focus on energy℠

Partnering with Wisconsin utilities

Wisconsin Focus on Energy
TECHNICAL REFERENCE MANUAL

October 22, 2015

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Executive Summary

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

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

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

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

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

Update Process

The TRM is updated twice each year, at the beginning of the year and in fall. The early-year update reflects the savings that will be in effect for the calendar year. The fall update incorporates savings updates from evaluation findings that will be effective for the following calendar year. The present edition presents deemed savings and inputs effective for calendar year 2016.

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

Annual updates keep the TRM relevant and useful by:

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

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

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

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

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

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

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

Measure additions and deactivations completed during the first half of the calendar year are incorporated into the August/September update. The January/February TRM update addresses additions and deactivations that occur later in the preceding year. The January/February update is limited to additions and deletions and does not incorporate any changes to continuing measures.

Navigating the TRM

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

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

Measure Detail Structure

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

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

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

a. Residential single-family homes;

b. Residential multifamily dwellings (such as apartment buildings and condominiums);

c. Commercial facilities;

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

   d. Industrial facilities;
   e. Agriculture facilities; and
   f. School and government facilities.

   In many cases, the energy savings calculated for a measure will be the same for each sector in which it is used. However, this can vary for measures that are used differently by different customer sectors. For example, research has confirmed that, on average, homeowners, commercial businesses, and industrial facilities use the same lighting product for different amounts of time and at different times of the day, resulting in different annual electricity savings and demand reductions.

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

all three sections specify the values of variables used in the calculation. These inputs may include assumptions about usage behavior or other details obtained through research. For custom and hybrid measures, the algorithms also note which inputs should be calculated on a project-by-project basis, from sources such as engineering reviews, modeling inputs, or on-site measurements.

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

Acknowledgements

Many individuals and companies have made valuable contributions to compiling and validating the TRM, as well as to preparing the measure write-ups and savings calculations that preceded the first edition. Special thanks go to:

- Robert McCormack and Brian Evans from Cadmus
- Carol Stemrich, Joe Fontaine, and Denise Schmidt from the PSC of Wisconsin
- Allison Carlson and Erinn Monroe from CB&I, the Focus on Energy Program Administrator
- Program Implementers, which includes:
    - CLEAResult – Bobbi Fey, Kate Wesselink, Phil Grupe, Carter Dedolph and Donna Bambrough and Seth Craigo-Snell
    - Franklin Energy Services – Frank Falter and Tony Haas
    - GDS Associates – Mark Bergum
    - JACO – Phil Sisson
    - CESA 10 – Melissa Rickert and Jason Garvens
    - Leidos – Amy Wanek and Craig Schepp
    - Staples Energy and GDS – Nathan Baer and Chase Kelm
    - The Weidt Group – Adam Niederloh
    - Wisconsin Energy Conservation Corporation – Andy Kuc

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Business (Nonresidential) Measures

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

The calendar year 2016 Nonresidential portfolio includes seven programs designed to meet the needs of different types of nonresidential customers.

Focus on Energy designed three programs to serve nonresidential customers with different levels of energy use.

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

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

Nonresidential customers who are building new facilities can receive support from the **Design Assistance Program**, which connects customers, builders, and developers with experts who can provide energy-saving recommendations, and provides incentives to customers who incorporate those recommendations into their new construction.

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

CADMUS

Agriculture

Grain Dryer, Energy Efficient, Hybrid

	Measure Details
Measure Master ID	Grain Dryer, Energy Efficient, Hybrid, 3386
Measure Unit	Per bushels/hour of grain dryer capacity
Measure Type	Hybrid
Measure Group	Agriculture
Measure Category	Dryer
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Calculated
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	Calculated
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[5,8]
Incremental Cost ($/unit)	N/A

Measure Description

This incentive offering is for agricultural operation replacing existing grain drying systems with more energy efficient batch or continuous flow grain drying systems that have less than a 1,500 bushels per hour capacity. Older equipment, although still operational, becomes efficiency obsolete and can be more expensive to operate. Newer grain dryers generally have larger drying capacities, which can process loads faster and at a greater efficiency. Installing a new and more efficient grain dryer will effectively allow for reduced annual hours of operation by allowing for faster process of grain through increased efficiency. The purpose of drying grain is to reduce the amount of water in the crop after harvest to an acceptable level for marketing, storage, or processing. This incentive will be provided based on the bushel per hour processing capacity of the new grain dryer.

In-bin drying and tower grain drying are excluded and will be handled as custom measures.

Description of Baseline Condition

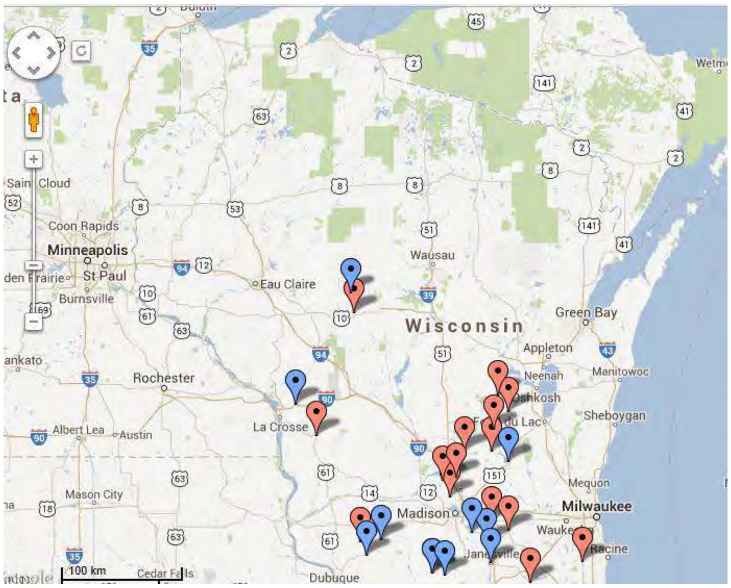
The baseline grain dryer system is assumed to be at least 20 years old, and operating at an efficiency of 2,241.20 Btu/lb moisture removed.[1] This baseline value was based on historical documentation from 27 completed Focus on Energy grain dryer upgrades/projects that received monetary incentives for improvements. Emphasis was placed on projects that reported at least two years of historical energy consumption and actual grain drying efficiencies based on the weather conditions during each specific year. Based on this emphasis, 10 projects were chosen to represent an accurate baseline (shown in table below).

Baseline Efficiency Data from Past Projects

Focus on Energy Project Number	Project Designation	Reported Baseline Efficiency [Btu/lb H2O]
26046	1	1,806.20
28478	2	2,187.00
29705	3	2,158.00
29713	4	2,159.67
29724	5	2,365.00
29995	6	1,569.33
35670	7	2,406.25
36208	8	2,147.00
37285	9	2,768.75
42041	10	2,844.80
Average Efficiency [Btu/lb H_2O]:		**2,241.20**

This measured data aligns with the reported efficiency of a traditional cross-flow dryer of 2,500 Btu/lb H_2O.[2] These projects are plotted below, with blue representing the 10 baseline projects and red representing the remaining 17 projects.

Past Grain Dryer Projects



It is understood that the proposed equipment efficiency, based on manufacturer specifications, will remain constant regardless of location. However, this efficiency is dependent on the month of harvest and the weather conditions during that harvest. Specifically, the enthalpy (Btu/lb dry air), which varies based on the dry-bulb temperature and relative humidity, will have the largest impact on the efficiency of the grain dryers.

It well known that grain is hygroscopic and will exchange moisture with the surrounding air until a state of equilibrium is reached, so using enthalpy to normalize the efficiency of the grain dryers allows for greater accuracy in formulating a baseline efficiency. Based on this, farmers typically wait to harvest their grain until the last few month of the year, specifically October through November.[3] Given the wide geography of past projects, the 13 past projects were chosen to represent a wide variety of locations and typical weather data, representing the state as a whole.

While the proposed grain dryer efficiency is very dependent on the weather conditions and time of harvest, there is no accurate way to depict or normalize this information without ongoing case studies to verify manufacturer claims.

Description of Efficient Condition

Per the North Dakota State University Extension Service, the minimum energy required to evaporate water from corn is approximately 1,200 Btu/lb H_2O, and the realistic dryer maximum efficiency is about 1,500 Btu/lb H_2O.[2]

The proposed efficiency was calculated using a historical representation of completed grain dryer projects (see the table below). This weighted average efficiency for proposed grain dryers is representative of completed projects in Wisconsin and illustrates manufacturer claims of ideal efficiencies. The proposed manufacturer efficiency should be used for determining the potential incentive and energy savings claim. The calculated proposed efficiency value is only an average, and can be improved pending the manufacturer claims for total system efficiency. However, the minimum qualifying efficiency for a grain dryer replacement should meet and/or exceed the claimed value of 1,625.20 Btu/lb H_2O.[1]

Proposed/Installed Efficiency Data from Past Projects

Focus on Energy Project Number	Project Designation	Proposed/Installed Efficiency [Btu/lb H_2O]
26046	1	1,644.00
28478	2	1,643.00
29705	3	1,634.00
29713	4	1,790.00
29724	5	1,702.00
29995	6	1,300.00
35670	7	1,517.00
36208	8	1,783.00
37285	9	1,803.00
42041	10	1,436.00
Average Efficiency [Btu/lb H2O]		**1,625.20**

As the measured dryer efficiency from past projects averages very close to the maximum efficiency of 1,500 Btu/lb H_2O, a revised efficient condition of 1,700 Btu/lb H_2O is conservative. Note that since this measure is hybrid, the actual drying efficiency will be calculated for the specific efficient grain that is installed.

To ensure that the efficient grain dryer is in fact more efficient than the previous dryer, the efficient grain dryer must use at least 250 Btu/lb H_2O less than the baseline dryer to qualify for an incentive. The efficient grain dryer must also have at least one of the following features specific to making the dryer more energy efficient:

- Staged temperature (higher temperature for wet grain, lower for dry grain)
- Grain turners or inverters (which rotate mostly dry grain away from plenum and wetter grain near plenum)
- Differential grain speed (column designed to move grain next to drying plenum faster to reduce excessive grain temperatures and provide a more uniform moisture content)
- Varied width of the drying column (narrower at top where the grain is wettest, allowing humid air to vent to the atmosphere faster)

Annual Energy-Savings Algorithm

The annual fuel savings is based on a conservative average of 15% to 22% moisture content removed for grain being dried. These values were estimated from actual reported moisture content for the 13 projects with historical documentation. In an effort to account for variance in weather conditions, a conservative average of 7.0 points of moisture content removed was assumed in lieu of the 8.7 points reported. Shelled corn at 15% and 22% moisture content equates to 55.67 lb/bu and 60.67 lb/bu, respectively.[4]

Note that the energy savings calculations remain constant regardless of the grain being dried. The only variables in drying other grains, such as wheat or soybeans, relates to the moisture content percentage and weights per bushel. This workpaper only identifies a savings estimate for shelled corn, as this was more representative of the completed projects used in the energy savings analysis.

$$\text{Therm}_{\text{SAVED}} = \text{bu} * (W_{\text{HARVEST}} - W_{\text{DRY}}) * (\eta_{\text{BASE}} - \eta_{\text{PROPOSED}}) * (1/100{,}000)$$

Where:

bu = Annual bushels of grain processed

W_{HARVEST} = Weight of corn at harvest at assumed 22% moisture (= 60.67 lb/bu)[4]

W_{DRY} = Weight of corn after drying at assumed 15% moisture (= 55.67 lb/bu)[4]

η_{BASE} = Energy efficiency of existing grain dryer (= 2,241.20 Btu/lb, unless there is historical data to calculate)

η_{PROPOSED} = Energy efficiency of proposed grain dryer (= 1,625.20 Btu/lb, unless there is detailed manufacturer data to calculate)

1/100,000 = Conversion factor from Btu to therms

If historical data is available to calculate the baseline efficiency for the existing grain dryer, it is determined by the following formula:

$$\eta_{\text{BASE}} = \Upsilon * [C_{P,H2O} * \rho * (T_F - T_I) * C_1] / [((M_I - M_F)/(100 - M_F)) * C_G * M_C * \eta_{\text{COMB}}]$$

Where:

Υ = Airflow rate in cubic feet per minute

$C_{P,H2O}$ = Specific heat of water vapor (= 0.443905 BTU/lb * Rankine)[5]

ρ = Density of water vapor (= 0.036745 lb/cubic foot)[5]

T_F = Plenum temperature of grain dryer (= 210°F)[6]

T_I = Average ambient temperature (= 40.73°F)[7]

C_1 = Conversion constant for 60 minutes per hour

M_I = Initial moisture content (= 22% unless otherwise proven)

M_F = Final moisture content (= 15% unless otherwise proven)

C_G = Existing grain dryer capacity flowrate in bushels per hour

M_C = Mass of corn at 22% moisture content (= 60.67 lb/bu, unless there is historical data to support a different value)[3]

η_{COMB} = Combustion efficiency of natural gas, assumed 95%

Summer Coincident Peak Savings Algorithm

There are no electric savings being claimed.

Lifecycle Energy-Savings Algorithm

$$\text{Therm}_{LIFECYCLE} = \text{bu} * (W_{HARVEST} - W_{DRY}) * (\eta_{BASE} - \eta_{PROPOSED}) * (1 \text{ therm} / 100{,}000 \text{ Btu}) * \text{EUL}$$

Where:

EUL = Expected useful life (= 20 years; sources list measure life of 30 years[5] and 10 to 12 years,[8] so 20 years was selected as the midpoint)

Deemed Savings

The annual and lifecycle savings for efficient grain dryers are calculated based on an algorithm, as this is a hybrid measure. This measure currently exists in SPECTRUM as a hybrid measure.

Assumptions

Energy savings for grain dryers is production-based, meaning that if more grain is dried, more savings are achieved. The amount of grain harvested can be effected by the weather and the number of acres of grain planted that year. The need for drying is also dependent on the weather, with drier weather during harvest requiring less grain drying.

To attempt to control for these variables, the bushels of grain dried over the past two to three years is collected on the application, along with anticipated drying needs in the upcoming two to three years. This will help identify the variability in grain dryer use based on past harvests, and will also identify any expected production increases or decreases after the grain dryer is installed, so that an accurate value of bushels of grain dried per year can be used in the hybrid calculations.

The specific energy efficiency of most high capacity grain dryers, including existing and proposed systems, range from 1,500 Btu/lb of water to 3,000 Btu/lb of water removed.[9]

The average cost of a grain dryer was determined as $56.00 per bushel per hour capacity.[10]

Sources

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Revision History

Version Number	Date	Description of Change
01	10/11/2013	New measure
02	01/29/2014	Revised per comments

Energy Efficient or Energy Free Livestock Waterer

	Measure Details
Measure Master ID	Waterer, Livestock: < 250 Watts, 2660 Energy Free, 3018
Measure Unit	Per waterer
Measure Type	Prescriptive
Measure Group	Agriculture
Measure Category	Livestock Waterer
Sector(s)	Agriculture
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	0 (winter use only)
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	10[1]
Incremental Cost	MMID 2660 = $710.33; MMID 3018 = $741.00

Measure Description

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

Description of Baseline Condition

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

Description of Efficient Condition

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

Annual Energy-Savings Algorithm

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

Where:

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

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

1,000 = Kilowatt conversion factor

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

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= 0)

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Average Annual Deemed Savings

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

Lifecycle Energy Savings

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

Peak Demand Deemed Reduction

Type	MMIDs	kWh
All Livestock Waterers	2660 and 3018	0

Assumptions

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

Source

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation: Business Programs: Measure Life Study." Final Report. August 25, 2009.
2. EnSave. Energy Efficient Stock Waterers. http://www.usdairy.com/~/media/usd/public/ensaveenergyefficientstockwaterers.pdf

Revision History

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

Circulation Fan, High Efficiency, Ag

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

Measure Description

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

Description of Baseline Condition

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

Description of Efficient Condition

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

Annual Energy-Savings Algorithm

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

Where:

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

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

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

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

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

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= 1.0)

Lifecycle Energy-Savings Algorithm

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

Where:

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

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation: Business Programs: Measure Life Study.” Final Report. August 25, 2009.

2. Deemed savings from Illinois Technical Reference Manual Version 2.0 dated June 7, 2013, referencing Illinois Act On Energy Commercial TRM No. 2010-4 dated May 31, 2011.

Revision History

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

Boilers & Burners

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

	Measure Details
Measure Master ID	Boiler, Hot Water, Near Condensing, ≥ 85% AFUE, ≥ 300 MBh, 3277
Measure Unit	Per MBh
Measure Type	Prescriptive
Measure Group	Boilers & Burners
Measure Category	Boiler
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	1.42
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	28.31
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Incremental Cost	$14.72

Measure Description

Mid-efficiency boilers use forced draft or induced draft power burners, instead of atmospheric draft, to push or pull gases through the firebox and heat exchanger. Because these boilers have relatively high efficiencies and relatively low flue gas temperatures, they are often constructed with stainless steel or other corrosion-resistant materials to tolerate condensation in the boiler. These boilers are typically used in applications where HESCCM boilers cannot be vented or where they will not have low enough return water temperatures to condense the water vapor in the flue gas.

Description of Baseline Condition

The baseline condition is a hot water boiler with 80% TE that is replaced on failure.[2]

Description of Efficient Condition

The efficient condition for a mid-efficiency boiler is a TE ≥ 85% for hot water boilers and being capable of modulating the firing rate. Redundant or backup boilers do not qualify.

Annual Energy-Savings Algorithm

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

Where:

BC = Boiler input capacity in MBh (= 1)

EFLH = Equivalent full-load hours (Multifamily residential= 1,759; Commercial, Industrial, Agriculture, Schools & Government = see table below)[3,4]

Effective Full Load Heating and Cooling Hours by City

City	EFLHheating
Green Bay	1,852
La Crosse	1,966
Madison	1,934
Milwaukee	1,883

$EFF_{BASELINE}$ = TE of the baseline measure (= 80%)

EFF_{EE} = TE of the efficient measure (= 87%)

100 = Conversion factor from MBtu to therms

Lifecycle Energy-Savings Algorithm

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

Where:

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

Assumptions

The equipment efficiency used for the deemed savings is assumed as 87% TE.

The analysis assumes that residential furnaces are operated similarly to this type of large, multi-family hot water boiler (i.e., both measures use a EFLH based on single unitary residential furnace data).

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. Code of Federal Regulations Energy Efficiency Standards, Title 10 Part 431 Section 87.

3. Multifamily: Full load hours for all residential natural gas measures estimate from: Pigg and Nevius. Electricity Use by New Furnaces. 2000. Available online: http://www.ecw.org/sites/d3efault/files/230-1.pdf

4. Non-residential: Several Cadmus metering studies reveal that the ENERGY STAR calculator EFLH are over-estimated by 25%. The heating EFLH were adjusted by population-weighted HDD and TMY-3 values.

Revision History

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

Boiler Plant Retrofit, Hybrid Plant, >1 MMBh

	Measure Details
Measure Master ID	Boiler Plant Retrofit, Hybrid Plant, >1 MMBh, 3275
Measure Unit	Per MBh
Measure Type	Prescriptive
Measure Group	Boilers & Burners
Measure Category	Boiler
Sector(s)	Commercial, Industrial, Schools & Government
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	1.54
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	30.79
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1,2]
Incremental Cost	$25.65

Measure Description

High-efficiency sealed combustion, condensing, and modulating (HESCCM) boilers operate by taking advantage of condensing in an effort to decrease energy consumption. Condensing boilers are designed to capture latent heat by condensing water vapor in the exhaust stream. For a boiler to properly condense, its return water temperature should be kept below 120°F. In order to capture as much latent heat as possible, condensing boilers are made from stainless steel or other corrosion-resistant materials.

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

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

Description of Baseline Condition

The baseline is for multiple 300 MBh to 1,000 MBh boilers with a thermal efficiency of 80%.[2]

Description of Efficient Condition

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

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

Annual Energy-Savings Algorithm

$\text{Therm}_{\text{SAVED}} = (C_Q * \text{BOF} * \text{HDD} * 24 / \Delta T) * (TE_Q / TE_B - 1) / 100$

Where:

C_Q = Input capacity of qualifying unit in MBh (= 1)

BOF = Boiler oversize factor (= 77%)[2]

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

Heating Degree Days by Location

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

24 = Conversion factor, hours per day

ΔT = Design temperature difference (= 80°F)[2]

TE_Q = Assumed thermal efficiency of mid- and high-efficiency boilers (= 87%)

TE_B = Thermal efficiency of baseline boilers (= 80%)

100 = Conversion factor from MBtus to therms

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 20 years)[1,2]

Assumptions

It is assumed that the equipment efficiency used for the deemed savings has 87% TE, as an approximate midpoint between the high-efficiency and mid-efficiency boilers jointly involved in the plant.

Sources

1. Similar measure in EUL Database (MMID 2208: Boiler Plant Retrofit, Hybrid Plant, 1- 5 MMBh)
2. PA Consulting Group Inc. Public Service Commission of Wisconsin Focus on Energy Evaluation, Business Programs: Deemed Savings Manual, Final Report. March 22, 2010.
3. Calculated from TMY3 weather files of the seven Wisconsin locations using *ASHRAE Estimation of Degree-Days: Fundamentals*, Chapter 14. Statewide weighted values calculated using 2010 U.S. Census data for Wisconsin.

Revision History

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

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

	Measure Details
Measure Master ID	Boiler Plant Retrofit, Mid Efficiency Plant, 1-5 MMBh, 2209
Measure Unit	Per MBh
Measure Type	Prescriptive
Measure Group	Boilers & Burners
Measure Category	Boiler
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	1.10
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	21.99
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Incremental Cost	$16.43

Measure Description

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

Description of Baseline Condition

The baseline is for multiple 300 MBh to 1,000 MBh boilers with a thermal efficiency of 80%.[2]

Description of Efficient Condition

The upgraded plant must meet the following requirements:

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

Annual Energy-Savings Algorithm

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

$Therm_{SAVED} = (C_Q * BOF * HDD * 24 / \Delta T) * (TE_Q / TE_B - 1) / 100$

Where:

C_Q = Input capacity of qualifying unit in MBh (= 1)

BOF = Boiler oversize factor (= 77%)[2]

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

Heating Degree Days by Location

Location	HDD[2]
Milwaukee	7,276
Green Bay	7,725
Wausau	7,805
Madison	7,599
La Crosse	7,397
Minocqua	8,616
Rice Lake	8,552
Statewide Weighted	**7,616**

24 = Conversion factor, hours per day

ΔT = Design temperature difference (= 80°F)[1]

TE_Q = Assumed thermal efficiency of qualifying unit (= 85%)

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

1 = Conversion factor to normalize difference

100 = Conversion factor from MBtus to therms

Lifecycle Energy-Savings Algorithm

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

Where:

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

Assumptions

The equipment efficiency used for the deemed savings is assumed to have 85% TE.

Sources

1. PA Consulting Group Inc. Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs: Deemed Savings Manual, Final Report. March 22, 2010.
2. Calculated from TMY3 weather files of the seven Wisconsin locations using *ASHRAE Estimation of Degree-Days: Fundamentals*, Chapter 14. Statewide weighted values calculated using 2010 U.S. Census data for Wisconsin.

Revision History

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

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

	Measure Details
Measure Master ID	Natural Gas Boilers (≤ 300 MBh) 90%+ AFUE, 2743
Measure Unit	Per Mbh
Measure Type	Hybrid
Measure Group	Boilers & Burners
Measure Category	Boiler
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by boiler capacity
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	Varies by boiler capacity
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Incremental Cost ($/unit)	Equipment Cost[3]: $24.11/kBtu * 150 kBtu = $3,616.50 Incremental Cost[3]: $11.80/kBtu * 150 kBtu = $1,770.00 Average Cost[4]: ($3,616.50 * 0.60) + ($1,770 * 0.40) = $2,877.90

Measure Description

High-efficiency sealed combustion condensing modulating (HESCCM) boilers operate by taking advantage of condensing to lower energy consumption. Condensing boilers are designed to capture the latent heat of condensed water vapor in the exhaust stream, which produces high-efficiency levels. For a boiler to operate in condensing mode, its return water temperature should be kept below 120°F.

In order to capture as much latent heat as possible, condensing boilers are made from stainless steel or other corrosion resistant materials. Chimney liners must be installed if the boiler is replacing a naturally drafting unit that was vented through the same flue as a water heater. Flue closure protocol must be followed where the chimney used by the replaced unit is no longer in use.[1]

Description of Baseline Condition

The baseline measure is an 82% AFUE boiler.[2]

Description of Efficient Condition

The efficient measure is a 90%+ AFUE boiler that is capable of modulating the firing rate, has integrated I/O reset control, and is used for space heating. Industrial process or DHW applications do not qualify.

Annual Energy-Savings Algorithm

$\Delta T = T_{indoor} - T_{out\ design}$

DHR=BC * 0.77

$DS = DHR * [(HDD * 24/\Delta T) * (1/\eta_e - 1/\eta_p)/100]$

Where:

T_{INDOOR} = Desired indoor temperature at winter design conditions (typically = 65°F)

$T_{OUT,DESIGN}$ = Outside winter design temperature

DHR = Design heating requirement, where 1 MBtuh = 1,000 Btu

BC = Boiler capacity rating (actual)

0.77 = Estimated average boiler oversizing

DS = Deemed therms saved per year

HDD = Heating degree days, base 65°F

24 = Conversion of hours per day

ΔT = Change in temperature

n_E = Standard AFUE

n_P = Proposed annual fuel utilization efficiency (AFUE)

100 = Conversion factor from MBtu to therms

DSM = Deemed savings multiplier

Summer Coincident Peak Savings Algorithm

There are no peak saving for this measure.

