture type that has been replaced under each measure is taken from a WISeerts analysis.[257] The replaced fixture wattage for each measure is the weighted average fixture wattage replaced based on these percentages. The SPC wattages, WISeerts percentages, and associated weighted average existing lighting fixture wattages are shown in Table 4-200.

Table 4-200. Existing Lighting Fixture Wattages

Fixture Type	Watts	250-399W to 2/4 lamp	400-999W to 4/6 lamp	400-999W to 6/8 lamp	1,000W to <=500W	1,000W to 501-800W
1,000W HPS	1,100	0%	0%	0%	2%	2%
400W HPS	465	0%	3%	3%	0%	0%
250W HPS	295	3%	0%	0%	0%	0%
400W MV	455	0%	1%	1%	0%	0%
250W MV	290	1%	0%	0%	0%	0%
1,000W MH	1,080	0%	0%	0%	98%	98%
750W MH	850	0%	0%	1%	0%	0%
400W MH	458	0%	96%	95%	0%	0%
250W MH	295	96%	0%	0%	0%	0%
750W PS MH	818	0%	0%	0%	0%	0%
320W PS MH	365	0%	0%	0%	0%	0%
250W PS MH	288	0%	0%	0%	0%	0%
Total		**100%**	**100%**	**100%**	**100%**	**100%**
Average Watts		**295 W**	**458 W**	**462 W**	**1,080 W**	**1,080 W**

New Lighting Fixture Wattage, Ltg. Watts$_{new}$. New Lighting Fixture Wattage is based on the same type of analysis as Existing Fixture Wattage, except that fixture wattages are based on data from the Advance Atlas catalogue rather than on the California SPC.[258] The percent of replacement fixtures for each measure is determined using the same WISeerts sample used for Existing Fixture Wattage. The fixture wattages, WISeerts percentages, and resulting weighted average New Lighting Fixture Wattages are shown in Table 4-201.

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[256] Southern California Edison Business Incentives & Services Standard Performance Contract Program. *Standard Performance Contract.* "Appendix B: Table of Standard Fixture Wattages and Sample Lighting Table." January 6, 2009.

[257] WISeerts analysis completed in July 2009. It is based on a sample of 54 projects representing 15,015 total fixtures and 9 percent of the total number of fixtures replaced during the database period.

[258] Advance Transformer Company. *Advance Atlas – 2008–2009*. The Advance wattages were chosen over SPC wattages for these fixtures because Advance lists the ballast factors used to determine fixture wattages.

Table 4-201. New Lighting Fixture Wattage

Fixture Type	Watts	250–399W to 2/4 lamp	400–999W to 4/6 lamp	400–999W to 6/8 lamp	1,000W+ to <=500W	1,000W+ to 501–800W
4L F32T8 HBF	144	100%	2%	0%	0%	0%
6L F32T8 HBF	222	0%	48%	0%	7%	0%
8L F32T8 HBF	288	0%	0%	2%	13%	0%
16L F32T8 HBF	576	0%	0%	0%	0%	28%
2L F54T5 HO	119	0%	13%	0%	0%	0%
4L F54T5 HO	237	0%	37%	0%	3%	0%
6L F54T5 HO	360	0%	0%	98%	54%	0%
(2) 4L F54T5 HO	474	0%	0%	0%	2%	0%
8L F54T5 HO	474	0%	0%	0%	21%	0%
10L F54T5 HO	593	0%	0%	0%	0%	63%
(2) 6L F54T5 HO	720	0%	0%	0%	0%	9%
Total		**100%**	**100%**	**100%**	**100%**	**100%**
Average Watts		**144 W**	**212 W**	**359 W**	**363 W**	**535 W**

Hours of Use & Coincidence Factor. The values for hours of use and coincidence factor are those used for most lighting measures, deemed by sector, as shown in Table 4-202.

Table 4-202. Hours of Use and Coincidence Factor

Sector	Hours	CF
Agriculture	4,698	67%
Commercial	3,730	77%
Industrial	4,745	77%
Schools-Gov't	3,239	64%

Substituting the existing wattages from Table 4-200, new wattages from Table 4-201, and the hours of use and coincidence factors from Table 4-202 into the savings equations yields the deemed savings reported in Table 4-199.

4.9.17 Occupancy Sensors for High Bay Fluorescent Fixtures

Group: Lighting

Category: Controls

Technology Description: Occupancy sensor for high bay fluorescent fixtures, per fixture controlled.

Qualifying Equipment: Indoor wall, ceiling, or fixture mounted occupancy sensor used to control a high bay fluorescent fixture.

Date Deeming Last Modified: December 2009

Date Previously Deemed: November 2008

Reviewed by: Jeremiah Robinson

Table 4-203. Deemed Savings for Occupancy Sensors for High Bay Fluorescents

WISeerts Tech Code	Measure Description	Agriculture		Commercial		Industrial		Schools/Gov't	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.5200.085	Occupancy sensor for high bay fluorescent fixtures (per controlled fixture), Gymnasium	0.0344	517	0.0344	348	0.0344	442	0.0344	302
2.5201.085	Occupancy sensor for high bay fluorescent fixtures (per controlled fixture), Industrial	0.0427	591	0.0427	398	0.0427	506	0.0427	346
2.5202.085	Occupancy sensor for high bay fluorescent fixtures (per controlled fixture), Retail	0.0142	197	0.0142	133	0.0142	169	0.0142	115
2.5203.085	Occupancy sensor for high bay fluorescent fixtures (per controlled fixture), Warehouse	0.0427	701	0.0427	472	0.0427	600	0.0427	409
2.5204.085	Occupancy sensor for high bay fluorescent fixtures (per controlled fixture), Public Assembly	0.0284	618	0.0284	416	0.0284	529	0.0284	361
2.5205.085	Occupancy sensor for high bay fluorescent fixtures (per controlled fixture), Other	0.0325	525	0.0325	353	0.0325	449	0.0325	307

Savings Basis, Equations, and Parameters

Occupancy sensors control lighting operation by turning off fixtures if they do not sense motion in an area. Sensors can detect people through infrared or ultrasonic methods or both. One sensor can control a single fixture or multiple fixtures. The sensor turns off the fixture(s) if motion is not detected over an adjustable period of time, typically between 5 and 120 minutes.

The kW savings for this measure are deemed by space type and kWh savings are deemed by sector and space type. Savings due to occupancy sensor installation are described by the following equations:

$$kW_{Savings} = \left(\frac{LtgWatts}{1{,}000}\right)(CF)$$

$$kWh_{Savings} = \left(\frac{LtgWatts}{1{,}000}\right)(\%Off)(Hours)$$

where:

- *Ltg. Watts = lighting wattage controlled, deemed 237 watts*
- *Hours = baseline hours per year, values in Table 4-207, hr/yr*
- *% Off = percent of time lights are controlled, values in Table 4-205, percent*
- *CF = coincidence factor, values in Table 4-206, percent*
- *1,000 = conversion factor, watts per kilowatt.*

Lighting Wattage, Ltg. Watts. Since the savings for this measure are determined per controlled fixture, the Lighting Wattage is equal to the average wattage of the fixtures controlled including lamps and ballasts.

Hours of Use, Hours. Hours of Use refers to the average annual hours that the fixtures would have operated without the occupancy sensor.

Coincidence Factor, CF. Coincidence Factor refers to the average percentage of time during peak demand hours that the lights will be off due to occupancy sensor operation when they otherwise would have been on.[259]

Percent Off, % Off. Percent Off refers to the percentage of time that the lights will be off due to occupancy sensor operation when they otherwise would have been on.

A. VALUES, ASSUMPTIONS, AND CALCULATIONS

Lighting Wattage, Ltg. Watts. Lighting Wattage refers to the wattage controlled by the occupancy sensor being installed. This occupancy sensor measure is specified as an add-on to HID-to-fluorescent replacement. As described in that measure section, fixture wattage is based on data from the Advance Atlas catalogue.[260]

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[259] Note that this definition of coincidence factor is different than that for other lighting measures. For other lighting measures, coincidence factor refers to the percent of total fixture wattage that is *on* during the peak period.

[260] Advance Transformer Company. *Advance Atlas – 2008–2009*.

The average wattage controlled by an occupancy sensor depends on the percentage of the occupancy sensors that are installed on each fixture type. These percentages are determined by an analysis of the WISeerts database. That analysis of the HID-to-fluorescent measures yields the percentages shown in Table 4-204. These percentages are used to calculate the weighted average wattage controlled by sector and across all sectors. The overall weighted average wattage controlled is 237 watts, which is the deemed Lighting Wattage value.

Table 4-204. Weighted Average HID-to-Fluorescent Lighting Replacement Wattage

Tech Code	Measure	Watts	Distribution of Savings Across Sectors				
			Ag	Com	Ind	S&G	Total
2.5170	T8 4 lamp or T5HO 2 lamp Replacing 250-399 W HID	144	13.90%	5.10%	9.70%	18.50%	9.00%
2.5180	T8 6 lamp or T5HO 4 lamp Replacing 400-999 W HID	212	73.50%	61.40%	74.90%	70.40%	70.70%
2.5182	T8 8 lamp or T5HO 6 lamp Replacing 400-999 W HID	359	12.60%	30.40%	10.30%	9.20%	16.00%
2.5185	T8 or T5HO <= 500W, Replacing >=1000 W HID	363	0.00%	2.50%	4.40%	1.10%	3.60%
2.5186	T8 or T5HO <= 800W, Replacing >=1000 W HID	535	0.00%	0.60%	0.70%	0.70%	0.70%
Total			**100%**	**100%**	**100%**	**100%**	**100%**
Average Watts			**221**	**259**	**230**	**217**	**237**

Percent Off, % Off. Percent Off values are deemed by space type and are based on values provided by the California SPC,[261] an RLW Schools study,[262] a Lighting Research Center study,[263] and Efficiency Maine's Technical Reference User Manual.[264] Each of these studies provides Percent Off values specific to high bay fixtures. These values are averaged to yield the deemed Percent Off values. Data for each study and the resulting averages are provided in Table 4-205.

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[261] Southern California Edison Business Incentives & Services Standard Performance Contract Program. *Standard Performance Contract.* "Section 2: Estimating Energy Savings and Incentives." January 6, 2009.

[262] RLW Analytics. *CT & MA Utilities 2004-2005 Lightng Hours of Use for School Buildings Baseline Study – Final Report.* September 7, 2006.

[263] Bill VonNeida, Lighting Research Center; Dorene Maniccia and Allan Tweed, U.S. EPA. *An Analysis of The Energy and Cost Savings Potential of Occupancy Sensors for Commercial Lighting Systems.* August 16, 2000.

[264] Efficiency Maine. *Technical Reference User Manual.* March 5, 2007.

Table 4-205. Percent Off Values from Various Sources

Space Type	Cal. SPC	RLW Schools	LRC	Maine	Avg.
Gymnasiums	35%	48%	-	35%	39%
Industrial	45%	-	-	-	45%
Retail	15%	-	-	-	15%
Warehouses	45%	-	65%	50%	53%
Public Assembly	35%	59%	-	-	47%
Other	-	-	-	-	40%

Coincidence Factor, CF. Values for coincidence factors are based on two of the four sources cited above, the California SPC and the RLW Schools study. Like the Percent Off values, these coincidence factors are specific to high bay fixtures. The data by space type from each source are presented in Table 4-206 along with their averages, which are the deemed coincidence factor values.

Table 4-206. Coincidence Factors from Various Sources

Type of Space	Cal. SPC	RLW Schools	Avg.
Gymnasiums	14%	15%	15%
Industrial	18%	-	18%
Retail	6%	-	6%
Warehouses	18%	-	18%
Public Assembly	14%	10%	12%
Other	-	-	14%

Hours of Use, Hours. The deemed values for Hours of Use are the standard deemed values by sector, presented in Table 4-207 and discussed in Section 3.1.

Table 4-207. Hours of Use

Sector	Hours
Agriculture	4,698
Commercial	3,730
Industrial	4,745
Schools-Gov't	3,239

Substituting the above parameter values into the savings equations yields the deemed kW savings values by space type and kWh savings values by space type and sector shown in Table 4-203.

4.9.18 T8 HP 2L Recessed Fixture Replacing 3L or 4L T8 or T12

Group: Lighting

Category: Fluorescent, Linear

Technology Description: T8 High Performance/Low Glare Recessed Fixture Replacing 3L or 4L T8 or T12

Qualifying Equipment:

- Existing fixtures for retrofit must be standard T12 or T8 systems.
- Fixture efficiency must be 80 percent or greater.
- All replacement lamps must be from Focus' "CEE High Performance T8" list.[265]
- Incentive and savings apply to installation of single fixture.
- Must be a new fixture or retrofit module incorporating advanced lighting distribution and glare control optics.

Date Deeming Last Modified: December 2009

Summarized by: John Dendy

Table 4-208. T8 HP 2L Recessed Fixture Replacing 3L or 4L T8 or T12

WISeerts Tech Code	Measure Description	Agriculture		Commercial		Industrial		Schools/Gov't	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.0901.170	T8 2L - HPT8 Fixture or Retrofit Module, Recessed Direct or Indirect 2x4, replacing 3L or 4L T8 or T12	0.0310	218	0.0355	173	0.0357	220	0.0299	150

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Savings are based on high performance 2-lamp recessed T8 fixtures replacing 3-lamp or 4-lamp standard T8 or T12 fixtures, using less energy to provide an equivalent amount of light. The kW and kWh savings are determined using the following equations:

$$kW\ Savings = \frac{\left(P_e - P_p\right) \times CF}{1{,}000}$$

$$kWh\ Savings = \frac{(P_e - P_p) \times H}{1{,}000}$$

[265] Qualified equipment can be found at www.focusonenergy.com/businesslighting.

where:

- *P_e = existing or baseline lighting wattage, deemed 97.4 W*
- *P_p = proposed installed lighting wattage, deemed 51 W*
- *CF = coincidence factor, values in Table 4-209*
- *H = annual operating hours, values in Table 4-209*
- *1,000 = conversion factor, watts per kilowatt.*

Lighting wattages, P_e and P_p. These variables refer to the average power used by the existing T12 or T8 fixtures and the proposed high performance recessed 2-lamp T8 fixtures, respectively.

Coincidence Factor, CF. Coincidence Factor refers to the average percentage of total system wattage that is operating during the peak period and is measured in percent.

Annual operating hours, H. This refers to the average annual operating hours of the light fixture and is measured in hours/year.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Existing or baseline lighting wattage, P_e. The deemed existing lighting wattage is 97.4 watts. This is based on values provided in ASHRAE Fundamentals 2005 for a 3-lamp T8 fixture with 32 W lamps and an electronic ballast (93 W) and a 3-lamp T12 fixture with energy saving lamps and an energy saving magnetic ballast (115 W).[266] The average is weighted according to the assumption that 80 percent of fixtures replaced will be T8 and 20 percent will be T12. This distribution is the standard linear fluorescent baseline agreed upon by the program and evaluators.

Proposed installed lighting wattage, P_p. The deemed value for the installed lighting wattage is 51 wattsTable 4-180. This value is based on the average of the 2-lamp fixtures on the CEE qualified ballast product list[267] while excluding technologies with a "high" ballast factor or those with a "normal" ballast factor but high fixture wattages.[268]

Coincidence factor, CF. This calculation uses the program's standard lighting coincidence factors, presented in Table 4-209 and discussed in Section 3.1.

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[266] Note that basing the existing fixture wattage on 3-lamp fixtures yields a conservative savings estimate when 4-lamp fixtures are replaced.

[267] Available through Focus on Energy at http://www.focusonenergy.com/Incentives/Business/Lighting.aspx.

[268] Two-lamp fixtures of greater than 60 W with a "normal" ballast factor were excluded along with "high" ballast factor fixtures.

Annual operating hours, H. This calculation uses the program's standard lighting operating hours, presented in Table 4-209 and discussed in Section 3.1.

Table 4-209. Lighting Operating Hours and Coincidence Factors by Sector

Sector	Hours	CF
Agriculture	4,698	67%
Commercial	3,730	77%
Industrial	4,745	77%
Schools-Gov't	3,239	64%

Substituting the above values into the kW and kWh savings equations yields the deemed savings presented in Table 4-208.

4.9.19 T12 Bounty

Group: Lighting

Category: Fluorescent, Linear

Technology Description: Fluorescent replacing T12

Qualifying Equipment:

- Existing fixtures for retrofit must be T12 systems.
- A variety of T12 replacement technologies can be installed, including T5 and T8 recessed high efficiency fixtures, high performance T8 retrofit systems, and low-Watt T8 systems where both the lamps and ballast are replaced.
- This measure is an add-on to other linear fluorescent measures that assume that the replaced fixtures are a combination of T8 and T12. It accounts for the wattage and savings differences associated with replacing 100 percent T12.

Date Deeming Last Modified: December 2009

Summarized by: John Dendy

Table 4-210. T12 Bounty Measures and Savings

WISeerts Tech Code	Measure Description	Tech Code	Agriculture		Commercial		Industrial		Schools & Gov't	
			kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.1061.170	BOUNTY - T5 2L replacing T12	2.1061.170	0.0341	240	0.0391	190	0.0393	242	0.0328	165
2.1062.170	BOUNTY - T8 1L replacing T12	2.1062.170	0.0054	38	0.0061	30	0.0062	38	0.0051	26
2.1063.170	BOUNTY - T8 2L replacing T12	2.1063.170	0.0064	45	0.0074	36	0.0074	46	0.0062	31
2.1064.170	BOUNTY - T8 3L replacing T12	2.1064.170	0.0118	83	0.0135	66	0.0136	84	0.0113	57
2.1065.170	BOUNTY - T8 4L replacing T12 4ft	2.1065.170	0.0128	90	0.0147	72	0.0148	91	0.0124	62
2.1066.170	BOUNTY - T8 4L replacing T12 8 ft	2.1066.170	0	0	0	0	0	0	0	0

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Savings estimates for most measures in which linear fluorescent fixtures are replaced assume that some of the fixtures replaced are T12 and some are T8. For cases that qualify for T12 Bounty measures, it is known that 100 percent of the fixtures replaced are T12, not a combination of T12 and T8. Therefore, savings are greater than estimated under the other linear fluorescent replacement measures. These T12 Bounty measures account for additional savings incurred above the savings already deemed under those measures. The measures that the T12 Bounty measures supplement are referred to herein as “companion measures,” presented in Table 4-211.

Table 4-211. Companion Measures to T12 Bounty Measures

Measure Description	Tech Code	Companion Measures
BOUNTY - T5 2L replacing T12	2.1061.170	2.0900
BOUNTY - T8 1L replacing T12	2.1062.170	2.0821, 2.0831, 2.0841, 2.0860
BOUNTY - T8 2L replacing T12	2.1063.170	2.0822, 2.0832, 2.0842, 2.0870, 2.0901
BOUNTY - T8 3L replacing T12	2.1064.170	2.0823, 2.0833, 2.0843, 2.0880
BOUNTY - T8 4L replacing T12 4ft	2.1065.170	2.0824, 2.0834, 2.0844, 2.0880
BOUNTY - T8 4L replacing T12 8 ft	2.1066.170	2.0810, 2.0811

The additional savings attributed to this measure are thus solely due to the difference in the assumed wattage of the replaced fixtures. The kW and kWh savings are determined using the following equations:

$$kW\ Savings = \frac{(P_{T12} - P_{base}) \times CF}{1{,}000}$$

$$kWh\ Savings = \frac{(P_{T12} - P_{base}) \times H}{1{,}000}$$

where:

- *P_{T12} = wattage of T12 fixture being replaced, values in Table 4-213*
- *P_{base} = normal baseline wattage of the fixture being replaced, values in Table 4-213Table 4-180*
- *CF = coincidence factor, values in Table 4-214*
- *H = annual operating hours, values in Table 4-214*
- *1,000 = conversion factor, watts per kilowatt.*

Wattage of T12 fixture, P_{T12}. The wattage of the T12 fixture is the average power used by the T12 fixture being replaced.

Normal baseline wattage, P_{base}. The normal baseline wattage is the assumed wattage of the fixture being replaced for the companion measures to these measures, which assumes 20 percent T12 and 80 percent T8.

Coincidence Factor, CF. Coincidence Factor refers to the average percentage of total system wattage that is operating during the peak period and is measured in percent.

Annual operating hours, H. This refers to the average annual operating hours of the light fixture and is measured in hours/year.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Wattage of T12 fixture, P_{T12}. The wattage of the T12 fixture being replaced is deemed according to the number of lamps in the fixture. It is assumed that the replaced T12 fixtures have energy saving magnetic ballasts and energy saving lamps. The values used are taken from an ASHRAE publication[269] and are presented in Table 4-212.

Normal baseline wattage, P_{base}. For most measures, the normal baseline wattage is calculated based on the assumption that 80 percent of the linear fluorescent fixtures replaced under the program are T8 and 20 percent are T12. Wattage values for each fixture type are taken from ASHRAE Fundamentals 2005 and a weighted average is calculated according to this percentage. The T12 fixtures are assumed to have energy saving lamps and ballasts, and the T8 fixtures are assumed to have 32 W lamps and electronic ballasts. ASHRAE wattage values and the weighted average results are presented in Table 4-212.

Table 4-212. ASHRAE Lighting Wattages and Weighted Average

Fixture Type	T12 Watts	T8 Watts	Weighted Average
1-Lamp 4 ft	42	32	34
2-Lamp 4 ft	72	60	62.4
3-Lamp 4 ft	115	93	97.4
4-Lamp 4 ft	144	120	124.8

For the T5 measure, Tech Code 2.1061, the base case is not a combination of T8 and T12 fixtures. The baseline is a 3-lamp T8 fixture of 93 W. This is the baseline for its companion measure, Tech Code 2.0900. Therefore, it is used for the baseline for this measure as well. For measure 2.1066, the replaced fixtures are 8-foot T12 fixtures. The companion measures are already for T12 replacements only. Therefore, the baseline and T12 wattages are the same, which results in no savings for this measure. The T12 and baseline wattages used for each measure with savings are presented in Table 4-213.

Table 4-213. T12 and Baseline Wattage by Measure

Measure Description	T12 Watts	Baseline Watts
BOUNTY - T5 2L replacing T12	144	93
BOUNTY - T8 1L replacing T12	42	34
BOUNTY - T8 2L replacing T12	72	62.4
BOUNTY - T8 3L replacing T12	115	97.4
BOUNTY - T8 4L replacing T12 4ft	144	124.8

Coincidence factor, CF. This calculation uses the program's standard lighting coincidence factors, presented in Table 4-214 and discussed in Section 3.1.

Annual operating hours, H. This calculation uses the program's standard lighting operating hours, presented in Table 4-214 and discussed in Section 3.1.

[269] ASHRAE Fundamentals, 2005.

Table 4-214. Lighting Operating Hours and Coincidence Factors by Sector

Sector	Hours	CF
Agriculture	4,698	67%
Commercial	3,730	77%
Industrial	4,745	77%
Schools-Gov't	3,239	64%

Substituting the above values into the kW and kWh savings equations yields the deemed savings presented in Table 4-210.

5. ARCHIVAL MANUAL ENTRIES

Over time, deemed measures may be added, removed, or changed. This archive section contains manual entries for measures that have undergone changes since the first draft of the manual. As changes to the deemed savings estimates continue, the new deemed savings estimates can be placed in Section 4, and the replaced entries can be moved to this archive.

This section is organized in the same way as Section 4, by measure group, with like measures grouped into a single entry.

5.1 BOILERS AND BURNERS

5.1.1 Boiler Oxygen Trim Controls

Group: Boilers & Burners

Category: Controls

Technology Description: Oxygen Trim Controls

Tech Code: 1.0710.085

Qualifying Equipment: Controls must be installed on a natural gas forced draft boiler 200 hp or greater that operates for a minimum of 4,000 hours per year.

Date Deeming Last Modified: November 2008

Summarized by: Brian Dunn

Table 5-1. Oxygen Trim Control Measure

Tech Code	Measure Description	Deemed Savings (therms per year per HP)
1.0710.085	Boiler Oxygen Trim Controls, per hp	13

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Although boilers require some excess oxygen to ensure the complete combustion of fuel, too much excess oxygen decreases boiler efficiency. An increase in excess oxygen requires an increase in combustion air. The higher volume of combustion air will heat up during combustion and this heat energy is lost up the stack. Installing a system to monitor excess oxygen in the flue allows excess air to be reduced to optimal levels. This improves the efficiency of the boiler.[270]

Savings due to the installation of oxygen trim controls are described by the following equations:

$$\frac{\text{Therm}_{\text{savings}}}{BoilerHP} = \left(\frac{33469.8 \times \text{BLF} \times \text{hours}}{\text{Eff}_{\text{Boiler}} \times 100{,}000}\right) * \text{SF}$$

where:

- *33,469.8 = Conversion Factor, Btuh per Boiler HP*
- *BLF = Boiler Load Factor, deemed 50 percent*

[270] Oxygen trim controls are generally an add-on feature to linkageless boiler controls and could be included as part of a linkageless control system. The savings deemed in this document are only for the portion of savings related to oxygen trim control.

- *Hours = Annual boiler operating hours, deemed 4,380 hours*
- *EFF_{Boiler} = Boiler Efficiency, deemed 80 percent*
- *100,000 = Conversion factor, Btu per therm*
- *SF = Savings Fraction due to oxygen* trim *controls, deemed 1.5 percent.*

Boiler Load Factor, BLF. The boiler load factor is the estimated percent load on the boiler in percent of full capacity. It is the average percent of boiler capacity at which the boiler operates.

Operating Hours, Hours. Operating hours refers to the average annual operating hours that the boiler operates.

Boiler Efficiency, EFF_{Boiler}. Boiler efficiency refers to the combustion efficiency of the boiler on which the oxygen trim controls are to be installed.

Savings Fraction, SF. Savings fraction is the percent of annual consumption that will be saved due to installing oxygen trim controls.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The values used for each parameter in the current deemed savings calculation are discussed below.

i. Boiler Load Factor

The existing deemed savings calculation assumes that the boiler will operate at an average of 50 percent of rated load. No source is given for this value.

ii. Operating Hours

The boilers that qualify for this measure must operate for a minimum of 4,000 hours per year. The assumed average annual operating hours are 4,380 hours, or one half of the year. Some boilers operate only during the heating season but many other large boilers operate year round.

iii. Boiler Efficiency

The baseline boiler efficiency is 80 percent. This is the minimum efficiency in the Wisconsin Commercial Code and was deemed in the modulating boiler measure review in May 2008.

iv. Savings Fraction

The savings fraction is the percentage of annual usage that is expected to be saved due to the oxygen trim control retrofit, deemed to be 1.5 percent. The example provided in the EPA Guide estimated possible fuel savings of three percent due to oxygen trim controls.[271] The 1.5 percent savings fraction that was proposed in the deeming calculation was a more conservative estimate, established to accommodate a wider range of boilers. During the deeming process, the evaluators cited two sources that refer to savings fraction estimates of 1 to 2 percent.

Substituting the above values into the savings equation yields a result of 13.7 therms saved per boiler horsepower output. The savings value was rounded down to the deemed value of 13 therm per boiler HP.

[271] U.S. EPA: Guide to Industrial Assessments for Pollution Prevention and Energy Efficiency. EPA/625/R-99/003, June 2001. p. 53-54.

5.1.2 Linkageless Boiler Controls

Group: Boilers & Burners

Category: Controls

Technology Description: Linkageless Boiler Controls

Tech Code: 1.0711.085

Qualifying Equipment: Controls must be installed on natural gas forced draft boilers 200 hp or greater that operate for a minimum of 4,000 hours per year.

Date Deeming Last Modified: November 2008

Summarized by: Brian Dunn

Table 5-2. Linkageless Boiler Controls Measure

Tech Code	Measure Description	Deemed Savings (therms per year per HP)
1.0711.085	Linkageless Boiler Control, per hp	27

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Traditional boiler combustion controls consist of a single servo motor and a series of linkages to control the air and fuel flows into the combustion chamber. The linkage connections are susceptible to hysteresis, which limits the accuracy of the control. In addition, linkage controls are unable to match the combustion curve for airflow and fuel flow across a range of burn rates. Therefore, combustion efficiency is not optimized. Linkageless controls eliminate these issues and can improve the efficiency of the boiler.[272]

Savings due to the installation of linkageless controls are described by the following equation:

$$\frac{\text{Therm}_{\text{savings}}}{BoilerHP} = \left(\frac{33{,}469.8 \times \text{BLF} \times \text{hours}}{\text{Eff}_{\text{Boiler}} \times 100{,}000}\right) * \text{SF}$$

where:

- *33,469.8 = Conversion Factor, Btuh per Boiler HP*
- *BLF = Boiler Load Factor, deemed 50 percent*

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[272] Oxygen trim controls are generally an add-on feature to linkageless boiler controls and could even be included as part of a linkageless control system. The savings deemed in this document are only for the portion of savings related to linkageless control. If oxygen trim is an option installed as part of the linkageless system, the savings need to be estimated separately.

- *Hours = Annual boiler operating hours, deemed 4,380 hours*
- *EFF_{Boiler} = Boiler Efficiency, deemed 80 percent*
- *100,000 = Conversion factor, Btu per therm*
- *SF = Savings Fraction due to linkageless controls, deemed 3.0 percent.*

Boiler Load Factor, BLF. The boiler load factor is the estimated average percent load on the boiler. It is the average percent of boiler capacity at which the boiler operates.

Operating Hours, Hours. Operating hours refers to the average annual operating hours of the boiler on which linkageless controls are being installed.

Boiler Efficiency, EFF_{Boiler}. Boiler efficiency in this calculation refers to the combustion efficiency of the boiler on which linkageless controls are installed.

Savings Fraction, SF. Savings fraction is the percent of annual consumption that will be saved due to linkageless controls.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The values used for each parameter in the current deemed savings calculation are discussed below.

i. Boiler Load Factor

The existing deemed savings calculation assumes that the boiler will operate at an average of 50 percent of rated load. No source is given for this value.

ii. Operating Hours

The minimum value required to receive the incentive is 4,000 hours. The assumed value for operating hours is 4,380 hours or one-half of the year. Some boilers operate only during the heating season, but many other large boilers operate year round.

iii. Boiler Efficiency

The baseline boiler efficiency is 80 percent. This is the minimum Wisconsin code value and was deemed in the modulating boiler measures review in May 2008.

iv. Savings Fraction

The savings fraction is the percent of annual energy usage that is expected to be saved due to a linkageless control retrofit. One source states that, "many engineers report having saved as much as five to 15 percent or more installing a linkageless-control upgrade on an existing burner package."[273] Another source claimed, "[installing

[273] http://hpac.com/bse/burner-controls-boilers/. Accessed July 7, 2009.

linkageless combustion controls] typically results in savings in the three to ten percent range."[274] Three percent of annual energy use was selected as a conservative estimate.

[274] http://thermalenergyconservation.biz/linkageless.html. Accessed July 7, 2009.

5.1.3 Boiler Tune-ups

Group: Boilers & Burners

Category: Boiler

Tech Code: 1.1300.430

Technology Description: Tune-up natural gas boilers to improve combustion efficiency.

Qualifying Equipment:

- The boiler must be fueled by natural gas and have a minimum output of 120MBh.
- The burner must be adjusted to improve combustion efficiency, and the service provider must perform pre- and post-service combustion efficiency tests.

Date Deeming Last Modified: May 2008

Reviewed by: Brian Dunn

Table 5-3. Boiler Tune-up Measure

Tech Code	Measure Description	Deemed Savings (therms per year per input MBh)
1.1300.430	Boiler Tune-up - service buy-down	0.679

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

As a boiler operates over a period of time, the combustion efficiency can decrease due to fouling, controls maladjustment, or other issues. The efficiency can be improved by tuning up the boiler to return it to near optimal operating conditions. This efficiency gain will save natural gas.

Savings due to performing a boiler tune-up are described by the following equation. Savings are determined by applying a savings factor to an estimate of the boiler consumption prior to the tune-up. The energy savings for this measure are determined per input boiler capacity in MBh.

$$\frac{Therm\ Savings}{MBh\ Input} = SF \times \frac{HDD \times 24}{(T_{Indoor} - T_{Outdoor}) \times Eff_{Pre-TuneUp} \times 100}$$

where:

- *SF = Savings Factor, deemed 2.5 percent*
- $Eff_{Pre\text{-}TuneUp}$ = *Efficiency of the boiler prior to the tune-up, deemed 85 percent*
- T_{Indoor} = *Indoor design temp, assumed to be 65°F.*
- $T_{Outdoor}$ = *Outdoor design temp, deemed -15°F.*

- *HDD = Heating Degree Days for Wisconsin, deemed 7,699*
- *100 = conversion factor, MBh (thousand Btu per hour) per therm.*

Savings Factor, SF. The savings factor is an estimate of the portion of the annual gas consumption that is saved due to tuning up the boiler.[275]

Efficiency of the Boiler Prior to Tune-up, $Eff_{Pre\text{-}TuneUp}$. The efficiency of the boiler prior to tune-up is the assumed combustion efficiency of the boiler that will be serviced.

Indoor design temperature, T_{Indoor}. The indoor design temperature is the standard balance temperature used in system design calculations.

Outdoor design temperature, $T_{Outdoor}$. In system design calculations, the outdoor design temperature is the coldest temperature for which a heating system is designed to meet the heating load, disregarding any over sizing. For this calculation, we use a population-weighted average of outdoor design temperatures for Wisconsin.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The values used for each parameter in the current deemed savings calculation are discussed below.

i. Efficiency of the Boiler Prior to Tune-up

The assumed boiler baseline efficiency is 85 percent. This value is halfway between the minimum boiler efficiency in the Wisconsin Commercial Code and the efficiency of the most efficient boilers available on the market. The estimate assumes that half of the serviced boilers met code at installation and half were high efficiency.

ii. Savings Factor

The current savings calculation uses a deemed savings factor of 2.5 percent. The deemed savings documentation states that boilers that are tuned regularly will have small efficiency improvements, near one percent, and those that are not maintained regularly can improve up to ten percent. It also states that typical efficiency improvements are in the three to five percent range. A savings factor of 2.5 percent was chosen which is thought to be a conservative estimate.

iii. Indoor Design Temperature

The indoor design temperature, 65°F, is the standard balance temperature in design calculations.

[275] Note that this savings factor is not the same thing as "efficiency improvement," a parameter that would represent the difference between the efficiency before the tune up and the efficiency after. If the value were for efficiency improvement, the equation would take a different form.

iv. Outdoor Design Temperature

The outdoor design temperature is based on a population-weighted average of Department of Commerce design temperatures. The average Wisconsin design temperature is -15°F.

5.2 FOOD SERVICE

5.2.1 Convection Ovens

Group: Food Service

Category: Ovens

Technology Description: Gas or Electric Convection Ovens

Qualifying Equipment: Oven must appear on the list for convection ovens on the Focus on Energy web site. [276]

Date Deeming Last Modified: April 2007

Summarized by: John Dendy

Table 5-4. Combustion Oven Measures

WISeerts Tech Code	Measure Description	Deemed Savings		
		kW	kWh	Therms
14.3101.290	Oven, Convection, Electric, High Efficiency	0.200	2,262	0
14.3102.290	Oven, Convection, Gas, High Efficiency	0	0	323

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Energy savings are based on installing a unit that is more efficient than the market standard, and depend on the type of unit installed. Unit types include gas and electric convection ovens.

Savings estimates are based on savings equations and assumptions provided to Pacific Gas and Electric by the Food Service Technology Center and shared with Focus through the Consortium on Energy Efficiency. Oven performance was determined by FSTC according to ASTM test methods.

For electric ovens, kW savings are not determined by a savings equation. Rather, they are reported based on metered data.

The savings equation for for electric ovens (kWh) and gas ovens (Btu) is of the same form, with only the units of the variables changed. The form of the equation shows that energy consumption of a oven is equal to the sum of energy used for cooking, idle, and preheating.

276 http://www.focusonenergy.com/files/Document_Management_System/Business_Programs/convectionovens_productlist.pdf.

$$E_{Day} = \frac{LB_{Food} \times E_{Food}}{Efficiency} + IdleRate \times (OpHrs - \frac{LB_{Food}}{PC} - \frac{T_{PreHt}}{60}) + E_{PreHt}$$

where:

- E_{Day} = *daily energy consumption (kWh or Btu), calculated*
- LB_{Food} = *pounds of food cooked per day (lb), values in Table 5-5*
- E_{Food} = *ASTM Energy to Food (kWh/lb or Btu/lb), values in Table 5-5*
- *Efficiency = ASTM Heavy Load Cooking Energy Efficiency (%), values in Table 5-5*
- *IdleRate = Idle Energy Rate (kW or Btu/hr), values in Table 5-5*
- *OpHrs = operating hours per day (hr), deemed 12 hr*
- *PC = Production Capacity (lb/hr), values in Table 5-5*
- T_{PreHt} = *Preheat Time (min), deemed 15 minutes*
- *60 = minute to hour conversion*
- E_{PreHt} = *Preheat Energy (kWh or Btu), values in Table 5-5.*

Pounds of Food Cooked per Day, LB_{Food}. This is an estimate of the average pounds of food cooked per day by each oven type.

Energy to Food, E_{Food}. Energy to Food is the amount of energy absorbed by the food during cooking (kWh/lb or Btu/lb).

Efficiency. Efficiency for this calculation is the ASTM Heavy Load Cooking Energy Efficiency, and represents the ratio of the energy absorbed by food during cooking (E_{Food}) to total energy consumed during cooking (%).

Idle Energy Rate, IdleRate. Idle energy rate is the amount of power drawn by the oven when on but not cooking (kW or Btu/hr).

Operating Hours, OpHrs. Operating hours refers to the number of hours that the oven is on per day, whether cooking or at idle.

Production Capacity, PC. Production capacity is the amount of food that a given oven can cook per hour.

Preheat Time, T_{PreHt}. Preheat time is the amount of time it takes an oven to reach operating temperature after being turned on.

Preheat Energy, E_{PreHt}. Preheat Energy is the amount of energy the oven consumes daily to reach operating temperature (*kWh or Btu).*

In order to estimate annual savings, the consumption of the baseline and qualifying units are calculated using the above equation, and the latter is subtracted from the former.

The resulting daily savings value is multiplied by operating days per year to yield annual savings.

$$Annual\ Savings = (E_{Day,B} - E_{Day,Q})\ x\ OpDay$$

where:

- *E_{DayB} = Daily energy use of baseline unit, kWh or Btu*
- *$E_{Day,Q}$ = Daily energy use of qualifying unit, kWh or Btu*
- *OpDay = number of operating days per year, deemed 365 days/yr.*

For electric ovens, the units of daily consumptions and energy savings are kWh. For gas ovens, the result Btu is divided by 100,000 to convert to therms.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

ASTM Variables. Values for ASTM variables for baseline and energy efficient cases were determined by FSTC according to the applicable ASTM standard test method.[277] These variables include Energy to Food, Heavy Load Cooking Efficiency, Idle Energy Rate, Residual Energy Rate, Production Capacity, and Preheat Energy. The values used for these variables are presented in the tables below.

All ASTM parameter values are thought to be averages of the values for ovens tested by FSTC,[278] besides the Heavy Load Cooking Efficiency of the qualifying ovens. The Heavy Load Cooking Efficiency of qualifying ovens is actually the minimum qualifying value for each measure. These minimum qualifying values used as the efficiencies of the qualifying ovens in the savings calculations.

Pound of Food per Day (LB_{Food}). The assumed value for pounds of food per day varies by oven type, as presented in tables below.

Operating Days (OpDay). The calculation assumes that the ovens operate 365 days/yr.

Preheat Time. A preheat time of 15 minutes is used in the savings equation for each oven.

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[277] It is not known which oven models were tested to produce the values. The test method that applies to each oven type is discussed by oven type below.

[278] The deeming calculation spreadsheet states "Measure data for savings calculations have been developed based on average equipment characteristics for customer participants for the Food Service Equipment program."

kW Savings. kW savings are reported to be from metering studies by Food Service Technology Center.[279] A more specific citation is not available. These values are reported by oven type in tables below.

Convection ovens were tested according to ASTM F1496, the Standard Test Method for the Performance of Convection Ovens. Parameter values, consumptions, and savings estimates are shown in Table 5-5 and Table 5-6.

Table 5-5. Convection Oven Parameter Values

Oven Fuel	Parameter	Baseline Model	Energy Efficient Model
Electric or Gas	Preheat Time (min)	15	15
	Production Capacity (lb/h)	70	80
	Operating Hours/Day	12	12
	Operating Days/Year	365	365
	Pounds of Food Cooked per Day	100	100
Electric	Preheat Energy (kWh)	1.5	1
	Idle Energy Rate (kW)	2	1.5
	Cooking Energy Efficiency (%)	65%	70%
	ASTM Energy to Food (kWh/lb)	0.0732	0.0732
Gas	Preheat Energy (Btu)	19,000	11,000
	Idle Energy Rate (Btu/h)	18,000	12,000
	Cooking-Energy Efficiency (%)	30%	40%
	ASTM Energy to Food (Btu/lb)	250	250

Table 5-6. Convection Oven Energy Consumptions and Savings

Fuel	Consumption	Baseline Model	Energy Efficient Model	Savings
Electric	Daily Energy Consumption (kWh)	33.4	27.2	6.2
	Demand (kW)	2.8	2.3	0.2
	Annual Energy Consumption (kWh)	12,193	9,931	2,262
Gas	Daily Energy Consumption (Btu)	288,119	199,500	88,619
	Annual Energy Consumption (therms)	1,052	728	323

279 If kW values were metered while the unit was firing, using these metered values to determine kW savings assumes that the unit is firing throughout the peak period.