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 20 years)[4]

Deemed Savings

Average annual savings for a high-efficiency condensing boiler project:[2,3]
187 MBh * 2.57 therms/Mbh = 480 therms

Average lifecycle savings for a high-efficiency condensing boiler project: 9,600 therms

Updated Recommended Deemed Savings Multiplier for Boiler Replacements by Zone

DOA Zone	DSM
1	2.71
2	2.69
3	2.67
4	2.50
5	2.66
6	2.66
7	2.57
8	2.60
9	2.58
10	2.50
11	2.52
WI Average	**2.57**

Assumptions

The assumed boiler baseline efficiency is the EISA requirement of 82%.

Sources

1. PA Consulting Group Inc., Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs: Measure Life Study, Final Report. August 25, 2009
1. PA Consulting Group Inc. Public Service Commission of Wisconsin, Focus on Energy Evaluation, ACES: Default Deemed Savings Review, Final Report. August 25, 2009.
2. Focus on Energy ACES Program, 2008-2010 deemed savings average for measure.
3. California Energy Commission and California Public Utilities Commission. Database for Energy Efficient Resources (DEER) 2008. http://www.energy.ca.gov/deer/ .Revision History
4. 40% replace on fail.

Revision History

Version Number	Date	Description of Change
01	01/02/2013	Updated baseline efficiency from 80% to 82%

Steam Fittings and Pipe Insulation

	Measure Details
Measure Master ID	Insulation, Steam Fitting, Removable, NG, 2429 Insulation, Steam Piping, NG, 2430
Measure Unit	Per linear foot (pipe insulation) Per fitting (fitting insulation)
Measure Type	Prescriptive
Measure Group	Boilers & Burners
Measure Category	Insulation
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	11.38 (per linear foot pipe insulation) 40.44 (per fitting insulation)
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	113.8 (per linear foot pipe insulation) 404.4 (per fitting insulation)
Water Savings (gal/yr)	0
Effective Useful Life (years)	10[1]
Incremental Cost	MMID 2429 = $45.44; MMID 2430 = $22.76

Measure Description

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

Description of Baseline Condition

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

Description of Efficient Condition

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

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

Annual Energy-Savings Algorithm

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

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

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

Where:

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

LF = Total linear feet of pipe (= 1)

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

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

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

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

Where:

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

NF = Number of fittings (= 1)

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

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

Lifecycle Energy-Savings Algorithm

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

Where:

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

Assumptions

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

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

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

Sources

1. PA Consulting Group Inc. Public Service Commission of Wisconsin Focus on Energy Evaluation, Business Programs: Deemed Savings Manual, Final Report. March 22, 2010.
2. 2009 IECC standards.
3. This program is available through NAIMA (North American Insulation Manufacturers Association) at http://www.pipeinsulation.org/.

Revision History

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

Compressed Air, Vacuum Pumps

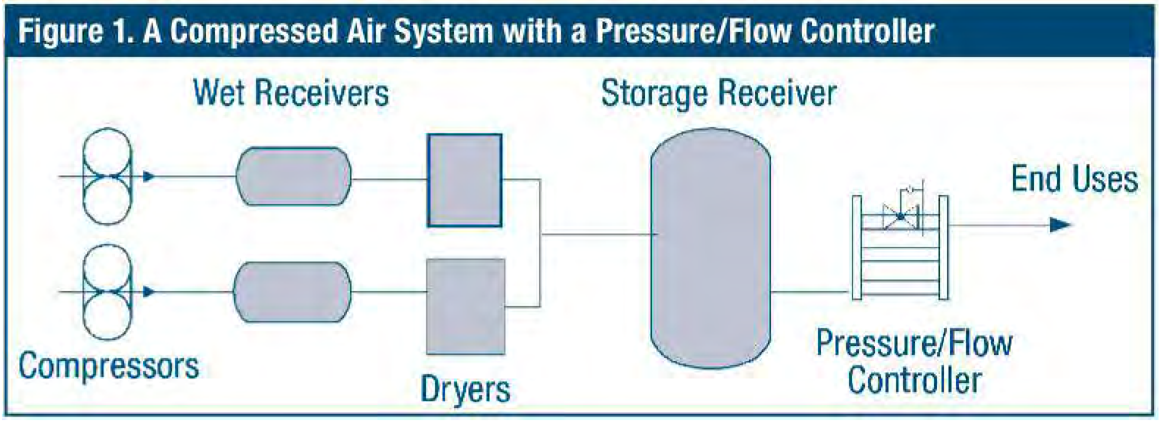
Compressed Air Controller, Pressure/Flow Controller

	Measure Details
Measure Master ID	Compressed Air Controller, Pressure/Flow Controller, 2255
Measure Unit	Per Compressed Air System
Measure Type	Hybrid
Measure Group	Compressed Air, Vacuum Pumps
Measure Category	Controls
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	178
Peak Demand Reduction (kW)	0.035
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	2,670
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost	$151.13

Measure Description

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

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



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

The benefits of having a pressure/flow controller include:

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

Description of Baseline Condition

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

Description of Efficient Condition

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

Annual Energy-Savings Algorithm

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

Where:

HP = Compressor motor size in horsepower
0.746 = Conversion factor from kilowatts to horsepower
Motor Eff. = Compressor motor efficiency (= 95%)[3]
Load Factor = Average load on compressor motor (= 89%)[3]
HOURS = Average annual run hours (= 5,083)[4]
% decrease = Percentage decrease in power input (= 5%)[5]

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= 1)[6]

Lifecycle Energy-Savings Algorithm

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

Where:

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

Sources

1. Estimate from product representative.
2. Industrial Technologies Program. *Compressed Air Tip Sheet #9.* August 2004.
3. Cascade Energy. Proposed Standard Savings Estimation Protocol for Ultra-Premium Efficiency Motors. November 5, 2012.
4. United States Department of Energy Office of Energy Efficiency & Renewable Energy. *United States Industrial Electric Motor Systems Market Opportunities Assessment*. Pg. 42. December 2002.
5. United States Department of Energy. Improving Compressed Air System Performance: A Sourcebook for Industry. Pg. 20. November 2003.
6. Army Corps of Engineers. *Compressed Air System Survey at Sierra Army Depot, CA*. Mike C.J. Lin, Ahmad R. Ganji, Shy-Sheng Liou, and Bryan Hackett. November 2000. www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA384166Revision History

Revision History

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

Compressed Air, Cycling Thermal Mass Air Dryers

	Measure Details
Measure Master ID	Compressed Air, Cycling Thermal Mass Air Dryers, 2264
Measure Unit	Per CFM
Measure Type	Prescriptive
Measure Group	Compressed Air, Vacuum Pumps
Measure Category	Dryer
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	1,430 per 100 CFM
Peak Demand Reduction (kW)	0.281 per 100 CFM
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	21,450 per 100 CFM
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost	$10.20

Measure Description

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

Description of Baseline Condition

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

Description of Efficient Condition

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

Annual Energy-Savings Algorithm

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

Where:

SF = Savings factor in kW/CFM (= see table below)[3]
LF = Load factor (= 89%)[4]
CFM = Cubic feet per minute; the actual rated capacity of air dryer
HOURS = Average annual run hours (= 5,083)[5]

Savings Factor by Dryer Capacity

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

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= 1)[6]

Lifecycle Energy-Savings Algorithm

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

Where:

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

Sources

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

4. Cascade Energy. Proposed Standard Savings Estimation Protocol for Ultra-Premium Efficiency Motors. November 5, 2012.
5. United States Department of Energy Office of Energy Efficiency & Renewable Energy. *United States Industrial Electric Motor Systems Market Opportunities Assessment*. Pg 42. December 2002.
6. Army Corps of Engineers. *Compressed Air System Survey at Sierra Army Depot, CA.* Mike C.J. Lin, Ahmad R. Ganji, Shy-Sheng Liou, and Bryan Hackett. November 2000. www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA384166Revision History

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

Compressed Air Heat Recovery, Space Heating

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

Measure Description

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

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

Description of Baseline Condition

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

Description of Efficient Condition

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

Annual Energy-Savings Algorithm

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

Where:

HR = Heat recoverable as a percentage of brake horsepower (= 50%)[2]
BHP = Compressor motor size, brake horsepower
2,545 = Conversion factor from Btu to BHP/hour
HOURS = Average annual run hours (= 5,083)[3]
Load Factor = Average load on compressor motor (= 89%)[4]
100,000 = Conversion from Btus to therms

Lifecycle Energy-Savings Algorithm

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

Where:

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

Sources

1. PA Consulting Group Inc. Public Service Commission of Wisconsin Focus on Energy Evaluation, Business Programs: Deemed Savings Manual, Final Report. March 22, 2010.

2. Bonneville Power Administration. Compressed Air System Energy Efficiency Measure Information Sheet. May 2006.
3. United States Department of Energy Office of Energy Efficiency & Renewable Energy. *United States Industrial Electric Motor Systems Market Opportunities Assessment*. Pg 42. December 2002.
4. Cascade Energy. Proposed Standard Savings Estimation Protocol for Ultra-Premium Efficiency Motors. November 5, 2012.

Revision History

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

Compressed Air Mist Eliminators

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

Measure Description

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

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

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

Description of Baseline Condition

The baseline measure is a standard coalescing filter.

Description of Efficient Condition

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

Annual Energy-Savings Algorithm

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

% Savings = $Total_{PR}$ * RS

Where:

HP = Compressor motor size horsepower

0.746 = Conversion factor from HP to kW

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

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

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

% Savings = Percentage of energy saved (= 2%)[4]

$Total_{PR}$ = Total pressure reduction from replacing filter (= 4 psig)[4]

RS = Percentage of energy saved for each psig reduced (= 0.5%)[5]

Summer Coincident Peak Savings Algorithm

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

Where:

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

Lifecycle Energy-Savings Algorithm

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

Where:

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

Sources

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

3. United States Department of Energy Office of Energy Efficiency & Renewable Energy. *United States Industrial Electric Motor Systems Market Opportunities Assessment*. Pg. 42. December 2002.
4. Sullair Corporation. *Compressed Air Filtration and Mist Eliminators Datasheet*. Available online: http://www.amcompair.com/products/brochures/sullair_brochures/_Sullair%20filtration.pdf.
5. United States Department of Energy. Improving Compressed Air System Performance: A Sourcebook for Industry. Pg. 20. November 2003.
6. Army Corps of Engineers. *Compressed Air System Survey at Sierra Army Depot, CA.* Mike C.J. Lin, Ahmad R. Ganji, Shy-Sheng Liou, and Bryan Hackett. November 2000. www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA384166Revision History

Revision History

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

Compressed Air Nozzles, Air Entraining

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

Measure Description

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

Description of Baseline Condition

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

Description of Efficient Condition

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

Annual Energy-Savings Algorithm

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

Where:

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

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

Eng. Flow = Flow of engineered nozzle (= 6 scfm)

HOURS = Average annual run hours (= 2,000)

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= 0.75)[4]

Lifecycle Energy-Savings Algorithm

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

Where:

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

Assumptions

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

Sources

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

Revision History

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

Compressed Air System Leak Survey and Repair

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

Measure Description

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

Description of Baseline Condition

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

Description of Efficient Condition

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

Annual Energy-Savings Algorithm

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

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

$$\Delta CFM\ Loss = \#ofLeaks * (CFM/leak)$$

Where:

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

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

0.06 = kWh $ rate

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

OpPressure = Adjustment factor for current operating pressure (= see table below)[3]

HOURS = Average annual run hours (participant input)

8,760 = Total hours per year

ΔCFM Loss = Total CFM lost in whole system (= see table below)[3]

#ofLeaks = Number of leaks at each orifice size

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

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

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

CFM Look-Up by Leak Orifice Size

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

Decibel Readings vs. CFM[2]

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

Lifecycle Energy-Savings Algorithm

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

Where:

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

Assumptions

Efficiency of Compressor Types:

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

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation: Business Programs: Measure Life Study." Final Report. August 25, 2009. Each year's tune-up should last two years.

2. UE Systems, Inc. *Compressed Air Ultrasonic Leak Detection Guide*. Available online: http://www.plantsupport.com/download/UCAGuide.pdf.

3. Department of Energy. http://www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/compressed_air3.pdf (originally from: Used with permission from Fundamentals of Compressed Air Systems Training offered by the Compressed Air Challenge®.)"

Revision History

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

Compressed Air Condensate Drains, No Loss Drain

	Measure Details
Measure Master ID	Compressed Air Condensate Drains, No Loss Drain, 2254
Measure Unit	Per drain
Measure Type	Prescriptive
Measure Group	Compressed Air, Vacuum Pumps
Measure Category	Other
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	1,525
Peak Demand Reduction (kW)	0.24
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	30,500
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Incremental Cost	$624.10

Measure Description

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

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

Description of Baseline Condition

The baseline measure is a timed solenoid drain.

Description of Efficient Condition

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

Annual Energy-Savings Algorithm

kWh_{SAVED} = SF * HOURS

Where:

SF = Saving factor in kilowatts per drain (= 0.3)[2]
HOURS = Average annual run hours (= 5,083)[3]

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = SF * CF

Where:

CF = Coincidence factor (= 0.80)

Lifecycle Energy-Savings Algorithm

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

Where:

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

Sources

1. 2011 Xcel Colorado DSM Plan. https://www.xcelenergy.com/staticfiles/xe/Regulatory/Regulatory%20PDFs/2011-CO-DSM-Plan.pdf .
2. TecMarket Works. New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs. Pgs. 193 and 194. October 15, 2010.
3. United States Department of Energy Office of Energy Efficiency & Renewable Energy. *United States Industrial Electric Motor Systems Market Opportunities Assessment*. Pg. 42. December 2002.

4. TecMarket Works, New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs, October 15, 2010, page 13.

Revision History

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

Domestic Hot Water

Water Heater, High Usage

	Measure Details
Measure Master ID	Water Heater, High Usage: ≥ 90% TE, NG, 3045 ≥ 0.82 EF, Tankless, NG, 3046 ≥ 2 EF, Heat Pump Storage, Electric, 3047
Measure Unit	Per heater
Measure Type	Hybrid
Measure Group	Domestic Hot Water
Measure Category	Water Heater
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by facility type
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by facility type
Lifecycle Energy Savings (kWh)	Varies by facility type
Lifecycle Therm Savings (Therms)	Varies by facility type
Water Savings (gal/yr)	0
Effective Useful Life (years)	10 (MMIDs 3045)[1] 15 (MMID 3046 and 3047)[2]
Incremental Cost	MMID 3045 = $7,303.00 MMID 3046 = $1,120.00 MMID 3047 = $2,893.00

Measure Description

This measure would substitute a less-efficient, code-compliant baseline DHW heater and deliver hot water at the same temperature and flow rate as the baseline water heater using less energy.

Description of Baseline Condition

New DHW heaters are only installed when the existing unit has failed, or is judged to have reached end-of-life. Therefore, the baseline unit is a new conventional electric or natural gas storage water heater intended for service in commercial and industrial buildings. Per the “Market Transformation Efforts for Water Heating Efficiency” report from ACEEE,[4] the following efficiency ratings are assumed:

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

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

Annual Operation and Usage in High Usage Applications

Category	Sub Category	Annual Operation (Minimum)	Usage (Minimum)
Food Service	Full Service Restaurant Fast Food	Days/Year (≥ 300)	Meals/Day (≥ 300)
	Cafeteria	Days/Year (≥ 175)	Meals/Day (≥ 300)
Lodging	Dormitory	Days/Year (≥ 200)	Beds (≥ 50)
	Hotel/Motel	Days/Year (≥ 300)	Rooms or Beds (≥ 30)
Healthcare	Hospital	Days/Year (≥ 300)	Beds (≥ 30)
	Nursing Home	Days/Year (≥ 300)	Beds (≥ 30)
Laundry	Laundromat	Days/Year (≥ 300)	Washes/Day (≥ 30)
Food Sales	Super Market	Days/Year (≥ 300)	Not Applicable

Description of Efficient Condition

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

Qualifying Natural Gas Equipment:

- 0.82 EF[6] Natural Gas Tankless Water Heaters
  - To be able to heat water to 70°F or more virtually instantaneously, most natural gas, tankless water heaters have an input of 100,000 Btu/hour or higher. Their major advantage is having no standby heat losses, which is made up by the heater firing whenever the water temperature drops below a set point. In addition, these heaters are typically installed close to the location where hot water is needed, which minimizes losses from the hot-water delivery piping.
- 90% TE[6] Condensing Natural Gas Storage Water Heaters
  - Condensing natural gas storage water heaters are designed to capture the latent heat from water vapor created when natural gas is burned. Conventional natural gas storage water heaters allow water vapor to leave the device, and therefore the latent heat is not captured; this means condensing natural gas heaters have a higher efficiency. Because flue gases have been significantly cooled, condensing natural gas water heaters require the use of a fan to propel combustion products gases through the exhaust flue.

Qualifying Electric Equipment:

- 2.0 EF[6] ENERGY STAR-Qualified Integrated Heat Pump Water Heaters
- 2.0 EF[6] Add-On Heat Pump Water Heaters

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

High usage, condensing, natural gas storage water heaters are not EF rated. For calculation purposes, an EF of 0.80 is used for condensing storage water heaters in high usage applications.[6]

Annual Energy-Savings Algorithm

$Btu_{SAVED} = GPY * 8.33 * 1.0 * 60 * [(1/EF_{BASELINE}) – (1/EF_{EFFICIENT})]$

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

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

Where:

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

8.33 = Density of water in pounds per gallon

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

60 = Annual average water temperature change produced by the DHW heater in °F

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

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

3,412 = Conversion factor for Btu per kWh

100,000 = Conversion factor for Btu per therm

Average Daily Gallons of DHW Usage by Facility Type

Facility Type	Average Daily Gallons	Source
Motels and Hotels[4] ≤ 20 rooms/suites 21 to 99 rooms/suites ≥ 100 rooms/suites	20 per room 14 per room 10 per room	ASHRAE HVAC Applications 2011, Chapter 50, Table 7
Dormitories[4]	12.7 per student	ASHRAE HVAC Applications 2011, Chapter 50, Table 7 (average of 13.1 for male dormitory and 12.3 for female dormitory)
Hospital[5]	50 per bed	http://smud.apogee.net/comsuite/content/ces/?id=971 (lists a range of 25 to 90 gallons/day/bed. 50 is on the

Facility Type	Average Daily Gallons	Source
		conservative side of a 57.5 midpoint)
Nursing Homes[4]	18.4 per bed	ASHRAE HVAC Applications 2011, Chapter 50, Table 7
Food Service[4] Full Service Restaurant Cafeteria Fast Food	 2.4 per meal 2.4 per meal 350 per day	Full Service and Cafeteria: ASHRAE HVAC Applications 2011, Chapter 50, Table 7 Fast Food: ASHRAE HVAC Applications 2011, Chapter 50, page 50.15 (lists range of 250 to 500. 350 is just under the midpoint of the range)
Supermarket[4]	650 per day	ASHRAE HVAC Applications 2011, Chapter 50, page 50.15 (lists range of 300 to 1,000. 650 is average)
Laundry[4]	21 per wash	ASHRAE HVAC Applications 2011, Chapter 50, page 50.12 (for low-flow clothes washer)

Summer Coincident Peak Savings Algorithm

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

Electric and Natural Gas Storage DHW Heaters

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

Electric Heat Pump DHW Heaters

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

Where:

CF = Coincidence factor (ratio of expected power demand at utility peak system demand to the maximum connected load of an item of equipment; see assumed values for various facility types in table below)

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

Coincidence Factors and Facility Utilization Factors[7]

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

*Excludes restaurants, kitchens, and laundries.

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

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

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

Lifecycle Energy-Savings Algorithm

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

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

Where:

EUL = Effective useful life (= 10 years[1] for natural gas storage, = 15 years[2] for natural gas tankless and electric heat pump)

Sources

1. MMID 3045: Based on Warranty of Equipment in 2013 Massachussetts TRM. http://ma-eeac.org/wordpress/wp-content/uploads/TRM_PLAN_2013-15.pdf .
2. MMID 3046 and 3047: CALMAC 2000 workshop report. Available online here: http://www.cpuc.ca.gov/NR/rdonlyres/7E3A4773-6D35-4D21-A7A2-9895C1E04A01/0/EEPolicyManualV5forPDF.pdf. and; PA Consulting Group Inc. State of

Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf .

3. American Council for an Energy-Efficient Economy (Jacob Talbot). “Market Transformation Efforts for Water Heating Efficiency.” ACEEE Report A121. January 2012.
4. American Society of Heating, Refrigeration, and Air-Conditioning Engineers, Inc. *ASHRAE Handbook, HVAC Applications*. Chapter 50 “Service Water Heating.” 2011.
5. Sacramento Municipal Utility District. “Energy Library / Facility Types / Healthcare / Hospitals.” http://smud.apogee.net/comsuite/content/ces/?id=971. Accessed November 12, 2014.
6. Title 10 Code of Federal Regulations, Part 431 sets minimum efficiency standards for gas-fired commercial storage water heaters at an EF=0.80
7. Coincidence Factors and Facility Utilization Factors were “developed by seeking consensus among a small group of engineers having experience performing energy audits in C&I facilities.” Seven experienced engineers were surveyed.

Revision History

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

Food Service

Dishwasher, ENERGY STAR Commercial

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

Measure Description

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

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

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

Description of Baseline Condition

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

Description of Efficient Condition

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

Annual Energy-Savings Algorithm

$$kWh_{SAVED} = \Delta kWh/yr_{WATER\ HEATER} + \Delta kWh/yr_{BOOSTER\ HEATER} + \Delta kWh/yr_{IDLE}$$

$$Therm_{SAVED} = \Delta Therms/yr_{WATER\ HEATER} + \Delta Therms/yr_{BOOSTER\ HEATER}$$

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

Energy-Savings Algorithms by Fuel and Machine Type

Fuel Type	Machine Type	Algorithm
Electric	Water Heater	$\Delta kWh/yr_{WATER\ HEATER} = Gallons_{SAVED} * kWh/gallon_{WATER\ HEATER}$
	Booster Heater	$\Delta kWh/yr_{BOOSTER\ HEATER} = Gallons_{SAVED} * kWh/gallon_{BOOSTER\ HEATER}$
Natural Gas	Water Heater	$\Delta Therms/yr_{WATER\ HEATER} = Gallons_{SAVED} * Therms/gallon_{WATER\ HEATER}$
	Booster Heater	$\Delta Therms/yr_{BOOSTER\ HEATER} = Gallons_{SAVED} * Therms/gallon_{BOOSTER\ HEATER}$

Energy Usage by Fuel and Machine Type

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

Where:

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

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

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

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

3,412 = Conversion factor from Btu to kWh

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

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

100,000 = Conversion factor from Btu to therms

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

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

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

Where:

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

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

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

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

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

60 = Minutes per hour

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

WT_{EE} = Washtime efficient equipment (= see table below)

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

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

Variable Values by Measure Type

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

Summer Coincident Peak Savings Algorithm

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

Where:

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

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

Lifecycle Energy-Savings Algorithm

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

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

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

Where:

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

Deemed Savings

Savings With Electric Water Heater and Booster Heater

	MMID	Baseline		ENERGY STAR		Savings	
		Electric (kWh)	Natural Gas (therm)	Electric (kWh)	Natural Gas (therm)	Electric (kWh)	Natural Gas (therm)
Low Temperature							
Under Counter	2298 (Electric) 2299 (NG)	11,085	0	8,508	0	2,577	0
Stationary Single-Tank Door	2280 (Electric) 2293 (NG) 3140 (Pots/Pans)	39,824	0	23,433	0	16,392	0
Single-Tank Conveyor	2296 (Electric) 2297 (NG)	42,687	0	28,868	0	13,819	0
Multitank Conveyor	2294 (Electric) 2295 (NG)	50,656	0	31,567	0	19,090	0
High Temperature (with electric booster heater)							
Under Counter	2287 (Electric) 2288 (NG)	12,474	0	9,278	0	3,196	0
Stationary Single-Tank Door	2281 (Electric) 2282 (NG) 2761 (Pots/Pans)	40,351	0	28,325	0	12,027	0
Single-Tank Conveyor	2285 (Electric) 2286 (NG)	46,069	0	36,758	0	9,311	0
Multitank Conveyor	2283 (Electric) 2284 (NG)	73,321	0	45,538	0	27,784	0
Pot, Pan, and Utensil	3137	21,351	0	17,991	0	3,360	0
High Temperature (with natural gas booster heater)							
Under Counter	2292	9,502	131	6,933	103	2,569	28
Stationary Single-Tank Door	2289	27,218	578	19,264	399	7,954	179
Single-Tank Conveyor	2291	33,415	557	26,577	448	6,838	109
Multitank Conveyor	2290	52,159	931	33,757	518	18,403	413
Pot, Pan, and Utensil	3138	14,224	314	12,086	260	2,138	54

Savings With Natural Gas Water Heater and Booster Heater

	MMID	Baseline		ENERGY STAR		Savings	
		Electric (kWh)	Natural Gas (therm)	Electric (kWh)	Natural Gas (therm)	Electric (kWh)	Natural Gas (therm)
Low Temperature							
Under Counter	2298 (Electric) 2299 (NG)	2,829	363	2,829	250	0	113
Stationary Single-Tank Door	2280 (Electric) 2293 (NG) 3140 (Pots/Pans)	2,409	1,647	2,409	925	0	721
Single-Tank Conveyor	2296 (Electric) 2297 (NG)	9,344	1,467	8,760	885	584	582
Multitank Conveyor	2294 (Electric) 2295 (NG)	10,950	1,747	10,950	907	0	840
High Temperature (with electric booster heater)							
Under Counter	2287 (Electric) 2288 (NG)	7,272	229	5,174	181	2,098	48
Stationary Single-Tank Door	2281 (Electric) 2282 (NG) 2761 (Pots/Pans)	17,368	1,012	12,468	698	4,900	314
Single-Tank Conveyor	2285 (Electric) 2286 (NG)	23,925	975	18,941	784	4,984	190
Multitank Conveyor	2283 (Electric) 2284 (NG)	36,288	1,630	24,921	907	11,367	723
Pot, Pan, and Utensil	3137	8,879	549	7,657	455	1,222	94
High Temperature (with natural gas booster heater)							
Under Counter	2292	4,300	360	2,829	284	1,471	76
Stationary Single-Tank Door	2289	4,234	1,590	3,407	1,097	827	493
Single-Tank Conveyor	2291	11,271	1,531	8,760	1,232	2,511	299
Multitank Conveyor	2290	15,126	2,561	13,140	1,426	1,986	1,135
Pot, Pan, and Utensil	3138	1,752	863	1,752	715	0	148

Annual Water Savings

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

Assumptions

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

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. United States Department of Energy. “ENERGY STAR Commercial Kitchens Calculator.” www.energystar.gov.
3. United State Environmental Protection Agency, Food Service Technology Center. http://www.fishnick.com/

4. Air Conditioning, Heating, and Refrigeration Institute. RWH research. Most common RE for non-heat pump water heaters: http://www.ahridirectory.org/ahridirectory/pages/rwh/defaultSearch.aspx.
5. Pennsylvania Public Utilities Commission. *Pennsylvania PUC Technical Reference Manual.* June 2013. Demand savings derived using dishwasher load shape.