5.2.2 Griddles

Group: Food Service

Category: Griddle

Technology Description: High Efficiency Electric or Gas Griddle

Qualifying Equipment: Griddle must appear on the list of qualifying equipment on the Focus on Energy web site.[280]

Date Deeming Last Modified: April 2007

Summarized by: John Dendy

Table 5-7. Griddle Measures

WISeerts Tech Code	Measure Description	Deemed Savings kW	Deemed Savings kWh	Deemed Savings Therms
14.3501.210	Griddle, Electric, High Efficiency	0.400	1,637	0
14.3502.210	Griddle, Gas, High Efficiency	0	0	88

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Energy savings are based on installing a more efficient unit than market standard. Savings estimates are based on savings equations and assumptions provided to Pacific Gas and Electric by the Food Service Technology Center and shared with Focus through the Consortium on Energy Efficiency. Griddle performance was determined by FSTC according to ASTM F1275, the Standard Test Method for Performance of Griddles.

For electric griddles, kW savings are not determined by a savings equation. Rather, they are reported based on metered data.

The equation for energy consumption for electric griddles (kWh) and gas griddles (Btu) is of the same form, with only the units of the variables changed. The form of the equation shows that energy consumption of a griddle is equal to the sum of energy used for cooking, idle, and preheating.

$$E_{Day} = \frac{LB_{Food} \times E_{Food}}{Efficiency} + IdleRate \times \left(OpHrs - \frac{LB_{Food}}{PC} - \frac{T_{PreHt}}{60}\right) + E_{PreHt}$$

280 http://www.focusonenergy.com/files/Document_Management_System/Business_Programs/griddles_productlist.pdf.

where:

- E_{Day} = *daily energy consumption (kWh or Btu), calculated*
- LB_{Food} = *pounds of food cooked per day (lb), values in Table 5-8 or Table 5-10*
- E_{Food} = *ASTM Energy to Food (kWh/lb or Btu/lb), values in Table 5-8 or Table 5-10*
- *Efficiency = ASTM Heavy Load Cooking Energy Efficiency (%), values in Table 5-8 or Table 5-10*
- *IdleRate = Idle Energy Rate (kW or Btu/hr), values in Table 5-8 or Table 5-10*
- *OpHrs = operating hours per day (hr/day), deemed 12 hr/day*
- *PC = Production Capacity (lb/hr), values in Table 5-8 or Table 5-10*
- T_{PreHt} = *Preheat Time (min), deemed 15 minutes*
- *60 = minute to hour conversion*
- E_{PreHt} = *Preheat Energy (kWh or Btu), values in Table 5-8 or Table 5-10.*

Pounds of Food Cooked per Day, LB_{Food}. This is an estimate of the average pounds of food cooked per day.

Energy to Food, E_{Food}. Energy to Food is the amount of energy absorbed by the food during cooking (kWh/lb or Btu/lb).

Efficiency. Efficiency for this calculation is the ASTM Heavy Load Cooking Energy Efficiency, and represents the ratio of the energy absorbed by food during cooking (E_{Food}) to total energy consumed during cooking (%).

Idle Energy Rate, IdleRate. Idle energy rate is the amount of power drawn by the griddle when on but not cooking (kW or Btu).

Operating Hours, OpHrs. Operating hours refers to the number of hours that the griddle is on per day, whether cooking or at idle.

Production Capacity, PC. Production capacity is the amount of food that a given griddle can cook per hour.

Preheat Time, T_{PreHt}. Preheat time is the amount of time it takes a griddle to reach operating temperature after being turned on.

Preheat Energy, E_{PreHt}. Preheat Energy is the amount of energy the griddle consumes daily to reach operating temperature (*kWh or Btu).*

In order to estimate annual savings, the consumption of the baseline and qualifying units are calculated using the above equation, and the latter is subtracted from the former. The resulting daily savings value is multiplied by operating days per year to yield annual savings.

$$Annual\ Savings = (E_{Day,B} - E_{Day,Q})\ x\ OpDay$$

where:

- E_{DayB} = *Daily energy use of baseline unit, kWh or Btu*
- $E_{Day,Q}$ = *Daily energy use of qualifying unit, kWh or Btu*
- *OpDay = number of operating days per year, deemed 365 days.*

For electric griddles, the units on daily consumptions and energy savings are kWh. For gas griddles, the resulting value in Btu is divided by 100,000 to convert to therms.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

ASTM Variables. Values for ASTM variables for baseline and energy efficient cases were determined by FSTC according to ASTM F1275, the Standard Test Method for Performance of Griddles.[281] These variables include Energy to Food, Heavy Load Cooking Efficiency, Idle Energy Rate, Residual Energy Rate, Production Capacity, and Preheat Energy. Values used for these variables are presented in Table 5-8 and Table 5-10 below.

All ASTM parameter values are thought to be averages of the values for griddles tested by FSTC,[282] besides the Heavy Load Cooking Efficiency of the qualifying griddles. The Heavy Load Cooking Efficiency of qualifying griddles is actually the minimum qualifying value for each measure. These minimum qualifying values of 38 percent for gas griddles and 70 percent for electric griddles are used as the efficiencies of the energy efficient griddles in the savings calculations.

Pound of Food per Day (LB_{Food}). The assumed value for pounds of food per day varies by griddle type, as presented in Table 5-8 and Table 5-10 below.

Operating Days (OpDay). The calculation assumes that the griddles operate 365 days/yr.

Preheat Time. A preheat time of 15 minutes is used in the savings equation for each griddle.

[281] It is not known which griddle models were tested to produce the values.

[282] The deeming calculation spreadsheet states "Measure data for savings calculations have been developed based on average equipment characteristics for customer participants for the Food Service Equipment program."

kW Savings. kW savings are reported to be from metering studies by Food Service Technology Center.[283] A more specific citation is not available. These values are reported by griddle type in tables below.

All parameter values, consumptions, and savings are presented in the tables below.

Table 5-8. Parameter Values for Electric Griddles

Parameter	Baseline Model	Energy Efficient Model
Preheat Time (min)	15	15
Preheat Energy (kWh)	4	2
Idle Energy Rate (kW)	2.5	2.3
Cooking-Energy Efficiency (%)	65%	70%
Production Capacity (lb/h)	35	40
Operating Hours/Day	12	12
Operating Days/Year	365	365
Pounds of Food Cooked per Day	100	100
ASTM Energy to Food (kWh/lb)	0.139	0.139

Table 5-9. Electric Griddle Consumption and Savings

Consumption	Baseline Model	Energy Efficient Model	Savings
Daily Energy Consumption (kWh)	48	43	4
Demand (kW)	4	3.6	0.4
Annual Energy Consumption (kWh)	17,380	15,743	1,637

Table 5-10. Parameter Values for Gas Griddles

Parameter	Base Model	Energy Efficient Model
Preheat Time (min)	15	15
Preheat Energy (Btu)	21,000	15,000
Idle Energy Rate (Btu/h)	19,000	16,000
Cooking-Energy Efficiency (%)	32%	38%
Production Capacity (lb/h)	25	45
Operating Hours/Day	12	12
Operating Days/Year	365	365
Pounds of Food Cooked per Day	100	100
ASTM Energy to Food (Btu/lb)	475	475

[283] We assume that these data for kW were metered while the unit or units were firing. The peak period kW savings are defined as the average kW from 1 to 4 pm, Monday through Friday, June through August. So, using these metered kW values tacitly assumes that the unit is firing throughout the peak period.

Table 5-11. Gas Griddle Consumptions and Savings

	Baseline Model	Energy Efficient Model	Savings
Daily Energy Consumption (Btu)	316,688	292,444	24,243
Annual Energy Consumption (therms)	1,156	1,067	88

5.2.3 Refrigerators and Freezers

Group: Food Service

Category: Refrigerator / Freezer, Commercial

Technology Description: Commercial Refrigerators and Freezers, either ENERGY STAR or Consortium on Energy Efficiency (CEE) Tier 2.

Qualifying Equipment:

- Refrigerators and Freezers must have a solid door and must appear on the list of qualifying equipment on the Focus web site.[284]
- To qualify for the Consortium on Energy Efficiency Tier 2 bonus, units must be listed as Tier 2 on the CEE list, as reported by Focus.[285]

Date Deemed: May 2008

Summarized by: John Dendy

Table 5-12. Refrigerator/Freezer Measures

WISeerts Tech Code	Measure Description	Deemed Savings		
		kW	kWh	Therms
14.4110.340	Refrigerator, < 20 cu ft, ENERGY STAR	0.0430	372	0
14.4120.340	Refrigerator, 20-48 cu ft, ENERGY STAR	0.0610	537	0
14.4130.340	Refrigerator, > 48 cu ft, ENERGY STAR	0.0960	838	0
14.4135.340	Refrigerator, Commercial, CEE Tier 2 efficiency, < 20 cu ft	0.0970	847	0
14.4136.340	Refrigerator, Commercial, CEE Tier 2 efficiency, 20-48 cu ft	0.1450	1,274	0
14.4137.340	Refrigerator, Commercial, CEE Tier 2 efficiency, >48 cu ft	0.2350	2,057	0
14.4210.340	Freezer, < 20 cu ft, ENERGY STAR	0.0370	320	0
14.4220.340	Freezer, 20-48 cu ft, ENERGY STAR	0.0350	307	0
14.4230.340	Freezer, > 48 cu ft, ENERGY STAR	0.0320	283	0
14.4235.340	Freezer, Commercial, CEE Tier 2 efficiency, <20 cu ft	0.1140	995	0
14.4236.340	Freezer, Commercial, CEE Tier 2 efficiency, 20-48 cu ft	0.2020	1,770	0
14.4237.340	Freezer, Commercial, CEE Tier 2 efficiency, >48 cu ft	0.3640	3,192	0

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Energy savings result from installing a more efficient unit than the standard efficiency on the market. Refrigerators and freezers must be ENERGY STAR qualified to receive an incentive. Additional savings are realized if the unit is also CEE Tier 2 qualified. Savings

[284] http://www.energystar.gov/ia/products/prod_lists/commer_refrig_prod_list.xls.

[285] http://www.focusonenergy.com/files/Document_Management_System/Business_Programs/fridge_productlist.xls.

for commercial refrigeration will vary according to whether the unit is a refrigerator or freezer, whether it is ENERGY STAR or Tier 2, and by unit size. Therefore, the savings estimates are broken down into 12 measures according to these categories.

The basic savings equations for all refrigeration types and efficiencies are:

$$kWh\ Savings = \left(kWh_b - kWh_q\right) x\ Days$$

$$kW\ Savings = \frac{kWh\ Savings}{HR}$$

where:

- kWh_b *= daily baseline unit consumption, expressions in Table 5-13*
- kWh_q *= daily qualifying unit consumption, expressions in Table 5-13*
- *Days = Annual days of operation, deemed 365*
- *HR = hours of operation, deemed 8,760*

Baseline consumption, kWh_b*.* Baseline consumption is an expression of the daily kWh consumption of a conventional refrigeration unit. The expression is in terms of the inside volume of the unit *(V)* and is defined by the 2004 California Energy Commission code.

Qualifying consumption, kWh_q*.* Qualifying unit consumption is an expression of the daily consumption of the ENERGY STAR or Tier 2 unit. The expressions are defined by the ENERGY STAR and CEE programs, and are also dependent on the inside volume of the unit *(V).*

Operating Days, days. This is the assumed annual operating days of the unit.

Operating hours, HR. This is the assumed annual operating hours of the unit.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

Expressions for baseline and qualifying consumptions as a function of unit volume are provided in Table 5-13. These expressions are substituted into the kWh Savings equation to yield the annual savings expression for each unit type.

Table 5-13. Consumption and Savings Expressions

Measure Category	Daily Baseline Consumption	Daily Qualifying Consumption	Daily Savings	Annual Savings
Refrigerator, ENERGY STAR	0.125V + 2.76	0.10V + 2.04	0.025V + 0.72	9.125V + 262.8
Refrigerator, CEE Tier 2	0.125V + 2.76	0.06V + 1.22	0.065V + 1.54	23.725V + 562.1
Freezer, ENERGY STAR	0.398V + 2.28	0.40V + 1.38	-0.002V + 0..9	-0.73V + 328.5
Freezer, CEE Tier 2	0.398V + 2.28	0.28V + 0.97	0.118V + 1.31	43.07V + 478.15

Baseline consumption, kWh_b. The baseline for all of these measures is the 2004 California Energy Commission (CEC) code. California values are used because there is no Wisconsin or national code for commercial refrigeration. This baseline is used as an estimate of the annual energy consumption of a new standard efficiency replacement unit.

Qualifying consumption, kWh_q. The expressions for the consumption of qualifying measures are defined by the ENERGY STAR and CEE programs, and are reported on the CEE web site.[286] These expressions reflect the maximum consumption allowed for units that qualify for ENERGY STAR and CEE Tier 2 status.

Volume, V. In order to generate annual savings estimates, the refrigerator volume in cubic feet must be substituted into the annual savings equations in Table 5-13. However, because the WISeerts database is limited in complexity, the volume of the actual installed unit cannot be used. Rather, a proxy volume for each size category is used. The volumes used for each size category are presented in Table 5-14.

Table 5-14. Assumed Volumes for Size Categories

Unit Size	Assumed Volume (cubic feet)
Less than 20 cubic feet	12
20 to 48 cubic feet	30
Greater than 48 cubic feet	63

In the deeming calculations, these volumes are referred to as previously deemed. A review of previous deeming rounds does indicate that commercial refrigeration was deemed as early as spring of 2006. However, there is no documentation available regarding the choice of these volumes to represent the size categories.

Hours and Days. Almost all refrigerators and freezers operate continuously, which is 8,760 hours per year or 365 days per year.

Substituting the volumes from Table 5-14 into the equations in Table 5-13 yields the annual kWh savings estimates presented in Table 5-12. Dividing these values by 8,760 yields the kW Savings in Table 5-12.

[286] http://www.cee1.org/com/com-kit/files/RefrigerationSpecificationFINAL20080617.pdf.

5.2.4 Ice Machines

Group: Food Service

Category: Ice Machine

Technology Description: High Efficiency Ice Machines, various sizes.

Qualifying Equipment:

- Must appear on either the air-cooled[287] or water-cooled[288] list of qualifying measures on the focus web site.
- To qualify for the ENERGY STAR incentive bonus, must appear on the list of ENERGY STAR qualified equipment on the Focus web site.[289]
- Flake and nugget type machines do not qualify.
- Size of the machine must be based on harvest rate as determined at standard rating conditions based on AHRI Standard 810.

Date Deemed: October 2006

Summarized by: John Dendy

Table 5-15. Ice Machine Measures

WISeerts Tech Code	Measure Description	Deemed Savings		
		kW	kWh	Therms
14.5100.235	Ice Machines, < 500 lbs, High Efficiency	0.320	1,200	0
14.5200.235	Ice Machines, 500-1000 lbs, High Efficiency	0.480	1,750	0
14.5300.235	Ice Machines, > 1000 lbs, High Efficiency	1.280	4,870	0

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Savings result from installing an icemaker that is more efficient than the standard model available on the market.

Deemed savings documentation does not provide a savings equation or rationale.

287 http://www.focusonenergy.com/files/Document_Management_System/Business_Programs/watercooledtier1icemachine_productlist.xls.

288 http://www.focusonenergy.com/files/Document_Management_System/Business_Programs/watercooledtier1icemachine_productlist.xls.

289 http://www.energystar.gov/ia/products/prod_lists/ice_machines_prod_list.pdf.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

During the deeming process, the program proposed the deemed values shown in Table 5-15. Documentation or sources for those values are not available.

Documentation does provide that the values are based on a load factor of 0.75, a demand diversity factor of 0.8, and 3,000 Equivalent Full Load Hours (EFLH).

The 3,000 EFLH is apparently based on a 2005 Itron report for We Energies.[290] The basis of this value is given as 10 hrs per day, 300 days per year. We manipulated the above parameter values and the savings estimate for < 500 lb icemakers in an effort to reverse-engineer a savings equation. Note that the deemed savings value of 0.32 kW times 3,000 EFLH divided by 0.8 demand diversity factor is equal to the deemed kWh savings value of 1,200 kWh. However, the same relationship does not exist for the other two ice maker sizes.

The Itron report does have a calculation methodology and savings results for many icemaker designs and sizes. These savings values do not correspond to the deemed savings values.

From process documentation, it appears that, once it was identified that Itron and program estimates were different, Itron verified that program values were reasonable.

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[290] *Development of Deemed Savings for the Commercial Prescriptive Rebate Program.* We Energies Energy Efficiency Procurement Plan, March 28, 2005.

5.3 HVAC

5.3.1 High Efficiency Ventilation Fans

Group: HVAC

Category: Fans

Technology Description: High efficiency ventilation fans in agricultural facilities.

Qualifying Equipment:

- Measure is limited for use by the agriculture sector only.
- Intended for barn ventilation propeller type fans.[291]
- Ventilation fans must have a minimum rating of 21 CFM/W at 0.00 inches H_2O static pressure, 20 CFM/W at 0.05 inches H_2O static pressure, or be approved by Focus on Energy prior to sale and must be rated through the Bioenvironmental and Structural Systems Laboratory (BESS Lab) or Air Movement and Control Association International laboratory (AMCA Lab).

Date Deeming Last Modified: May 2008

Reviewed by: Dale Tutaj

Table 5-16. High Efficiency Ventilation Fan Measures

Tech Code	Measure Description	Deemed Savings		
		kW	kWh	Therms
4.0736.150	Ventilation Fans, High Efficiency - 36"	0.322	1,094	0
4.0742.150	Ventilation Fans, High Efficiency - 42"	0.396	1,483	0
4.0748.150	Ventilation Fans, High Efficiency - 48"	0.470	1,872	0
4.0750.150	Ventilation Fans, High Efficiency - 50"	0.664	2,553	0
4.0751.150	Ventilation Fans, High Efficiency - 51"	0.664	2,553	0
4.0752.150	Ventilation Fans, High Efficiency - 52"	0.664	2,553	0
4.0754.150	Ventilation Fans, High Efficiency - 54"	0.664	2,553	0
4.0755.150	Ventilation Fans, High Efficiency - 55"	0.664	2,553	0
4.0760.150	Ventilation Fans, High Efficiency - 60"	0.664	2,553	0
4.0772.150	Ventilation Fans, High Efficiency - 72"	0.664	2,553	0

A. SAVINGS BASIS, EQUATIONS, AND VALUES

High efficiency ventilation fans replace existing, less efficient ventilation fans. High efficiency fans are able to move an equivalent amount of air with less power. Fan

[291] Deemed savings documentation refers to this equipment as "ventilation fan." This language is consistent with the previous Dairy and Livestock Incentive Application (valid January 1, 2009, to June 30, 2009). However, the current application (valid from July to December 31, 2009), refers to this equipment as "exhaust fan."

efficiency is a function of all of the components of fan design including fan motors, fan blades, fan drive, housing, shutters, guards, and other accessories.

Savings due to ventilation fan installations are described by the following equations:

$$kW_{savings} = kW_b - kW_q + (kW_T \times TR)$$

$$kWh_{Savings} = (kW_{savings} \times Hours) + (kW_T \times Hours \times TR)$$

or

$$kWh_{Savings} = \left(kW_b - kW_q + (kW_T \times TR)\right) \times Hours + (kW_T \times Hours \times TR)$$ [292]

where:

- *Hours = annual fan runtime, deemed 3,397 hours/year*
- *kW_b = baseline fan power, values in Table 5-20, kilowatts*
- *kW_q = qualifying fan power, values in Table 5-20, kilowatts*
- *kW_T = fan power savings due to size transition, values in Table 5-22, kilowatts*
- *TR = transition rate, values in Table 5-22, percent.*

Annual Runtime, Hours. Annual fan runtime represents the hours per year that the average fan will operate.

Fan Power, Baseline, kW_b Baseline fan power represents the power drawn by the average replaced fan in kilowatts.

Fan Power, Qualifying, kW_q. Qualifying fan power represents the power drawn by the average high efficiency fan in kilowatts.

Size Transition Power Savings, kW_T. The overall reduction in fan power from increasing fan size and reducing the number of fans in kilowatts.

Transition Rate, TR. The percent of projects in which many smaller existing fans are replaced with fewer larger fans.

It should be noted that 42" fans do not follow this calculation method, but are given kW and kWh savings values which are an average between 36" and 48" fans.

[292] This equation reflects the calculation that is used for deemed savings. However, it is likely that this is not the intended equation for $kWh_{Savings}$, as it has redundancies. This is discussed further in Section 1.1.3.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

i. Annual Fan Runtime

Annual fan runtime estimates are based on industry recommendations and the program's experience for three different types of dairy facilities. The calculation includes a description about each of these types, as follows:

- **Free stall barn.** The most widely researched and utilized barn style today. They are open structures, or partially enclosed. Often a long wall of curtains can be dropped to allow for natural ventilation, though some fan use is required year 'round to ensure that ammonia and unhealthy concentrations of gases do not build up. Air movement also helps prevent flies from congregating and reduces the moisture buildup on the barn facilities. Thus, it is standard practice to set 10 percent of fans run to continuously, while 30 percent run during moderate temperatures and 60 percent run during the hottest weather.[293]
- **Stall barn.** Typically has three fans controlled manually and by thermostats. Temperatures in the barn are higher than ambient air due to heat gain. For hours of operation, we assume one fan operates at "cold" temperatures, two at "moderate" temperatures, and all three at "hot" temperatures. Since there are usually only three fans in stall barns, it is impossible to have 10 percent of fans operating–in actual practice, one of the fans runs usually runs 18 hours/day, every day (observed practice).
- **Cross-ventilated barn.** Similar to stall barn. These barns are a growing trend and use many fans. Cross-ventilated barns are enclosed free stall barns that use banks of fans to move air across the width of the barn (not length). They operate similarly to stall barns in terms of maintaining cow comfort, air quality, and moisture management. However, one bank of fans operates continuously.