Revision History

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

CEE Tier 2 Ice Machines

	Measure Details
Measure Master ID	Ice Machine, CEE Tier 2: Air Cooled: Self Contained, 0-499 lbs/day, 3414 Ice Making Head, 0-499 lbs/day, 3416 Ice Making Head, 500-999 lbs/day, 3417 Ice Making Head, ≥1,000 lbs/day, 3418 Remote Condensing, 0-499 lbs/day, 3422 Remote Condensing, 500-999 lbs/day, 3423 Remote Condensing, ≥1,000 lbs/day, 3424 Water Cooled: Self Contained, 0-499 lbs/day, 3415 Ice Making Head, <500 lbs/day, 3419 Ice Making Head, 500-999 lbs/day, 3420 Ice Making Head, ≥1,000 lbs/day, 3421
Measure Unit	Per ice machine
Measure Type	Prescriptive
Measure Group	Food Service
Measure Category	Ice Machine
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by machine type and size
Peak Demand Reduction (kW)	Varies by machine type and size
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by machine type and size
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	53[1]
Effective Useful Life (years)	10[2]
Incremental Cost	Varies by measure, see Appendix D (MMIDs 2388-2418)

Measure Description

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

Description of Baseline Condition

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

Description of Efficient Condition

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

Annual Energy-Savings Algorithm

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

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

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

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

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

Where:

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

H = Harvest rate of ice in pounds

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

365 = Number of days per year

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

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

Summer Coincident Peak Savings Algorithm

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

Where:

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

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Annual Deemed Savings

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

Lifecycle Deemed Savings

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

Assumptions

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

Sources

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

Revision History

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

ENERGY STAR Commercial Combination Ovens (Natural Gas or Electric)

	Measure Details
Measure Master ID	Oven, Combination, ENERGY STAR, 3118 (Electric) and 3119 (NG)
Measure Unit	Per oven
Measure Type	Prescriptive
Measure Group	Food Service
Measure Category	Oven
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	15,096
Peak Demand Reduction (kW)	3.446
Annual Therm Savings (Therms)	1,103
Lifecycle Energy Savings (kWh)	181,146
Lifecycle Therm Savings (Therms)	13,237
Water Savings (gal/yr)	0
Effective Useful Life (years)	12[1]
Incremental Cost	$4,300.00

Measure Description

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

Description of Baseline Condition

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

Description of Efficient Condition

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

Annual Energy-Savings Algorithms

Electric Combination Oven:

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

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

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

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

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

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

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

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

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

Natural Gas Combination Oven:

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

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

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

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

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

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

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

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

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

Where:

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

1,000 = Kilowatt conversion factor

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

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

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

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

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

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

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

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

60 = Minutes in an hour

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

100,000 = Conversion factor from Btu to therms

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

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

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

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

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

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

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

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

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

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

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

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

Production Capacity by Unit Type

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

Cooking Energy Efficiency by Type of Unit

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

Measured Energy Used per Preheat by Type of Unit

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

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= 1)[5]

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

Lifecycle Energy-Savings Algorithm

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

Where:

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

Assumptions

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

Sources

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

Revision History

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

Oven, Convection, ENERGY STAR, Electric

	Measure Details
Measure Master ID	Oven, Convection, ENERGY STAR, Electric, 2485
Measure Unit	Per oven
Measure Type	Prescriptive
Measure Group	Food Service
Measure Category	Oven
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	2,083
Peak Demand Reduction (kW)	0.48
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	24,998
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	12[1]
Incremental Cost	$50.00

Measure Description

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

Description of Baseline Condition

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

Description of Efficient Condition

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

Annual Energy-Savings Algorithm

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

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

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

Where:

OpDay = Operating days per year (= see table below)

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

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

E_{FOOD} = ASTM Energy to Food (kWh/lb or Btu/lb; = see table below)

Efficiency = ASTM Heavy Load Cooking Energy Efficiency percentage (= see table below)

IdleRate = Idle energy rate (kW or Btu/hr; = see table below)

OpHrs = Operating hours per day (= see table below)

PC = Production capacity in pounds per hour (= see table below)

T_{PREHT} = Preheat time in minutes (= see table below)

60 = Conversion from minutes to hours

E_{PREHT} = Preheat energy (kWh or Btu; = see table below)

Parameter Values by Model and Oven Fuel

Oven Fuel	Parameter	Baseline Model	ENERGY STAR Model	Source
Electric or Natural Gas	Preheat Time (min)	15	15	Deemed
	Operating Hrs/Day	12	12	4
	Operating Days/Year	365	365	4
	Pounds of Food Cooked per Day	100	100	4
Electric	Production Capacity (lb/h)	90	90	4
	Preheat Energy (kWh)	1.5	1	**Error! Reference source not found.**
	Idle Energy Rate (kW)	2	1.6	4
	Cooking Energy Efficiency (%)	65%	71%	4
	ASTM Energy to Food (kWh/lb)	0.0732	0.0732	4
Natural Gas	Production Capacity (lb/h)	83	86	4
	Preheat Energy (Btu)	19,000	11,000	**Error! Reference source not found.**
	Idle Energy Rate (Btu/h)	15,100	12,000	4
	Cooking Energy Efficiency (%)	44%	46%	4
	ASTM Energy to Food (Btu/lb)	250	250	4

Summer Coincident Peak Savings Algorithm

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

Lifecycle Energy-Savings Algorithm

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

Where:

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

Sources

1. Food Service Technology Center. Convection Oven Life-Cycle Cost Calculator.
2. Business Programs, Deemed Savings Manual V1.0, March 22, 2010.
3. ENERGY STAR Commercial Ovens Program Requirements, Version 2.1.
4. ENERGY STAR Commercial Kitchen Equipment Calculator.

Revision History

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

Oven, Convection, ENERGY STAR, Natural Gas

	Measure Details
Measure Master ID	Oven, Convection, ENERGY STAR, NG, 2486
Measure Unit	Per full size oven
Measure Type	Prescriptive
Measure Group	Food Service
Measure Category	Oven
Sector(s)	Commercial, Industrial, Agriculture, Schools and Government
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	156
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	1,872
Water Savings (gal/yr)	0
Effective Useful Life (years)	12[1]
Incremental Cost	$50.00

Measure Description

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

Description of Baseline Condition

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

Description of Efficient Condition

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

Annual Energy-Savings Algorithm

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

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

Where:

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

OpDays = Operating days per year (= see table below)

1/100,000 = Btu to therms conversion

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

E_{FOOD} = ASTM Energy to Food (kWh/lb or Btu/lb; = see table below)

Efficiency = ASTM Heavy Load Cooking Energy Efficiency percentage (= see table below)

IdleRate = Idle energy rate (kW or Btu/hr; = see table below)

OpHrs = Operating hours per day (= see table below)

PC = Production capacity (lb/hr; = see table below)

T_{PREHT} = Preheat time in minutes (= see table below)

60 = Conversion from minutes to hours

E_{PREHT} = Preheat energy (kWh or Btu; = see table below)

Parameter Values by Model and Oven Fuel

Oven Fuel	Parameter	Baseline Model	ENERGY STAR Model	Source
Electric or Natural Gas	Preheat Time (min)	15	15	Deemed
	Operating Hrs/Day	12	12	3
	Operating Days/Year	365	365	3
	Pounds of Food Cooked per Day	100	100	3
Electric	Production Capacity (lb/h)	90	90	3
	Preheat Energy (kWh)	1.5	1	4
	Idle Energy Rate (kW)	2	1.6	3
	Cooking Energy Efficiency (%)	65%	71%	3
	ASTM Energy to Food (kWh/lb)	0.0732	0.0732	3
Natural Gas	Production Capacity (lb/h)	83	86	3
	Preheat Energy (Btu)	19,000	11,000	4
	Idle Energy Rate (Btu/h)	15,100	12,000	3
	Cooking Energy Efficiency (%)	44%	46%	3
	ASTM Energy to Food (Btu/lb)	250	250	3

Lifecycle Energy-Savings Algorithm

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

Where:

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

Sources

1. Food Service Technology Center. Gas Convection Oven Life-Cycle Cost Calculator.
2. ENERGY STAR Commercial Ovens Program Requirements, Version 2.1.

3. ENERGY STAR Commercial Kitchen Equipment Calculator.
4. Food Service Technology Center. Electric Convection Oven Life-Cycle Cost Calculator.

Revision History

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

Commercial Refrigerator, ENERGY STAR

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

Measure Description

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

Description of Baseline Condition

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

Description of Efficient Condition

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

Annual Energy-Savings Algorithm

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

Where:

$kWh_{BASELINE}$ = Daily baseline unit consumption (= see table below)[4]

$kWh_{ENERGY\ STAR}$ = Daily qualifying unit consumption (= see table below)[4]

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

Parameter Values by Unit Type

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

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

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= 1)[5]

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

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Deemed Savings Values by Measure

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

Sources

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

Revision History

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

Commercial Freezers, ENERGY STAR

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

Measure Description

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

Description of Baseline Condition

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

Description of Efficient Condition

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

Annual Energy-Savings Algorithm

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

Where:

$kWh_{BASELINE}$ = Daily baseline unit consumption (= see table below)[4]

$kWh_{ENERGY\ STAR}$ = Daily qualifying unit consumption (= see table below)[4]

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

Parameter Values by Unit Type

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

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

Summer Coincident Peak Savings Algorithm

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

Where:

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

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Deemed Savings Values by Measure

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

Sources

1. ENERGY STAR Program Calculator for Commercial Refrigerators and Freezers http://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx
2. ENERGY STAR Program Requirements for Commercial Refrigerators and Freezers, Version 3.0.
3. U.S. Department of Energy. *Commercial Refrigeration Equipment Standards*. Effective January 20, 2010.
4. U.S. Environmental Protection Agency. Masked data set for commercial refrigerators and freezers, provided May 2013.

Revision History

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

HVAC

Demand Control Ventilation for Air Handling Units

Measure Master ID	Demand Control Ventilation for Air Handling Units, 2853
Measure Unit	Per CFM of outside air controlled
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Controls
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Calculated
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Calculated
Lifecycle Energy Savings (kWh)	Calculated
Lifecycle Therm Savings (Therms)	Calculated
Water Savings (gal/yr)	0
Effective Useful Life (years)	10[1]
Incremental Cost ($/unit)	$0.60[2]

Measure Description

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

Description of Baseline Condition

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

Cooling Efficiency Code Requirements

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

Description of Efficient Condition

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

Annual Energy-Savings Algorithm

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

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

Where:

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

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

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

$EFLH_{COOL}$ = Effective full load cooling hours (= depends on building type; see table below)[6]

12 = Conversion factor from EER to kW/ton

EER = Energy efficiency ratio of the existing equipment, assumed to be code (= see table above)

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

3,412 = BTU per kWh

HOURS = Hours of operation per day, provided by customer

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

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

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

η = Heating efficiency (= assumed to be 0.83)

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

Enthalpies, HDD, and Incremental Costs

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

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

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

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

Summer Coincident Peak Savings Algorithm

There are no peak savings associated with this measure.

Lifecycle Energy-Savings Algorithm

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

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

Where:

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

Assumptions

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

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

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

Savings assume a constant volume air system.

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

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

Sources

1. 2013 Conneticut TRM. http://www.energizect.com/sites/default/files/2013%20PSD_ProgramSavingsDocumentation-Final110112.pdf
2. Franklin Energy Services. Assumed zone size of 1,500 outside air CFM. Assumed standard combustion efficiency of heating equipment.
3. "ANSI/AHRI 210/240-2008: 2008 Standard for Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment."
4. Trane. "Psychometric Chart at Barometric Pressure 29.921 Inches of Mercury." and ASHRAE 2009 Fundamentals. Cooling DB/MCWB @ 0.4% averaged for state.
5. Franklin Energy Services. Assumed cooling setpoint of 74°F with 50% relative humidity and a 2°F temperature rise in the return plenum.
6. Focus on Energy Deemed Savings Manual.
7. Franklin Energy Services. Calculated through energy modeling with certain building type square footage modified based on economizer operation hours. Savings limited to 40% based on professional experience due to concerns for negative building pressurization and minimum outside air requirements per square footage of occupied facility. Higher values may be obtained, requiring custom calculations.

Revision History

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

Parking Garage Ventilation Controls

	Measure Details
Measure Master ID	Parking Garage Ventilation Controls, 3493
Measure Unit	Per exhaust fan system
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Controls
Sector(s)	Residential- multifamily; Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by fan horsepower
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by fan horsepower
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Incremental Cost ($/unit)	$8,000.00[2]

Measure Description

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

Description of Baseline Condition

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

Description of Efficient Condition

The efficient condition is garage exhaust fan(s) controlled by carbon monoxide sensor(s) with a minimum 5 hours of daily operation.

Annual Energy-Savings Algorithm

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

$kWh_B = HP_{FAN} * 0.746 * 24 * 365$

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

Where:

kWh_B = Annual electricity consumption of baseline fan control system

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

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

0.746 = Kilowatts per horsepower

24 = Hours per day

365 = Days per year

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

Summer Coincident Peak Savings Algorithm

There are no coincident peak savings associated with this measure.

Lifecycle Energy-Savings Algorithm

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

Where:

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

Sources

1. State of Wisconsin Public Service Commission of Wisconsin. *Focus on Energy Evaluation Business Programs: Measure Life Study – Ventilation Controls Installed - Final Report*. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. Measure incremental cost based on historical project data.
3. Wisconsin Legislature SPS 364.0404 - minimum enclosed garage ventilation https://docs.legis.wisconsin.gov/code/admin_code/sps/safety_and_buildings_and_environment/361_366/364/II/0404

Revision History

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

Surgery Occupancy, HVAC Controls

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

Measure Description

The savings expected to be realized in the business commercial sector, specifically within hospital air handlers serving surgery spaces. These air handlers currently operate continuously at a minimum of 20 Air Changes per Hour (ACH), and 4 ACH of outside air. After Building Automation Systems are upgraded to an extended architecture, the capability to reduce airflow to operating rooms when unoccupied may be obtained. However, space pressure relationships between an operating room and adjoining spaces are critical and steps must be taken to prevent an operating room from having negative pressure when airflow is reduced. Typically, these steps involve installing additional equipment on the return and/or supply ductwork serving the operating room. Once the equipment and controls changes have been made, an airflow reduction to 6 ACH, 1.6 ACH OA is feasible. The cost of these upgrades varies widely, depending on the existing equipment. However, if a base system of building automation system is present, the additional controls and possible VFD cost is within expected program range of 1 to 10 years.

Description of Baseline Condition

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

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

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

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

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

Description of Efficient Condition

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

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

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

Annual Energy-Savings Algorithm

Heating Load Savings (therms/yr)

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

Cooling Load Savings (kWh/yr)

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

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

Fan Power Savings (kWh/yr)

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

Reheat Savings (therms/yr)

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

Where:

Total CFM Existing = Actual total building airflow

Total CFM Proposed = Proposed total building airflow

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

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

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

Outside Air CFM Existing = Actual outside air supply airflow

Outside Air CFM Proposed = Proposed outside air supply airflow

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

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

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

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

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

Return Air CFM Existing = Actual return air supply airflow

Return Air CFM Proposed = Proposed return air supply airflow

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

Total Air CFM Existing = Actual total airflow

Total AirCFM Proposed = Proposed total airflow

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

6,356 = Horsepower conversion factor

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

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

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

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

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

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

Total Hours = Number of hours per year, per bin

Occupied Hours = Number of hours facility is occupied

Summer Coincident Peak Savings Algorithm

There are no peak savings from this measure.

Lifecycle Energy-Savings Algorithm

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

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

Where:

EUL = Effective useful life (= 10 years)

Sources

1. Grumman Butkus. “Greening the OR Symposium.” Presentation. September 11, 2014.
2. The American Society for Healthcare Engineering. Operating Room HVAC Setback Strategies. 2011. Available online: http://www.ashe.org/resources/management_monographs/pdfs/mg2011love.pdf
3. ANSI/ASHRAE/ASHE 170-2008 Ventilation of Healthcare Facilities
4. ASHRAE 90.1-2007 Energy Standard for Buildings Except Low-Rise Residential Buildings
5. ASHRAE 62.1-2007 Ventilation for Acceptable Indoor Air Quality
6. Savings-weighted average of historical Focus on Energy incentives. The four projects below were done as custom incentives under retrocommissioning and HVAC control measures. Going forward, these project types can be done under this new measure. The cost has variability based on the amount of equipment and controls installed at the customer site.

Historical Focus on Energy Surgery HVAC Projects

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

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

Revision History

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

Economizer, RTU Optimization

	Measure Details
Measure Master ID	Economizer, RTU Optimization, 3066
Measure Unit	Per ton
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Economizer
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by location
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by location
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	10[1]
Incremental Cost	$155.00

Measure Description

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

Description of Baseline Condition

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

Description of Efficient Condition

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

Annual Energy-Savings Algorithm

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

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

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

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

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

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

Where:

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

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

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

12 = Conversion factor from EER to kW/ton

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

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

Summer Coincident Peak Savings Algorithm

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

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

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

Deemed Savings by Location

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

Assumptions

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

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

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

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

Sources

1. California Energy Commission and California Public Utilities Commission. Database for Energy Efficient Resources (DEER) 2008. http://www.energy.ca.gov/deer/ .
2. International Energy Conservation Code. Table 503.2.3(1). 2009. Straight unweighted average of minimum EER standards for RTUs of cooling capacities greater than 11.25 tons.
3. National Renewable Energy Laboratory. “TMY3 Weather Data: National Solar Radiation Data Base.” http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html.

Revision History

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

Energy Recovery Ventilator

	Measure Details
Measure Master ID	Energy Recovery Ventilator, 2314
Measure Unit	Per CFM
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Energy Recovery
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	72 (reference savings)
Peak Demand Reduction (kW)	9.43 (reference savings)
Annual Therm Savings (Therms)	13,576 (reference savings)
Lifecycle Energy Savings (kWh)	1,080 (reference savings)
Lifecycle Therm Savings (Therms)	203,640 (reference savings)
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[3]
Incremental Cost	$1,500.00 per ventilator

Measure Description

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

Description of Baseline Condition

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

Description of Efficient Condition

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

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

Annual Energy-Savings Algorithm

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

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

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

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

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

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

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

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

Where:

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

60 = Conversion factor from hours to minutes

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

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

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

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

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

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

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

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

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

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

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

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

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

0.746 = Conversion factor from horsepower to kilwatts

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

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

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

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

100,000 = Btu to therm conversion

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

Summer Coincident Peak Savings Algorithm

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

Where:

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

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

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Deemed Energy Savings by Heating or Cooling

	Annual Energy Savings	Peak Demand Reduction	Lifecycle Energy Savings
Yearlong	72 kWh	-	1,080 kWh
	13,576 therms	-	203,640 rherms

Cooling	11,867 kWh	9.43 kW	178,005 kWh
	-	-	-
Heating	-11,795 kWh	-	176,925 kWh
	13,576 therms	-	203,640 therms

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

Assumptions

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

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

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

Weather Intervals and Corresponding Operating Hours

	Temperature Range (°F)	Range Midpoint (°F)	Hours Operating in Each Temperature Interval (hours)	Enthalpy (Btu/lb)
Cooling	95 to 100	97.5	4.18	42.12
	90 to 95	92.5	20.56	40.57
	85 to 90	87.5	70.72	39.45
	80 to 85	82.5	266.68	35.13
	75 to 80	77.5	421.24	32.40
	70 to 75	72.5	474.69	30.69
Heating	65 to 70	67.5	698.74	28.33
	60 to 65	62.5	877.28	25.22
	55 to 60	57.5	574.89	21.97
	50 to 55	52.5	642.02	19.17
	45 to 50	47.5	466.10	17.11
	40 to 45	42.5	639.90	15.06
	35 to 40	37.5	859.58	12.95
	30 to 35	32.5	730.96	10.99
	25 to 30	27.5	429.07	9.13
	20 to 25	22.5	507.80	7.61
	15 to 20	17.5	388.02	5.87
	10 to 15	12.5	229.07	4.04

	Temperature Range (°F)	Range Midpoint (°F)	Hours Operating in Each Temperature Interval (hours)	Enthalpy (Btu/lb)
	5 to 10	7.5	147.38	2.53
	0 to 5	2.5	95.69	1.30
	-5 to 0	-2.5	93.43	0.08
	-10 to -5	-7.5	79.95	-1.39
	-15 to -10	-12.5	27.69	-2.52
	-20 to -15	-17.5	9.57	-3.90
	-25 to -20	-22.5	3.49	-4.86
	-30 to -25	-27.5	1.31	-6.22

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. Focus on Energy Program, Energy Recovery Ventilator Calculator prepared by Franklin Energy..
3. Wisconsin PSC EUL Database. 2013. See Appendix C.

Revision History

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

Natural Gas Furnace with ECM, 95%+ AFUE (Existing)

	Measure Details
Measure Master ID	Natural Gas Furnace with ECM, 95%+ AFUE (Existing), 1981
Measure Unit	Per furnace
Measure Type	Prescriptive
Measure Group	HVAC
Measure Category	Furnace
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	831
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	97.3
Lifecycle Energy Savings (kWh)	14,967
Lifecycle Therm Savings (Therms)	1,751
Water Savings (gal/yr)	0
Effective Useful Life (years)	18[1] Single family: 23[2]
Incremental Cost	$345.93

Measure Description

Conventional natural gas furnaces produce by-products, such as water vapor and carbon dioxide, that are usually vented out through a chimney, along with a considerable amount of heat. This occurs not only when the furnace is in use, but also when it is turned off. Newer designs increase energy efficiency by reducing the amount of heat that escapes and by extracting heat from the flue gas before it is vented. These furnaces use much less energy than conventional furnaces.

Description of Baseline Condition

The baseline condition is a conventional furnace with AFUE < 78%.

Description of Efficient Condition

The efficient condition is furnaces with AFUE ≥ 95%, a multi-stage burner, variable speed ECM or brushless DC blower motor, and at least two firing stages.

Annual Energy-Savings Algorithm

Therm savings are calculated as 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.

$$Therm_{SAVED} = CAP * HOURS_{HEATING} * (1/AFUE_{BASE} - 1/AFUE_{EE}) * (1/100)$$

$$kWh_{SAVED} = (kWh/therm) * CAP * HOURS_{HEATING} * (1/100)$$

Where:

CAP = Actual output capacity of furnace (= 90 MBtu/hour)[2]

$HOURS_{HEATING}$ = Engineering estimate using 20% oversize factor, 80°F design temperature differential, and 7,699 HDD

$AFUE_{BASE}$ = Efficiency rating of standard efficiency furnace, deemed (= 78%)

$AFUE_{EE}$ = Efficiency rating of high-efficiency furnace, deemed (= 95%)

100 = Conversion factor for MBtus per therm

kWh/therm = High-efficiency electric savings factor, deemed (= 0.5 kWh/therm when based on 100% AFUE system)

Lifecycle Energy-Savings Algorithm

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

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

Where:

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

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. Cadmus completed a survey of small commercial furnace sizes and relied on various utilities studies. Completed November 2014.

Revision History

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

Variable Frequency Drive HVAC Applications

	Measure Details
Measure Master ID	Variable Frequency Drive, HVAC Fan, 2643 Variable Frequency Drive, HVAC Heating Pump, 2644
Measure Unit	Per horsepower
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Motors and Drives
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	880 (reference savings)[1]
Peak Demand Reduction (kW)	0.13 (reference savings)[2]
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	13,200 (reference savings)[1]
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[3]
Incremental Cost	$130.00

Measure Description

This measure is a VFD installed on an existing HVAC fan or pump (retrofit only). Units must operate a minimum of 2,000 hours annually. The reference savings values are based on average motor size of 7.5 hp.

Description of Baseline Condition

The baseline condition is a pump or fan that operates at a constant speed.

Description of Efficient Condition

VFDs physically slow motor driving pumps and fans to achieve reduced flow rates at considerable energy savings. Traditionally, flow rates have been reduced by increasing the head pressure drop in a system and riding the pump or fan curve back to a new flow rate (throttling control). Alternately, some systems have bypasses that divert a portion of the flow back to the pump or fan inlet to reduce system flow (bypass control).

This measure is VFDs installed on existing HVAC fans and pumps. The installation of a VFD must accompany the permanent removal or disabling of any throttling devices, such as inlet vanes, bypass dampers, and throttling valves. The unit must operate a minimum of 2,000 hours annually. VFDs on new equipment are not eligible. Redundant, back-up units and replacing existing VFDs do not qualify.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{BASE} – kWh_{VSD}$

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

$kWh_{VSD} = Σ(Watts_{VSD,i} * CAP_i × HOURS) / 1,000$

Where:

$Watts_{BASE}$ = Power draw of baseline motor at constant baseline speed

HOURS = Annual operating hours

1,000 = Kilowatt conversion factor

$Watts_{VSD,i}$ = Power draw of motor with VFD at capacity *i*

CAP_i = Percentage of time motor runs at capacity *i* (CAP_i should add to 100%)

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kW_{BASE} – kW_{VSD}$

$kW_{BASE} = Watts_{BASE} * HOURS_{PEAK}$

$kW_{VSD} = Σ(Watts_{VSD,i} * CAP_{i,PEAK} * HOURS_{PEAK}) / 1,000$

Where:

$HOURS_{PEAK}$ = Annual operating hours during peak period

$CAP_{i,PEAK}$ = Percentage of time motor runs at capacity *i* during the peak period ($CAP_{i,PEAK}$ should add to 100%)

Lifecycle Energy-Savings Algorithm

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

Where:

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

Sources

1. State of Wisconsin Public Service Commission of Wisconsin. *Focus on Energy ACES Program*. 2008-2010 average project savings for measure (based on an average of 7.5 hp).
2. Michigan Public Service Commission, Department of Licensing and Regulatory Affairs. “Michigan Energy Measures Database.” http://www.michigan.gov/mpsc/0,1607,7-159-52495_55129---,00.html.
3. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf

Revision History

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

RTU Optimization - Programmable Thermostat

	Measure Details
Measure Master ID	Programmable Thermostat, RTU Optimization Advanced, 3120 Programmable Thermostat, RTU Optimization Standard, 3121
Measure Unit	Per 1,000 square feet (kSF)
Measure Type	Hybrid
Measure Group	HVAC
Measure Cateogry	Other
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by inputs
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by inputs
Lifecycle Energy Savings (kWh)	Varies by inputs
Lifecycle Therm Savings (Therms)	Varies by inputs
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Incremental Cost ($/unit)	$150.00 (standard)[2], $292.00 (advanced)[3]

Measure Description

A majority of commercial spaces are heated and cooled by packaged rooftop units. This measure allows for installing and programming a programmable thermostat to reset space temperatures during unoccupied periods and save energy. The advanced measure involves installing a more advanced programmable thermostat that can operate two modes of ventilation for occupied and unoccupied periods, thus reducing or eliminating ventilation when not needed. The advanced thermostat option requires an economizer with multiple ventilation set points, a more advanced thermostat, and additional wiring.

Description of Baseline Condition

The baseline equipment is a non-programmable thermostat controlling a packaged rooftop unit.

Description of Efficient Condition

The efficient equipment includes a programmed programmable thermostat controlling a packaged rooftop unit. System must reset by 5 degrees or more for at least 6 hours per day.

Annual Energy-Savings Algorithm

Savings are calculated using the Honeywell Savings Estimator[5] tool for Rooftop Units, with inputs given in the table below.

Honeywell Savings Estimator Inputs

Data Input	Programmable Thermostat	Advanced Programmable Thermostat
Outdoor CO_2 Level	390 ppm	390 ppm
Building Type	Space Type[4]	Space Type[4]
Area	Tons[4] * 400 CFM/ton * 1 sq.ft./CFM	Tons[4] * 400 CFM/ton * 1 sq.ft./CFM
Construction	Frame Construction	Frame Construction
Thermal Envelope	ASHRAE Standard 90.1 - 2007	ASHRAE Standard 90.1 - 2007
City	Nearest to Site Address[4] of Eau Claire, Green Bay, La Crosse, Madison, Milwaukee	Nearest to Site Address[4] of Eau Claire, Green Bay, La Crosse, Madison, Milwaukee
Equipment Type	Unitary AC and Heating Type[4]	Unitary AC and Heating Type[4]
Efficiency	Cooling EER 10.0 Heating Natural Gas – 0.8 Heating Electric – 1.0	Cooling EER 10.0 Heating Natural Gas – 0.8 Heating Electric – 1.0
Damper Leakage	0%	0%
Base Case	Unoccupied Fan Cycling	Unoccupied Fan Cycling
Set Points Heating	Occupied 70°F Unoccupied (70°F – Heating Set Back)	Occupied 70°F Unoccupied (70°F – Heating Set Back)
Set Points Cooling	Occupied 75°F Unoccupied (75°F + Cooling Set Up)	Occupied 75°F Unoccupied (75°F + Cooling Set Up)
CO_2 Setpoint	1,100 ppm	1,100 ppm
Occupancy	Default Occupancy	Default Occupancy
Utility Rates	$0.70/therm, $0.10/kWh	$0.70/therm, $0.10/kWh

Annual Therm Savings (Natural Gas Heat)

Standard Programmable Thermostat = Natural Gas Energy (Base) – Natural Gas Energy (Setback)

Advanced Programmable Thermostat = Natural Gas Energy (Base) – Natural Gas Energy (Dry Bulb)

Annual Energy Savings (Natural Gas Heat)

Standard Programmable Thermostat = Electric Energy (Base) – Electric Energy (Setback)

Advanced Programmable Thermostat = Electric Energy (Base) – Electric Energy (Setback)

Annual Energy Savings (Electric Heat)

Standard Programmable Thermostat = Electric Energy (Base) – Electric Energy (Setback)

Advanced Programmable Thermostat = Electric Energy (Base) – Electric Energy (Setback) + Night Ventilation Savings

To determine Night Ventilation Savings, change heating type to natural gas and use the following formula: (Natural Gas Energy (Setback) – Natural Gas Energy (Dry Bulb)) * 29.3 kWh/therm * 0.8 (Electric Efficiency/Natural Gas Efficiency)

The following example provides savings for the retail sector in Milwaukee, using natural gas heating and inputs from the table above:

Inputs Calculated:

Area = 50 Tons (from application) * 400 CFM/ton * sq. ft./CFM

Where:

29.3 = Conversion from therms to kWh
CFM = Outside air flow in cubic feet per minute
EER = Energy efficiency ratio for cooling
Electric Energy = Model output from Honeywell savings estimator in kWh
Natural Gas Energy = Model output from Honeywell savings estimator in therms

Example Output Results

	Base	Setback	Dry Bulb	Enthalpy	Diff Enth	DCV	DCV+DB	DCV+Enth	DCV+DiffE
Natural Gas Energy (therms)	2,231	2,042	1,952	1,952	1,952	1,325	1,325	1,325	1,325
Electric Energy (kWh)	22,193	21,406	21,129	21,140	19,332	21,547	20,986	21,033	19,018
Electric Demand (kW)	18	18	18	18	18	16	16	16	16
Electricity Cost ($)	1,775	1,713	1,690	1,691	1,547	1,724	1,679	1,683	1,521
Natural Gas Cost ($)	1,562	1.430	1,367	1,367	1,367	928	928	928	928
Total Utility Cost ($)	3,337	3,142	3,057	3,058	2,913	2,652	2,607	2,610	2,449
Comp Run Time (hrs)	526	520	511	511	413	540	514	515	399
CO2 Emissions (mTons)	25	24	23	23	22	20	20	20	19
Equip Cost ($)	0	0	0	0	0	0	0	0	0
Cost Savings (%)	0	5,844	8,391	8,361	12,706	20,527	21,876	21,786	26,611
Cost Savings ($)	0	195	280	279	424	685	730	727	888

	Base	Setback	Dry Bulb	Enthalpy	Diff Enth	DCV	DCV+DB	DCV+Enth	DCV+DiffE
Payback (yrs)	0	0	0	0	0	0	0	0	0

Summer Coincident Peak Savings Algorithm

There are no peak savings for this measure.

Lifecycle Energy-Savings Algorithm

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

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

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. DEER Measure Cost Summary. Revised June 2, 2008.
3. Median material cost for preapproved list is $180.00; additional labor is required for programming and running wire from output to economizer, estimated at 2 hours per thermostat at labor rate of $56.48.
4. Inputs from program application.
5. Honeywell. https://customer.honeywell.com/Documents/setupFullSE4_2_0_1.zip

Revision History

Version Number	Date	Description of Change
01	03/11/2013	New measure
02	05/07/2013	Revised

A/C Split or Packaged System, High Efficiency

	Measure Details
Measure Master ID	A/C Split or Packaged System, High Efficiency, 3022
Measure Unit	Per system
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Rooftop Unit / Split System AC
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by capacity
Peak Demand Reduction (kW)	Varies by capacity
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by capacity
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost	$100.00 per ton

Measure Description

This measure is installing high-efficiency, unitary packaged, and split air conditioning equipment. This measure also applies to replacing an existing unit at the end of its useful life or installing a new unit in a new or existing building.

Description of Baseline Condition

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

Baseline Equipment for New Construction

IECC 2009, Table 503.2.3(1)	Minimum Efficiency[2]
Standard AC Unit < 65 kBtu/hour (5.42 tons or less)	13.0 SEER
Standard AC Unit ≥ 65 and < 135 kBtu/hour (5.42 to 11.25 tons)	11.2 EER
Standard AC Unit ≥ 135 and < 240 kBtu/hour (11.25 to 20 tons)	11.0 EER
Standard AC Unit ≥ 240 and < 760 kBtu/hour (20 to 63.33 tons)	10.0 EER
Standard AC Unit ≥ 760 kBtu/hour (63.33 tons or more)	9.7 EER

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

Baseline Equipment for Existing Building

IECC 2006 Table 503.2.3(1)	Minimum Efficiency[3]
Standard AC Unit < 65 kBtu/hour (5.42 tons or less)	10.0 SEER
Standard AC Unit ≥ 65 and < 135 kBtu/hour (5.42 to 11.25 tons)	10.2 EER
Standard AC Unit ≥ 135 and < 240 kBtu/hour (11.25 to 20 tons)	9.7 EER
Standard AC Unit ≥ 240 and < 760 kBtu/hour (20 to 63.33 tons)	9.5 EER
Standard AC Unit ≥ 760 kBtu/hour (63.33 tons or more)	9.2 EER

Description of Efficient Condition

The efficient equipment is a high-efficiency packaged air conditioner that exceeds the minimum CEE energy-efficiency requirements listed in the table below.

Efficient Equipment

CEE High Efficiency RTU Efficiencies by Size	Minimum to Qualify[2]
High Eff AC Unit < 65 kBtu/hour (5.42 tons or less)	15.0 SEER / 12.0 EER
High Eff AC Unit ≥ 65 and < 135 kBtu/hour (5.42 to 11.25 tons)	12.0 EER / 13.8 IEER
High Eff AC Unit ≥ 135 and < 240 kBtu/hour (11.25 to 20 tons)	12.0 EER / 13.0 IEER
High Eff AC Unit ≥ 240 and < 760 kBtu/hour (20 to 63.33 tons)	10.6 EER / 12.1 IEER
High Eff AC Unit ≥ 760 kBtu/hour (63.33 tons or more)	10.2 EER / 11.4 IEER

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{BASE} – kWh_{EE}$

Annual Energy-Savings Algorithms by Size

Baseline (kWh_{BASE})	
≥ 65 kBtu	kWh_{BASE} = Capacity * RLF * EFLH $_{C}$ * (1/EER $_{BASE}$) * (1 kW/1,000)
< 65 kBtu	kWh_{BASE} = Capacity * RLF * EFLH $_{C}$ * (1/SEER $_{BASE}$) * (1 kW/1,000)
Efficient (kWh_{EE})	
≥ 65 kBtu	kWh_{EE} = Capacity * RLF * EFLH $_{C}$ * (1/EER $_{EE}$) * (1 kW/1,000)
< 65 kBtu	kWh_{EE} = Capacity * RLF * EFLH $_{C}$ * (1/SEER $_{BASE}$) * (1 kW/1,000)

Where:

Capacity = Capacity (size) of the unit in Btu/hour

RLF = Rated load factor; the peak cooling load/nameplate capacity. This factor compensates for oversizing of the air conditioning unit (= 0.90)

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

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

1,000 = Conversion factor

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

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

Cooling Equivalent Full Load Hours by Building Type

Building Type	$EFLH_C$[4]
College	877
Food Sales	749
Food Service	578
Healthcare	803
Hotel/Motel	663
Industrial	519
Office	578
Other	589
Public Assembly	535
Public Services (non-food)	535
Retail	567
School	439
Warehouse	358
Average	**599**

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kW_{BASE} - kW_{EE}$

Summer Coincident Peak Savings Algorithms by Size

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

Where

CF = Coincidence factor (= 0.8)[5]

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Deemed Savings Values by Capacity

Capacity (Btu/hour)	SEER/ EER_{BASE}	SEER/ EER_{EE}	MMID	kWh_{BASE}	kWh_{EE}	kWh_{SAVED}	kW_{BASE}	kW_{EE}	kW_{SAVED}	$kWh_{LIFECYCLE}$
50,000	10	15	3022	2,695.50	1,797.00	899	4.00	2.67	1.33	13,478
100,000	10.3	12.0		5,233.98	4,492.50	742	7.77	6.67	1.10	11,122
187,000	9.7	12.0		10,392.96	8,400.98	1,627	15.42	12.47	2.96	29,880
517,500	9.5	10.6		29,366.76	26,319.27	3,048	43.58	39.06	4.52	45,712
800,000	9.2	10.2		46,878.26	42,282.35	3,315	69.57	62.75	6.82	68,939

Assumptions

The average (mean) value for all building types was used to determine cooling EFLH.

A default value of 0.90 was assumed for the rated load factor.

The deemed savings values were calculated for hypothetical units with capacities equal to the midpoint of each interval found in the IECC 2009 standard, with the exception of units < 65 kBtu/hour (which used 50 kBtu/hour) and units ≥ 760 kBtu/hour (which used 800 kBtu/hour).

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf; And Similar A/C measures (MMIDs 123-124, 821-879, 2192-2194).
2. International Energy Conservation Code. Table 503.2.3(1). 2009.
3. International Energy Conservation Code. Table 503.2.3(1). 2006.
4. DEER model runs that were weather normalized for statewide use by population density.
5. Focus on Energy Business Programs Deemed Savings Manual V1.0. March 22, 2010.

Revision History

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

Demand Control Ventilation, RTU Optimization

	Measure Details
Measure Master ID	Demand Control Ventilation, RTU Optimization, 3266
Measure Unit	Per RTU
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Rooftop Unit / Split System AC
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by area of conditioned space and number of occupants
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by area of conditioned space and number of occupants
Lifecycle Energy Savings (kWh)	Varies by area of conditioned space and number of occupants
Lifecycle Therm Savings (Therms)	Varies by area of conditioned space and number of occupants
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	$900.00[2]

Measure Desription

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

Description of Baseline Condition

The baseline equipment is a packaged RTU with an air side economizer and a fixed minimum ventilation rate.

Description of Efficient Condition

The efficient equipment includes a sensor that measures the carbon dioxide level of the space and an economizer that can adjust the ventilation rate to maintain carbon dioxide levels within the space according to code.

Annual Energy-Savings Algorithm

Savings are calculated using the Honeywell Savings Estimator[4] tool for RTUs, with inputs given in the following table.

Honeywell Savings Estimator Inputs

Data Input	Demand Controlled Ventilation
Outdoor CO_2 Level	390 ppm
Building Type [3]	Space type
Area [3]	Tons * 400 cfm/ton * 1 sq.ft./cfm
Construction	Frame
Thermal Envelope	ASHRAE Standard 90.1 - 2007
City	Nearest to site address[3] in Eau Claire, Green Bay, La Crosse, or Madison, Milwaukee
Equipment Type	Unitary AC and heating[3]
Efficiency	Cooling EER = 10 Heating Natural Gas EER = 0.8 Heating Electric EER = 1.0
Damper Leakage	0%
Base Case	Unoccupied fan cycling
Set Points Heating	Occupied 70°F Unoccupied (70°F heating set back)
Set Points Cooling	Occupied 75°F Unoccupied (75°F cooling set up)
CO_2 Setpoint	1,100 ppm
Occupancy	Default occupancy
Utility Rates	$0.70/therm; $0.10/kWh

Savings from Honeywell Estimator:

$\text{Therm}_{\text{SAVED}}$ = Natural Gas Energy (DCV + DB) – Natural Gas Energy (Dry Bulb)

$\text{kWh}_{\text{SAVED}}$ = Electric Energy (DCV + DB) – Electric Energy (Dry Bulb)

Where:

Natural Gas Energy = Model output from Honeywell Savings Estimator in therms[4]
DCV = Demand control ventilation
DB = Decibels
Dry Blub = The ambient air temperature
Electric Energy = Model output from Honeywell Savings Estimator in kWh[4]

Summer Coincident Peak Savings Algorithm

There are no peak savings for this measure.

Lifecycle Energy-Savings Algorithm

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

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

Where:

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

Assumptions

The minimum ventilation is based on ASHRAE 62.1-2007, which is representative or conservative for building stock addressed by measure.

Sources

1. 2013 Minnesota TRM: http://mn.gov/commerce-stat/pdfs/trm-version-1.3.pdf . 2013 Illinois TRM: http://www.ilsag.info/technical-reference-manual.html.The Minnesota TRM uses 15 year measure life. The Minnesota TRM EUL is sourced in the US Department of Energy Efficiency and Renewable Energy document: “Demand Control Ventilation Using CO2 Sensors”.
2. US Department of Energy Efficiency and Renewable Energy. “Demand Control Ventilation Using CO2 Sensors”.
3. Inputs collected from customer in Focus on Energy application.
4. Honeywell Savings Estimator Model located at: https://customer.honeywell.com/Documents/setupFullSE4_2_0_1.zip

Revision History

Version Number	Date	Description of Change
01	03/11/2013	Intial measure entry

Steam Trap Repair, >50 PSIG, General Heating

	Measure Details
Measure Master ID	Steam Trap Repair, 50-125 psig, General Heating, Prescriptive: 7/32" or Smaller, 3516 1/4", 3583 5/16", 3515 3/8" or Larger, 3514 Steam Trap Repair, 126-225 psig, General Heating, Prescriptive: 7/32" or Smaller, 3520 1/4", 3517 5/16", 3519 3/8" or Larger, 3518 Steam Trap Repair, > 225 psig, General Heating, Prescriptive: 7/32" or Smaller, 3524 1/4", 3521 5/16", 3523 3/8" or Larger, 3522
Measure Unit	Per steam trap
Measure Type	Prescriptive and Hybrid
Measure Group	HVAC
Measure Category	Steam Trap
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential-multifamily
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by pressure and orifice size
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	Varies by pressure and orifice size
Water Savings (gal/yr)	0
Effective Useful Life (years)	6[1]
Incremental Cost	Varies, see Appendix D

Measure Description

This measure is the repair of failed open steam traps leaking steam into the condensate lines of HVAC only steam systems.

Steam distribution systems contain steam traps, which are automatic valves that remove condensate, air, and other non-condensable gases, while preventing or minimizing steam loss. This measure is for the repair of failed steam traps that are leaking steam within the trap, and are part of an HVAC steam system.

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 measure specifications are as follows:

- 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.

A steam trap survey and repair log must be completed. Required information includes a trap identification tag number, location description, nominal steam pressure, trap type, trap condition (functioning, failed open, or failed closed), and orifice size.

Description of Baseline Condition

The measure baseline is a steam trap that has failed in the open position and is leaking steam into the condensate line in a high-pressure (>50 psig) steam system. The steam from the boiler must be used for space heating and not for process applications. The boiler is assumed to operate with 80% efficiency. It is important to note that the trap must be failed in the open position and not failed closed or plugged.

Description of Efficient Condition

The efficient condition is replacing or repairing traps that have failed in the open position, providing the ability to use steam heat that was previously wasted.

Annual Energy-Savings Algorithm

$W = 24.24 * P\_abs * OD^2 * \text{Napier's Formula}$

$Therm_{SAVED} = 24.24 * D^2 * (P_g + P_{atm}) * h_{fg} * HOURS * DF / 100,000 / Eff$

Where:

W = The pounds of steam flowing per second

24.24 = Constant from Napier equation

P_abs = Absolute Pressure in pounds per square inch absolute.

OD^2 = Diameter of orifice, in.

Napier's Formula = W = p_a / 70 (p = the absolute pressure in pounds per square inch, a = the area of the orifice in square inches, and 70 = constant)

D = Steam trap orifice diameter in inches (= 7/32, 1/4, 5/16, or 3/8)

P_g = Gauge pressure in pounds per square inch (= 87.5, 175.5, or 226)

P_{atm} = Atmospheric pressure at sea level in pounds per square inch (= 14.7)

h_{fg} = Latent heat of steam at P_g in Btu/lb (= 887.8, 847.2, or 828.7)

HOURS = Annual hours of operation the boiler is on and the system is at design pressure (= 4,706)[2]

DF = De-rating factor to account for the percentage that the trap is failed open (= 50%)[3]

100,000 = Conversion factor from Btu to therms

Eff = Boiler efficiency; for this calculation refers to boiler combustion efficiency (= 80%)

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Annual and Lifecycle Savings by Measure

Measure Name	MMID	Annual Savings (Therms)	Lifecycle Savings (Therms)
Steam Trap Repair, 126-225 psig, General Heating, 7/32" or Smaller	3520	5,497	32,984
Steam Trap Repair, 126-225 psig, General Heating, 1/4"	3517	7,180	43,082
Steam Trap Repair, 126-225 psig, General Heating, 5/16"	3519	11,219	67,315
Steam Trap Repair, 126-225 psig, General Heating, 3/8" or Larger	3518	16,156	96,934
Steam Trap Repair, >225 psig, General Heating, 7/32" or Smaller	3524	6,805	40,831
Steam Trap Repair, >225 psig, General Heating, 1/4"	3521	8,888	53,330
Steam Trap Repair, >225 psig, General Heating, 5/16"	3523	13,888	83,328
Steam Trap Repair, >225 psig, General Heating, 3/8" or Larger	3522	19,999	119,992

Assumptions

The steam trap is assumed to be failed open, for an HVAC steam distribution system operating with a boiler efficiency of 80%.

The following pressures were used to calculate the deemed savings for each pressure range and their corresponding latent heat values:

- 50-125 psig: 87.5 psig; 887.8 Btu/lb
- 126-225 psig: 175.5 psig; 847.2 Btu/lb
- >225 psig: 226 psig; 828.7 Btu/lb

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. State of Wisconsin Public Service Commission. *Focus on Energy Evaluation – Business Programs: Deemed Savings Manual V1.0*. Calculated based on weighted average between float and thermostaticand thermostatic steam trap types.
3. Enbridge Steam Saver Program. 2005.

Revision History

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

A/C Split System, ≤ 65 MBh, SEER 14/15/16+

	Measure Details
Measure Master ID	A/C Split System, ≤ 65 MBh: SEER 14, 2194 SEER 15, 2192 SEER 16+, 2193
Measure Unit	Per system
Measure Type	Prescriptive
Measure Group	HVAC
Measure Category	Rooftop Unit / Split System AC
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by SEER level
Peak Demand Reduction (kW)	Varies by SEER level
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by SEER level
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[7]
Incremental Cost	Varies by measure, see Appendix D

Measure Description

A split-system air conditioner has a compressor and condenser located outside of the building, and has an evaporator mounted inside the building in an air handler or blower. The system is connected by pipes that cycle refrigerant between the two heat exchangers. Energy savings result from installing a more efficient unit than the market standard. Additional savings are incurred because the unit must be installed with proper RCA. Proper adjustment of the RCA results in more efficient operation. Installation by a qualified contractor and regular servicing are required to maintain proper RCA.

Description of Baseline Condition

The baseline condition is a SEER 13 unit.[1]

Description of Efficient Condition

The efficient condition is an air conditioning split system ≤ 65 MBh with SEER 14 or greater. Both the condenser and evaporator coils must be replaced. The refrigerant line diameters must meet manufacturer specifications.

The condenser model and serial number, evaporator model and serial number, and AHRI reference number are required for all installations.

System efficiency is based solely on the evaporator and condenser coils; the SEER may not be increased by factoring in the efficiency of a variable speed forced air heating system fan, except where a two-stage air conditioner is installed.

All efficiency ratings will be verified using the AHRI database.[2]

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (CAP / 1{,}000) * (1 / SEER_{BASE} – 1 / SEER_{EE}) * EFLH_{COOL}$

Where:

CAP = Rated cooling capacity of the energy-efficient unit (= 29,100 in BtuHcool)[4]

1,000 = Kilowatt conversion factor

$SEER_{BASE}$ = Seasonal energy efficiency rating of baseline unit (= 13)

$SEER_{EE}$ = Seasonal energy efficiency rating of efficient unit (= 14, 15, or 16)

$EFLH_{COOL}$ = Equivalent full-load hours for cooling season (= 380; see table below)[6]

Equivalent Full-Load Cooling Hours by Location

Location	$EFLH_{COOL}$
Green Bay	344
La Crosse	323
Madison	395
Milwaukee	457
Wisconsin Average	**380**

Summer Coincident Peak Savings Algorithm

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

Where:

EER_{BASE} = Energy efficiency rating of baseline unit (=11 for SEER 13 unit)

EER_{EE} = Energy efficiency rating of efficient unit (= 11.7 for 14 SEER; = 12.2 for 15 SEER; = 12.7 for 16 SEER)

CF = Coincidence factor (= 0.66)[5]

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 15 years)[7]

Deemed Savings

Deemed Savings by SEER Level

SEER	MMID	Annual kWh Savings	kW Savings	Lifecycle kWh Savings
14	2194	60.7	0.104	1,093
15	2192	113.3	0.172	2,040
16+	2193	159.4	0.234	2,869

Assumptions

For the typical cooling capacity (size) of the unit, 2.425 tons was used.[3] This is equivalent to 29,100 Btu/hour (12,000 Btu/hour is equivalent to 1 ton).