According to the deemed savings documentation, industry recommended runtimes are as shown in Table 5-17 though no source is cited. Hours listed for the given outdoor dry bulb temperature ranges are determined from typical meteorological year (TMY2) data (location not specified).

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[293] It should be noted that 10 percent, 40 percent, and 100 percent of fans run during "cold," "moderate," and "hot" temperatures, respectively. In the previous round of deeming, there was confusion on this issue. The text of the spreadsheet and the memo suggested that 10 percent, 30 percent, and 60 percent of fans run during these periods, respectively. This was a misunderstanding made by both Focus and KEMA, and a misinterpretation of the calculations (which were correct). In other words, the 10 percent of fans running during "cold" temperatures will also run during "moderate" and "hot" temperatures, and the 30 percent of fans that come on during "moderate" temperatures will stay on during "hot" temperatures. All fans run during "hot" temperatures.

Table 5-17. Industry-Recommended Fan Runtimes

Bin Category	Definition	Hours	Percent of Fans Operating
Cold	<50°F	4,577	10%
Moderate	≥ 50°F	2,908	40%
Hot	≥ 70°F	1,275	100%

The hot period is defined as 70°F and greater; therefore, 100 percent of fans will run for 1,275 hours/yr. Based on this information, the percent of fans running in each category for each dairy facility type is described in Table 5-18. It should be noted that stall barns use different bin category definitions, as described in the assumptions.

Table 5-18. Dairy Facility Type Weighted Hours and Assumptions

Dairy Facility Type	Bin Category	Hours	Percent of Fans Operating	Weighted Hours	Assumptions
Stall Barn	Cold and warmer	6,570	33%	4,009	Assumes one fan, 18 hours per day
	Moderate and warmer	4,183	33%		Assumes one fan added at 50°F or higher
	Hot	1,275	33%		Assumes one fan added at 70°F or higher
Free Stall /Cross-ventilated Barns	Cold	4,577	10%	2,896	Industry-recommended values
	Moderate	2,908	40%		Industry-recommended values
	Hot	1,275	100%		Industry-recommended values

The hours for each temperature bin are weighted by the percent of fans operating at those temperatures to determine the average weighted hours. The annual runtime is weighted by the market share of each dairy facility type, shown in Table 5-19. No source was provided for these values.

Table 5-19. Dairy Facility Type Market Share and Average Weighted Hours

Dairy Facility Type	Market Share of Fan Sales	Weighted Hours
Stall Barns	45%	4,009
Free Stall Barns	50%	2,896
Cross Ventilated Barns	5%	2,896
Average Weighted Runtime	-	3,397

Based on the market share of each facility type, the average annual runtime is 3,397 hr/yr.

ii. Fan Power, Baseline and Qualifying

Fan power is determined from the BESS Lab performance test data.[294] The results from each test are listed with the fan's manufacturer, model number, nominal fan diameter, cone use, and shutter type. Fans are tested for airflow and ventilating efficiency ratio

[294] Website: http://bess.illinois.edu., Agricultural Ventilation Fans Performance and Efficiencies, Bioenvironmental and Structural Systems Laboratory, Department of Agricultural and Biological Engineering, The University of Illinois at Urbana-Champaign.

(VER) at 0.05 and 0.10 inches H_2O static pressure. BESS Lab tests with duplicate entries (tests that have identical model number, fan diameter, cone, and shutter) are consolidated by averaging the VER, airflow, and airflow ratio for each identical test.

Motor input kW for each test case is calculated using the airflow and VER at 0.05 inches H_2O static pressure. The input kW values are determined based on a parameter with values of 0, 0.5, 1.0, or 1.5 and is assigned to each fan. It is unclear why this process is used. The following equations are used to calculate the motor input kW.

If unnamed parameter = 0,

$$\text{Motor Input kW} = \left(\frac{0.625 \times \text{Airflow}}{1{,}000 \times \text{VER}}\right) \times 0.85$$

If unnamed parameter = 1,

$$\text{Motor Input kW} = \left(\frac{0.5 \times \text{Airflow}}{1{,}000 \times \text{VER}}\right) \times 0.85$$

where:

- *Airflow = air flow rate, CFM*
- *VER = ventilation efficiency ratio, CFM/W.*

For test cases with an unnamed parameter of 0.5 or 1.5, motor input kW is a fixed value, which was entered into the spreadsheet without a calculation. It is unclear how the fixed values were determined.

For each fan size, results are separated by VER ≥ 20 CFM/W (qualifying) and VER < 20 CFM/W (baseline).[295] The average input kW for baseline (kW_b) and qualifying (kW_q) fans is determined by taking the average input kW for fans in for the appropriate VER group, as shown in Table 5-20.

Table 5-20. Fan Power, Baseline and Qualifying

Fan Size	kW_q (VER ≥ 20 CFM/W)	kW_b (VER < 20 CFM/W)
36 inch	0.86	1.19
48 inch	1.71	2.10
50 inch+	1.87	2.44

iii. Size Transition Power Savings & Transition Rate

Deemed savings values incorporate savings due to the movement from smaller to larger fans. On average, larger fans have a higher efficiency, moving more air with less energy.

295 Based on 0.05 H_2O static pressure test conditions.

Installing larger fans allows the total number of fans to be reduced and energy to be saved due to the higher efficiency.

To determine transition rate, the calculation splits fans into three categories: 36", 48", and 50+". The transition rate was based on information provided by the program with no supporting documentation. It is assumed that 25 percent of customers purchasing 48" or 50+" fans would have bought smaller fans if Focus had not been involved. In other words, a customer purchasing 48" fans might have bought 36" fans without Focus. A customer purchasing 50+" fans might have bought either 36" fans or 48" fans without Focus. It is also assumed that customers who were influenced to purchase larger fans maintained the same design air flow, thus purchasing fewer fans than they had intended. This trend is illustrated in Table 5-21.

Table 5-21. Values Needed to Calculate kW Savings from Fan Size Transition[296]

Transition	Description	kW/Fan$_{Smaller}$	kW/Fan$_{Larger}$	Fan Ratio	kW Savings
T1	from 36" to 48"	1.13	1.89	1.95	0.32
T2	from 36" to 50+"	1.13	2.01	2.25	0.54
T3	from 48" to 50+"	1.89	2.01	1.15	0.16

A transition from 36" to 48" fans will result in a kW savings of 0.32 for each 48" fan installed. Given the average airflow for each fan size, (1.95) 36" fans are needed to move the same amount of air as (1) 48" fan.

Table 5-22 shows how these size transition savings are applied to deemed savings. Since customers choosing to purchasing 50+" fans could have installed either 36" or 48" fans, Focus assumed that half of these customers fell into each category. In other words, half of 50+" transition customers upgraded from 36" fans, and half from 48" fans. The TR of 25 percent is used for the larger fan sizes. No source was provided to support the TR estimate.

Table 5-22. Transition Rates and kW Savings from Transition

Fan Size (dia.)	Transition	kW$_T$	TR
36 inch	N/A	N/A	N/A
48 inch	T1	0.32	25%
50 inch+	Average of T2 & T3	0.35	25%

[296] kW/Fan$_{Smaller}$ and kW/Fan$_{Larger}$ are the average motor input kW for all BESS Lab test data in each respective size category. Similarly, airflow (used to determine fan ratio) is the airflow for all BESS Lab test data in each respective size category.

The size transition kW savings is calculated using the following equation.[297]

$$kW_T = (kW/Fan_{smaller} \times Fan\ Ratio) - kW/Fan_{larger}$$

where:

- $kW/Fan_{smaller}$ = *power used by smaller fan, kilowatts*
- kW/Fan_{larger} = *power used by larger fan, kilowatts*
- *Fan Ratio = ratio of the number of smaller fans needed to create the same airflow as one larger fan, dimensionless*
- kW_T = *power savings resulting from the transition to the larger fan, kilowatts.*

Substituting the above values into the savings equation yields the deemed savings values in Table 5-16.

[297] The deemed savings calculation uses additional parameters such as CFM per cow and cows per farm. However, these values cancel out and are not needed. The reduced equation is shown here for simplicity.

5.3.2 HVAC Steam Traps

Group: HVAC

Category: Steam Trap

Technology Description: Repair leaking steam trap, building space conditioning system

Tech Code: 4.1000.390

Qualifying Equipment:

- Boiler must be used for space heating, not process applications.
- Repaired traps must be leaking steam, not failed closed or plugged.
- Incentive is available once per year per system.
- Municipal steam systems do not qualify.

With a steam trap survey:

- Repairs should be performed within 9 months of steam trap survey completion.[298]
- A steam trap survey and repair log must be completed. Required information includes a trap ID tag Number, location description, nominal steam pressure, trap type, trap condition (functioning, failed not leaking, failed leaking), and orifice size. A survey form can be found on the Focus web site.[299]

Without a steam trap survey:

- If mass replacement of steam traps occurs without a survey, it is assumed that 30 percent of the replaced traps were leaking, and the incentive is paid for 30 percent of the replaced traps.

Date Deeming Last Modified: May 2008

Summarized by: Brian Dunn

[298] Because the language used is “should,” rather than “must,” it is not clear whether this is a requirement.

[299] http://www.focusonenergy.com/files/Document_Management_System/Business_Programs/steamtrapsurveyrepairlog_template.xls.

Table 5-23. HVAC Steam Trap Measure

Tech Code	Measure Description	Deemed Savings (therms per year)
4.1000	Repair leaking steam trap, building space conditioning system	718

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Steam traps that fail in the open position allow steam to escape into the condensate lines before the available heat energy can be used for space heating, wasting the energy used to make the steam. By replacing or repairing traps that have failed in the open position, the wasted heat energy can be conserved. Savings due to steam trap repairs are described by the following equations:

$$therm\ savings = DF \times Loss\ Rate \times Energy\ Content \times \left(\frac{1}{eff}\right) \times Hr \div 100{,}000$$

where:

- *DF = derating factor, deemed 50%*
- *Loss Rate = discharge rate of steam through the leaking trap, values in* Table 5-28*, lb/hr*
- *Energy Content = energy content of steam, deemed 1,000 Btu/lb*
- *eff = combustion efficiency of boiler, deemed 75%*
- *Hr = annual hours of trap operation, deemed 1,696 hr for thermostatic traps and 4,664 hr for float and thermostatic*
- *100,000 = conversion factor, Btu per therm.*

Derating factor, DF. The derating factor adjusts the maximum trap orifice size to account for partial trap closures or condensate in the orifice, which affects the discharge rate of the steam. The effective orifice size is often not equal to the actual orifice size when fully open. Traps can fail at 100 percent open or at any fraction thereof. The derating factor is measured in percent.

Discharge Rate of Steam, Loss Rate. Discharge rate refers to the rate that steam passes through a given orifice size from a given system pressure to atmospheric pressure.

Boiler Efficiency, eff. Boiler efficiency refers to the boiler's combustion efficiency in percent.

Annual hours of operation, Hr. The annual hours of operation correspond to the number of hours per year that the steam trap is exposed to steam. This varies based on the location of the steam trap in the system. Since different types of steam traps are used at different locations within the system, operating hours may also be based on steam trap type.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

i. Derating Factor

According to the Department of Energy (DOE), "assuming a trap has failed with an orifice size equivalent to one-half its fully open condition is probably prudent.[300]" Therefore, the derating factor is assumed to be 50 percent.

ii. Energy Content of Steam

The energy content of steam is assumed to be 1,000 Btu/lb.

iii. Discharge Rate of Steam

The steam lost through leaking traps is a function of the system pressure and the size of the orifice through which the steam is leaking. Table 5-24 shows estimates of steam loss for various system pressures and orifice sizes.

Table 5-24. Steam Loss in Leaking Traps by Pressure and Orifice Size

Orifice Diameter	Steam Loss, lb/hr						
	2 psi	5 psi	10 psi	15 psi	25 psi	50 psi	75 psi
1/32"	0.31	0.49	0.7	0.85	1.14	1.86	2.58
1/16"	1.25	1.97	2.8	3.4	4.6	7.4	10.3
3/32"	2.81	4.44	6.3	7.7	10.3	16.7	15.4
1/8"	4.5	7.9	11.2	13.7	18.3	29.8	41.3
5/32"	7.8	12.3	17.4	21.3	28.5	46.5	64.5
3/16"	11.2	17.7	25.1	30.7	41.1	67	93
7/32"	15.3	24.2	34.2	41.9	55.9	91.2	126
1/4"	20	31.6	44.6	54.7	73.1	119	165
9/32"	25.2	39.9	56.5	69.2	92.5	151	209
5/16"	31.2	49.3	69.7	85.4	114	186	258
11/32"	37.7	59.6	84.4	103	138	225	312
3/8"	44.9	71	100	123	164	268	371
13/32"	52.7	83.3	118	144	193	314	436
7/16"	61.1	96.6	137	167	224	365	506
15/32"	70.2	111	157	192	257	419	580
1/2"	79.8	126	179	219	292	476	660

Source: http://uesystems.com/tech_support_charts_steam_loss.asp (accessed July 3, 2009)

In order to use the above values in the savings calculation, certain further assumptions and calculations are made.

- Assumptions were made regarding the market prevalence of various orifice sizes and the prevalence of steam system pressures based on interviews with Tim Thuemling, owner of Thuemling Industrial Products, Inc. in 2005. Table

[300] *Steam Trap Performance Assessment.* Federal Energy Management Program. DOE/EE-0193, July 1999, p.12. Available at: http://www1.eere.energy.gov/femp/pdfs/FTA_SteamTrap.pdf.

5-25 shows the assumed prevalence of orifice size for thermostatic steam traps, Table 5-26 shows the assumed prevalence of orifice size for float and thermostatic (F&T) steam traps, and Table 5-27 shows the prevalence of steam system pressures.

Table 5-25. Thermostatic Steam Trap Prevalence

Orifice Size	Prevalence
7/32"	5%
1/4"	5%
5/16"	90%

Table 5-26. F&T Steam Trap Prevalence

Orifice Size	Prevalence
7/32"	48%
1/4"	47%
5/16"	5%

Table 5-27. Steam System Pressure Prevalence

Pressure (psig)	Prevalence
5	45%
10	45%
15	10%

The discharge rate of steam is determined by entering Table 5-24 at the three orifice sizes and three steam pressures identified by Mr. Thuemling. Table 5-28 shows the discharge rates for the nine combinations.

Table 5-28. Discharge Rates of Steam

	Discharge Rate (lb/hr)		
	Steam Pressure, psig		
Orifice Size	5	10	15
7/32"	24.2	34.2	41.9
1/4"	31.6	44.6	54.7
5/16"	49.3	69.7	85.4

iv. Annual Operating Hours

As stated above, the operating hours of a steam trap depend on where the trap is located in the system. Thermostatic steam traps are typically downstream from a steam control valve and are only exposed to steam when the zone is actively being heated. Float and thermostatic control valves are typically exposed to steam whenever the boiler is operating.

The values for annual operating hours are shown in Table 5-29. These hours are based on 212 boiler operating days per year which corresponds to a heating season from October to April. This timeframe is based on the actual operating schedule per school building operators. During these operating days, thermostatic steam traps are assumed to be exposed to steam for eight hours per day. In the deeming documentation, this eight-hour estimate is described as a blend of outside air heating hours and simple building envelope heat loss hours.

Table 5-29. Existing Annual Operating Hours Values

Trap Type	Hours
Thermostatic	1,696
Float and Thermostatic	4,664

Float and thermostatic steam traps are assumed to be exposed to steam for 22 hours per day. This is based on the assumption that most boilers operate 24 hours per day during the heating season, but some boilers may be turned off at night.

v. Boiler Efficiency

The savings calculation assumes a 75 percent boiler combustion efficiency. This is based on the assumption that most large old buildings (especially schools) are using old and inefficient boilers.

vi. Calculation Method

The energy loss was calculated for each discharge rate in Table 5-28 using the operating hours from Table 5-29. Separate calculations were conducted for the two trap types. Then the weighted average energy loss was determined across the orifice size distribution in Table 5-25 and Table 5-26 and again across the steam system pressure distribution in Table 5-27. Finally, thermostatic steam traps were assumed to make up approximately 90 percent of the population and mechanical F&T traps were assumed to make up approximately 10 percent. This distribution was used to determine the final average energy savings for this measure, 718 therms/year.

5.4 LIGHTING

5.4.1 Lighting Hours of Use and Coincidence Factors

Group: Lighting

Category: N/A

Technology Description: Lighting hours of use and coincidence factor (CF) values for all lighting measures.

Qualifying Equipment: N/A

Date Deeming Last Modified: Pre-2006 (exact date unclear)

Summarized by: Jeremiah Robinson

Table 5-30. Deemed Lighting Operating Hours and Coincidence Factors

Sector	Hours	CF
Agriculture	4,368	90%
Commercial	3,680	90%
Industrial	4,576	90%
Schools & Government	3,230	71%

A. DEFINITIONS AND EXISTING VALUES

Lighting hours of use and coincidence factor are not, in and of themselves, an energy savings measure. However, they are parameters which are used to calculate deemed savings for all lighting measures except low-wattage CFLs. Each sector has its own value for hours of use and coincidence factor.

Hours of Use, Hours. Hours of Use refers to the average annual operating hours of the light fixture and is measured in hours/year. The current values are shown in Table 5-30.

Coincidence Factor, CF. Coincidence Factor refers to the average percentage of total system wattage that is operating during the peak period and is measured in percent. The peak period is defined as 1 pm to 4 pm, Monday through Friday, June through August. The values are shown in Table 5-30.

B. DISCUSSION OF EXISTING VALUES

i. Hours of Use

The existing values for hours of use have been used in prescriptive and deemed estimates for a number of years. The origin of the existing hours of use is unknown and no source can be found either by personnel at Focus on Energy or in documentation maintained by KEMA.

The logic behind the hours for use for each sector is as follows:

- Agriculture sector hours are based on 12 hours per day, 7 days per week (4,368 hr/yr)
- Commercial sector hours are based on the average of eight different industries per the statewide database. (3,680 hr/yr)
- Industrial sector hours are based on 16 hours per day, 5.5 days per week (4,576 hr/yr)
- Schools and Government sector hours are based on 12 hours per day, 5 days per week, 12 months per year (3,120 hr/yr).

ii. Coincidence Factor

It is not clear when the values currently used for coincidence factor first came to be used. However, the justification for the 90 percent factor used for Agriculture, Commercial, and Industrial was presented in March 2005 in the CFL deemed savings calculations. This report claims that the data was based on a suggestion by the Edison Electric Institute (EEI). We have not been able to track down this source, and the single value of 90 percent across different sectors suggests that it was not a thoroughly researched value.

We could not find the source of the 71 percent value used for the Schools & Government sector. The 2005 CFL deemed savings document suggests a value of 63 percent, which was abandoned at some indeterminate point in time.

5.4.2 Screw-in CFL ≤ 32W and CFL Reflector Flood Lamp ≤ 30W

Group: Lighting

Category: Fluorescent, Compact (CFL)

Technology Description:

- Screw-in compact fluorescent lamp rated 32 watts or less replacing an incandescent lamp rated ≤ 100W.
- Screw-in compact fluorescent reflector flood lamp rated 30 watts or less replacing an incandescent reflector flood lamp rated ≤100W.

Qualifying Equipment:

- Lamps must be screw-in type.
- New lamps must replace existing lamps one-for-one.
- Rebated lamps may not be used for resale or giveaway type promotions.
- Lamps must be installed indoors.

Date Deeming Last Modified:

- CFL ≤ 32W deemed March 2005.
- CFL Reflector Flood Lamp deemed May 2008.

Summarized by: Jeremiah Robinson

Table 5-31. CFL Lighting Measures, Deemed Savings

Tech Code	Measure Description	Ag		Com		Ind		S-G	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.0300.1650	CFL <= 32 Watts, replacing incandescent	0.051	199	0.050	175	0.048	323	0.038	161
2.0307.1650	CFL reflector flood lamps replacing incandescent reflector flood lamps	0.0495	192	0.0495	172	0.0495	336	0.0391	178

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

CFL lamps save energy when replacing incandescent lamps because they are able to produce the same light output with a lower input wattage. The two measures reviewed here, CFL ≤ 32 Watts and CFL Reflector Flood Lamps, currently have different sets of formulas for calculating kW and kWh savings.

i. CFL ≤ 32 Watts

Savings due to replacing low wattage CFL lamps are described by the following equations:

$$kW_{savings} = \left(\frac{\Delta Watts}{1000}\right) * CF$$

$$kW_{savings} = \left(\frac{\Delta Watts}{1000}\right) * Hours$$

where:

- *Δ Watts = nominal wattage savings, values in Table 5-32, watts*
- *Hours = hours of use per year, values in Table 5-32, hours/year*
- *CF = coincidence factor, values in Table 5-32 percent*
- *1,000 = conversion factor, watts per kilowatt.*

Nominal Wattage Savings, Δ Watts. The difference in wattage between the new CFL lamp and the replaced incandescent lamp in watts.