Additional savings incurred from proper adjustment of the RCA is highly variable, and was unaccounted for in the savings algorithm.

Sources

1. Appliance Standards Awareness Project. "Central Air Conditioners and Heat Pumps." Available online: http://www.appliance-standards.org/product/central-air-conditioners-and-heat-pumps.
2. Air-Conditioning, Heating, and Refrigeration Institute. "Directory of Certified Product Performance." Last updated 2013. Available online: www.ahridirectory.org.
3. *Focus on Energy Evaluation, Residential Programs: CY09 Deemed Savings Review*. March 26, 2010.
4. Morgan Marketing Partners. *Michigan Energy Measures Database*. Details online:http://www.michigan.gov/mpsc/0,1607,7-159-52495_55129---,00.html.
5. Opinion Dymanics Corporation. *Delaware Technical Reference Manual*. April 30, 2012. Available online: http://www.dnrec.delaware.gov/energy/information/otherinfo/Documents/EM-and-V-guidance-documents/DELAWARE_TRM_August%202012.pdf.
6. Several Cadmus metering studies reveal that EFL_{HCOOL} is over-estimated in the ENERGY STAR calculator by 30%. These values were adjusted by population-weighted CDD TMY-3 values.

7. Measure Life Study prepared for The Massachusetts Joint Utilities: http://rtf.nwcouncil.org/subcommittees/nonreslighting/Measure%20Life%20Study_MA%20Joint%20Utilities_2005_ERS-1.pdf Revision History

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

Steam Trap Repair, < 50 psig, General Heating

	Measure Details
Measure Master ID	Steam Trap Repair, < 10 psig, Radiator, 2772
Measure Unit	Per steam trap
Measure Type	Prescriptive
Measure Group	HVAC
Measure Category	Steam Trap
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	245
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	1,470
Water Savings (gal/yr)	0
Effective Useful Life (years)	6[1]
Incremental Cost	$219.40

Measure Description

These measures are the repair of a radiator steam trap that is < 10 psig and the repair of general heating or industrial steam trap that is < 50 psig.

Steam systems distribute heat from boilers to satisfy space heating requirements. Steam distribution systems contain steam traps, which are automatic valves that remove condensate, air, and other non-condensable gases, while preventing or minimizing steam loss. Steam traps that fail may allow excess steam to escape, thus increasing the amount of steam that must be generated to meet end-use requirements.

All traps are susceptible to wear and dirt contamination and require periodic inspection and maintenance to ensure correct operation. Faulty steam traps (with blocked, leaking, or blow-through) can be diagnosed with ultrasonic, temperature, or conductivity monitoring techniques. Regular steam trap maintenance and faulty steam trap replacement are steps that minimize steam loss. There are four major types of steam traps: 1) thermostatic (including float and thermostatic), 2) mechanical, 3) thermodynamic, and 4) fixed orifice (fixed orifice traps do not qualify for incentives).

Individual steam traps must be failed open to qualify. When mass replacing steam traps, 30% of traps replaced will qualify. Systems on a city steam do not qualify for incentives. Traps can be repaired or replaced.

Description of Baseline Condition

The baseline condition is that a steam trap failed to open.

Description of Efficient Condition

The efficient condition is that the steam trap is operating per design with the same specifications as the baseline.

Annual Energy-Savings Algorithm

The steam leakage rate is calculated using the Napier equation:

$\text{Therm}_{\text{SAVED}} = [24.24 * (P_1 – P_2) * D^2 * h_{fg} * \text{HOURS} * \beta] / (100{,}000 * \eta)$

Where:

24.24 = 24.24 is a constant depending on the units of P and D. For pounds per square inch and inches it is 24.24.

P_1 = Steam pressure (psig)

P_2 = Condensate tank pressure (psig)

D = Size of steam trap orifice (inches)

h_{fg} = Heat of evaporation of water to steam at P_1 (Btu/lb)

HOURS = Average annual run hours per year

β = Adjustment factor to account for actual vs. theoretical steam loss (%)

100,000 = Conversion from Btu to therm

η = Combustion efficiency of boiler (%)

Lifecycle Energy-Savings Algorithm

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

Where:

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

Assumptions

The following assumptions are true for both types of steam traps (< 50 psig and < 10 psig operating pressure, general heating):

- Average diameter of steam trap orifice (D) = default of 1/4-inch
- HOURS = 5,392 hours per year (based on a Wisconsin temperature bin analysis; see Appendix B)
- P_2 = 0 psig

- η^1 = 80%
- β^1 = 50%

For steam traps < 50 psig operating pressure, general heating:

- P_1 = 30 psig
- h_{fg} = 929 Btu/lb

For steam traps < 10 psig operating pressure, radiators:

- P_1 = 5 psig
- h_{fg} = 961 Btu/lb

The HOURS for the steam systems were calculated using bin analysis of weather data across Wisconsin and a 55°F balance point on the heating system.

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf

Revision History

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

Air Conditioning Unit Tune Up - Coil Cleaning

	Measure Details
Measure Master ID	A/C Coil Cleaning: < 10 Tons, 3059 10-20 Tons, 3061 > 20 Tons, 3060
Measure Unit	Per ton of refrigeration capacity
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by sector and cooling capacity
Peak Demand Reduction (kW)	Varies by sector and cooling capacity
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector and cooling capacity
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	3[1]
Incremental Cost	$35.00

Measure Description

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

Description of Baseline Condition

The baseline condition is an AC system with fouled condenser coils.

Description of Efficient Condition

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

Annual Energy-Savings Algorithm

For AC units < 65,000 Btu/hour, use SEER instead of EER to calculate:

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

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

Where:

$EFLH_C$ = Equivalent full load hours for mechanical cooling (= see table below)[2]

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

1,000 = Conversion Factor

EER = Energy efficiency ratio (for AC and heat pump units < 65,000 Btu/hour, SEER should be used for cooling savings; = based on actual participant information)

CCF = Condenser coil fouling COP degradation factor for cooling (= 93.2%)[4]

SEER = Seasonal energy efficiency ratio (for AC and heat pump units > 65,000 Btu/hour, EER should be used for cooling savings; = based on actual participant information)

Summer Coincident Peak Savings Algorithm

For AC units < 65,000 Btu/hour, convert SEER to EER to calculate, using 11.3/13 as the conversion factor:

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

Where:

CF = Coincidence factor (= 0.90)[5]

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 3 years)[1]

Assumptions

Calculation Variable Assumptions

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

Equivalent Full Load Hours by Business Type

Building Type	$EFLH_C$ [3]
College	877
Food Sales	749
Food Service	578
Healthcare	803
Hotel/Motel	663
Industrial	519
Office	578
Other	589
Public Assembly	535
Public Services (non-food)	535
Retail	567
School	439
Warehouse	358
Average	**599**

Sources

1. California Energy Commission and California Public Utilities Commission. Database for Energy Efficient Resources (DEER) 2008. http://www.energy.ca.gov/deer/.DEER model runs weather normalized for statewide use by population density.
2. Weighted value for bin charges based on Southern California Edison program results for commerical and industrial buildings with 3,154 participating units. The weighting assumptions are calibrated annually to reflect Wisconsin findings.
3. Energy Center of Wisconsin (Scott Pigg). *Central Air Conditioning in Wisconsin*. ECW Report Number 241-1. 2008.

Revision History

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

Air Conditioning Unit Tune Up - Refrigerant Charge Correction

	Measure Details
Measure Master ID	A/C Refrigerant Charge Correction: < 10 Tons, 3062 10-20 Tons, 3064 > 20 Tons, 3063
Measure Unit	Per ton of refrigeration capacity
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by sector and cooling capacity
Peak Demand Reduction (kW)	Varies by sector and cooling capacity
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector and cooling capacity
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Incremental Cost	$35.00
Effective Useful Life (years)	10[2]

Description

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

Description of Baseline Condition

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

Description of Efficient Condition

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

Annual Energy-Savings Algorithm

For AC units < 65,000 Btu/hour, use SEER instead of EER to calculate:

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

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

Where:

$EFLH_C$ = Equivalent full load hours for mechanical cooling (= see table below)[3]

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

1,000 = Conversion Factor

EER = Energy efficiency ratio (for AC and heat pump units < 65,000 Btu/hour, SEER should be used for cooling savings; = use actual participant information)

RCF = Refrigerant charge COP degradation factor for cooling (= 98.3%)[5]

SEER = Seasonal energy efficiency ratio (for AC and heat pump units > 65,000 Btu/hour, EER should be used for cooling savings; = use actual participant information)

Summer Coincident Peak Savings Algorithm

For AC units < 65,000 Btu/hour, convert SEER to EER to calculate, using 11.3/13 as the conversion factor:

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

Where:

CF = Coincidence factor (= 0.90)[4]

Lifecycle Energy-Savings Algorithm

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

Where:

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

Assumptions

Calculation Variable Assumptions

Component	Type	Value	Source
$CAPY_C$	Variable	Nameplate	Data Gathering
EER	Variable	Nameplate	Data Gathering
$EFLH_C$	Variable	See Equivalent Full Load Hours by Business Type (table below)	3
RCF	Variable	98.3%	3, 5
CF	Fixed	90%	4

Charge Correction Factor Weighting

Correction Needed	Bin Charge	Weighting	RCF
≥-20%	-20%	5%	92%
-5% to -20%	-13%	27%	97%
-5% to 5%	0%	46%	100%
5% to 20%	13%	20%	97%
≥ 20%	20%	2%	92%

Equivalent Full Load Hours by Business Type

Building Type	$EFLH_C$ [3]
College	877
Food Sales	749
Food Service	578
Healthcare	803
Hotel/Motel	663
Industrial	519
Office	578
Other	589
Public Assembly	535
Public Services (non-food)	535
Retail	567
School	439
Warehouse	358
Average	**599**

Sources

1. California Energy Commission and California Public Utilities Commission. Database for Energy Efficient Resources (DEER) 2008. http://www.energy.ca.gov/deer/ . DEER model runs weather normalized for statewide use by population density.
2. Energy Center of Wisconsin (Scott Pigg). *Central Air Conditioning in Wisconsin*. ECW Report Number 241-1. 2008.
3. U.S. Department of Energy, Weatherization Center. *Energy OutWest – Weatherization Field Guide.* "3.8 Evaluating Refrigerant Charge." Available online: http://www.waptac.org/data/files/website_docs/training/standardized_curricula/curricula_resources/us%20doe_evaluating%20refrigerant%20charge.pdf.

Revision History

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

Chiller Plant Setpoint Adjustment

	Measure Details
Measure Master ID	EBTU Chiller Plant Chilled Water Setpoint Adjustment, 3659 EBTU Chiller Plant Condenser Water Setpoint Adjustment, 3660
Measure Unit	Per ton
Measure Type	Custom
Measure Group	HVAC
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Commercial, Industrial, Schools & Government
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	Varies by measure
Annual Therm Savings (Therms)	0
Life-cycle Energy Savings (kWh)	Varies by measure
Life-cycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Incremental Cost ($/unit)	$108.00[2]

Measure Description

The intent of this measure is to capture savings associated with adjusting the chilled water setpoint to a higher temperature that is determined to still meet the building cooling load requirement. This involves re-programming the chiller plant controls to optimize chilled water setpoint temperatures for the building based on usage. This measure includes condenser water temperature setpoint adjustments as well.

This measure is not applicable to DX cooling systems. This measure is not applicable to buildings that already use a chilled water reset control strategy or that normally change their chilled water setpoint temperature on a regular basis for control.

The measure can be applied only once per building during the EUL. This measure is meant to be a part of the Express Building Tune-Up Program to help optimize building HVAC systems to operate more efficiently at existing building load conditions. It does not apply to newly constructed facilities that have not been commissioned.

Description of Baseline Condition

The baseline measure is a chiller plant with an opportunity for energy savings from adjusting either the chilled and/or condenser water supply setpoint temperature values of a chiller system up or down a few degrees, respectively. The existing chiller cannot already use a chiller control that varies the chiller and condenser temperatures on a regular basis.

Description of Efficient Condition

This efficient measure is a chiller plant that has undergone a setpoint increase in the chilled water and/or a setpoint decrease in the condenser water loop supply temperatures. The HVAC professional implementing these changes must also verify that any change in setpoint temperature values must still be determined to adequately meet building cooling loads to avoid undoing the setpoint changes at a later date.

Annual Energy-Savings Algorithm

Savings are determined by summing the baseline and proposed energy consumption formulas below across the bin data temperature ranges and corresponding bin temperature hours found in the EBTU workbook.[3,4]

$$kWh_{SAVED} = kWh_{BASELINE} - kWh_{PROPOSED}$$

$$kWh_{BASELINE} = \Sigma\ [(\Delta T_{EXISTING\ CHILLED\ H2O} * 500 * \text{Chiller GPM} * \text{bin hrs} * \text{Chiller\_Eff} * \text{Area Load} / 12{,}000) - (\Delta T_{BASELINE\ LMTD} * 500 * \text{Condenser GPM} * \text{bin hrs} * \text{Chiller\_Eff} * \text{Area Load} / 12{,}000)]$$

$$kWh_{PROPOSED} = \Sigma\ [(\Delta T_{PROPOSED\ CHILLED\ H2O} * 500 * \text{Chiller GPM} * \text{bin hrs} * \text{Chiller\_Eff} * \text{Area Load} / 12{,}000) - (\Delta T_{PROPOSED\ LMTD} * 500 * \text{Condenser GPM} * \text{bin hrs} * \text{Chiller\_Eff} * \text{Area Load} / 12{,}000)]$$

Where:

$\Delta T_{EXISTING\ CHILLED\ H2O}$ = Estimated chilled water return temperature - existing chilled water supply temperature

$\Delta T_{PROPOSED\ CHILLED\ H2O}$ = Estimated chilled water return temperature - proposed chilled water supply temperature

500 = Water sensible heat equation constant

Chiller GPM = (= 2 GPM/ton)[5]

bin hours = Bin hours used in workbook for each respective city[4]

Chiller_Eff = kW/ton partial load rating (= based on chiller type; see table below)

Area Load = Percentage based on linear interpolation of a 60°F dry bulb OAT balance point, bin data dry bulb OAT, and 2.5% dry bulb design summer/winter conditions for different Wisconsin cities[6] (see Assumptions for more explanation of 2.5% dry bulb design conditions)

12,000 = Btu to ton conversion factor

$\Delta T_{\text{BASLINE LMTD}}$ = Logarithmic mean (see equation below)

LMTD = $(\Delta T_A - \Delta T_B) / [\ln (\Delta T_A / \Delta T_B)] = (\Delta T_A - \Delta T_B) / [\ln \Delta T_A - \ln \Delta T_B)]$

Where:

ΔT_A = Existing condenser water supply temperature (= 95°F)[7]

ΔT_B = Existing chilled water return temperature – existing chilled water supply temperature

Condenser GPM = (= 3 GPM/ton for electric chillers)[5]

$\Delta T_{\text{PROPOSED LMTD}}$ = Logarithmic mean (see equation below)

LMTD = $(\Delta T_A - \Delta T_B) / [\ln (\Delta T_A / \Delta T_B)] = (\Delta T_A - \Delta T_B) / [\ln \Delta T_A - \ln \Delta T_B)]$

Where:

ΔT_A = Proposed condenser water supply temperature (=95°F)[7]

ΔT_B = Proposed chilled water return temperature – proposed chilled water supply temperature

Cooling Efficiency Factor by System Type[8]

Cooling System Type	Cooling System Efficiency Factor at Partial Load (kW/ton)
Air-Cooled Chiller	0.95
Water-Cooled Chiller	0.64

The workbook calculator requires the following measure-specific inputs to be provided from the trained professional performing the tune-up/optimization measure:

- Chiller capacity (tons) = AHRI rated capacity (if possible), otherwise = general rated capacity
- Existing and proposed chilled water setpoints
- Existing and proposed condenser water setpoints
- Cooling system type (air-cooled chiller or water-cooled chiller)

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} / Hours_{COOL} * CF$

Where:

$Hours_{COOL}$ = Annual cooling hours of operation (= based on city; see table below)

Annual Cooling Hours by City

City	BIN Annual Cooling Hours (Outside Air Temperature > 60°F)[9]
Green Bay	2,748
La Crosse	2,971
Madison	2,876
Milwaukee	2,830

CF = Coincidence factor (= 1)

Lifecycle Energy-Savings Algorithm

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

Where:

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

Assumptions

- Chilled and condenser water flow rates are assumed to be 2 GPM and 3 GPM per ton, respectively, of cooling system refrigeration capacity.[5]
- 2.5% dry bulb design conditions means that for cooling/heating seasons, the HVAC system is designed to adequately handle the cooling/heating of a given building for all outdoor air temperatures that do not exceed the hottest/coldest 2.5% of hours in the respective season. Explained another way, this is the point where the cooling/heating system can adequately handle the cooling/heating load of a given building for 97.5% of the total anticipated peak cooling/heating hours for the year.

Sources

1. Cadmus. *EUL Response Memo.* April 26, 2013. (Used RCx Program EUL standard and direction from CB&I to keep 5 year EUL standard).
2. RSMeans. *Facilities Construction Cost Data*. 29th Edition. 2013. ($54/hour labor rate for general work performed on water cooled chillers; 2 hours to install based on project experience).
3. Wisconsin Focus on Energy. *EBTU Measures Workbook Calculator.*

4. National Renewable Energy Laboratory. Bin temperature data from respective Wisconsin city TMY3 weather data. Available online: http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html#W
5. Edison Electric Institute. *Technical Information Handbook*. Pg. 23. 2000.
6. ASHRAE Handbook, Fundamentals Volume for Wisconsin Cities. 1985. Available online: http://publicecodes.cyberregs.com/icod/ipc/2012/icod_ipc_2012_appd.htm
7. Edison Electric Institute. *Technical Information Handbook.* Pg. 12. 2000.
8. ASHRAE 90.1-2007. Table 6.8.1C. Simple average of minimum efficiency for chillers with capacity between 0 tons and 300 tons.

Revision History

Version Number	Date	Description of Change
01	09/2013	Initial TRM entry

Cooling System Tune-Up

	Measure Details
Measure Master ID	Chiller System Tune Up, Air Cooled, ≤ 500 Tons, 2666 Chiller System Tune Up, Air Cooled, > 500 Tons, 2667 Chiller System Tune Up, Water Cooled, ≤ 500 Tons, 2668 Chiller System Tune Up, Water Cooled, > 500 Tons, 2669
Measure Unit	Per ton
Measure Type	Prescriptive
Measure Group	HVAC
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by cooling mechanism
Peak Demand Reduction (kW)	Varies by cooling mechanism
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by cooling mechanism
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Incremental Cost	$35.00

Measure Description

This measure is a chiller system tune-up for air and water cooled chillers completed in accordance with the chiller system tune-up checklist.

Tune-up requirements:

- Clean condenser coil/tubes
- Check cooling tower for scale or buildup
- Check contactors condition
- Check evaporator condition
- Check low-pressure controls
- Check high-pressure controls
- Check filter, replace as needed
- Check belt, replace as needed

- Check crankcase heater operation
- Check economizer operation

Measurement requirements:

- Record system pressure psig
- Record compressor amp draw
- Record liquid line temperature in °F
- Record subcooling and superheat temperatures in °F
- Record suction pressure psig and temperature in °F
- Record condenser fan amp draw
- Record supply motor amp draw

Description of Baseline Condition

The baseline is air-cooled and water-cooled chillers that operate at a diminished efficiency from design specifications.

Description of Efficient Condition

The efficient condition is a chiller system tune-up conducted to ensure that equipment is operating at its best and as preventative maintenance to extend the life of the equipment. Tune-ups improve the chiller's efficiency and performance and are useful system checks, as regular maintenance keeps the equipment operating as specified.

Annual Energy-Savings Algorithm

Because the existing chiller efficiency cannot be determined without extensive testing, the ASHRAE 90.1-2007[3] minimum efficiency for chillers is used for the baseline efficiency.

Minimum Efficiencies from ASHRAE 90.1-2007

Equipment Type	Size Category	Minimum Efficiency
Air Cooled, with Condenser	All capacities	2.80 COP; 3.05 IPLV
Air Cooled, without Condenser	All capacities	3.10 COP; 3.45 IPLV
Water Cooled, Electrically Operated, Positive Displacement (Reciprocating)	All capacities	4.2 COP; 5.05 IPLV
Water Cooled, Electrically Operated, Positive Displacement (Rotary Screw and Scroll)	< 150 tons	4.45 COP; 5.20 IPLV
Water Cooled, Electrically Operated, Positive Displacement (Rotary Screw and Scroll)	≥ 150 tons and < 300 tons	4.90 COP; 5.60 IPLV
Water Cooled, Electrically Operated, Positive Displacement (Rotary Screw and Scroll)	≥ 300 tons	5.50 COP; 6.15 IPLV

Water Cooled, Electrically Operated, Centrifugal	< 150 tons	5.00 COP; 5.25 IPLV
Water Cooled, Electrically Operated, Centrifugal	≥ 150 tons and < 300 tons	5.55 COP; 5.90 IPLV
Water Cooled, Electrically Operated, Centrifugal	≥ 300 tons	6.10 COP; 6.40 IPLV

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

Existing Equipment as a Baseline:

$kWh_{SAVED} = (IPLV_{BASLINE\ EXISTING})$ * ton * HOURS * % savings

Where:

$IPLV_{BASLINE\ EXISTING}$ = Integrated part load value of baseline chiller (= 3.05 for air cooled; = 5.85 for water cooled)[3]

ton = Equipment size (= 50, 100, 150 for air cooled; = 100, 200, 300 for water cooled)

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

% savings = Percentage savings associated with a chiller tune-up (= 5%)[2]

Summer Coincident Peak Savings Algorithm

Existing Equipment as a Baseline:

kW_{SAVED} = (Full Load $kW/Ton_{BASELINE\ EXISTING}$ * % savings) * CF * Tons

Where:

Full Load $kW/ton_{BASELINE\ EXISTING}$ = Full load power draw of baseline chiller[3]

CF = Coincidence factor (= 0.80)

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Deemed Savings by Measure Type

	Measure	
	Air Cooled (MMID 2666 if ≤ 500 Tons; MMID 2667 if > 500 Tons)	Water Cooled (MMID 2668 if ≤ 500 Tons; MMID 2669 if > 500 Tons)
Average Annual Deemed Savings (kWh/yr/ton)	83	44
Peak Demand Reduction (kW/ton)	0.0461	0.0242
Average Lifecycle Deemed Savings (kWh/yr/ton)	415	218

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. United States Department of Energy. *Building Technologies Program: Hospitals Benefit by Improving Inefficient Chiller Systems.* White paper. August 2011. The paper found that coil cleaning, the primary savings associated with this cooling tune-up measure, reduces annual cooling energy consumption by 5% to 7%.
3. ASHRAE 90.1-2007 air cooled and water cooled chiller efficiencies. Simple averages were taken from the following sizes (in tons): air cooled 50, 100, 150; water cooled 100, 200, 300. The respective IPLVs were applied: air cooled 3.05, 3.05, 3.05; water cooled 5.25, 5.9, 6.4.

Revision History

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

Economizer Optimization

	Measure Details
Measure Master ID	Economizer Optimization, 3066
Measure Unit	Per ton of refrigeration
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by cooling system type
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Life-cycle Energy Savings (kWh)	Varies by cooling system type
Life-cycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	10[1]
Incremental Cost ($/unit)	$108.00[2]

Measure Description

The intent of this measure is to determine economizer health and capture savings associated with correcting improper operation of or damaged outside air economizer units. The measure can be applied only once per building during the EUL. This measure is meant to be a part of the Express Building Tune-Up Program to help optimize HVAC systems to operate more efficiently at existing building load conditions. It does not apply to newly constructed facilities that have not been commissioned.

Description of Baseline Condition

The baseline measure is an air handling unit with an economizer that is either not in operation or has a limited OAT range of operation that could be expanded.

Description of Efficient Condition

The efficient measure is bringing a non-operational economizer back to at least a baseline value, or adjusting the economizer OAT operating range to be larger than baseline. The efficient condition OAT economizer range should not exceed 55°F to 75°F.

Annual Energy-Savings Algorithm

The following algorithms are based off another measure's workpaper.[3]

Hours iterated for and summed over bin data[4,5] of every hour of the year (from April 1 to September 30) that has an outside air dry-bulb temperature greater than or equal to 55°F (the estimated average balance point of the buildings addressed).

$kWh_{SAVED} = kWh/year_{BASELINE} - kWh/year_{PROPOSED}$

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

$kWh/year_{PROPOSED} = kW_{HOUR\text{-}INTERVAL\text{-}PROPOSED} * 1\ hour$

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

$kW_{OUR\text{-}INTERVAL\text{-}PROPOSED} = CAP * R_{CAP} * (12 / EER) * Econ_{PROP}$

Where:

CAP = Cooling capacity of equipment, in tons (= varies by equipment; actual equipment values should be used)

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

12 = Conversion factor from EER to kW/ton

EER = Energy efficiency ratio of rooftop air handling unit, in Btu/ (W * hour) (= varies by equipment, see table below)

Cooling Efficiency by System Type

Cooling System Type	Cooling System Efficiency Factors (EER)
Direct Expansion	10.43[6]
Air-Cooled Chiller	12.63[7]
Water-Cooled Chiller	18.75[7]

$Econ_{BASE}$ = Binary variable (0 or 1) that indicates whether the economizer is in operation; baseline economizer operation occurs when the OAT range (dry-bulb) is operating between 55°F and 65°F

$Econ_{PROP}$ = Binary variable (0 or 1) that indicates whether the economizer is in operation; proposed economizer operation when the OAT range (dry-bulb) is greater than the baseline of 55°F to 65°F

1 hour = Hour-long time interval

The following information is required to be supplied by the customer/trade ally applying for this measure:

- Type of facility chiller unit and capacity (tons)
- Efficiency of facility chiller unit (EER) when possible, otherwise use a default value based on chiller unit type
- Existing economizer OAT range (°F); when different than 55°F to 65°F, 'none' is also a possibility
- Proposed economizer OAT range (°F)

Summer Coincident Peak Savings Algorithm

There are no peak demand savings because economizers are not expected to operate during peak demand hours (based on typical economizer temperature ranges).

Lifecycle Energy-Savings Algorithm

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

Where:

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

Assumptions

- Economizer modulation (mixing of outside air and inside air to match the setpoint temperature) is not account for in the savings analysis.
- The full capacity of the air conditioning compressor operation is assumed to be a linear function of outside air dry-bulb temperature (0% at 55°F and 90% at 95°F). This assumes correct sizing of the air conditioning unit for each installation, including some extra capacity for cooling beyond 95°F.
- It is assumed that the facility sizes within the EBTU scope will require ≤ 300 tons of cooling.
- The economizer operating time period is assumed to be between April and September, including the peak summer months and some of the shoulder months when facility cooling needs are most expected. Temperature data for these months was pulled from the general TMY3 bin temperature data used for all EBTU measures.[5]

Sources

1. California Energy Commission and California Public Utilities Commission. Database for Energy Efficient Resources (DEER) 2008. http://www.energy.ca.gov/deer/ .
2. RSMeans. Facilities Construction Cost Data. 29th Edition. 2013. Assumed $54/hour labor rate for work performed on air cooling equipment. Estimated 2 hours for completion based on project experience.
3. Wisconsin Focus on Energy. Technical Reference Manual. Pgs. 69-71. 2015. Measure 3066 / Economizer, RTU Optimization.
4. Wisconsin Focus on Energy. EBTU Measures Workbook Calculator.
5. National Renewable Energy Laboratory. TMY3 weather data. Bin temperature data from respective Wisconsin cities. Available online: http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html#W
6. International Energy Conservation Code. Table 503.2.3(1). 2009. DX cooling efficiency values determined from simple average of minimum efficiencies for systems with capacity ≥ 5.5 tons.
7. ASHRAE 90.1-2007. Table 6.8.1C. Chiller unit part load efficiency values determined from simple averages of minimum efficiencies for chiller with capacity of 0 tons to 300 tons.

Revision History

Version Number	Date	Description of Change
01	11/2014	Initial TRM entry

Hot Water Supply Reset

	Measure Details
Measure Master ID	Hot Water Supply Reset, 3662
Measure Unit	Per MBh
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Commercial, Industrial, Schools & Government
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by temperature setpoint
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	Varies by temperature setpoint
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Incremental Cost ($/unit)	$108.00[2]

Measure Description

The intent of this measure is to capture savings by lowering the boiler hot water supply setpoint temperature for the primary heating loop based on actual building load and outdoor air temperature. This measure applies to non-condensing natural gas boilers only. This measure is meant to help optimize HVAC systems to operate more efficiently at existing building load conditions. It does not apply to newly constructed facilities that have not been commissioned.

Description of Baseline Condition

The baseline measure is an eligible building with a boiler hot water heating system that has working controls in place but does not use a hot water reset supply strategy, or has a reset strategy that an HVAC service professional determines can be optimized further.

Description of Efficient Condition

The efficient measure is a trained HVAC service professional determining if a new/change in the hot water supply reset strategy is possible to implement while still safely meeting buildings heating load requirements. The reset strategy should incorporate maximum and minimum water temperatures to correspond with the minimum and maximum outdoor air temperature range, respectively. Savings are calculated based on the particular existing and proposed reset strategy, accounting for boiler capacity. Hot water supply reset control incentives are for existing space heating boilers only. The controls should be set so that the boiler return water is not more than 10°F above the manufacturer's recommended minimum return temperature. The system must have an outdoor air temperature sensor in a shaded location, preferably on the north side of the building.

Annual Energy-Savings Algorithm

Savings are determined by summing the baseline and proposed energy consumption formulas below across the bin data temperature ranges and corresponding bin temperature hours found in the EBTU workbook.[3,4]

$\text{Therm}_{SAVED} = \text{Therms}_{BASELINE} - \text{Therms}_{PROPOSED}$

$\text{Therms}_{BASELINE} = \Sigma\ [500 * \text{GPM} * (\text{HW Supply Temp}_{BASE} - \text{HW Return Temp}) * \text{Area Load} / 100{,}000 / \text{boiler eff} * \text{Bin Hours}]$

$\text{Therms}_{PROPOSED} = \Sigma\ [500 * \text{GPM} * (\text{HW Supply Temp}_{PROP} - \text{HW Return Temp}) * \text{Area Load} / 100{,}000 / \text{boiler eff} * \text{Bin Hours}]$

Where:

500 = Water sensible heat formula constant[5]

GPM = Average gallons per minute of heating water during heating season (= user defined)

$\text{HW Supply Temp}_{BASE}$ = Existing hot water maximum supply temperature in °F (= user defined)

$\text{HW Supply Temp}_{PROP}$ = Proposed hot water reset curve temperature in °F (= user defined)

HW Return Temp = Hot water return temperature (= estimated based on OAT and hottest water supply temperature in the system; return temperature schedule is a constant between baseline and proposed used to model heat loss reduction

Area Load = Percentage of area load based on linear interpolation of a 60°F dry bulb OAT balance point, bin data dry bulb OAT, and 2.5% dry bulb design summer/winter conditions for different Wisconsin cities;[6] see Assumptions for more explanation of 2.5% dry bulb design conditions

100,000 = Conversion from Btu to therm

boiler eff = Efficiency of natural gas to heat conversion for heating purposes (= 80%)

Bin Hours = Dry-bulb temperature and time of day (also known as temperature bin data) (= based on statewide BIN weather data)[4]

The workbook calculator requires the following measure-specific inputs provided from the trained professional performing the tune-up/optimization measure:

- Actual average heating water supply loop flow rate (GPM) if known, or at ΔT=20°F conditions (can be listed or calculated based on boiler output rating)
- Boiler input MBh and efficiency rating (used for incentive calculation purposes)
- Existing constant hot water setpoint temperature
- Existing OAT hot water reset range along with corresponding maximum and minimum setpoints (°F; if prior reset strategy was in place)
- New OAT hot water reset range along with corresponding maximum and minimum setpoints (°F)

Summer Coincident Peak Savings Algorithm

There are no peak demand savings for this measure.

Lifecycle Energy-Savings Algorithm

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

Where:

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

Assumptions

- Return water temperature schedule is assumed to be at ΔT=30°F for the coldest OAT and at ΔT=10°F for the warmest OAT compared to the existing hot water heating setpoint.[5]
- Assumed that the return water temperature schedule across the OAT range will stay the same between existing and hot water reset schedule to model the reduction of heat losses and subsequent energy savings.
- Assumed a constant GPM flow rate (should be based on the heating season average GPM if possible, or the rated boiler flow rate when boiler is at ΔT=20°F operation).
- Assumed that the hot water setpoint at minimum OAT range will be greater than or equal to the existing hot water setpoint constant.

- If hot water reset temperatures at higher OAT dip below the constant estimated for return water scheduled temperatures, then the hot water reset supply temperature will equal the calculated return temperature (since it effectively shuts off the boiler).
- Assumed that boiler operation occurs only during periods when OAT < 60°F.
- Assumed that the HVAC service professional making adjustment ensures that boiler return water will stay above the boiler minimum.
- 2.5% dry bulb design conditions means that for cooling/heating seasons, the HVAC system is designed to adequately handle the building cooling/heating for all outdoor air temperatures that do not exceed the hottest/coldest 2.5% of hours of the respective season. Explained another way, this means that the cooling/heating system can adequately handle the cooling/heating load of a given building for 97.5% of the total anticipated peak cooling/heating hours for the year.

Sources

1. Cadmus. *EUL Response Memo.* April 26, 2013. Used the RCx Program EUL standard and direction from CB&I to keep 5 year EUL standard).
2. RSMeans. *Facilities Construction Cost Data.* 29th Edition. 2013. (Assumed $54/hour labor rate for work performed on natural gas boilers; estimated 2 hours for completion of this measure based on project experience).
3. Wisconsin Focus on Energy. EBTU Measures Workbook Calculator.
4. Natural Renewable Energy Laboratory. Bin temperature data comes from respective Wisconsin cities TMY3 weather data. Available online: http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html#W
5. Edison Electric Institute. *Technical Information Handbook*. Pg. 24. 2000.
6. ASHRAE. *Handbook, Fundamentals Volume for Wisconsin Cities*. 1985. Available online: http://publicecodes.cyberregs.com/icod/ipc/2012/icod_ipc_2012_appd.htm

Revision History

Version Number	Date	Description of Change
01	08/10/2015	Initial TRM entry

Outside Air Intake Control Optimization

	Measure Details
Measure Master ID	Outside Air Intake Control Optimization, 3663
Measure Unit	Per CFM reduced
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Commercial, Industrial, Schools & Government
Annual Energy Savings (kWh)	Varies by baseline and proposed energy consumption
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by baseline and proposed energy consumption
Life-cycle Energy Savings (kWh)	Varies by baseline and proposed energy consumption
Life-cycle Therm Savings (Therms)	Varies by baseline and proposed energy consumption
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Incremental Cost ($/unit)	$212.00[2]

Measure Description

The intent of this measure is to capture savings associated with reducing outside air (OA) supply CFM to a minimum. The outside air intake levels should always conform to local codes and ASHRAE 62.1 standards. This measure applies to buildings that currently do not use a variable outside air intake control strategy. Measure can be applied only once per building during the EUL. This measure is meant to be a part of the Express Building Tune-Up Program to help optimize building HVAC systems to operate more efficiently at existing building load conditions. It does not apply to newly constructed facilities that have not been commissioned.

Description of Baseline Condition

The baseline measure is an eligible building that a qualified HVAC control professional has verified can save energy by reducing the outside air intake CFM compared to existing levels. The building must currently exceed the minimum outside air intake levels for standard occupancy as defined by local or state requirements.

Description of Efficient Condition

The efficient measure is having a trained HVAC professional determine an appropriate adjustment to the outside air intake levels that conforms to all applicable building codes but is reduced and will still meet the buildings requirements for proper ventilation. Measure rebates do not apply if the outside air CFM needs to increase.

Annual Energy-Savings Algorithm

Savings are determined by summing the baseline and proposed energy consumption formulas below across the bin data temperature ranges and corresponding bin temperature hours found in the EBTU workbook.[3,4]

$\text{kWh}_{\text{SAVED}} = (\text{Btu}_{\text{BASELINE}} - \text{Btu}_{\text{PROPOSED}}) / 12{,}000 * \text{Chiller\_Eff} + (\text{Fan Energy}_{\text{BASE}} - \text{Fan Energy}_{\text{PROP}})$

$\text{Therm}_{\text{SAVED}} = (\text{Btu}_{\text{BASELINE}} - \text{Btu}_{\text{PROPOSED}}) / 100{,}000 / \text{Gas Eff}$

$\text{Btu}_{\text{BASELINE}} = \Sigma\ (1.08 * \text{OA existing supply CFM} * |\text{ST} - \text{OAT}| * \text{Bin Hours})$

$\text{Btu}_{\text{PROPOSED}} = \Sigma\ (1.08 * \text{OA proposed supply CFM} * |\text{ST} - \text{OAT}| * \text{Bin Hours})$

$\text{Fan Energy}_{\text{BASE}} = \text{Supply Fan HP} * 0.7465 * \text{Load Factor} / \text{Fan motor Efficiency} * \text{annual hours of fan operation}$

$\text{Fan Energy}_{\text{PROP}} = \text{Supply Fan HP} * (\text{OA proposed supply CFM} / \text{OA existing supply CFM})\ \hat{}\ 2.5 * 0.7465 * \text{Load Factor} / \text{Fan motor Efficiency} * \text{annual hours of fan operation}$

Where:

1.08 = Constant for air sensible heat equation[5]

OA existing supply CFM = Actual outside air supply airflow (= based on user input)

ST = Building setpoint temperature (= 70°F for OAT > 60°F = 75°F for OAT < 60°F)

OAT = Outside air temperature (= determined by Wisconsin BIN data in EBTU workbook)[4]

Bin Hours = Dry-bulb temperature and time of day (also known as temperature bin data)

OA proposed supply CFM = Proposed air supply airflow (= based on user input) (= based on user input)

12,000 = Conversion factor from Btu to tons

Chiller_Eff = Kilowatts per ton (= varies by chiller type based on 80% of full load rating (= see table below)

Cooling Efficiency by System Type

Cooling System Type	Cooling System Efficiency Factor at Partial Load (kW/ton)
Direct Expansion	1.15[6]
Air-Cooled Chiller	0.95[7]
Water-Cooled Chiller	0.64[7]

Supply Fan HP = Horsepower of supply fan (= based on user input)

0.7465 = Conversion from horsepower to kW

Load Factor = Ratio of average demand to maximum demand (= 80%)

Fan motor efficiency = Ratio between power transferred to the airflow and the power used by the fan (= actual motor nameplate rating)

Annual hours of fan operation = Hours in use (= based on user input)

2.5 = Fan affinity law

100,000 = Conversion from Btu to therm

Gas Eff = Efficency of gas unit (= 80%)

The workbook calculator requires the following measure-specific inputs to be provided from the trained professional performing the tune-up/optimization measure:

- Existing outside air intake volume in CFM
- Modified outside air intake volume in CFM (must still meet code minimum for carbon dioxide level control)
- Air supply fan size (hp)
- Number of hours outside air supply fan runs annually

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} / Hours_{COOL} * CF$

Where:

$Hours_{COOL}$ = Annual cooling hours of operation (= based on city; see table below)

Annual Cooling Hours by City[8]

City	BIN Annual Cooling Hours (OAT > 60°F)
Green Bay	2,748
La Crosse	2,971
Madison	2,876
Milwaukee	2,830

CF = Coincidence factor (= 1 assuming that the reduction of outside air intake CFM will be constant over entire summer peak period)

Lifecycle Energy-Savings Algorithm

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

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

Where:

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

Assumptions

- Partial load kW/ton rating for DX, air cooled, and water cooled chillers is the average of the IEER and IPLV minimum efficiency values.[6,7]
- Assumed use of 1 CFM of total supply air per square foot of conditioned building space.
- Assumed heating and cooling balance temperature of 60°F

Sources

1. Cadmus. *EUL Response Memo*. April 26, 2013. Used the RCx Program EUL standard and direction from CB&I to keep 5 year EUL standard.
2. RSMeans. Facilities Construction Cost Data. 29th Edition. 2013. Assumed $56/hour labor rate for work performed on HVAC control systems; estimated 2 hours for completion of this measure based on project experience; estimated engineer design time at $100/hour for 1 hour.
3. Wisconsin Focus on Energy. EBTU Measures Workbook Calculator.
4. Natural Renewable Energy Laboratory. Bin temperature data from respective Wisconsin City TMY3 weather data. Available online: http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html#W
5. Edison Electric Institute. Technical Information Handbook. Pg. 24. 2000.

6. International Energy Conservation Code. Table 503.2.3(1). 2009. DX cooling efficiency values determined from simple average of minimum efficiencies for systems with ≥ 5.5 ton capacity.
7. ASHRAE 90.1-2007, Table 6.8.1C. Chiller unit part load efficiency values determined from simple average of minimum efficiencies for chillers with capacity 0 tons to 300 tons.
8. Wisconsin Focus on Energy. Technical Reference Manual. Pg. 389, Outside Air Temperature Bin Analysis. January 2015.

Revision History

Version Number	Date	Description of Change
01	11/2014	Initial TRM entry

Retrocommissioning, Express Building Tune-Up

	Measure Details
Measure Master ID	Retrocommissioning, Express Building Tune-Up, 3224
Measure Unit	Per project
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by project
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by project
Lifecycle Energy Savings (kWh)	Varies by project
Lifecycle Therm Savings (Therms)	Varies by project
Water Savings (gal/yr)	0
Effective Useful Life (years)	5 [1]
Incremental Cost ($/unit)	Varies by project [2]

Measure Description

The Retrocommissioning Lite Program is an expansion to the Retrocommissioning Program, making retrocommissioning services available to customers without complex systems or large buildings that operate at a high cost per square foot. In addition, the program is focused on addressing deficiencies in mechanical and electrical systems to reduce energy consumption and operating costs while minimizing the out-of-pocket cost to the customer.

Mechanical issues that cause energy waste are frequently found in the targeted market segment. For example, motors are put in hand mode, broken damper actuators go unnoticed, and schedules set for the holiday shopping season are not set back to the current time of year. In most cases, targeted customers do not have a qualified facility manager onsite to identify the reason for increased energy consumption, and often lack awareness of the benefits associated with retrocommissioning services. In addition, they often have neither the resources nor the sufficient complexity to warrant a comprehensive audit. Because customers in the target demographic often cannot afford advanced energy efficiency services, these services are not invest marketed to them. This program raises awareness and offers package incentives for targeted customers to implement a highly focused set of low-cost measures.

Typical Details of Retrocommissioning Project

Measure	Peak Electric	Electric	Natural Gas	Incremental	Effective

Description	Demand Reduction (kW/Unit)	Savings (kWh/Unit)	Savings (therms)	Measure Cost ($/unit)	Useful Life (years)
Retrocommissioning Express Building Tune-Up: Typical Project Summary	0	37,500	1,875	$4,000.00	5

Description of Baseline Condition

The baseline condition is maintaining the current operations of the facility. This condition is documented during the comprehensive facility audit as a required pre-requisite to program participation.

Description of Efficient Condition

The efficient condition is implementing all, or part, of the recommended measures identified through the comprehensive facility audit mechanism. The savings for the efficiency improvements will be determined for each individual measure (e.g., setpoint adjustments, sensor calibrations) within the given facilities. Then, upon final implementation of the measures, the total energy savings through the efficiency improvements will be provided at the project level.

Annual Energy-Savings Algorithm

Annual energy savings methodologies will be used within the individual measure workbooks (or end use workbooks) to calculate the potential savings within a given facility. These savings will be provided at the project level upon implementation of the prescribed efficiency improvements.

Summer Coincident Peak Savings Algorithm

No peak demand savings have been identified for this offering.

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 5 years)

Assumptions

The energy savings associated with the Retrocommissioning Lite Program will be determined through engineered workbooks that account for specific facility inputs, along with industry accepted standards and methodologies. The project savings will predominantly be achieved through optimizing four different measure end-use categories within the facility: Air-Side, Water-Side, Chiller Plant, and Lighting.

Annual energy savings are determined through engineering workbooks for both electric (gross kWh) and natural gas savings (gross therms).

The measure workbooks use assumptions based on accepted engineering methodologies, industry codes, and standards.

Sources

1. RCx Lite End Measure and End Use Engineering Summary. April 24, 2013.
2. The measure incremental cost is the measure installed cost, and varies based on facilities, opportunities, and implementation of the individual identified measures. For each project, the final installed cost of the combined efficiency improvements will be used for determining potential incentive caps through the fulfillment process.

Revision History

Version Number	Date	Description of Change
01	04/26/2013	Initial TRM entry

Schedule Optimization

	Measure Details
Measure Master ID	Schedule Optimization: Weekday: Heating, 0-50,000 square feet, 3664 Cooling, 0-50,000 square feet, 3665 Heating, 50,000-100,000 square feet, 3668 Cooling, 50,000-100,000 square feet, 3669 Weekend: Heating, 0-50,000 square feet, 3666 Cooling, 0-50,000 square feet, 3667 Heating, 50,000-100,000 square feet, 3670 Cooling, 50,000-100,000 square feet, 3671
Measure Unit	Per hour reduction
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Commercial, Industrial, Schools & Government
Annual Energy Savings (kWh)	Varies by type of schedule optimization
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by type of schedule optimization
Lifecycle Energy Savings (kWh)	Varies by type of schedule optimization
Lifecycle Therm Savings (Therms)	Varies by type of schedule optimization
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Measure Incremental Cost ($/unit)	$168.00[2]

Measure Description

This measure captures savings associated with resetting the scheduled weekly building nighttime (or unoccupied) supply air setpoint temperatures via programmable thermostats or direct digital control (DDC) systems. This is a simple temperature setback measure and not a temperature reset control strategy.

For this measures' savings to apply, the heating supply fuel must be natural gas, and cooling must be supplied by an electrically powered system. The measure can be applied only once per building during the EUL. This measure is meant to be a part of the Express Building Tune-Up Program to help optimize buildings HVAC systems to operate more efficiently at existing building load conditions. It does not apply to newly constructed facilities that have not been commissioned.

Description of Baseline Condition

The baseline measure is a building that already has an HVAC system not using its hourly setback scheduling or a building that can increase its scheduled setback hours. Building must have a consistent weekly operation schedule throughout the year. A buildings standard heating and cooling schedule are both eligible for adjustment.

Description of Efficient Condition

This efficient measure is an increased number of scheduled setback hours controlled through a building programmable HVAC system. A buildings' standard daily scheduled setback time must be increased by at least 1 hour during the weekdays or weekends to be eligible for an incentive.

Annual Energy-Savings Algorithm

Savings are the sum of the baseline and proposed energy consumption formulas below across the bin data temperature ranges and corresponding bin temperature hours.[3,4]

Energy savings are effectively summed over every hour of the year, effectively assuming that the same hour of the day (e.g., 1:00 a.m. to 2:00 a.m.) for each day in a given month will yield the same Btu/hour of energy use.

$kWh_{SAVED} = kWh_{BASELINE} - kWh_{PROPOSED}$

$Therm_{SAVED} = Therm_{BASELINE} - Therm_{PROPOSED}$

$kWh_{BASELINE} = \Sigma_{EXISTING}$ (1.08 * Hourly CFM * |SAT – MAT| * # of days per month / 12,000 * chiller_eff)

$Therm_{BASELINE} = \Sigma_{EXISTING}$ (1.08 * Hourly CFM * |SAT - MAT| * # of days per month / 100,000 / boiler_eff)

Baseline data is based on user-defined existing building schedule.

$kWh_{PROPOSED} = \Sigma_{PROPOSED}$ (1.08 * Hourly CFM * |SAT - MAT| * # of days per month / 12,000 * chiller_eff)

$Therm_{PROPOSED} = \Sigma_{PROPOSED}$ (1.08 * Hourly CFM * |SAT - MAT| * # of days per month / 100,000 / boiler_eff)

Proposed data is based on user-defined proposed building schedule, and should reflect a reduction of HVAC/occupied hours compared to baseline.

Where:

1.08 = Constant for air sensible heat equation[5]

Hourly CFM = Total building airflow in CFM * hourly area load (where the area load is a percentage value based on a linear interpolation of a 60°F dry bulb OAT balance point, bin data dry bulb OAT, and 2.5% dry bulb design summer/winter conditions for different Wisconsin cities.[6] See the Assumptions section for more explanation about the 2.5% dry bulb design conditions)

SAT = Supply air temperature for occupied hours (= 60°F for OAT > 60°F, 75°F for OAT ≤ 60°F); for scheduled unoccupied temperature setback hours, SAT = standard occupied hour temperature setting ± user-defined setback temperature for cooling and heating periods, respectively

MAT = (RAT * Return Air CFM + Weighted Average Hourly Temperature * Outside Air CFM) / Total Airflow CFM

Where:

RAT = Return air temperature (75°F for OAT > 60°F, 68°F for OAT ≤ 60°F)

Return Air CFM = Total airflow CFM - Outside Air CFM

Weighted Average Hourly Temperature = Calculated based on the maximum and minimum temperatures over every given hour of the day and number of occurrences per month based on bin data[3]

Outside Air CFM = Amount of outside air expected based on facility type and square footage as determined through CBECS statistical data inserted in the EBTU workbook[7,3]

Total Airflow CFM = 1 CFM per square foot of facility space

# of days per month = Variable by month (= 31 in January; = 28 in February; etc.)

12,000 = Btu to ton conversion factor

chiller_eff = Varies based on chiller type; see table below

Cooling Efficiency by System Type

Cooling System Type	Cooling System Efficiency Factor at Partial Load Rating (kW/ton)
Direct Expansion	1.15[8]
Air-Cooled Chiller	0.95[9]
Water-Cooled Chiller	0.64[9]

100,000 = Btu to therm conversion factor

boiler_eff = Efficiency of natural gas to heat conversion for heating purposes (= 80%)

The workbook calculator requires the following inputs to be provided from the trained professional performing the tune-up/optimization measure:

- Majority facility space type (e.g., offices, classroom, lobby, health club)
- Square footage of facility’s conditioned space affected by schedule change
- Baseline (pre) and efficient (post) heating and cooling schedule hours, indicating when the system turns on and off during a typical weekday and weekend in 24 hour time format
- Amount of planned temperature setback degrees during scheduled unoccupied times
- Type of facility cooling system (direct expansion, air cooled, or water cooled)

Summer Coincident Peak Savings Algorithm

There are no peak savings for this measure, as the temperature setback scheduling is not expected to occur during Wisconsin Focus on Energy peak demand hours of 1:00 p.m. to 4:00 p.m. from June through August.