Hours of Use, Hours. Hours of use refers to the average annual operating hours of the light fixture and is measured in hours/year.

Coincidence Factor, CF. Coincidence factor refers to the average percentage of total system wattage that is operating during the peak period and is measured in percent. The peak period is defined as 1 pm to 4 pm, Monday through Friday, June through August.

ii. CFL Reflector Flood Lamp

Savings due to replacing CFL reflector flood lamps are described by the following equations:

$$kW_{savings} = \left(\frac{Ltg.\ Watts_{old} - Ltg.\ Watts_{new}}{1000}\right) * CF$$

$$kW_{savings} = \left(\frac{Ltg.\ Watts_{old} - Ltg.\ Watts_{new}}{1000}\right) * Hours$$

where:

- *Ltg. $Watts_{old}$ = lighting wattage of existing lamp, values in Table 5-32, watts*
- *Ltg. $Watts_{new}$ = lighting wattage of new lamp, values in Table 5-32, watts*
- *Hours = hours of use per year, values in Table 5-32, hr/yr*
- *CF = coincidence factor, values in Table 5-32, percent*
- *1,000 = conversion factor, watts per kilowatt.*

Existing Lamp Wattage, Ltg. $Watts_{old}$. The Existing Lamp Wattage is the total wattage of the incandescent lamp being replaced, in watts.

New Lamp Wattage, Ltg. Watts$_{new}$. The New Lamp Wattage for this measure is the total fixture wattage of the CFL lamp being installed, in watts.

Hours of Use, Hours. Hours of Use refers to the average annual operating hours of the light fixture and is measured in hours/year.

Coincidence Factor, CF. Coincidence Factor refers to the average percentage of total system wattage that is operating during the peak period and is measured in percent.

Table 5-32. Deemed Savings Parameters

<table>
<tr><th rowspan="3">Tech Code</th><th rowspan="3">Measure Description</th><th colspan="2" rowspan="2">Technology</th><th colspan="12">Parameters</th></tr>
<tr><th colspan="3">Ag</th><th colspan="3">Com</th><th colspan="3">Ind</th><th colspan="3">S-G</th></tr>
<tr><th>New Watts</th><th>Old Watts</th><th>Delta Watts</th><th>Hours</th><th>CF</th><th>Delta Watts</th><th>Hours</th><th>CF</th><th>Delta Watts</th><th>Hours</th><th>CF</th><th>Delta Watts</th><th>Hours</th><th>CF</th></tr>
<tr><td>2.0300.1650</td><td>CFL <= 32W, replacing incandescent <=100W</td><td>N/A</td><td>N/A</td><td>57</td><td rowspan="2">3,490</td><td rowspan="2">90%</td><td>56</td><td rowspan="2">3,130</td><td rowspan="2">90%</td><td>53</td><td rowspan="2">6,100</td><td rowspan="2">90%</td><td>53</td><td>3,040</td><td rowspan="2">71%</td></tr>
<tr><td>2.0307.1650</td><td>CFL reflector flood lamps <=30W replacing incandescent reflector flood lamps <=100W</td><td>20</td><td>75</td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td><td>3,230</td></tr>
</table>

Note: The CFL Reflector Flood Lamps measure had been using an hours of use value of 3,040 hr/yr as shown in the table above. This was due to a copying error when transferring values from the CFL ≤ 32W measure to here. The error is corrected everywhere it occurs in this review, starting here.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

i. Nominal Wattage Savings (CFL ≤ 32W)

The Nominal Wattage Savings for the Commercial and Agricultural sectors were based on a review of the data collected from impact evaluation surveys conducted with Focus customers who installed low wattage CFLs. Customers were asked to identify the wattage of the bulbs that they installed and the wattage of the bulbs that they removed. KEMA calculated the weighted average of the incandescent lamp wattage and the CFL wattage. Subtracting these two values yielded the nominal wattage savings used for this measure.

The data from the impact evaluation surveys was not available for the Industrial or Schools & Government sectors. However, overall sales data was available and represented the Commercial, Industrial, and Schools & Government sectors combined. The average wattage savings from the overall sales data was calculated and assigned to the Industrial and Schools & Government sectors.

ii. Existing Lamp Wattage (CFL Reflector Flood Lamps)

This value was deemed to be 75 watts with no source or justification provided.

iii. New Lamp Wattage (CFL Reflector Flood Lamps)

This value was deemed to be 20 watts with no source or justification provided.

iv. Hours of Use

The CFL hours of use are currently deemed differently than the hours of use for the rest of the lighting measures. Measures which use the CFL deemed hours of use are as shown in Table 5-33.

Table 5-33. Measures Which Use CFL Hours of Use

Tech Code	Description
2.0300.165	CFL <= 30 Watts, replacing incandescent
2.0307.165	CFL reflector flood lamps replacing incandescent reflector flood lamps
2.0310.165	CFL Direct Install, replacing incandescent, WPS Hometown Checkup
2.0400.165	CFL Fixture, replacing incandescent fixture

The Hours of Use for the Agriculture and Commercial sectors were based on a review of the data collected from impact evaluation surveys conducted with Focus customers who installed low wattage CFLs. Customers were asked a series of questions that were used to determine the annual hours of use for each bulb installed. KEMA calculated the weighted average of the annual hours of use.

The Hours of Use for the Industrial and Schools & Government sectors were based on data from the *U.S. Lighting Market Characterization,*[301] which was a large national inventory of installed lighting wattages and operating hours. For the Industrial sector, “Industrial” data was taken directly from tables in the study. For the Schools & Government sector, data was taken from the “Office/Professional” category to represent government installations and the “Schools” category to represent school installations. The average of the two values was taken for the sector. The results of the Hours of Use analysis are shown in Table 5-34.

Table 5-34. Hours of Use Values

Sector	Hours	Source
Agricultural	3,490	Engineering Reviews
Commercial	3,130	Engineering Reviews
Industrial	6,100	DOE Study
Schools & Government	3,230	Average of Office and Schools
Office	3,720	DOE Study
Schools	2,740	DOE Study

It should be noted that the CFL Reflector Flood Lamps measure had been using an hours of use value of 3,040 hours/yr, but this was due to a copying error when

[301] Navigant Consulting. *U.S. Lighting Market Characterization – Volume 1: National Lighting Inventory and Energy Consumption Estimate*. September 2002.

transferring values from the other CFL measures to this measures. The error is corrected everywhere it occurs in this review.

v. Coincidence Factor

The Coincidence Factors (CF) used for the CFL deemed savings calculation are currently the same as the CF used for non-CFL lighting measures and assigned by sector. It is not clear when the current CF values first came to be used. However, the justification for the 90 percent factor used for the Agriculture, Commercial, and Industrial sectors was presented in March 2005 in the CFL deemed savings calculation documentation. The documentation claims that the data was based on a suggestion by the Edison Electric Institute (EEI). We have not been able to identify this source.

We also could not find the source of the 71 percent value used for the Schools & Government sector. The 2005 CFL deemed savings documentation suggests a value of 63 percent, which was apparently abandoned at some indeterminate point in time.

Substituting the above values into the savings equations yields the deemed savings reported in Table 5-31.

5.4.3 CFL High Wattage

Group: Lighting

Category: Fluorescent, Compact (CFL)

Technology Description: Replacement of high wattage incandescent or metal halide bulbs with high wattage compact fluorescent lamps (CFL).

Qualifying Equipment:

- Existing lamps must be incandescent or metal halide.
- CFL bases for incandescent replacements must be medium Edison screw base.
- Incentive applies to replacement of single bulb.
- Existing and replacement bulbs must coincide with bulb type and wattages presented in Table 4-8.

Date Deeming Last Modified: October 2006

Summarized by: Peter McPhee

Table 5-35. CFL High Wattage Replacement

WISeerts Tech Code	Measure Description	Deemed Savings							
		Agriculture		Commercial		Industrial		Schools/Gov't	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.0301.165	CFL High Wattage 31-115 Watts, replacing incandescent	0.1215	590	0.1215	497	0.1215	618	0.0959	432
2.0302.165	CFL High Wattage 116-149 Watts, replacing metal halide	0.0900	437	0.0900	368	0.0900	458	0.0710	320
2.0303.165	CFL High Wattage 150-199 Watts, replacing metal halide	0.1305	633	0.1305	534	0.1305	664	0.1030	464

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Savings result from replacing incandescent or metal halide bulbs with high wattage CFLs. High wattage CFLs use less electricity than incandescent or metal halide lamps to produce an equivalent amount of light. The electric deemed savings for this measure per bulb are provided in Table 4-8 based on customer sector.

kW and kWh savings are determined by the following equations:

$$kW\ Savings = \frac{\left(P_e\text{-}P_p\right) \times CF}{1000}$$

$$kWh\ Savings = \frac{(P_e - P_p) \times H}{1{,}000}$$

where:

- P_e = *existing lighting wattage, values in Table 5-36*
- P_p = *proposed replacement lighting wattage, values in Table 5-36*
- *CF = coincidence factor, values in Table 5-37*
- *H = annual operating hours, , values in Table 5-37*
- *1,000 = conversion factor, watts per kilowatt.*

Lighting wattages, P_e and P_p. These variables refer to the average power used by the existing incandescent or metal halide lamps and the installed CFLs, respectively. *Coincidence factor, CF.* The coincidence factor represents the fraction of lights operating during peak period and is deemed by sector.

Annual operating hours, H. This is the average annual operating hours of the existing and replacement lamps, deemed by sector.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Existing lighting wattage, P_e. The deemed values used are shown in Table 5-36. The source of these values is not known. We believe that the value of 200 W for a high wattage incandescent is an approximation of the average value weighted by market share of incandescents over 100 W. The wattage of existing metal halides which would be replaced by a 116–149 W CFL was deemed to be 205 W. The wattage of metal halides eligible for replacement by a 150–199 W CFL was deemed to be 295 W. We believe both of these values were chosen based on lumen equivalents of modern metal halides and CFLs.

Table 5-36. Deemed Lighting Technology Wattages

Existing Lighting Technology	Existing Wattage	Replacement CFL Description	Replacement CFL Wattage
Incandescent (>100 W)	200	31 - 115 W	65
Metal Halide	205	116 - 149 W	105
Metal Halide	295	150 - 199 W	150

Proposed replacement lighting wattage, P_p. The deemed values for the lighting replacements are also shown in Table 5-36. The source of the deemed replacement wattages of the CFLs are unknown, though we expect that they are derived from the wattage bins chosen.[302]

Coincidence factor, CF. This calculation uses the program's standard lighting coincidence factors, presented in Table 5-37 and discussed in section 3.1.

Annual operating hours, H. This calculation uses the program's standard lighting operating hours, presented in Table 5-37 and discussed in section 3.1.

Table 5-37. Lighting Operating Hours and Coincidence Factors by Sector

Sector	Hours	CF
Agriculture	4,368	90%
Commercial	3,680	90%
Industrial	4,576	90%
Schools and Government	3,230	71%

Substituting the above values into the kW and kWh savings equations yields the deemed savings presented in Table 5-35.

[302] The wattage value of 105 W for the CFLs in the 116 – 149 W range appears inconsistent with the other wattage values chosen. Because this wattage level is below the CFL rated wattage range, there might be value in further investigating the deeming of this measure.

5.4.4 CFL Cold Cathode

Group: Lighting

Category: Cold Cathode

Technology Description: CFL Cold Cathode Screw-in, replacing incandescent.

Qualifying Equipment:

- Existing lamps must be incandescent and 100 W or less.
- Bulbs must be screw base.

Date Deeming Last Modified: October 2006

Summarized by: Peter McPhee

Table 5-38. CFL Cold Cathode Replacement

WISeerts Tech Code	Measure Description	Deemed Savings							
		Agriculture		Commercial		Industrial		Schools/Gov't	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.0305.060	CFL Cold Cathode Screw-In, replacing incandescent	0.0189	92	0.0189	77	0.0189	96	0.0149	67

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Saving result from replacing incandescent bulbs with cold cathode CFLs. Cold cathode CFLs use less electricity than incandescent lamps to produce an equivalent amount of light. The per-unit electric deemed savings for this measure are provided in Table 5-38 and are based on customer sector.

kW and kWh savings are determined by the following equations:

$$kW\ Savings = \frac{\left(P_e\text{-}P_p\right) \times CF}{1{,}000}$$

$$kWh\ Savings = \frac{(P_e - P_p) \times H}{1{,}000}$$

where:

- *P_e = existing lighting wattage, deemed 25 W*
- *P_p = proposed lighting wattage, deemed 4 W*
- *CF = coincidence factor, values in Table 5-40*
- *H = annual operating hours, values in Table 5-40*

- *1,000 = conversion factor, watts per kilowatt.*

Lighting wattages, P_e and P_p. These variables refer to the average power used by the existing incandescent lamps and the proposed cold cathode CFLs, respectively. *Coincidence factor, CF.* The coincidence factor represents the fraction of lights operating during the peak period and is deemed by sector.

Annual operating hours, H. This is the average annual operating hours of the existing and replacement lamps, deemed by sector.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values are assumed for the calculation input parameters:

Proposed and Existing lighting wattage, P_p and P_e. Lighting wattages are based a PG&E presentation and specification sheets from the lighting manufacturer TCP. Wattages for these cold cathode lamps and the incandescent lamps they are reported to replace are presented in Table 5-39.

Table 5-39. Cold Cathode Lamp Equivalents

Representative Cold Cathode Lighting	Cold Cathode Watts	Incandescent Watts
PG&E Small sign size #1	3	15
PG&E Small sign size #2	5	20
TCP Small sign size #1	3	20
TCP Small sign size #2	5	30
Deemed Value	4	25

The proposed lighting wattage, P_p, is deemed 4 W, which is the average of the cold cathode CFL wattages in Table 5-39. The existing lighting wattage, P_e, is deemed 25 W. This is greater than the average of the incandescent watts reported in Table 5-39. Thus, it seems that the value used for the existing wattage is weighted toward the higher wattage lamps.

Coincidence factor, CF. This calculation uses the program's standard lighting coincidence factors, presented in Table 5-40 and discussed in section 3.1.

Annual operating hours, H. This calculation uses the program's standard lighting operating hours, presented in Table 5-40 and discussed in section 3.1.

Table 5-40. Lighting Operating Hours and Coincidence Factors by Sector

Sector	Hours	CF
Agriculture	4,368	90%
Commercial	3,680	90%
Industrial	4,576	90%
Schools and Government	3,230	71%

Substituting the above values into the kW and kWh savings equations yields the deemed savings presented in Table 5-38.

5.4.5 Occupancy Sensors – Wall or Ceiling Mount

Group: Lighting

Category: Occupancy Sensors – Wall or Ceiling Mount

Technology Description: Installation of wall or ceiling mounted occupancy sensors to control non-high bay lighting.

Qualifying Equipment:

- Occupancy sensors must be ultrasonic or passive infrared sensors.
- Sensors must control non-high bay fixture types.
- Sensors may not be socket based or fixture mounted.
- Sensors must control lighting wattages as shown in Table 5-41.
- Incentive applies to installation of a single sensor.

Date Deeming Last Modified: October 2006

Summarized by: Peter McPhee

Table 5-41. Occupancy Sensor Installation Deemed Savings

WISeerts Tech Code	Measure Description	Deemed Savings							
		Agriculture		Commercial		Industrial		Schools/Gov't	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.0505.085	Occupancy Sensors - Wall Mount <= 200 Watts	0	269	0	226	0	281	0	197
2.0506.085	Occupancy Sensors - Wall Mount >= 201 Watts	0	627	0	528	0	657	0	459
2.0507.085	Occupancy Sensors - Ceiling Mount <= 500 Watts	0	627	0	528	0	657	0	459
2.0508.085	Occupancy Sensors - Ceiling Mount 501-1000 Watts	0	1,343	0	1,132	0	1,407	0	984
2.0509.085	Occupancy Sensors - Ceiling Mount >= 1001 Watts	0	2,149	0	1,811	0	2,251	0	1,574

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Deemed savings result from installing wall mounted or ceiling mounted occupancy sensors for lighting control purposes. Occupancy sensors can reduce the hours of operation for lighting systems and thereby reduce electricity consumption. The electric deemed savings for this measure per sensor are provided in Table 5-41 based on customer sector.

There are no deemed demand savings associated with installing occupancy sensors. When savings were deemed, it was reasoned that the program's peak hours are during a period of high occupancy, and thus even lights controlled by occupancy sensors would be on.

kWh savings are determined using the following equation:

$$kWh\ Savings = \frac{F_S \times H \times P_L}{1{,}000}$$

where:

- *F_S = savings factor, deemed 41 percent*
- *H = annual operating hours, values in Table 5-43*
- *P_L = Controlled lighting wattage, values in Table 5-44*
- *1,000 = conversion factor, watts per kilowatt*
- *kWh Savings = deemed annual energy consumption savings.*

Savings factor, F_S. The savings factor represents the percentage of operating time that is reduced for a lighting system through the installation of an occupancy sensor.

Annual operating hours, H. This is the average annual operating hours of the lighting system before installation of the occupancy sensor, deemed by sector.

Controlled lighting wattage, P_L. The controlled lighting wattage is the average power used by the lighting system controlled with the occupancy sensor.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Savings factor, F_S. A savings factor of 41 percent is used across all sectors for calculating kWh savings. The savings factor is derived from estimates made by the EPA and EPRI for different applications.[303] The applications and savings factor estimates are provided in Table 5-42. The deemed value of 41 percent is the average of the savings factors for the different applications. The savings factors for some applications do not have a distinct source but are estimated based on similar applications with similar usage patterns.

[303] The EPA values can be seen at http://www.esource.com/BEA/demo/BEA_esource/PA_10.html.

Table 5-42. Assumed Savings Factor

Application	Savings Factor		
	From EPA	From EPRI	Assumed
Private office	13–50%	25%	25%
Open office			20%
Classroom	40–46%		40%
Conference room	22–65%	35%	35%
Break room			35%
Restroom	30–65%	40%	40%
Corridor	30–80%		50%
Storage area	45–80%		50%
Hotel meeting room		65%	65%
Warehouse			50%
		Average	41%

Annual operating hours, H. This calculation uses the program's standard lighting operating hours, presented in Table 5-43 and discussed in section 3.1.

Table 5-43. Lighting Operating Hours by Sector

Sector	Hours
Agriculture	4,368
Commercial	3,680
Industrial	4,576
Schools and Government	3,230

Controlled lighting wattage, P_L. The wattage of the lighting system controlled by the occupancy sensor is binned into power ranges for both ceiling mounted and wall mounted occupancy sensors. Table 5-44 shows the controlled lighting wattage bins and the deemed values associated with the bins. For bins where a lower and upper bound exist, the average value is used as the deemed value. For open-ended bins, the method of choosing a single deemed value is unknown. The chosen values may be intended to reflect an assumed population weighting of fixture wattages in that range.

Table 5-44. Controlled Lighting Wattage

Lighting System Description	Lighting System Wattage
Wall Mount <200 W	150
Wall Mount 201+ W	350
Ceiling Mount <500 W	350
Ceiling Mount 501 to 1,000 W	750
Ceiling Mount 1,001+ W	1,200

Substituting the above values into the kWh savings equation yields the deemed savings reported in Table 5-41.

5.4.6 High/Low Control for 320 W PSMH

Group: Lighting

Category: Controls

Technology Description: High/low control for a 320 W pulse start metal halide (PSMH), per fixture controlled.

Qualifying Equipment:

- PSMH lamp must be indoors.
- Fixture must be mounted more than 15 feet above the floor.
- Occupancy sensor must control a PSMH rated 320 W.
- Fixture must be a permanently-wired ballast and lamp retrofit or complete new fixture.
- Incentive applies to the installation of an individual control.

Date Deeming Last Modified: November 2008

Summarized by: Peter McPhee

Table 5-45. High/Low Control Installation Deemed Savings

WISeerts Tech Code	Measure Description	Deemed Savings							
		Agriculture		Commercial		Industrial		Schools/Gov't	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.0515.085	High / low control for 320W PSMH, per fixture controlled	0	502	0	423	0	526	0	253

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Deemed savings result from installing a high/low control on a 320 W pulse start metal halide (PSMH) fixture. High/Low controls can reduce the light output when a space is unoccupied, thereby reducing the electricity consumption of a lamp that would otherwise be operating at full output. The savings for this measure are provided in Table 5-45 based on customer sector.

The deemed kWh savings are calculated by multiplying the number of hours at the reduced lighting level by the difference in wattage between the high and low operating levels. The kWh savings are deemed by sector.

There are no deemed kW savings associated with installing high/low controls for PSMH's. When savings were deemed, it was reasoned that the program's peak hours are during a period of high occupancy, and thus even lights controlled by occupancy sensors would be on.

The kWh savings are determined using the following equation:

$$kWh\ Savings = F_D \times H \times (P_F - P_L)$$

where:

- F_D = *Dimmed time factor of high/low controls, values in Table 5-46*
- *H = Annual operating hours, values in Table 5-47*
- P_F = *Full output lighting wattage, deemed 0.368 kW*
- P_L = *Low output lighting wattage, deemed 0.184 kW.*

Dimmed time factor, F_D*.* The dimmed time factor represents the percentage of operating hours that a lighting fixture is dimmed from full output to low output resulting from the installation of the control.