Lifecycle Energy-Savings Algorithm

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

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

Where:

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

Assumptions

- RAT fixed values of (75°F for OAT > 60°F, 68°F for OAT < 60°F) for calculation purposes
- SAT setpoints are increased or decreased by 5°F during weekly scheduled unoccupied hours during cooling and heating periods, respectively
- Heating and cooling balance temperature of 60°F

- Therm savings are calculated when daily weighted hourly temperatures are less than 60°F
- kWh savings are calculated when daily weighted hourly temperatures are greater than 60°F
- Same average weekly hours schedule is repeated throughout the year
- Total supply is 1 CFM per building square foot
- 2.5% dry bulb design conditions for cooling/heating seasons means that the HVAC system is designed to adequately handle the cooling/heating of a given building for all outdoor air temperatures that do not exceed the hottest/coldest 2.5% of hours of the respective season. Explained put another way, it means the cooling/heating system can adequately handle the cooling/heating load of a given building for 97.5% of the total anticipated peak cooling/heating hours for the year.

Sources

1. Cadmus. *EUL Response Memo*. April 26, 2013. (Used RCx Program EUL standard and direction from CB&I to keep 5 year EUL standard)
2. RSMeans. Facilities Construction Cost Data. 29th Edition. 2013. ($56/hour labor rate for work performed on HVAC control systems). Estimated 3 hours for completion based on project experience.
3. Wisconsin Focus on Energy. EBTU Measures Workbook Calculator.
4. National Renewable Energy Laboratory. Bin temperature data comes from respective Wisconsin cities TMY3 weather data. Available online: http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html#W
5. Edison Electric Institute. Technical Information Handbook. Pg. 24. 2000.
6. ASHRAE Handbook, Fundamentals Volume for Wisconsin Cities. 1985. Available online: http://publicecodes.cyberregs.com/icod/ipc/2012/icod_ipc_2012_appd.htm
7. U.S. Energy Information Administration. “2003 CBECS Survey Data.” http://www.eia.gov/consumption/commercial/data/2003/
8. International Energy Conservation Code. Table 503.2.3(1). 2009. (Direct expansion cooling efficiency values determined as simple averages of minimum efficiencies for system capacities of ≥ 5.5 tons).
9. ASHRAE 90.1-2007, Table 6.8.1C. (Chiller unit part load efficiency values determined as simple averages of minimum efficiencies, for chillers with capacity of 0 tons to 300 tons).

Revision History

Version Number	Date	Description of Change
01	11/2014	Initial TRM entry

Supply Air Temperature Reset

	Measure Details
Measure Master ID	Supply Air Temperature Reset, Heating, 3672 Supply Air Temperature Reset, Cooling, 3673
Measure Unit	Per degree Fahrenheit
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Commercial, Industrial, Schools & Government
Annual Energy Savings (kWh)	Varies by type of reset
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by type of reset
Lifecycle Energy Savings (kWh)	Varies by type of reset
Lifecycle Therm Savings (Therms)	Varies by type of reset
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Incremental Cost ($/unit)	$96.00[2]

Measure Description

This measure captures savings associated with implementing a new supply air temperature (SAT), cooling or heating, reset strategy or optimizing a programmed SAT reset strategy based on OAT ranges. To claim the measure savings, the heating must be supplied by a natural gas boiler, and the cooling system must be electrically powered. The savings apply specifically to constant air volume (CAV) systems.

This measure is meant to be a part of the Express Building Tune-Up Program to help optimize building HVAC systems to operate more efficiently at existing building load conditions. It does not apply to newly constructed facilities that have not been commissioned.

Description of Baseline Condition

This baseline measure is an HVAC system with preset SAT setpoints that are not based on OAT.

Description of Efficient Condition

This efficient measure is implementing or optimizing an SAT reset strategy based on OAT. The reset strategy should incorporate a maximum and minimum supply air temperature for both heating and cooling modes to correspond with a minimum and maximum outdoor air temperature range, respectively.

Annual Energy-Savings Algorithm

Savings are the sum of the baseline and proposed energy consumption formulas below across the bin data temperature ranges and corresponding bin temperature hours.[3,4]

$\text{kWh}_{\text{SAVED}}$ = Σ (SAT Btu Baseline – SAT Btu Proposed) / 12,000 * chiller_eff * % building affected

$\text{Therm}_{\text{SAVED}}$ = Σ (SAT Btu Baseline – SAT Btu Proposed) / 100,000 / boiler_eff * % building affected

SAT Btu Baseline = [(1.08 * Area_Load * $|\text{SAT}_{\text{BASE}}$ - OAT$|$ * Outside Air CFM + 1.08 * Area_Load * $|\text{SAT}_{\text{BASE}}$ - RAT$|$ * Return Air CFM] * bin hours

SAT Btu Proposed = [(1.08 * Area_Load * $|\text{SAT}_{\text{RESET}}$ - OAT$|$ * Outside Air CFM + 1.08 * Area_Load * $|\text{SAT}_{\text{RESET}}$ - RAT$|$ * Return Air CFM] * bin hours

Where:

1.08 = Constant for air sensible heat equation[5]

Area Load = Percentage value based on linear interpolation of a 60°F dry bulb OAT balance point, bin data dry bulb OAT, and 2.5% dry bulb design summer/winter conditions for different Wisconsin cities[6] (see Assumptions for more explanation about the 2.5% dry bulb design conditions)

SAT_{BASE} = Supply air temperature baseline (= user defined input; constant)

OAT = Outside Air Temperature (= determined from workbook bin data)

Outside Air CFM = Amount of outside air expected based on facility type and square footage as determined through CBECS statistical data inserted in the EBTU workbook[7,3]

RAT = Return air temperature (= 75°F for OAT > 60°F; = 68°F for OAT < 60°F)

Return Air CFM = Total building airflow – Outside Air CFM

bin hours = Heating and cooling hours for each city based on OAT[4]

$\text{SAT}_{\text{RESET}}$ = OAT reset range (= user input)

12,000 = Btu to ton conversion factor

chiller_eff = Varies by chiller type (= see table below)

Cooling Efficiency by System Type

Cooling System Type	Cooling System Efficiency Factor at Partial Load (kW/ton)
Direct Expansion	1.15[8]
Air-Cooled Chiller	0.95[9]
Water-Cooled Chiller	0.64[9]

% building affected = Amount of total building conditioned square footage affected by implementing the SAT reset control (= user defined input)

100,000 = Btu to therm conversion factor

boiler_eff = Efficiency of natural gas to heat conversion for heating purposes (= 80%)

The workbook calculator requires the following measure-specific inputs to be provided from the trained professional performing the tune-up/optimization measure:

- OAT Reset Range – Heating and Cooling (°F)
- Existing Facility Supply Air Heating and Cooling Temperature Setpoints (°F)
- SA Reset Temperature Range – Heating and Cooling (°F)
- Facility Type (e.g., office, library, retail)
- Useable Facility Square Footage
- Percentage of Total Facility Area Cooled
- Percentage of Total Facility Area Heated
- Number of Building Zones Affected
- Type of Chiller System
- Percentage of Building Square Footage Affected

Summer Coincident Peak Savings Algorithm

There are no peak demand savings because during peak demand times, the cooling system will be operating above the bounds of the SAT reset curve.

Lifecycle Energy-Savings Algorithm

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

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

Where:

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

Assumptions

- Partial load kW/ton rating for air cooled and water cooled chillers is average IPLV minimum efficiency value found in Focus on Energy HVAC catalog[9]
- Total supply of 1 CFM per building conditioned square foot
- Heating and cooling balance temperature = 60°F
- 2.5% dry bulb design conditions means that for cooling/heating seasons, the HVAC system is designed to adequately handle the cooling/heating of a given building for all outdoor air temperatures that do not exceed the hottest/coldest 2.5% of hours of the respective season. Explained another way, this means the cooling/heating system can adequately handle the cooling/heating load of a given building for 97.5% of the total anticipated peak cooling/heating hours for the year.

Sources

1. Cadmus. *EUL Response Memo*. April 26, 2013.(Used RCx Program EUL standard and direction from CB&I to keep 5 year EUL standard)
2. RSMeans. Facilities Construction Cost Data. 29th Edition. 2013. ($48/hour labor rate for work on CAV terminal units; estimated 2 hours for completion based on project experience).
3. Wisconsin Focus on Energy. EBTU Measures Workbook Calculator.
4. National Renewable Energy Laboratory. Bin temperature data from respective Wisconsin cities TMY3 weather data. Available online: http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html#W
5. Edison Electric Institute. Technical Information Handbook. Pg. 24. 2000.
6. ASHRAE. Handbook, Fundamentals Volume for Wisconsin Cities. 1985. Available online: http://publicecodes.cyberregs.com/icod/ipc/2012/icod_ipc_2012_appd.htm
7. U.S. Energy Information Administration. National CBECS Statistical Data. 2003. Available online: http://www.eia.gov/consumption/commercial/data/2003/
8. International Energy Conservation Code. Table 503.2.3(1). 2009. DX cooling efficiency values determined as simple average minimum efficiencies for systems with capacity ≥ 5.5 tons.
9. ASHRAE 90.1-2007. Table 6.8.1C. Chiller unit part load efficiency values are simple average minimum efficiencies for chillers with capacity of 0 tons to 300 tons.

Revision History

Version Number	Date	Description of Change
01	11/2014	Initial TRM entry

Temperature Sensor Calibration

	Measure Details
Measure Master ID	Temperature Sensor Calibration, 3674
Measure Unit	Per degree of calibration
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Commercial, Industrial, Schools & Government
Annual Energy Savings (kWh)	Varies by temperature ranges and hours
Peak Demand Reduction (kW)	Varies by temperature ranges and hours
Annual Therm Savings (Therms)	Varies by temperature ranges and hours
Lifecycle Energy Savings (kWh)	Varies by temperature ranges and hours
Lifecycle Therm Savings (Therms)	Varies by temperature ranges and hours
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Incremental Cost ($/unit)	$108.00[2]

Measure Description

This measure captures savings by calibrating temperature sensors in an air handling unit feeding a particular building zone. The measure savings are specific to air distribution systems, but are otherwise flexible. This measure does not include the cost to replace sensors that have completely failed.

To apply measure savings, the heating supply must be produced by a natural gas boiler, while the cooling system must be electrically powered. The measure can be applied only once per building during the EUL. This measure is meant to be a part of the Express Building Tune-Up Program to help optimize building HVAC systems to operate more efficiently at existing building load conditions. It does not apply to newly constructed facilities that have not been commissioned.

This measure is applicable for supply air temperature (SAT) and indoor air room temperature (IAT) sensors that are measuring and providing control feedback to the building HVAC systems.

Description of Baseline Condition

The baseline measure is a facility's SAT and IAT sensors not having been calibrated and no Wisconsin Focus on Energy rebate applied for at least five years.

Description of Efficient Condition

The efficient measure is to re-calibrate SAT and IAT sensors by averaging three separate temperature readings with a secondary calibrated temperature device within close proximity of the sensor to be calibrated. This will determine the amount the facility temperature sensors are off from actual in order to make the necessary calibrations. The recalibrated sensors will help ensure that excess energy is not being wasted to heat or cool a space. Broken sensors that need total replacement are not eligible. Calibrated sensors should be adjusted to within two decimal places.

Annual Energy-Savings Algorithm

Savings are the sum of the baseline and proposed energy consumption formulas below across the bin data temperature ranges and corresponding bin temperature hours found in the EBTU workbook.[3,4]

kWh_{SAVED} = Σ (Temp Sensor cooling Btu Baseline – Temp Sensor cooling Btu Proposed) / 12,000 * chiller_eff * % building affected * bin hours

$Therm_{SAVED}$ = Σ (Temp Sensor heating Btu Baseline – Temp Sensor heating Btu Proposed) / 80% / 100,000 * % building affected * bin hours

Temp Sensor cooling/heating Btu Baseline = 1.08 * $Area\_Load_{BASE}$ * |SAT - OAT| * Outside Air CFM + 1.08 * $Area\_Load_{BASE}$ * Δ(SAT - RAT) * Return Air CFM

Temp Sensor cooling/heating Btu Proposed = 1.08 * $Area\_Load_{PROP}$ * |SAT - OAT| * Outside Air CFM + 1.08 * $Area\_Load_{PROP}$ * Δ(SAT - RAT) * Return Air CFM

Where:

1.08 = Constant for air sensible heat equation[5]

$Area\_Load_{BASE}$ = Percentage value based on linear interpolation of a 60°F dry bulb OAT balance point, bin data dry bulb OAT, and 2.5% dry bulb design summer/winter conditions for different Wisconsin cities[6] (see Assumptions for more explanation about the 2.5% dry bulb design conditions)

SAT = Supply air temperature (= 60°F for OAT > 60°F; = 75°F for OAT < 60°F)

OAT = Outside air temperature

Outside Air CFM = Amount of outside air expected based on facility type and square footage as determined through CBECS statistical data inserted in the EBTU workbook[7,3]

RAT = Return air temperature (= 75°F for OAT > 60°F; = 68°F for OAT < 60°F)

Return Air CFM = Total building airflow – Outside Air CFM (per zone)

$Area\_Load_{PROP}$ = Percentage value based on linear interpolation of a 60°F dry bulb OAT balance point, bin data dry bulb OAT ± calibrated values, and 2.5%

dry bulb design maximum/minimum temperatures for different Wisconsin cities[6]

12,000 = Btu to ton conversion factor

chiller_eff = kW/ton based on 80% of full load rating of chiller units (= based on type of chiller; see table below),

Cooling Efficiency by System Type

Cooling System Type	Cooling System Efficiency Factor at Partial Load (kW/ton)
Direct Expansion	1.15[8]
Air-Cooled Chiller	0.95[9]
Water-Cooled Chiller	0.64[9]

% building affected = Amount of total building square footage affected by sensor calibration (= user defined)

bin hours = Heating and cooling hours for each city based on OAT[4]

80% = Efficiency of natural gas to heat conversion for heating purposes

100,000 = Btu to therm conversion factor

The workbook calculator requires the following measure-specific inputs to be provided from the trained professional performing the tune-up/optimization measure:

- An average of three separate measurement reading of the un-calibrated air handling unit temperature sensor to determine the current baseline reading (measurements should be out two decimal places)
- An average of three separate temperature readings of the calibrated air flowing near the un-calibrated temperature sensor, used to read and calibrate the un-calibrated sensor (measurements should be out two decimal places)
- Majority facility space type (e.g., offices, classroom, lobby, health club)
- Percentage of facility being heated
- Percentage of facility being cooled
- Square footage of usable facility space
- Chiller system type (direct expansion, air cooled, or water cooled)

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} / Hours_{COOL} * CF$

Where:

$Hours_{COOL}$ = Annual cooling hours of operation (= based on city; see table below)

Annual Cooling Hours by City

City	BIN Annual Cooling Hours (OAT > 60°F)[10]
Green Bay	2,745
La Crosse	2,971
Madison	2,874
Milwaukee	2,830

CF = Coincidence factor (= 1)

Lifecycle Energy-Savings Algorithm

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

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

Where:

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

Assumptions

- Therm savings are calculated only when the calibrated reading is greater than the original sensors reading
- kWh savings are calculated only when the calibrated reading is less than the original sensor reading
- Heating and cooling balance temperature = 60°F
- Total supply of 1 CFM per building square foot
- 2.5% dry bulb design conditions means that for cooling/heating seasons, the HVAC system is designed to adequately handle the cooling/heating of a given building for all outdoor air temperatures that do not exceed the hottest/coldest 2.5% of hours of the respective season. Explained another way, this means the cooling/heating system can adequately handle the cooling/heating load of a given building for 97.5% of the total anticipated peak cooling/heating hours for the year.

Sources

1. Cadmus. *EUL Response Memo.* April 26, 2013.(Used RCx Program EUL standard and direction from CB&I to keep 5 year EUL standard)
2. RSMeans. Facilities Construction Cost Data. 29th Edition. 2013. ($54/hour labor rate for work on temperature sensors; estimated 2 hours for completion based on project experience).
3. Wisconsin Focus on Energy. EBTU Measures Workbook Calculator.
4. National Renewable Energy Laboratory. Bin temperature data from respective Wisconsin cities TMY3 weather data. Available online: http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html#W
5. Edison Electric Institute. Technical Information Handbook. Pg. 24. 2000.
6. ASHRAE. Handbook, Fundamentals Volume for Wisconsin Cities. 1985. Available online: http://publicecodes.cyberregs.com/icod/ipc/2012/icod_ipc_2012_appd.htm
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8. International Energy Conservation Code. Table 503.2.3(1). 2009. DX cooling efficiency values determined as simple average minimum efficiencies for systems with capacity ≥ 5.5 tons.
9. ASHRAE 90.1-2007. Table 6.8.1C. Chiller unit part load efficiency values are simple average minimum efficiencies for chillers with capacity of 0 tons to 300 tons.
10. Wisconsin Focus on Energy Technical Reference Manual. Outside Air Temperature Bin Analysis, pg. 389. January 2015.

Revision History

Version Number	Date	Description of Change
01	11/2014	Initial TRM entry

Valve Repair

	Measure Details
Measure Master ID	Valve Repair, Chilled Water, 3675 Valve Repair, Hot Water, 3676
Measure Unit	Per MBh
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by type of repair
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by type of repair
Life-cycle Energy Savings (kWh)	Varies by type of repair
Life-cycle Therm Savings (Therms)	Varies by type of repair
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Incremental Cost ($/unit)	$112.00[2]

Measure Description

This measure captures savings associated with repairing a chilled or hot water valve serving a cooling/heating coil in a central air handling unit. This measure is for addressing a valve that has a 70% failure rate at open or higher.

The measure incremental cost does not account for the potential replacement of unrepairable/broken valves. The heating supply must be produced by a natural gas boiler, and the cooling system must be electrically powered. The measure can be applied only once per building during the EUL. This measure is meant to be a part of the Express Building Tune-Up Program to help optimize building HVAC systems to operate more efficiently at existing building load conditions. It does not apply to newly constructed facilities that have not been commissioned.

Description of Baseline Condition

The baseline measure is a chilled or hot water valve in need of repair due to being stuck open at 70% or greater. If the valve is stuck at some point less than 70% open, this measure does not apply.

Description of Efficient Condition

The efficient measure is replacing or repairing a failed valve back to its optimal working state.

Annual Energy-Savings Algorithm

Savings are the sum of the baseline and proposed energy consumption formulas below across the bin data temperature ranges and corresponding bin temperature hours found in the EBTU workbook.[3,4]

kWh_{SAVED} = Σ [(Valve cooling Btu Baseline – Valve cooling Btu Proposed) / 12,000 * chiller_eff * Adjusted Hours]

$Therm_{SAVED}$ = Σ [(Valve heating Btu Baseline – Valve heating Btu Proposed) / 80% / 100,000 * Adjusted Hours]

Valve heating/cooling Btu Baseline = Capacity of heat_cool coil being served * 1,000 * stuck valve position % * Area Load

Valve heating/cooling Btu Proposed = Capacity of heat_cool coil being served * 1,000 * working valve position % * Area Load

Where:

Capacity of heat_cool coil being served = Expressed in MBh or Tons (= user defined; MBh for chilled water = # tons * 12)

1,000 = Kilowatt conversion factor

Stuck valve position % = Percentage open (= user defined)

Area Load = Percentage value based on linear interpolation of a 60°F dry bulb OAT balance point, bin data dry bulb OAT, and 2.5% dry bulb design summer/winter conditions for different Wisconsin cities[5] (see Assumptions for more explanation about the 2.5% dry bulb design conditions)

Working valve position % = Workbook-calculated value based on bin data OAT

12,000 = Btu to ton conversion factor

chiller_eff = Units kilowatts per ton (= based on type of chiller; see table below)

Cooling Efficiency by System Type

Chiller Type	Cooling System Efficiency Factor at Partial Load (kW/ton)
Air-Cooled	0.95[6]
Water-Cooled	0.64[6]

Adjusted Hours = Bin hours * EFLH (see table below) / 8,760 total annual hours[4]

Effective Full Load Heating and Cooling Hours by City

City	EFLHcooling[7]	EFLHheating[7]
Green Bay	344	1,852
La Crosse	323	1,966
Madison	395	1,934
Milwaukee	457	1,883

80% = Efficiency of natural gas to heat conversion for heating purposes

100,000 = Btu to therm conversion factor

Summer Coincident Peak Savings Algorithm

There are no peak savings for this measure.

Lifecycle Energy-Savings Algorithm

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

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

Where:

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

Assumptions

- Heating and cooling balance temperature = 60°F
- 2.5% dry bulb design conditions means that for cooling/heating seasons, the HVAC system is designed to adequately handle the cooling/heating of a given building for all outdoor air temperatures that do not exceed the hottest/coldest 2.5% of hours of the respective season. Explained another way, this means the cooling/heating system can adequately handle the cooling/heating load of a given building for 97.5% of the total anticipated peak cooling/heating hours for the year.

Sources

1. Cadmus. *EUL Response Memo*. April 26, 2013.(Used RCx Program EUL standard and direction from CB&I to keep 5 year EUL standard)
2. RSMeans. Facilities Construction Cost Data. 29th Edition. 2013. ($56/hour labor rate for work on heating/cooling control valves; estimated 2 hours for completion based on project experience).
3. Wisconsin Focus on Energy. EBTU Measures Workbook Calculator.

4. National Renewable Energy Laboratory. Bin temperature data from respective Wisconsin cities TMY3 weather data. Available online: http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html#W
5. ASHRAE. Handbook, Fundamentals Volume for Wisconsin Cities. 1985. Available online: http://publicecodes.cyberregs.com/icod/ipc/2012/icod_ipc_2012_appd.htm
6. ASHRAE 90.1-2007. Table 6.8.1C. Chiller unit part load efficiency values are simple average minimum efficiencies for chillers with capacity of 0 tons to 300 tons.
7. Several Cadmus metering studies reveal that the ENERGY STAR calculator EFLH are over-estimated by 25%. The heating EFLH were adjusted by population-weighted HDD and TMY-3 values.

Revision History

Version Number	Date	Description of Change
01	11/2014	Initial TRM entry

VFD Fan Motor Control Restoration

	Measure Details
Measure Master ID	VFD Fan Motor Control Restoration, 3677
Measure Unit	Per horsepower
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by temperature ranges and hours
Peak Demand Reduction (kW)	Varies by temperature ranges and hours
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by temperature ranges and hours
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Incremental Cost ($/unit)	$56.00[2]

Measure Description

This measure captures savings associated with correcting the operating setting on a variable frequency drive (VFD) controlling an HVAC system-related fan motor that is stuck in ‘hand’ mode or is in bypass mode. Measure rebate does not apply if the original VFD was incented by Wisconsin Focus on Energy. Measure rebate applies to all other VFDs only once per building during the EUL. This measure is meant to be a part of the Express Building Tune-Up Program to help optimize building HVAC systems to operate more efficiently at existing building load conditions. It does not apply to newly constructed facilities that have not been commissioned.

Description of Baseline Condition

The baseline measure is a fan motor in a facility using a VFD for motor control, but not using the ‘automatic’ VFD control features.

Description of Efficient Condition

The efficient measure is restoring the automatic control features of a VFD controlling a fan motor load. The VFD should not be manually altered in its control operation after being set to automatic mode.

Annual Energy-Savings Algorithm

Savings are the sum of the baseline and proposed energy consumption formulas below across the bin data temperature ranges and corresponding bin temperature hours found in the EBTU workbook.[3,4]

kWh_{SAVED} = VFD Motor Baseline - VFD Motor Proposed

VFD Motor Baseline = Σ [Motor hp * 0.7465 / Motor eff * (Motor loading $\%_{BASE}$)^2.5 * Adjusted Run Hours]

VFD Motor Proposed = Σ [Motor hp * 0.7465 / Motor eff * (Motor loading $\%_{PROP}$)^2.5 * Adjusted Run Hours]

Where:

Motor hp = VFD controlled motor nameplate horsepower rating

0.7465 = Horsepower to kW conversion factor

Motor eff = Specific VFD controlled motor nameplate efficiency; otherwise use default of 90%

Motor Loading $\%_{BASE}$ = Percent capacity (Load Factor) of motor at baseline (= user defined)

Adjusted Run Hours = Bin hours * (annual VFD operational hours / 8,760 annual hours)

Motor Loading $\%_{PROP}$ = Percent capacity (Load Factor) of motor proposed; assumes the VFD is set back to ‘automatic’ control based on user-defined loading minimum and maximum percentages and on area load (area load is a percentage based on a linear interpolation of a 60°F dry bulb OAT balance point, bin data dry bulb OAT, and 2.5% dry bulb design summer/winter conditions for different Wisconsin cities;[5] see Assumptions for more explanation about the 2.5% dry bulb design conditions)

The workbook calculator requires the following measure-specific inputs to be provided from the trained professional performing the tune-up/optimization measure:

- Annual hours of VFD/fan operation
- Fan VFD application (cooling tower fan, chiller system fan, boiler/heating fan)
- Existing VFD control state (auto, manual, bypassed/off)
- Fan motor nameplate capacity controlled by VFD (horsepower)
- Fan motor nameplate efficiency percentage
- Measured speed at set point if VFD is stuck in ‘hand’ mode (Hz)
- VFD fan control loading minimum and maximum percentages

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} / Hours_{FAN} * CF$

Where:

$Hours_{FAN}$ = Annual hours of operation for the fan controlled by the VFD

CF = Coincidence factor (= based on VFD fan use; see table below)

Coincidence Factor by VFD Fan Use[6]

VFD Use	CF	Details
Cooling Tower Fan	0.9	DEER model runs are weather-normalized for statewide use by population density
Boiler Draft/Heating Fan	0.0	Assumed that heating fan not operating at peak summer period

Lifecycle Energy-Savings Algorithm

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

Where:

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

Assumptions

- Assumes 100% load factor for all motors running in a VFD bypassed state.
- 2.5% dry bulb design conditions means that for cooling/heating seasons, the HVAC system is designed to adequately handle the cooling/heating of a given building for all outdoor air temperatures that do not exceed the hottest/coldest 2.5% of hours of the respective season. Explained another way, this means the cooling/heating system can adequately handle the cooling/heating load of a given building for 97.5% of the total anticipated peak cooling/heating hours for the year.