Annual operating hours, H. This is the average annual operating hours of the PSMH fixtures at all outputs, deemed by sector.

Full output lighting wattage, P_F*.* This variable refers to the power used by the PSMH lighting fixture while providing full light output.

Low output lighting wattage, P_L*.* This refers to the power used by the fixture while providing reduced light output as a result of the control.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Dimmed time factor, F_D*.* The dimmed time factor values are shown in Table 5-46. The Agricultural, Commercial, and Industrial sectors' factor of 62.5 percent is based on a range of estimates made by the EPA which reflect the dimmed time factor for a warehouse or storage area.[304] The value used in the calculation is the midpoint of the range of estimates. The qualifying equipment in these sectors (installed more than 15 feet above the floor) are most commonly found in storage areas, warehouses, and garages. The usage patterns of these spaces are best reflected in the EPA space type "storage area".

The value of 43 percent used for the Schools and Government sector assumes that the majority of PSMH lighting is used in gymnasiums and auditoriums. The EPA study estimates classroom occupancy sensor savings of 40–46 percent. The deemed value of 43 percent is the midpoint of this range.

[304] http://www.esource.com/BEA/demo/BEA_esource/PA_10.html.

Table 5-46. Dimmed Time Factors by Sector

	Agriculture	Commercial	Industrial	Schools/Gov't
Dimmed Time Factor	62.5%	62.5%	62.5%	43.0%

Annual operating hours, H. This calculation uses the program's standard lighting operating hours, presented in Table 5-46 and discussed in and discussed in section 3.1.

Table 5-47. Lighting Operating Hours by Sector

Sector	Hours
Agriculture	4,368
Commercial	3,680
Industrial	4,576
Schools and Government	3,230

Full output lighting wattage, P_F. The full output lighting wattage includes the power drawn by the lamp and the ballast. The exact method for determining the full wattage estimate (368 W) is not clear, though it appears to reflect a population of both electronic and magnetic ballasts.

Low output lighting wattage, P_L. The low output wattage is assumed to be one half of the full output wattage, or 184W. The source for this value is unknown, but it is possible that it was taken directly from manufacturer specifications.

Substituting the above values into the kWh savings equation yields the values presented in Table 5-45.

5.4.7 Daylighting Controls

Group: Lighting

Category: Controls

Technology Description: Daylighting controls, automatic stepped or automatic dimming.

Qualifying Equipment:

- Controlled lighting must be T5, T5HO, or T8 fluorescent lighting.
- Control system must consist of daylighting sensor and lighting control.
- The control system must be located such that the fixture's lighting level will reduce to its lowest possible level on sunny summer afternoons.
- Savings apply per controlled kW.
- For automatic stepped controls, controlled lighting must have at least two illumination levels, plus off.
- For automatic dimming controls, lighting fixture must utilize dimmable ballasts.

Date Deeming Last Modified: November 2008

Summarized by: Peter McPhee

Table 5-48. Daylighting Controls Deemed Savings

WISeerts Tech Code	Measure Description	Deemed Savings							
		Agriculture		Commercial		Industrial		Schools/Gov't	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.0520.085	Daylighting Controls - Automatic stepped, minimum 3 lighting levels (per kW controlled)	0.9000	1,747	0.9000	1,472	0.9000	1,414	0.7100	1,280
2.0530.085	Daylighting Controls - Automatic dimming ballasts (per kW controlled)	0.8100	1,747	0.8100	1,472	0.8100	1,414	0.6390	1,280

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Energy savings result from installing an automatic daylighting control system on T5, T5 High Output (HO), or T8 fluorescent lighting. Automatic daylighting controls can reduce the light output of a lighting system during times when there is sufficient infiltration of natural light, thereby reducing electricity consumption. Two daylighting controls are deemed: automatic stepped systems and automatic dimming ballasts. The deemed savings for these measures are provided in Table 5-48 based on customer sector.

These savings are deemed per controlled kW. The kW controlled is taken from the application and multiplied by the deemed savings values to yield kW and kWh savings.

The deemed demand savings (per controlled kW) are calculated by multiplying a lighting reduction percentage by the coincidence factor. The deemed kWh savings (per controlled kW) are calculated by multiplying the existing lighting system's operating hours by a savings percentage.

kW and kWh savings are and determined using the following equations:

$$kW\ Savings = F_{PR} \cdot CF$$

$$kWh\ Savings = F_{DS} \cdot H$$

where:

- *F_{PR} = Peak reduction factor, values in Table 5-49*
- *CF = Coincidence factor, values in Table 5-50*
- *F_{DS} = Daylighting savings factor of daylighting controls, deemed 40 percent*
- *H = Annual operating hours, values in Table 5-50*
- *kW Savings = deemed electric demand savings per kW controlled*
- *kWh Savings = deemed annual energy consumption savings per kW controlled.*

Peak Reduction Factor, F_{PR}. The peak reduction factor represents the percentage reduction in the lighting system wattage as a result of the controls during peak hours.

Coincidence factor, CF. The coincidence factor represents the fraction of lights that are operating during the peak period and is deemed by sector.

Daylighting savings factor, F_{DS}. The daylighting savings factor represents the percentage of kWh savings realized through the proper installation of daylighting controls.

Annual operating hours, H. This represents the average annual operating hours of the existing lighting system, deemed by sector.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Peak Reduction Factor, F_{PR}. Peak reduction factor values are shown in Table 5-49. The values are independent of sector as they reflect the applied technology and not usage patterns. The automatic stepped controls were examined as part of a study conducted by the Energy Center of Wisconsin (ECW).[305] The study reported that, on a peak usage day, properly located stepped daylighting controls would reduce the lighting output to zero, thereby reducing wattage by 100 percent. The report also examined automatic dimming ballasts under the same peak design day scenario and found that lighting levels

[305] "Daylighting Technologies and Incentive Research", Energy Center of Wisconsin. Report for Focus on Energy. 30 November 2006.

would be reduced by 90 percent. This is consistent with most dimming ballasts, which reduce output to about 10 percent of full output levels.

Table 5-49. Peak Reduction Factors by Measure

Measure Description	Peak Reduction Factor
Daylighting Controls - Automatic stepped, minimum 3 lighting levels (per kW controlled)	100%
Daylighting Controls - Automatic dimming ballasts (per kW controlled)	90%

Coincidence factor, CF. These calculations use the program's standard lighting coincidence factors, presented in Table 5-50. For a more complete discussion of deemed coincidence factors, refer to and discussed in section 3.1.

Daylighting savings factor, F_{DS}. The daylighting savings factor value of 40 percent is used across sectors and for both stepped and dimming controls. The value is taken from an ACEEE study that examined integrated daylight controls.[306]

Annual operating hours, H. This calculation uses the standard the standard lighting operating hours except for the industrial sector. Values are presented in Table 5-50 and discussed in section 3.1.

Since the Industrial sector has many operating hours during dark or low light hours (when no dimming takes place), the effective operating hours are reduced from the standard Industrial operating hours assumption used for other lighting measures by 1,040 hours per year. This value is equivalent to 4 hours/day, 5 days/week, for 52 weeks/year. This reduction in hours represents the hours in the Industrial operating schedule for which daylighting is not available and no dimming or stepped switching occurs. Industrial hours of operation for dimmable ballasts are thus 3,536 hours per year.

Table 5-50. Annual Operating Hours and Coincidence Factors by Sector

Sector	Hours	CF
Agriculture	4,368	90%
Commercial	3,680	90%
Industrial	3,536	90%
Schools/Gov't	3,230	71%

Substituting the above values into the savings equations yields the deemed kW and kWh savings per kilowatt controlled, as presented in Table 5-48. These values are multiplied by the controlled lighting kW from the application to yield measure savings.

[306] "ACEEE's Emerging Technologies Report: Integrated Daylight Controls", 2006. This report is available at http://www.aceee.org/emertech/2006_LightingControls.pdf.

5.4.8 T-8 Replacing 8’ T-12 Fluorescent Lighting

Group: Lighting

Category: Fluorescent, Linear

Technology Description: 4’ 4-Lamp T-8 fluorescent light fixtures replacing 8’ 2-Lamp T-12 fluorescent light fixtures in retrofit applications.

Qualifying Equipment:

- New construction projects are not included.
- Must be replacing existing 8’ T-12 fixtures.
- T-8 lamps must be high-performance T-8 (≥ 3100 initial lumens with 24,000 hour lamp life at 3-hour rated start) and be on the *CEE High Performance T-8* list.
- T-8 ballasts must be ≤ 0.78 ballast factor or be an approved ballast on the *CEE High Performance T-8* list.
- Fixtures must be installed indoors.

Date Deeming Last Modified: May 2008

Reviewed by: Jeremiah Robinson

Table 5-51. T-8 Replacing 8’ T-12 Fluorescent Lighting Measures

Tech Code	Measure Description	Savings							
		Ag		Com		Ind		S-G	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.0810.170	T8 4L-4ft High Performance Replacing T12 2L-8 ft	0.0234	114	0.0234	96	0.0234	119	0.0185	83
2.0811.170	T8 4L-4ft High Performance Replacing T12HO/VHO 2L-8 ft	0.1008	489	0.1008	412	0.1008	513	0.0795	358

Savings Basis, Equations, and Parameters

T-8 fluorescent light fixtures save energy when replacing T-12 fluorescent fixtures because they are able to produce the same light output with a lower wattage. Savings due to replacing light fixtures are described by the following equations:

$$kW_{savings} = \left(\frac{Ltg.\ Watts_{old} - Ltg.\ Watts_{new}}{1000} \right) * CF$$

$$kWh_{savings} = \left(\frac{Ltg.\ Watts_{old} - Ltg.\ Watts_{new}}{1000} \right) * Hours$$

where:

- *Ltg. $Watts_{old}$ = lighting wattage of existing fixture, values in Table 5-52, watts*
- *Ltg. $Watts_{new}$ = lighting wattage of new fixture, values in Table 5-52, watts*
- *Hours = hours of use per year, values in values in Table 5-52, hr/year*
- *CF = coincidence factor, values in values in Table 5-52, percent*
- *1,000 = conversion factor, watts per kilowatt.*

Existing Lighting Fixture Wattage, Ltg. $Watts_{old}$. The Existing Lighting Fixture Wattage is the total fixture wattage of the old fixture being replaced, including lamps and ballast.

New Lighting Fixture Wattage, Ltg. $Watts_{new}$. The New Lighting Fixture Wattage is the total fixture wattage of the new fixture being installed, including lamps and ballast.

Hours of Use, Hours. Hours of Use refers to the average annual operating hours of the light fixture and is measured in hours/year.

Coincidence Factor, CF. Coincidence Factor refers to the average percentage of total system wattage that is operating during the peak period and is measured in percent.

Table 5-52. Deemed Savings Parameters

Tech Code	Measure Description	Technology		Parameters							
				Agriculture		Commercial		Industrial		Schools-Government	
		New Watts	Old Watts	Hours	CF	Hours	CF	Hours	CF	Hours	CF
2.0810.170	T8 4L-4ft High Performance Replacing T12 2L-8 ft	98	124	4,368	90%	3,680	90%	4,576	90%	3,230	71%
2.0811.170	T8 4L-4ft High Performance Replacing T12HO/VHO 2L-8 ft	130	242								

A. VALUES, ASSUMPTIONS, AND CALCULATIONS

Note: We will herein refer to measure 2.0810.170 (Table 5-52) as the “standard T-12 replacement” and measure 2.0811.170 (Table 5-52) as the “high output T-12 replacement.”

i. Existing Lighting Fixture Wattage

According to the energy savings spreadsheets provided by Focus on Energy, lighting fixture wattage was determined using American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) sources. However, we have found that the wattages reported by ASHRAE do not correspond to the wattages used in calculations. A review of other sources revealed that the wattages were actually taken from the

California Standard Performance Contract.[307] The program used fixture wattages assigned to the types of fixtures that would most likely be replaced with these measures.

For both measures, the baseline was chosen to be an 8' 2-lamp fixture with "energy saving" lamps. For the standard T-12 replacement, the fixture was a standard T-12 fixture with an energy saving magnetic ballast. For the high-output T-12 replacement, the baseline was determined by assuming that 80 percent of fixtures would be high output (HO) fixtures with energy saving magnetic ballasts (207-watt), and 20 percent would be very high output (VHO) fixtures with standard magnetic ballasts (380-watt). The deemed values for existing fixture lighting wattages are shown in Table 5-52.

ii. New Lighting Fixture Wattage

The New Lighting Fixture Wattage was defined as the average of the Consortium for Energy Efficiency (CEE) reported ballast wattages for the types of fixtures that would be installed with these measures. For both measures, the new fixture was a 4' 4-lamp T-8 fixture with 32-watt lamps. For the standard T-12 replacement, the new lighting fixture wattage was assigned the average of the ballast wattage for CEE-reported ballasts with ballast factors less than 0.98. For the high output T-12 replacement, the new lighting fixture wattage was assigned the average of the ballast wattage for CEE-reported ballasts with "high" and "normal" ballast factors. The calculation assumed that 50 percent of fixtures would be "high" (average of 144 watts) and 50 percent "normal" (average of 116 watts). The deemed values for new fixture lighting wattages are shown in Table 5-52.

iii. Hours of Use & Coincidence Factor

The values for hours of use and coincidence factor are those used for most lighting measures, deemed by sector. These sector-specific values are shown in Table 5-53.

Table 5-53. Existing Hours of Use Values

Sector	Hours	CF
Agriculture	4,368	90%
Commercial	3,680	90%
Industrial	4,576	90%
Schools-Government	3,230	71%

Substituting the above values into the savings equation yields the deemed savings values in Table 5-51.

[307] Southern California Edison Business Incentives & Services Standard Performance Contract Program. *Standard Performance Contract.* "Appendix B: Table of Standard Fixture Wattages and Sample Lighting Table." January 6, 2009.

5.4.9 T8 Low Watt with CEE Ballast

Group: Lighting

Category: Fluorescent, Linear

Technology Description: T8 four foot Low Watt with CEE Ballast

Qualifying Equipment:

- Existing lamps must be standard T12 or T8 systems.
- Replacement lamps must be four foot 25 W, 28 W, or 30 W linear T8s or 29 W or 30 W U lamps.
- All replacement lamps must be paired with an approved ballast.[308]
- Incentive and savings apply to replacement of single fixture.
- Replacement bulbs must coincide with bulb type and wattages presented in Table .

Date Deeming Last Modified: May 2008

Summarized by: Peter McPhee

Table 5-54. T8 Low Watt with CEE Ballast

WISeerts Tech Code	Measure Description	Deemed Savings							
		Agriculture		Commercial		Industrial		Schools/Gov't	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.0821.170	T8 1L-4 ft Low Watt with CEE Ballast - 25 Watts	0.0126	61	0.0126	52	0.0126	64	0.0099	45
2.0822.170	T8 2L-4 ft Low Watt with CEE Ballast - 25 Watts	0.0214	104	0.0214	88	0.0214	109	0.0169	76
2.0823.170	T8 3L-4 ft Low Watt with CEE Ballast - 25 Watts	0.0365	177	0.0365	149	0.0365	186	0.0288	130
2.0824.170	T8 4L-4 ft Low Watt with CEE Ballast - 25 Watts	0.0442	214	0.0442	181	0.0442	225	0.0349	157
2.0831.170	T8 1L-4 ft Low Watt with CEE Ballast - 28 Watts	0.0114	55	0.0114	47	0.0114	58	0.0090	41
2.0832.170	T8 2L-4 ft Low Watt with CEE Ballast - 28 Watts	0.0161	78	0.0161	66	0.0161	82	0.0127	57
2.0833.170	T8 3L-4 ft Low Watt with CEE Ballast - 28 Watts	0.0287	139	0.0287	117	0.0287	146	0.0227	102
2.0834.170	T8 4L-4 ft Low Watt with CEE Ballast - 28 Watts	0.0333	162	0.0333	136	0.0333	169	0.0263	118
2.0841.170	T8 1L-4 ft Low Watt with CEE Ballast - 30 Watts	0.0089	43	0.0089	36	0.0089	45	0.0070	32

[308] Qualified ballasts can be found at www.focusonenergy.com/businesslighting.

WISeerts Tech Code	Measure Description	Deemed Savings							
		Agriculture		Commercial		Industrial		Schools/Gov't	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.0842.170	T8 2L-4 ft Low Watt with CEE Ballast - 30 Watts	0.0150	73	0.0150	61	0.0150	76	0.0118	53
2.0843.170	T8 3L-4 ft Low Watt with CEE Ballast - 30 Watts	0.0268	130	0.0268	110	0.0268	136	0.0212	95
2.0844.170	T8 4L-4 ft Low Watt with CEE Ballast - 30 Watts	0.0314	153	0.0314	129	0.0314	160	0.0248	112

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Savings result from replacing standard T12 or T8 fixtures with low watt T8s and CEE ballasts. Low watt T8s with CEE ballasts use less electricity to produce an equivalent amount of light than standard T12 or T8 fixtures. The electric deemed savings for this measure per fixture are provided in Table 5-54 based on customer sector.

kW and kWh savings are determined using the following equations:

$$kW\ Savings = \frac{(P_e - P_p) \times CF}{1{,}000}$$

$$kWh\ Savings = \frac{(P_e - P_p) \times H}{1{,}000}$$

where:

- *P_e = existing lighting wattage, values in Table 5-55*
- *P_p = proposed replacement lighting wattage, values in Table 5-55*
- *CF = coincidence factor, deemed depending on sector*
- *H = annual operating hours, deemed depending on sector*
- *1,000 = conversion factor, watts per kilowatt.*

Lighting wattages, P_e and P_p. These variables refer to the average power used by the existing T12 or T8 fixtures and the proposed low wattage T8s, respectively.

Coincidence factor, CF. The coincidence factor represents the fraction of lights operating during the peak period and is deemed by sector.

Annual operating hours, H. This is the average annual operating hours of the existing and replacement lamps, deemed by sector.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Existing lighting wattage, P_e. The deemed values for the existing lighting wattages are shown in Table 5-55. The existing wattage is based on an assumed linear fluorescent distribution of 40 percent T12 and 60 percent T8 technologies across the applicable population. This distribution is discussed in a memo between Focus on Energy and the evaluation team.[309] The deemed wattages of the T12 and T8 fixtures for which the distribution applies are taken from a 2005 ASHRAE publication,[310] and are presented in Table 5-56. The T12 wattage is for fixtures with energy savings lamps and energy saving magnetic ballasts. The T8 wattage assumes 32 W lamps with electronic ballasts.

Table 5-55. Deemed Lighting Technology Wattages

Existing Lighting Technology	Existing Wattage	Replacement Lighting Technology	Replacement Wattage
T12 or T8 1L-4 ft Standard	36.0	T8 1L-4 ft Low Watt with CEE Ballast - 25 Watts	22.0
T12 or T8 2L-4 ft Standard	64.8	T8 2L-4 ft Low Watt with CEE Ballast - 25 Watts	41.0
T12 or T8 3L-4 ft Standard	101.8	T8 3L-4 ft Low Watt with CEE Ballast - 25 Watts	61.3
T12 or T8 4L-4 ft Standard	129.6	T8 4L-4 ft Low Watt with CEE Ballast - 25 Watts	80.5
T12 or T8 1L-4 ft Standard	36.0	T8 1L-4 ft Low Watt with CEE Ballast - 28 Watts	23.3
T12 or T8 2L-4 ft Standard	64.8	T8 2L-4 ft Low Watt with CEE Ballast - 28 Watts	47.0
T12 or T8 3L-4 ft Standard	101.8	T8 3L-4 ft Low Watt with CEE Ballast - 28 Watts	69.9
T12 or T8 4L-4 ft Standard	129.6	T8 4L-4 ft Low Watt with CEE Ballast - 28 Watts	92.6
T12 or T8 1L-4 ft Standard	36.0	T8 1L-4 ft Low Watt with CEE Ballast - 30 Watts	26.2
T12 or T8 2L-4 ft Standard	64.8	T8 2L-4 ft Low Watt with CEE Ballast - 30 Watts	48.1
T12 or T8 3L-4 ft Standard	101.8	T8 3L-4 ft Low Watt with CEE Ballast - 30 Watts	72.0
T12 or T8 4L-4 ft Standard	129.6	T8 4L-4 ft Low Watt with CEE Ballast - 30 Watts	94.7

Table 5-56. Existing Lighting Wattage Assumptions

Fixture Type	T12 Wattage	T8 Wattage
1 Bulb - 4 feet	42	32
2 Bulb - 4 feet	72	60
3 Bulb - 4 feet	115	93
4 Bulb - 4 feet	144	120

[309] Correspondence from a memo from Chuck Sasso (Focus on Energy / WECC) to KEMA and Itron evaluation teams, dated October 13, 2006. Subject is “Follow up to October 4, 2006 Meeting.”

[310] ASHRAE Fundamentals, 2005.

Proposed replacement lighting wattage, P_p. The deemed values for the lighting replacements are also shown in Table 5-55. The deemed replacement wattages of the low watt T8s are based on the average of wattages in manufacturer data from MaxLite, Sylvania, GE, Advance, and Philips.

Coincidence factor, CF. This calculation uses the program's standard lighting coincidence factors, presented in Table 5-57 and discussed in section 3.1.

Annual operating hours, H. This calculation uses the program's standard lighting operating hours, presented in Table 5-57 and discussed in section 3.1.

Table 5-57. Lighting Operating Hours and Coincidence Factors by Sector

Sector	Hours	CF
Agriculture	4,368	90%
Commercial	3,680	90%
Industrial	4,576	90%
Schools and Government	3,230	71%

Substituting the above values into the kW and kWh savings equations yields the deemed savings presented in Table 5-54.

5.4.10 T8 Low Watt Relamp

Group: Lighting

Category: Fluorescent, Linear

Technology Description: T8 Low Watt Relamp

Qualifying Equipment:

- Existing lamps must be either four foot 32 W T8 lamps or eight foot 59 W T8 lamps.
- Replacement lamps must be four foot 25 W, 28 W, 29 W[311] or 30 W linear T8s or eight foot 54 W linear T8s.
- Incentive and savings apply to installation of a single lamp.
- Replacement bulbs must coincide with bulb type and wattages presented in Table 5-58.

Date Deeming Last Modified: April 2007

Summarized by: Peter McPhee

Table 5-58. T8 Low Watt Relamping Deemed Savings

WISeerts Tech Code	Measure Description	Deemed Savings							
		Agriculture		Commercial		Industrial		Schools/Gov't	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.0851.170	T8 Low Watt Relamp - 25 Watts	0.0079	38	0.0079	32	0.0079	40	0.0062	28
2.0852.170	T8 Low Watt Relamp - 28 Watts	0.0059	29	0.0059	24	0.0059	30	0.0047	21
2.0853.170	T8 Low Watt Relamp - 30 Watts	0.0042	21	0.0042	17	0.0042	22	0.0033	15
2.0856.170	T8 Low Watt Relamp 8 ft - 54 Watts	0.0045	22	0.0045	18	0.0045	23	0.0036	16

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Savings result from replacing four foot 32 W or eight-foot 59 W T8 lamps with low watt T8 lamps. Low watt T8s use less electricity than the standard T8 fixtures to produce an equivalent amount of light. The electric deemed savings for this measure per lamp are provided in Table 5-58 based on customer sector.

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[311] The incentive application states that replacement lamps may be 29W, but a measure is not defined for this lamp wattage. If 29W lamps do receive an incentive, it is not known which measure is used for those lamps. Choosing the 30W measure for 29W lamps would produce a conservative savings estimate.

kW and kWh savings are determined using the following equations:

$$kW\ Savings = \frac{(P_e\text{-}P_p) \times CF}{1{,}000}$$

$$kWh\ Savings = \frac{(P_e - P_p) \times H}{1{,}000}$$

where:

- *P_e = existing lighting wattage, values in Table 5-59*
- *P_p = proposed replacement lighting wattage, values in Table 5-59*
- *CF = coincidence factor, values in Table 5-61*
- *H = annual operating hours, values in Table 5-61*
- *1,000 = conversion factor, watts per kilowatt.*

Lighting wattages, P_e and P_p. These variables refer to the average power used by the existing T8 lamps and the proposed low wattage T8s, respectively.

Coincidence factor, CF. The coincidence factor represents the fraction of lights operating during peak period and is deemed by sector.

Annual operating hours, H. This is the average annual operating hours of the existing and replacement lamps, deemed by sector.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Existing lighting wattage, P_e. The deemed values for existing lighting wattages are shown in Table 5-59. The assumed values are based on ASHRAE estimates[312] for four-foot fixtures of one to four lamps and eight-foot fixtures of one to two lamps. These values are presented in Table 5-60. For each lamp length, the total fixture wattage is divided by the number of lamps to yield a value for watts per lamp. Then, these wattages are averaged to produce an average watts per lamp of 30.8 W for 4-foot and 59 W for 8-foot fixtures.

Table 5-59. Deemed Lighting Technology Wattages

Existing Technology	Existing Wattage	Replacement Technology	Replacement Wattage
4 ft 32W Standard T8	30.8	4 ft Low Watt T8 - 25W	22.0
4 ft 32W Standard T8	30.8	4 ft Low Watt T8 - 28W	24.2
4 ft 32W Standard T8	30.8	4 ft Low Watt T8 - 30W	26.1
8 ft 59W Standard T8	59.0	8 ft Low Watt T8 - 54W	54.0

[312] ASHRAE Fundamentals, 2005.

Table 5-60. Existing Lighting Wattage Assumptions

Lamp Length	Fixture Type	Fixture Wattage	Per Lamp Wattage	Average Wattage per Lamp
4 foot	1 Bulb - 4 foot 32W T8	32	32	30.8
	2 Bulb - 4 foot 32W T8	60	30	
	3 Bulb - 4 foot 32W T8	93	31	
	4 Bulb - 4 foot 32W T8	120	30	
8 foot	1 Bulb - 8 foot 59W T8	59	59	59.0
	2 Bulb - 8 foot 59W T8	118	59	

Proposed replacement lighting wattage, P_p. The deemed values for the replacement lighting wattage are also shown in Table 5-59. The deemed wattages of the low watt T8s are based on averages of manufacturer data from Advance, GE, MaxLite, Sylvania, and Universal for normal ballast factor T8s.

Coincidence factor, CF. This calculation uses the program's standard lighting coincidence factors, presented in Table 5-61 and discussed in section 3.1.

Annual operating hours, H. This calculation uses the program's standard lighting operating hours, presented in Table 5-61 and discussed in section 3.1.

Table 5-61. Lighting Operating Hours and Coincidence Factors by Sector

Sector	Hours	CF
Agriculture	4,368	90%
Commercial	3,680	90%
Industrial	4,576	90%
Schools and Government	3,230	71%

Substituting the above values into the kW and kWh savings equations yields the deemed savings presented in Table 5-58.

5.4.11 T8 High Lumen Lamp with Low Ballast Factor

Group: Lighting

Category: Fluorescent, Linear

Technology Description: T8 High Lumen with Low BF

Qualifying Equipment:

- Existing fixtures for retrofit must be standard T12 or T8 systems.
- Replacement lamps must be high performance four foot 32W linear T8s. Specifically, replacement lamps must be high lumen, long life F32T8s with at least 3,100 initial lumens and a 24,000 hour rated life.
- All replacement lamps must be from Focus' "CEE High Performance T8" list.[313]
- Replacement lamp ballast must be either a low ballast factor (BF) electronic ballast (≤0.78 BF) or an approved ballast from the "CEE High Performance T8" qualified product list.
- Incentive and savings apply to installation of single fixture.
- Incentive and savings available for both new construction and retrofit.
- Replacement fixtures must coincide with fixture types presented in Table 5-62.

Date Deeming Last Modified: May 2008

Summarized by: Peter McPhee

Table 5-62. T8 High Lumen Lamp with Low BF Deemed Savings

WISeerts Tech Code	Measure Description	Deemed Savings							
		Agriculture		Commercial		Industrial		Schools/Gov't	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.0895.170	T8 1L-4 ft Hi Lumen Lamp with Low BF (New Construction)	0.0036	17	0.0036	15	0.0036	18	0.0028	13
2.0896.170	T8 2L-4 ft Hi Lumen Lamp with Low BF (New Construction)	0.0081	39	0.0081	33	0.0081	41	0.0064	29
2.0897.170	T8 3L-4 ft Hi Lumen Lamp with Low BF (New Construction)	0.0153	74	0.0153	63	0.0153	78	0.0121	54
2.0898.170	T8 4L-4 ft Hi Lumen Lamp with Low BF (New Construction)	0.0198	96	0.0198	81	0.0198	101	0.0156	70

[313] Qualified equipment can be found at www.focusonenergy.com/businesslighting.

WISeerts Tech Code	Measure Description	Deemed Savings							
		Agriculture		Commercial		Industrial		Schools/Gov't	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.0860.170	T8 1L-4 ft Hi Lumen Lamp with Low BF	0.0072	35	0.0072	29	0.0072	37	0.0057	26
2.0870.170	T8 2L-4 ft Hi Lumen Lamp with Low BF	0.0124	60	0.0124	51	0.0124	63	0.0098	44
2.0880.170	T8 3L-4 ft Hi Lumen Lamp with Low BF	0.0232	113	0.0232	95	0.0232	118	0.0183	83
2.0890.170	T8 4L-4 ft Hi Lumen Lamp with Low BF	0.0284	138	0.0284	116	0.0284	145	0.0224	101

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Savings are deemed for both new construction and retrofit installations. For new construction installations, deemed savings result from installing high lumen, low ballast factor (BF) T8s instead of standard T8s. For retrofit installations, savings result from replacing existing standard T12 or T8 fixtures with the high lumen, low BF T8s. High lumen T8s with low BFs use less electricity than standard T12 or T8 fixtures to produce an equivalent amount of light. The electric deemed savings for this measure per fixture are provided in Table 5-62 based on customer sector.

kW and kWh savings are determined using the following equations:

$$kW\ Savings = \frac{\left(P_e - P_p\right) \times CF}{1{,}000}$$

$$kWh\ Savings = \frac{(P_e - P_p) \times H}{1{,}000}$$

where:

- P_e = *existing or baseline lighting wattage, values in Table 5-63*
- P_p = *proposed installed lighting wattage, values in Table 5-63*
- *CF = coincidence factor, values in Table 5-65*
- *H = annual operating hours, values in Table 5-65*
- *1,000 = conversion factor, watts per kilowatt.*

Lighting wattages, P_e and P_p. These variables refer to the average power used by the existing T12 or T8 fixtures (retrofit installations) or the standard T8 fixtures (new construction installations) and the proposed high lumen T8s with low BF, respectively.

Coincidence factor, CF. The coincidence factor represents the fraction of lights operating during peak period and is deemed by sector.

Annual operating hours, H. This is the average annual operating hours of the existing and replacement lamps, deemed by sector.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Existing or baseline lighting wattage, P_e. The deemed lighting wattages for both new construction and retrofit installations are shown in Table 5-63. These wattages are based on values provided in ASHRAE Fundamentals 2005 found in Table 5-64. For new construction installations, the deemed wattages are equal to those provided by ASHRAE for T8s.

For the retrofit case, the deemed wattage is based on an assumed linear fluorescent distribution of 40 percent T12 and 60 percent T8. This distribution was discussed in a memo between Focus on Energy and the evaluation team.[314] The existing lighting wattage is calculated by weighting the ASHRAE wattages of T8s and T12s for each fixture type according to these percentages. For T12s, the value used is for energy saving lamps with energy saving magnetic ballasts. For T8s, the value used is for 32 W lamps with electronic ballasts. The resulting values are presented in Table 5-63.

Proposed installed lighting wattage, P_p. The deemed values for the installed lighting wattages are also shown in Table 5-63. The deemed high lumen T8 wattages are based on averages (by the number of lamps per fixture) of technologies presented on the CEE qualified ballast product list[315] while excluding technologies with a "high" ballast factor or those with a "normal" ballast factor but high fixture wattages.[316]

Table 5-63. Deemed Lighting Wattages

Existing Lighting Technology	Existing Wattage	Replacement Lighting Technology	Replacement Wattage
New Construction - Assuming Standard 1L-4 ft 32W T8 with Electronic Ballast Baseline	32.0	High Performance 1L-4 ft T8 (High Lumen Lamp with Low BF)	28.0
New Construction - Assuming Standard 2L-4 ft 32W T8 with Electronic Ballast Baseline	60.0	High Performance 2L-4 ft T8 (High Lumen Lamp with Low BF)	51.0
New Construction - Assuming Standard 3L-4 ft 32W T8 with Electronic Ballast Baseline	93.0	High Performance 3L-4 ft T8 (High Lumen Lamp with Low BF)	76.0
New Construction - Assuming Standard 4L-4 ft 32W T8 with Electronic Ballast Baseline	120.0	High Performance 4L-4 ft T8 (High Lumen Lamp with Low BF)	98.0

[314] Correspondence from a memo from Chuck Sasso (Focus on Energy / WECC) to KEMA and Itron evaluation teams, dated October 13, 2006. Subject is "Follow up to October 4, 2006 Meeting."

[315] Available through Focus on Energy at http://www.focusonenergy.com/Incentives/Business/Lighting.aspx.

[316] For single lamp fixtures, "normal" BF fixtures with wattages above 34 W were excluded. For two lamp fixtures, those above 60 W were excluded. For three lamps, "normal" BF fixtures with wattages above 84 W were excluded. For four lamps, those above 108 W were excluded. These exclusions in the "normal" BF category are in addition to exclusions of all "high" BF fixtures for these calculations.

Existing Lighting Technology	Existing Wattage	Replacement Lighting Technology	Replacement Wattage
Retrofit - Replacing Standard 1L-4 ft T12 or T8	36.0	High Performance 1L-4 ft T8 (High Lumen Lamp with Low BF)	28.0
Retrofit - Replacing Standard 2L-4 ft T12 or T8	64.8	High Performance 2L-4 ft T8 (High Lumen Lamp with Low BF)	51.0
Retrofit - Replacing Standard 3L-4 ft T12 or T8	101.8	High Performance 3L-4 ft T8 (High Lumen Lamp with Low BF)	76.0
Retrofit - Replacing Standard 4L-4 ft T12 or T8	129.6	High Performance 4L-4 ft T8 (High Lumen Lamp with Low BF)	98.0

Table 5-64. ASHRAE Lighting Wattages

Fixture Type	T12 Wattage	T8 Wattage
1 Bulb - 4 feet	42	32
2 Bulb - 4 feet	72	60
3 Bulb - 4 feet	115	93
4 Bulb - 4 feet	144	120

Coincidence factor, CF. This calculation uses the program's standard lighting coincidence factors, presented in Table 5-65 and discussed in section 3.1.

Annual operating hours, H. This calculation uses the program's standard lighting operating hours, presented in Table 5-65 and discussed in section 3.1.

Table 5-65. Lighting Operating Hours and Coincidence Factors by Sector

Sector	Hours	CF
Agriculture	4,368	90%
Commercial	3,680	90%
Industrial	4,576	90%
Schools and Government	3,230	71%

Substituting the above values into the kW and kWh savings equations yields the deemed savings presented in Table 5-62.

5.4.12 T5 2-Lamp Replacing 3-Lamp T8 or 4-Lamp T12

Group: Lighting

Category: Fluorescent, Linear

Technology Description: Replacement of a 3-Lamp T8 system or 4-Lamp T12 system with a recessed, indirect 2-Lamp T5 system.

Qualifying Equipment:

- Existing fixtures may be 3-Lamp or 4-Lamp F32T8 or F40T12.[317]
- Replacement lamps must be high efficiency, low glare 2'x4' recessed indirect F28T5 fixtures or retrofit modules with an efficiency of 80% or greater.
- Approved replacement lamps appear on Focus' approved product list.[318]
- Specular reflector kits are not eligible for this incentive.
- T5HO lamps are not eligible for this incentive.

Date Deeming Last Modified: May 2008

Summarized by: Peter McPhee

Table 5-66. T5 2-Lamp Replacing T8 3-Lamp Deemed Savings[1]

WISeerts Tech Code	Measure Description	Deemed Savings							
		Agriculture		Commercial		Industrial		Schools/Gov't	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.0900.170	T5 2L - F28T5 Fixture, Recessed Indirect 2x4, replacing 3LT8 or 4LT12	0.0270	131	0.0270	110	0.0270	137	0.0213	96

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Deemed savings result from replacing standard 3-Lamp or $-Lamp T8 or T12 fixtures with 2-Lamp T5 fixtures. The electric deemed savings for this measure per fixture are provided in Table 5-66 based on customer sector.

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317 The application is worded such that existing fixtures may be 3-Lamp T8, 4-Lamp T8, 3-Lamp T12, or 4-Lamp T12. The measure description is worded such that existing fixtures may be 3-Lamp T8 or 4-Lamp T12.

318 Approved products can be found at www.focusonenergy.com/businesslighting.

kW and kWh savings are determined by the following equations:

$$kW\ Savings = \frac{(P_e - P_p) \times CF}{1{,}000}$$

$$kWh\ Savings = \frac{(P_e - P_p) \times H}{1{,}000}$$

where:

- *P_e = existing lighting wattage, deemed 93 W*
- *P_p = proposed replacement lighting wattage, deemed 63 W*
- *CF = coincidence factor, values in Table 5-67*
- *H = annual operating hours, values in Table 5-67*
- *1,000 = conversion factor, watts per kilowatt.*

Lighting wattages, P_e and P_p. These variables refer to the power used by the existing fixtures and the proposed 2-Lamp T5s, respectively.

Coincidence factor, CF. The coincidence factor represents the fraction of lights operating during peak period and is deemed by sector.

Annual operating hours, H. This is the average annual operating hours of the existing and replacement lamps, deemed by sector.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Existing lighting wattage, P_e. Existing lighting wattage is based on the wattage of a 3-Lamp fixture with 32 W T8s, and is deemed to be 93 W. This wattage is taken from a 2005 ASHRAE estimate for this fixture.[319] Note that this yields a conservative savings estimate, since the other fixture types that qualify for the incentive have a greater wattage.

Proposed replacement lighting wattage, P_p. The deemed wattage for the 2-Lamp T5 is 63 W. This wattage is taken from Advance Transformer's specifications for the ICN-2S28, a representative 2-Lamp T5 fixture.[320]

Coincidence factor, CF. This calculation uses the program's standard lighting coincidence factors, presented in Table 5-67 and discussed in section 3.1.

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[319] ASHRAE Fundamentals, 2005.

[320] The Advance Transformer catalog can be accessed at http://www.advancetransformer.com/ecatalog/.

Annual operating hours, H. This calculation uses the program's standard lighting operating hours, presented in Table 5-67 and discussed in section 3.1.

Table 5-67. Lighting Operating Hours and Coincidence Factors

Sector	Hours	CF
Agriculture	4,368	90%
Commercial	3,680	90%
Industrial	4,576	90%
Schools and Government	3,230	71%

Substituting the above values into the kW and kWh savings equations yields the deemed savings presented in Table 5-66.

5.4.13 LED Recessed Downlight

Group: Lighting

Category: LED Recessed Downlight

Technology Description: Replacement of 60W–100W incandescent with ENERGY STAR qualified LED recessed downlight ≤ 18W.

Qualifying Equipment:

- Existing lamps must be 60W-100W incandescent.
- Replacement LED downlight consists of a complete replacement luminaire unit including housing trim, reflector, lens, heat sink, driver, and light source.
- Replacement LED must appear on ENERGY STAR SSL qualified products list or meet ENERGY STAR eligibility criteria.
- Replacement LED downlight must be ≤ 18W.
- Incentive applies to replacement of single lamp.

Date Deeming Last Modified: November 2008

Summarized by: Peter McPhee

Table 5-68. LED Recessed Downlight Replacement

WISeerts Tech Code	Measure Description	Deemed Savings							
		Agriculture		Commercial		Industrial		Schools/Gov't	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.0970.260	LED recessed downlight - ENERGY STAR qualified	0.0471	228	0.0471	192	0.0471	239	0.0371	167

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Energy savings result from replacing incandescent bulbs with LED recessed downlights. LEDs use less electricity than incandescent lamps to produce an equivalent amount of light. The electric deemed savings for this measure per bulb are provided in Table 5-68 based on customer sector.

kW and kWh savings are determined by the following equations:

$$kW\ Savings = \frac{\left(P_e\text{-}P_p\right) \times CF}{1{,}000}$$

$$kWh\ Savings = \frac{(P_e - P_p) \times H}{1{,}000}$$

where:

- P_e = *existing lighting wattage, deemed 65 W*
- P_p = *replacement lighting wattage, deemed 12.7 W*
- *CF = coincidence factor, values in Table 5-69*
- *H = annual operating hours, values in Table 5-69*
- *1,000 = conversion factor, watts per kilowatt.*

Lighting wattages, P_e and P_p. These variables refer to the average power used by the existing incandescent lamp and the proposed LED, respectively.

Coincidence factor, CF. The coincidence factor represents the fraction of lights operating during the peak period and is deemed by sector.

Annual operating hours, H. This is the average annual operating hours of the existing and replacement lamps, deemed by sector.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Existing lighting wattage, P_e. The deemed value of the existing incandescent wattage is 65 W. The measure calls for the replacement of 60-100 W incandescent downlights. Most of the flood lights that will be replaced are expected to be 65 W or 75 W. The assumed value of 65 W is intended to be a conservative assumption of the wattage of incandescent downlights in the population eligible for replacement by the LED downlight.[321]

Proposed replacement lighting wattage, P_p. The deemed value for the LED recessed downlight replacement is 12.7 W. This value reflects the prevalence of two common LED downlights at the time of deeming. The Cree LR6 (12 W) and Cooper's Halo ML706830 (14.8 W) accounted for approximately 75 percent and 25 percent of eligible installed LED downlights, respectively.[322] The value of 12.7 W is a weighted average of the two LED downlights.

Coincidence factor, CF. This calculation uses the program's standard lighting coincidence factors, presented in Table 5-69 and discussed in section 3.1.

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[321] The chosen value of existing lighting wattage was discussed in a correspondence between WECC and KEMA in a memo dated 4 November 2008. The subject of the memo is "Fall '08 Deemed Savings Review." No specific sources are cited for the wattage values or prevalence of lamps in the population.

[322] The LED lighting wattage was also discussed in the WECC/KEMA memo dated 4 November 2008.

Annual operating hours, H. This calculation uses the program's standard lighting operating hours, presented in Table 5-69 and discussed in section 3.1.

Table 5-69. Lighting Operating Hours and Coincidence Factors by Sector

Sector	Hours	CF
Agriculture	4,368	90%
Commercial	3,680	90%
Industrial	4,576	90%
Schools and Government	3,230	71%

Substituting the above values into the kW and kWh savings equations yields that values presented in Table 5-68.

5.4.14 Metal Halide Ceramic, Pulse Start, and Electronic Ballast Pulse Start

Group: Lighting

Category: High Intensity Discharge (HID)

Technology Description: Replacement of incandescent, HID, or standard metal halide lamps with ceramic, pulse start, or electronic ballast pulse start metal halides.

Qualifying Equipment:

Ceramic Metal Halide (CMH) Measures:

- Existing fixtures or lamps must be incandescent.[323]
- Replacement fixtures or screw in lamps must be CMHs with wattages as shown in Table 5-70.[324]
- CMH fixtures or lamps may replace more than one incandescent.
- Total CMH wattage must be lower than existing total incandescent wattage.
- For measure 2.2110.220, incentive is for complete hardwired fixtures containing qualified CMH lamp and ballast.
- For measure 2.2115.220, incentive is for CMH reflector lamp with integrated ballast.

Pulse Start and Electronic Ballast Pulse Start Metal Halide Measures:

- Lighting systems must be for indoor applications only.
- Existing lighting technology must be standard HID or standard MH fixtures/components.
- Replacement technologies must coincide with technologies shown in Table 5-70.
- Replacement fixtures must be permanently-wired ballast and lamp retrofit or complete new fixture—screw in retrofit lamps do not qualify.
- Incentive is per fixture installed.

[323] The 2.2115.220 measure description indicates that the existing incandescent bulb must be 75-90 W. However, the Focus on Energy incentive application shows that the replaced bulb may be from 70-100 W.

[324] The 2.2115.220 measure description states that the replacement CMH must be 25 W, while the Focus incentive application allows the CMH to be ≤25 W.

Date Deeming Last Modified:

- October 2006 (2.2110.220, 2.2150.220)
- April 2007 (2.2115.220)
- May 2008 (2.2155.220, 2.2170.220, 2.2171.220)

Summarized by: Peter McPhee

Table 5-70. CMH, PSMH, and Electronic Ballast PSMH Deemed Savings

WISeerts Tech Code	Measure Description	Deemed Savings							
		Agriculture		Commercial		Industrial		Schools/Gov't	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.2110.220	Metal Halide (MH) Ceramic 20-100 Watts - Replaces Incandescent	0.1175	570	0.1175	480	0.1175	597	0.0927	418
2.2150.220	Metal Halide (MH), Pulse Start, 320W replacing 400W HID	0.0846	411	0.0846	346	0.0846	430	0.0667	301
2.2115.220	Metal Halide (MH) Ceramic 25 Watts - Replaces 75-90 Watts Incandescent	0.0518	251	0.0518	212	0.0518	263	0.0408	184
2.2155.220	Metal Halide (MH), Pulse Start - 750W replacing 1000W MH	0.2565	1,245	0.2565	1,049	0.2565	1,304	0.2024	912
2.2170.220	Metal Halide (MH), Electronic Ballast Pulse Start - 250W replacing 400W HID	0.1629	791	0.1629	666	0.1629	828	0.1285	579
2.2171.220	Metal Halide (MH), Electronic Ballast Pulse Start - 320W replacing 400W HID	0.1026	498	0.1026	420	0.1026	522	0.0809	365

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Deemed savings result from replacing incandescent or standard HID/MH bulbs or fixtures with CMH, PSMH, or electronic ballast PSMH fixtures as shown in Table 5-70. The replacement metal halides use less electricity than incandescent or standard HID lamps to produce an equivalent amount of light. The electric deemed savings for these measures per fixture are provided in Table 5-70 based on customer sector.

kW and kWh savings are determined by the following equations:

$$kW\ Savings = \frac{(P_e - P_p) \times CF}{1{,}000}$$

$$kWh\ Savings = \frac{(P_e - P_p) \times H}{1{,}000}$$

where:

- *P_e = existing lighting wattage, values in Table 5-71*
- *P_p = proposed replacement lighting wattage, values in Table 5-71*
- *CF = coincidence factor, values in Table 5-72*
- *H = annual operating hours, values in Table 5-72*
- *1,000 = conversion factor, watts per kilowatt.*

Lighting wattages, P_e and P_p. These variables refer to the average power used by the existing incandescent or standard HID/MH lamps and the proposed efficient MHs, respectively.

Coincidence factor, CF. The coincidence factor represents the average fraction of fixtures operating during peak period and is deemed by sector.

Annual operating hours, H. This is the average annual operating hours of the existing and replacement lamps, deemed by sector.

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

The following values were assumed for the calculation input parameters:

Existing lighting wattage, P_e. The deemed values for existing lighting wattage used in the savings calculations are shown in Table 5-71. For incandescents being replaced by 20-100 W CMHs, the wattage of the incandescent is derived from the CMH wattage for lamps of equivalent light output. The CMH wattages are based on a select number of CMH lamps on the market, though the specific lamp technologies are not presented. The deemed incandescent wattage of 55 W reflects the average of the equivalent incandescent wattages.

For the replacement of the rated 400 W standard HID with a rated 320 W PSMH, the source of the deemed value is unclear. However, both existing and proposed wattage values appear to utilize a ballast factor of 1.16. This value is used to determine the 400 W HID's actual wattage of 465 W.

For an incandescent (75-90 W) being replaced by a CMH (25 W), the existing incandescent wattage value of 82.5 W is a simple average of the incandescent range considered.

The existing wattage of the standard HID/MH lamps used in the remaining measures is derived from lighting technologies available through Advance Transformer.[325] The appropriate rated wattages of the standard HID/MH lamps that fit the measure descriptions were averaged to determine the deemed wattage values of existing lighting for measures 2.2155.220, 2.2170.220, and 2.2171.220.

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[325] The Advance Transformer catalog is available at http://www.advancetransformer.com/ecatalog/.

Table 5-71. Deemed Lighting Technology Wattages

Existing Technology	Existing Wattage	Replacement Technology	Replacement Wattage
Incandescent	185.5	CMH (20-100W)	55.0
400W Standard HID	465.0	PSMH (320W)	371.0
Incandescent (75-90 W)	82.5	CMH (25W)	25.0
1000W Standard MH	1100.0	PSMH (750W)	815.0
400W Standard HID	459.0	Electronic Ballast PSMH (250W)	278.0
400W Standard HID	459.0	Electronic Ballast PSMH (320W)	345.0

Proposed replacement lighting wattage, P_p. The deemed values for the lighting replacements are also shown in Table 4-195. The 55 W deemed wattage for the 20-100 W range was based on an average of four CMH lamps in that size range, though the specific lamps and source of these values is unclear.

The source of the deemed wattage of the rated 320 W PSMH is also unknown, but appears to be based on the same ballast factor assumption (BF = 1.16) as the existing 400 W standard HID. Multiplying the 320 W rating by 1.16 yields the replacement fixture wattage of 371 W.

The deemed wattage value of the 25 W CMH is taken directly from the nameplate rating of the lamp. The measure itself refers to this replacement lamp wattage; therefore, no other lamp wattages were considered.

The 750 W PSMH and the electronic ballasted PSMH deemed wattages were taken from manufacturer data for these lamps as provided though the Advance Transformer catalog. The deemed values are averages of the actual wattage of the applicable lamps.

Coincidence factor, CF. This calculation uses the program's standard lighting coincidence factors, presented in Table 5-72 and discussed in section 3.1.

Annual operating hours, H. This calculation uses the program's standard lighting operating hours, presented in Table 5-72 and discussed in section 3.1.

Table 5-72. Lighting Operating Hours and Coincidence Factors by Sector

Sector	Hours	CF
Agriculture	4,368	90%
Commercial	3,680	90%
Industrial	4,576	90%
Schools and Government	3,230	71%

Substituting the above values into the kW and kWh savings equations yields the deemed savings presented in Table 5-70.

5.4.15 High Bay Fluorescent Replacing HID

Group: Lighting

Category: Fluorescent, Linear

Technology Description: T-8 or T-5 linear fluorescent light fixtures replacing high bay HID light fixtures.

Qualifying Equipment:

- New fixtures must be replacing existing fixtures one-for-one, two-for-one, or in a consistent ratio which (adding fixture wattages together as appropriate) corresponds to the wattage requirements listed below.
- Fixtures must be installed indoors.
- Installed and removed fixture wattages must conform to the requirements shown in Table 5-73.

Table 5-73. Wattage Requirements for HID to Fluorescent Replacement

Tech. Code	Installed Wattage	Removed Wattage
2.5170.170	≤155	250–399
2.5180.170	≤365	400–999
2.5182.170	≤250	400–999
2.5185.170	≤800	1,000+
2.5186.170	≤500	1,000+

Date Deeming Last Modified: November 2008.[326]

Reviewed by: Jeremiah Robinson

Table 5-74. High Bay Fluorescent Replacing HID Measures, Existing Deemed Savings

Tech Code	Measure Description	Agriculture		Commercial		Industrial		Schools-Government	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.5170.170	T8 4 lamp or T5HO 2 lamp Replacing 250-399 W HID	0.1345	653	0.1345	550	0.1345	684	0.1061	478
2.5180.170	T8 6 lamp or T5HO 4 lamp Replacing 400-999 W HID	0.2120	1,029	0.2120	867	0.2120	1,078	0.1672	754
2.5182.170	T8 8 lamp or T5HO 6 lamp Replacing 400-999 W HID	0.1437	697	0.1437	587	0.1437	731	0.1133	511

[326] 2.5182.170 added April 2007. 2.5185.170 added November 2008.

Tech Code	Measure Description	Agriculture		Commercial		Industrial		Schools-Government	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.5185.170	T8/T5HO <= 500 Watts Replacing >=1000 W HID	0.5589	2,713	0.5589	2,285	0.5589	2,842	0.4409	1,987
2.5186.170	T8 or T5HO <= 800W, Replacing >=1000 W HID	0.4244	2,060	0.4244	1,735	0.4244	2,158	0.3348	1,509

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Linear fluorescent light fixtures save energy when replacing high bay HID light fixtures because they are able to produce the same light output with a lower input wattage. Savings due to replacing light fixtures are described by the following equations:

$$kW_{savings} = \left(\frac{\text{Ltg. Watts}_{old} - \text{Ltg. Watts}_{new}}{1000} \right) * CF$$

$$kW_{savings} = \left(\frac{\text{Ltg. Watts}_{old} - \text{Ltg. Watts}_{new}}{1000} \right) * \text{Hours}$$

where:

- *Ltg. Watts$_{old}$ = lighting wattage of existing fixture, values in Table 5-75, watts*
- *Ltg. Watts$_{new}$ = lighting wattage of new fixture, values in Table 5-75, watts*
- *Hours = hours of use per year, values in Table 5-75, hr/yr*
- *CF = coincidence factor, values in Table 5-75, percent*
- *1,000 = conversion factor, watts per kilowatt.*

Existing Lighting Fixture Wattage, Ltg. Watts$_{old}$. The Existing Lighting Fixture Wattage is the total fixture wattage of the old fixture being replaced, including lamps and ballast.

New Lighting Fixture Wattage, Ltg. Watts$_{new}$. The New Lighting Fixture Wattage is the total fixture wattage of the new fixture being installed, including lamps and ballast.

Hours of Use, Hours. Hours of Use refers to the average annual operating hours of the light fixture and is measured in hours/year.

Coincidence Factor, CF. Coincidence Factor refers to the average percentage of total system wattage that is operating during the peak period and is measured in percent.

Table 5-75. Deemed Savings Parameters

Tech Code	Measure Description	Technology		Agriculture		Commercial		Industrial		Schools-Government	
		New Watts	Old Watts	Hours	CF	Hours	CF	Hours	CF	Hours	CF
2.5170.170	T8 4 lamp or T5HO 2 lamp Replacing 250-399 W HID	146	295	4,368	90%	3,680	90%	4,576	90%	3,200	71%
2.5180.170	T8 6 lamp or T5HO 4 lamp Replacing 400-999 W HID	230	465								
2.5182.170	T8 8 lamp or T5HO 6 lamp Replacing 400-999 W HID	305	465								
2.5185.170	T8/T5HO <= 500 Watts Replacing >=1000 W HID	459	1,080								
2.5186.170	T8 or T5HO <= 800W, Replacing >=1000 W HID	608	1,080								

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

i. Existing Lighting Fixture Wattage

Except for the 1000W replacement measures, it is unclear how the existing lighting fixture wattages were determined for each of these measures. There is no documentation available, except for data in a recent Focus spreadsheet that references standard wattages from the Advance and Universal ballast manufacturers. It appears that the deemed wattages may have been determined by selecting the wattage for the most popular existing fixture from the source listed and increasing it somewhat to account for other possible existing fixtures with higher wattages, as shown in Table 5-76.

The existing fixture wattage for the 1000W replacement measures is based on ASHRAE data for 1000W probe start MH fixture.

Table 5-76. Deemed Existing Fixture Wattages

Measure	Fixture	Fixture Wattage	Source	Deemed Wattage
2.5170.170	250W Probe Start MH	278	Universal	295
2.5180.170	400W Probe Start MH	459	Advance	465
2.5182.170	400W Probe Start MH	459	Advance	465
2.5185.170	1000W Probe Start MH	1,080	ASHRAE	1,080
2.5186.170	1000W Probe Start MH	1,080	ASHRAE	1,080

Here we see that the deemed wattages for all but 1000W replacements are slightly higher than the most popular fixture wattage as listed in the Focus spreadsheet. This may account for existing fixtures under these measures with higher wattages. For example, 320W Pulse Start MH fixtures could be replaced under measure 2.5170.170.

ii. New Lighting Fixture Wattage

Except for measure 2.5185.170, it is unclear how the new lighting wattages were developed. There is no documentation available, except for data in a recent Focus spreadsheet, which references standard wattages for fixtures without listing sources. Using these listed wattages, it is possible to reverse-engineer the calculations which were used to determine deemed wattages. Table 5-77 shows this process. For measure 2.5185.170, this calculation is shown in the deemed savings spreadsheet. For the other measures listed, the calculations were reverse-engineered.

Table 5-77. Deemed New Fixture Wattages and Possible Calculations

Measure	2.5170.170	2.5180.170	2.5182.170	2.5185.170
T5 Fixture	2L T5HO	4L T5HO	6L T5HO	8 lamp T5 HO
T5 Wattage	-	237	350	470
T5 Factor	-	60%	25%	50%
T8 Fixture	4L T8	6L T8	8L T8	(2) 6 lamp T8
T8 Wattage	146	219	290	448
T8 Factor	100%	40%	75%	50%
Deemed Wattage	146	230	305	459

Here we see calculations to determine deemed new lighting fixture wattages. As an example, deemed wattage for measure 2.5180.170 may have been based on an assumption of 60 percent 4-lamp T5HO fixtures and 40 percent 6-lamp T8 fixtures. For measure 2.5170.170, the T5 fixture was ignored and the wattage used was for the 4-lamp T8 fixture.

For measure 2.5186.170, there are not two obvious fixture choices to compare. Deemed new fixture wattage for this measure is 608W, which is slightly higher than that of the 10-lamp T5HO fixture (597) wattage but not close to any other fixture wattage or fixture combination.

iii. Hours of Use & Coincidence Factor

The values for hours of use and coincidence factor are those used for most lighting measures, deemed by sector. These sector-specific values are shown in Table 5-78.

Table 5-78. Hours of Use and CF Values

Sector	Hours	CF
Agriculture	4,368	90%
Commercial	3,680	90%
Industrial	4,576	90%
Schools & Government	3,230	71%

Substituting the above values into the savings equation yields the deemed savings values in Table 5-74.

5.4.16 Occupancy Sensors for High Bay Fluorescent Fixtures

Group: Lighting

Category: Controls

Technology Code: 2.5192.085

Technology Description: Occupancy sensor for high bay fluorescent fixtures, per fixture controlled.

Qualifying Equipment: Indoor wall, ceiling, or fixture mounted occupancy sensor used to control a high bay fluorescent fixture.

Date Deeming Last Modified: November 2008

Summarized by: Jeremiah Robinson

Table 5-79. Occupancy Sensors for High Bay Fluorescent Fixtures, Existing Deemed Savings

Tech Code	Measure Description	Savings							
		Agriculture		Commercial		Industrial		Schools-Government	
		kW	kWh	kW	kWh	kW	kWh	kW	kWh
2.5192.085	Occupancy sensor for high bay fluorescent fixtures, per fixture controlled	0.0000	676	0.0000	569	0.0000	708	0.0000	344

A. SAVINGS BASIS, EQUATIONS, AND PARAMETERS

Occupancy sensors control lighting operation by turning off fixtures if they do not sense motion in an area. Sensors can detect people through infrared or ultrasonic methods or both. One sensor can control a single fixture or multiple fixtures. The sensor turns off the fixture(s) if motion is not detected over an adjustable period of time, typically between 5 and 120 minutes. Savings due to occupancy sensor installation are described by the following equations:

$$kW_{savings} = \left(\frac{Ltg.\,Watts}{1000}\right) * CF$$

$$kWh_{savings} = \left(\frac{Ltg.\,Watts}{1000}\right) * \%\,Off * Hours$$

where:

- *Ltg. Watts = lighting wattage controlled, deemed 247 watts*
- *Hours = baseline hours per year, values in Table 5-80, hr/yr*
- *% Off = percent of time lights are controlled, values in Table 5-80, percent*
- *CF = coincidence factor, deemed 0 percent.*

Lighting Wattage, Ltg. Watts. Since the savings for this measure are determined per controlled fixture, the Lighting Wattage is equal to the average wattage of the fixtures controlled including lamps and ballasts.

Hours of Use, Hours. Hours of Use refers to the annual hours that the fixtures would have operated without the occupancy sensor.

Coincidence Factor, CF. Coincidence Factor refers to the average percentage of time during peak demand hours that the lights will be off due to occupancy sensor operation when they otherwise would have been on. The peak period is defined as 1–4 pm, Monday through Friday, June through August.

Percent Off, % Off. Percent Off refers to the percentage of time that the lights will be off due to occupancy sensor operation when they otherwise would have been on.

Table 5-80. Deemed Savings Parameters

Tech Code	Measure Description	Parameters															
		Agriculture				Commercial				Industrial				Schools-Government			
		% Off	Hours	CF	Avg. Watts	% Off	Hours	CF	Avg. Watts	% Off	Hours	CF	Avg. Watts	% Off	Hours	CF	Avg. Watts
2.5192.085	Occupancy sensor for high bay fluorescent fixtures, per fixture controlled	62.5%	4,368	0%	247	62.5%	3,680	0%	247	62.5%	4,576	0%	247	43.0%	3,230	0%	247

B. VALUES, ASSUMPTIONS, AND CALCULATIONS

i. Lighting Wattage

When first deemed, the average lighting wattage was determined by using a weighted average (by number of projects) of the fluorescent fixture wattages installed as part of HID-to-fluorescent replacement measures reported in the WISeerts database. This value is the same for all sectors, at 247 watts.

ii. Hours of Use

The values for Hours of Use are those used for most lighting measures, deemed by sector. These sector-specific values are shown in Table 5-81.

Table 5-81. Hours of Use Values

Sector	Hours
Agriculture	4,368
Commercial	3,680
Industrial	4,576
Schools & Government	3,230

The table shows that the Industrial sector has the highest hours of use at 4,576 hours/year and the Schools & Government sector the lowest at 3,230 hours/year.

The development of these values, as well as a proposed update, is discussed in Section 4.1. For a thorough discussion of current and proposed lighting hours of use, refer to that section.

iii. Percent Off

The Percent Off values were based on data from the EPA as presented on the E-Source website.[327] These values are sector-specific, and are shown in Table 5-82.

Table 5-82. Percent Off Values

Sector	% Off
Agriculture	62.5%
Commercial	62.5%
Industrial	62.5%
Schools-Government	43.0%

The calculation for the last round of deeming used data for “Storage Area/Closet” for the Commercial, Industrial, and Agriculture sectors to represent energy savings in warehouses, with a value of 62.5 percent. Data for “Classrooms” was used for the Schools & Government sector to represent energy savings in gymnasiums, with a value of 43 percent.

iv. Coincidence Factor

The Coincidence Factor is currently deemed as 0 percent for all sectors. The peak period of 1 pm to 4 pm, Monday through Friday, June through August, is a time of high occupancy for most building types, so it was judged that occupancy sensors are unlikely to control lights during this time.

Substituting the above values into the savings equations yields the deemed savings values presented in Table 5-79.

[327] Section of the E-Source website describing EPA energy savings estimates for occupancy sensors: http://www.esource.com/BEA/demo/BEA_esource/PA_10.html.