Sources

1. Cadmus. *EUL Response Memo.* April 26, 2013. Used the RCx Program EUL standard and direction from CB&I to keep 5 year EUL standard.
2. RSMeans. Facilities Construction Cost Data. 29th Edition. 2013. Assumed $56/hour labor rate for work performed on HVAC control systems; estimated 1 hour for completion of this measure based on project experience.
3. Wisconsin Focus on Energy. EBTU Measures Workbook Calculator.

4. Natural Renewable Energy Laboratory. Bin temperature data from respective Wisconsin City TMY3 weather data. Available online: http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html#W
5. ASHRAE. Handbook, Fundamentals Volume for Wisconsin Cities. 1985. Available online: http://publicecodes.cyberregs.com/icod/ipc/2012/icod_ipc_2012_appd.htm
6. Wisconsin Focus on Energy Technical Reference Manual. Pg. 225, Variable Frequency Drive, summer coincident peak savings algorithm VFD coincidence factor chart. 2015.

Revision History

Version Number	Date	Description of Change
01	10/2014	Initial TRM entry

VFD Pump Control Restoration

	Measure Details
Measure Master ID	VFD Pump Control Restoration, 3678
Measure Unit	Per horsepower
Measure Type	Hybrid
Measure Group	HVAC
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by temperature ranges and hours
Peak Demand Reduction (kW)	Varies by temperature ranges and hours
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by temperature ranges and hours
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Incremental Cost ($/unit)	$56.00[2]

Measure Description

This measure captures savings associated with correcting the operating setting on a variable frequency drive (VFD) controlling an HVAC system-related pump motor that is stuck in ‘hand’ mode or is in bypass mode. Measure rebate does not apply if the original VFD was incented by Wisconsin Focus on Energy. Measure rebate applies to all other VFDs only once per building during the EUL. This measure is meant to be a part of the Express Building Tune-Up Program to help optimize building HVAC systems to operate more efficiently at existing building load conditions. It does not apply to newly constructed facilities that have not been commissioned.

Description of Baseline Condition

The baseline measure is a pump motor in a facility using a VFD for pump control, but not using the ‘automatic’ VFD control features.

Description of Efficient Condition

The efficient measure is restoring the automatic control features of a VFD controlling a pump load. The VFD should not be manually altered in its control operation after being set to automatic mode.

Annual Energy-Savings Algorithm

Savings are the sum of the baseline and proposed energy consumption formulas below across the bin data temperature ranges and corresponding bin temperature hours found in the EBTU workbook.[3,4]

kWh_{SAVED} = VFD Pump Baseline - VFD Pump Proposed

VFD Pump Baseline = Σ [Motor hp * 0.7465 / Motor eff * (Motor loading $\%_{BASE}$)^2.5 * Adjusted Run Hours]

VFD Pump Proposed = Σ [Motor hp * 0.7465 / Motor eff * (Motor loading $\%_{PROP}$)^2.5 * Adjusted Run Hours]

Where:

Motor hp = VFD controlled motor nameplate horsepower rating

0.7465 = Horsepower to kW conversion factor

Motor eff = Specific VFD controlled pump motor nameplate efficiency; otherwise use default of 90%

Motor Loading $\%_{BASE}$ = Percent capacity (Load Factor) of motor at baseline (= user defined)

Adjusted Run Hours = Bin hours * (annual VFD operational hours / 8,760 annual hours)

Motor Loading $\%_{PROP}$ = Percent capacity (Load Factor) of motor proposed; assumes the VFD is set back to 'automatic' control based on user-defined loading minimum and maximum percentages and on area load (area load is a percentage based on a linear interpolation of a 60°F dry bulb OAT balance point, bin data dry bulb OAT, and 2.5% dry bulb design summer/winter conditions for different Wisconsin cities;5 see Assumptions for more explanation about the 2.5% dry bulb design conditions)

The workbook calculator requires the following measure-specific inputs to be provided from the trained professional performing the tune-up/optimization measure:

- Annual hours of VFD/fan operation
- Fan VFD application (cooling tower fan, chiller system fan, boiler/heating fan)
- Existing VFD control state (auto, manual, bypassed/off)
- Fan motor nameplate capacity controlled by VFD (horsepower)
- Fan motor nameplate efficiency percentage
- Measured speed at set point if VFD is stuck in 'hand' mode (Hz)
- VFD fan control loading minimum and maximum percentages

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} / Hours_{PUMP} * CF$

Where:

$Hours_{PUMP}$ = Annual hours of operation for the pump controlled by the VFD

CF = Coincidence factor (= based on VFD pump use; see table below)

Coincidence Factor by VFD Pump Use[6]

VFD Use	CF	Source
Chilled Water Pump	0.9	DEER model runs are weather-normalized for statewide use by population density
Hot Water Pump	0.0	Assumed that heating/hot water pump not operating at peak times

Lifecycle Energy-Savings Algorithm

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

Where:

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

Assumptions

- Assumes 100% load factor for all motors running in a VFD bypassed state.
- 2.5% dry bulb design conditions means that for cooling/heating seasons, the HVAC system is designed to adequately handle the cooling/heating of a given building for all outdoor air temperatures that do not exceed the hottest/coldest 2.5% of hours of the respective season. Explained another way, this means the cooling/heating system can adequately handle the cooling/heating load of a given building for 97.5% of the total anticipated peak cooling/heating hours for the year.

Sources

1. Cadmus. *EUL Response Memo.* April 26, 2013. Used the RCx Program EUL standard and direction from CB&I to keep 5 year EUL standard.
2. RSMeans. *Facilities Construction Cost Data*. 29th Edition. 2013. Assumed $56/hour labor rate for work performed on HVAC control systems; estimated 1 hour for completion of this measure based on project experience.
3. Wisconsin Focus on Energy. *EBTU Measures Workbook Calculator.* January 2015.

4. Natural Renewable Energy Laboratory. Bin temperature data from respective Wisconsin City TMY3 weather data. Available online: http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html#W
5. ASHRAE. *Handbook, Fundamentals Volume for Wisconsin Cities*. 1985. Available online: http://publicecodes.cyberregs.com/icod/ipc/2012/icod_ipc_2012_appd.htm
6. *Wisconsin Focus on Energy Technical Reference Manual.* Pg. 225., Variable Frequency Drive, summer coincident peak savings algorithm VFD coincidence factor chart. 2015

Revision History

Version Number	Date	Description of Change
01	10/2014	Initial TRM entry

Variable Speed ECM Pump, Domestic Hot Water Recirculation, Heating Water Circulation, and Cooling Water Circulation

	Measure Details
Measure Master ID	Variable Speed ECM Pump: Domestic Hot Water Recirculation: < 100 Watts Max Input, 3494 100 - 500 Watts Max Input, 3495 > 500 Watts Max Input, 3496 Heating Water Circulation: < 100 Watts Max Input, 3497 100 - 500 Watts Max Input, 3498 > 500 Watts Max Input, 3499 Cooling Water Circulation: < 100 Watts Max Input, 3500 100 - 500 Watts Max Input, 3501 > 500 Watts Max Input, 3502 Water Loop Heat Pump Circulation: < 100 Watts Max Input, 3503 100 - 500 Watts Max Input, 3504 > 500 Watts Max Input, 3505
Measure Unit	Per pump
Measure Type	Prescriptive
Measure Group	HVAC
Measure Category	Variable Speed Drive
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by wattage
Peak Demand Reduction (kW)	Varies by wattage
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by wattage
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost	Varies by measure and wattage, see Appendix D

Measure Description

ECMs are high-efficiency brushless DC motors. They are typically fractional horsepower motors that have several benefits over the more common PSC fractional horsepower motor. One of these advantages is higher overall efficiency. PSC motors are generally 20% to 60% efficient, depending on their loading, while ECM motor efficiencies range from 70% to 80%. Other advantages include a reduction in the pump motor size, the variable speed capability of the pump, the ability to provide constant flow with varying pressures, a wider range of rpm, and the ability to be controlled by direct digital controls.

DHW recirculating pumps are commonly used in multifamily and commercial buildings to shorten the amount of time it would otherwise take for hot water to reach the occupants on upper floors and that have long piping runs. These recirculation pumps can be operated continuously or be controlled by a timer or an aquastat. An aquastat turns on the pump only when the temperature of the return line falls below a certain set point. Many of the ECM recirculating pumps currently on the market have integrated aquastat controls and the ability to be controlled and monitored wirelessly.

Heating and cooling water circulation pumps are commonly used in baseboard and radiant floor heating systems, as well as in coils in forced air systems in multifamily and commercial buildings. Cooling loops are often part of heat pump circulation systems. Often the primary and secondary loops run constantly throughout the heating or cooling season. ECM circulator pumps can modulate their speed to match the load.

Description of Baseline Condition

The baseline condition is a standard efficiency, constant volume PSC pump for domestic heating or cooling circulation without variable speed capabilities.

Description of Efficient Condition

The efficient condition is a properly sized, high-efficiency ECM pump for domestic heating or cooling circulation with variable speed capabilities to match demand.

Savings for this measure are from the reduction in the pump motor size, the variable speed capability of the pump, and the increased efficiency of the ECMs versus the fraction horsepower PSC motors.

Annual Energy-Savings Algorithm

Heating and Cooling Circulation Pumps:

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

$Watts_{BASE} = Watts_{EE} * R$

$HOURS_{HEATING} = HDD * 24 * \Delta T$

$HOURS_{COOLING} = CDD * 24 * \Delta T$

Water Loop Heat Pump Circulation Pumps:

$kWh_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1{,}000 * (HOURS_{HEATING} + HOURS_{COOLING})$

$Watts_{BASE} = Watts_{EE} * R$

$HOURS_{HEATING} = HDD * 24 * \Delta T$

$HOURS_{COOLING} = CDD * 24 * \Delta T$

DHW Recirculation Pumps:

$kWh_{SAVED} = (Watts_{BASE} / 1{,}000 * HOURS_{DHW\text{-}BASE}) – (Watts_{EE} / 1{,}000 * HOURS_{DHW\text{-}EE})$

$HOURS_{DHW\text{-}BASE} = HOURS_{UNCONTROLLED} * 44.5\% + HOURS_{CONTROLLED} * 55.5\%$

$HOURS_{DHW\text{-}EE} = HOURS_{CONTROLLED}$

Where:

$Watts_{BASE}$ = Power consumption of constant speed PSC pump (= 278 watts for < 100 watt VSD ECM pumps; = 1,389 watts for 100 watt to 500 watt VSD ECM pumps; = 5,556 watts for > 500 watt VSD ECM pumps)

$Watts_{EE}$ = Power consumption of variable speed ECM pump (= 50 watts for < 100 watt VSD ECM pumps; = 250 watts for 100 watt to 500 watt VSD ECM pumps; = 1,000 watts for > 500 watt VSD ECM pumps)

1,000 = Kilowatt conversion factor

HOURS = Average annual pump run hours

R = Ratio of ECM watts to baseline watts based on measured data of comparable efficient and nonefficient pumps (18%)[2]

$HOURS_{HEATING}$ = Average annual pump run hours for heating (= 2,285)[3]

HDD = Heating degree days (= 7,616; see table below)[5]

24 = Conversion factor, hours per day

ΔT = Design temperature difference (= 80°F for heating; = 20°F for cooling as 95°F outdoor design - 75°F indoor design)[6]

$HOURS_{COOLING}$ = Average annual pump run hours for cooling (= 678)[3]

CDD = Cooling degree days (= 565; see table below)[5]

Heating and Cooling Degree Days by Location

Location	HDD[5]	CDD[5]
Milwaukee	7,276	548
Green Bay	7,725	516
Wausau	7,805	654
Madison	7,599	630
La Cross	7,397	729
Minocqua	8,616	423
Rice Lake	8,552	438
Statewide Weighted	**7,616**	**565**

$HOURS_{DHW\text{-}BASE}$ = Average annual pump run hours for DHW recirculating (= 5,114)[3]

$HOURS_{DHW\text{-}EE}$ = Average annual pump run hours for DHW recirculating (= 2,190)[3]

$HOURS_{UNCONTROLLED}$ = Average annual pump run hours for DHW recirculating continuously running (= 8,760)

44.5% = Constant[4]

$HOURS_{CONTROLLED}$ = Average annual pump run hours for DHW recirculating controlled by a timer or aquastat (= 2,190)[3]

55.5% = Constant[4]

Summer Coincident Peak Savings Algorithm

The summer coincident peak savings algorithm only applies to cooling circulation pumps and DHW recirculation pumps.

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

Where:

CF = Coincidence factor (= 0.299 for chilled water pumps,[5] = 1.0 for DHW pumps)

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Energy Savings for DHW Recirculation

Savings	< 100 Watt VSD ECM Pump MMID 3494	100 - 500 Watt VSD ECM Pump MMID 3495	> 500 Watt VSD ECM Pump MMID 3496
Energy Savings (kWh)	1,311	6,555	26,221
Lifecycle Savings (kWh)	19,666	98,329	393,317
Demand Reduction (kW)	0.228	1.139	4.556

Energy Savings for Heating Circulation

Savings	< 100 Watt VSD ECM Pump MMID 3497	100 - 500 Watt VSD ECM Pump MMID 3498	> 500 Watt VSD ECM Pump MMID 3499
Energy Savings (kWh)	520	2,602	10,409
Lifecycle Savings (kWh)	7,807	39,035	156,142
Demand Reduction (kW)	0.000	0.000	0.000

Energy Savings for Cooling Circulation

Savings	< 100 Watt VSD ECM Pump MMID 3500	100 - 500 Watt VSD ECM Pump MMID 3501	> 500 Watt VSD ECM Pump MMID 3502
Energy Savings (kWh)	154	772	3,089
Lifecycle Savings (kWh)	2,317	11,583	46,330
Demand Reduction (kW)	0.068	0.341	1.362

Energy Savings for Water Loop Heat Pump Circulation

Savings	< 100 Watt VSD ECM Pump MMID 3503	100 - 500 Watt VSD ECM Pump MMID 3504	> 500 Watt VSD ECM Pump MMID 3505
Energy Savings (kWh)	675	3,375	13,498
Lifecycle Savings (kWh)	10,124	50,618	202,472
Demand Reduction (kW)	0.068	0.341	1.362

Assumptions

Variable Speed ECM Pump, < 100 Watts Max Input

- Wattage inputs for qualifying pumps under 100 watts range from 3 watts to 93 watts. 50 watts was used as a conservative midpoint.

Variable Speed ECM Pump, 100 - 500 Watts Max Input

- Wattage inputs for qualifying pumps between 100 watts and 500 watts range from 130 watts to 500 watts. 250 watts was used as a conservative midpoint.

Variable Speed ECM Pump, > 500 Watts Max Input

- Wattage inputs for qualifying pumps greater than 500 watts range from 587 watts to 2,500 watts. 1,000 watts was used as a conservative midpoint.

Sources

1. U.S. Department of Energy. *Pump Life Cycle Costs: A Guide to LCC Analysis for Pumping Systems*. January 2001. Page 4. January 2001. Available online: https://www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/pumplcc_1001.pdf.
2. Cadmus. Impact Evaluation of the 2011–2012 ECM Circulator Pump Pilot Program. Table 2. Pump Spot Measurements. October 18, 2012.
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4. Lawrence Berkeley National Laboratory. Water Heaters and Hot Water Distribution Systems. Prepared for California Energy Commission Public Interest Energy Research Program. Pg. 16, Figure 10: Control Types Installed or Maintained by Contractors. May 2008.
5. Illinois Statewide Technical Reference Manual for Energy Efficiency, Version 2.0. Pg. 235. June 7, 2013.
6. Used to match other measures: example: Natural Gas Furnace with ECM, 95%+ AFUE (Existing), 1981.

Revision History

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

Lighting

Lighting Fixture, Agricultural Daylighting

	Measure Details
Measure Master ID	Lighting Fixture, Agricultural Daylighting: ≤ 155 Watts, 3019 156 - 250 Watts, 3020 251 - 365 Watts, 3021
Measure Unit	Per luminaire or complete retrofit kit
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Controls
Sector(s)	Agriculture
Annual Energy Savings (kWh)	Varies by wattage
Peak Demand Reduction (kW)	Varies by wattage
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by wattage
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Measure Incremental Cost ($/unit)	$246.43[2]

Measure Description

Various lighting technologies—such as LED, induction, ceramic metal halide, pulse start metal halide, and linear fluorescent high bay products—are energy-efficient alternatives to 320-watt pulse start metal halide fixtures. These options have become a popular for dairy facilities upgrades to long day lighting, a process used to help increase cows' milk production by simulating longer days and therefore increasing the animal food intake and thus milk production. Long day lighting requires a minimum of 15 footcandles of photopic light being present at cow eye level for 16 hours to18 hours each day.

Energy savings are achieved when installing energy-efficient LED, induction, ceramic metal halide, pulse start metal halide, and/or linear fluorescent options instead of 250-watt and 320-watt pulse start metal halide fixtures. When the design is optimized to the technology, a considerable amount of energy can be saved.

Description of Baseline Condition

The baseline condition is 250-watt and 320-watt pulse start metal halide options in new construction buildings and upon retrofit upgrades to long day lighting.

Description of Efficient Condition

The efficient condition is qualifying LED, induction, ceramic metal halide, pulse start metal halide, and/or linear fluorescent high bay options. Pulse start metal halides are not acceptable for new construction applications.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{320\ WATT\ PSMH} – kWh_{EE\ HIGH\ BAY}$ * Hours

Where:

$kWh_{320\ WATT\ PSMH}$ = Annual electricity consumption of pulse start metal halide

$KWh_{EE\ HIGH\ BAY}$ = Annual electricity consumption of an eligible high/low bay option using LED, induction, ceramic metal halide, pulse start metal halide, or linear fluorescent technology

Hours = 6,205 hours; full details in Assumptions section below

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = Qty * (kWh_{SAVED})/1{,}000 * CF$

Where:

Qty = Quantity

1,000 = Kilowatt conversion factor

CF = Demand coincidence factor (= 1.0)

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Annual Deemed Savings for Agricultural Long Day Lighting

Measure	MMID	Existing Building	New Construction
Long Daylighting High Bay Fixtures, ≤ 155 Watts	3019	834 kWh, 0.1344 kW	874 kWh, 0.1409 kW
Long Daylighting High Bay Fixtures, 156 - 250 Watts	3020	908 kWh, 0.1463 kW	956 kWh, 0.1541 kW
Long Daylighting High Bay Fixtures, 251 - 365 Watts	3021	847 kWh, 0.1365 kW	892 kWh, 0.1438 kW

Lifecycle Deemed Savings for Agricultural Long Day Lighting

Measure	MMID	Existing Building	New Construction
Long Daylighting High Bay Fixtures, ≤ 155 Watts	3019	12510 kWh	13110 kWh
Long Daylighting High Bay Fixtures, 156 - 250 Watts	3020	13620 kWh	14340 kWh
Long Daylighting High Bay Fixtures, 251 - 365 Watts	3021	12705 kWh	13380 kWh

Assumptions

A 320-watt pulse start metal halide was used as the baseline (it is the industry standard for lighting in several high bay applications including agricultural facilities), but 250-watt pulse start metal halides are also used in lower wattage applications.

The design of the long day lighting system should be based on the energy-efficient technology used.

Hours was based on long day lighting studies, which reveal that in order for long day lighting to work, the lights must deliver a minimum of 15 footcandles at cow eye level for 16 hours to 18 hours a day (17 * 365 = 6,205 hours).

The coincidence factor of 1 was based on the system being on for 16 hours to 18 hours each day.[3,4]

The energy-efficient high bay option is based on the following:

- An average of the following replacements was used to generate the deemed savings values in place of 320-watt PSMH:
    - Eligible Replacements = 5.8% 200-watt induction, 5.8% 225-watt induction, 5.8% 165-watt induction, 5.8% 200-watt PSMH or CMH, 5.8% 210-watt PSMH or CMH, 5.8% 220-watt PSMH or CMH, 5.8% 4-foot 6-lamp T8, 5.8% 4-foot 4-lamp T5HO, 5.8% LED < 250 watts, 5.8% 250-watt induction, 5.8% 300-watt induction, 5.8% 250-watt PSMH or CMH, 5.8% 270-watt PSMH or CMH, 5.8% 315-watt PSMH or CMH, 5.8% 4-foot 8-lamp T8, 5.8% 4-foot 6-lamp T5HO, and 5.8% LED < 365 watts
- An average of the following replacements was used to generate the deemed savings values in place of 250-watt metal halide:
    - Eligible Replacements = 10% 120-watt to 125-watt induction,10% 150-watt induction,10% 165-watt induction,10% 125-watt PSMH or CMH, 10% 140-watt PSMH or CMH, 10% 150-watt PSMH or CMH, 10% 4-foot 4-lampT8, 10% 4-foot 3-lamp T5HO, 10% 4-foot 2-lamp T5HO, and 10% LED < 155 watts

Sources

1. *Focus on Energy Evaluation Business Programs: Measure Life Study Final Report*. August 25, 2009.
2. *Focus on Energy Evaluation Business Programs: Incremental Cost Study Final Report. October 28, 2009.*
3. *Photoperiod Manipulation of Lactation in Dairy Cattle. (2001-2004). Retrieved April 30, 2012. http://www.livestocktrail.illinois.edu/photoperiod.*
4. *University of Wisconsin Madison. Long Day Lighting in Dairy Barns (August 2000). Healthy Farmers, Healthy Profits Project. Second Edition.*

Revision History

Version Number	Date	Description of Change
01	01/01/2013	Initial TRM entry
02	04/23/2013	Updated proposed fixture wattage for new construction, removed PSMH as option for new construction, and updated savings values

Daylighting Control

	Measure Details
Measure Master ID	Daylighting Control, 3406
Measure Unit	Per watt controlled
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Controls
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	8[1]
Incremental Cost ($/unit)	Varies by sector[2]

Measure Description

Daylighting controls save energy by reducing the total wattage input of the connected lighting load by matching the light output of the connected electric lighting system to the amount of natural light supplied by the sun that enters the space being lit. This is accomplished using dimming light sources or a system that steps the light of the connected fixtures based on controlling the lamps inside each connected fixture to produce different levels of illumination. This measure will provide reinforcement that integrating daylighting controls is an effective method to further reduce energy consumption.

Description of Baseline Condition

The baseline condition is any lighting equipment that is not connected to a daylighting controls system.

Description of Efficient Condition

The efficient condition is any lighting equipment that is connected to a daylighting controls system.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{UNCONTROLLED} * \text{Savings Factor}$

$kWh_{UNCONTROLLED} = Wattage_{UNCONTROLLED} / 1{,}000 * CF * HOURS$

Where:

$KWh_{UNCONTROLLED}$ = Annual electricity consumption per watt of lighting load that is not controlled by daylighting controls

Savings Factor = Savings percentage achieved per watt of lighting load that is controlled by daylighting controls[7]

$Wattage_{UNCONTROLLED}$ = Instantaneous electric consumption of lamp or fixture

1,000 = Kilowatt conversion factor

CF = Demand coincidence factor (= see table below)

Demand Coincidence Factor by Sector

Sector	CF[4, 6]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64
Multifamily	0.77

HOURS = Average annual run hours (= see table below)

Average Annual Run Hours by Sector

Sector	HOURS[3, 5]
Commercial	3,730
Industrial	3,299
Agriculture	4,745
Schools & Government	4,698
Multifamily	5,950

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = Wattage_{UNCONTROLLED} / 1{,}000 * CF$

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Annual Savings per Watt of Lighting Load Controlled by Daylighting Controls

Measure	Commercial 3,730 (0.77)		Industrial 4,745 (0.77)		Agriculture 4,698 (0.67)		Schools & Gov 3,239 (0.64)		Multifamily 5,950 (0.77)	
	kWh	kW	kWh	kWh	kW	kW	kWh	kW	kWh	kW
Daylighting Control	1.12	0.0	1.43	0.97	0.0	0.0	1.41	0.0	1.78	0.0

Lifecycle Savings per Watt of Lighting Load Controlled by Daylighting Controls

Measure	Commercial 3,730 (0.77)	Industrial 4,745 (0.77)	Agriculture 4,698 (0.67)	Schools & Gov 3,239 (0.64)	Multifamily 5,950 (0.77)
	kWh	kWh	kWh	kWh	kWh
Daylighting Control	8.96	11.44	11.28	7.76	14.24

Sources

1. California Energy Commission and California Public Utilities Commission. Database for Energy Efficient Resources (DEER) 2008. http://www.energy.ca.gov/deer/ .
2. Varies based on wattage connected. For example, a $250 daylighting sensor system connected to 100 watts of lighting load will cost $2.50 per watt controlled; but the same $250 daylighting sensor system connected to 10,000 watts of lighting load will only cost $0.025 per watt controlled.
3. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
4. Focus on Energy Business Programs Deemed Savings Manual V1.0. Lighting in Commercial Applications. March 22, 2010.
5. ACES. Deemed Savings Desk Review. November 3, 2010.
6. ACES. Default Deemed Savings Review Final Report. June 24, 2008. Available online: http://www.coned.com/documents/Con%20Edison%20Callable%20Load%20Study_Final%20Report_5-15-08.pdf. CF is within range of similar programs; see Table 4-1 showing multifamily housing (in unit) CF of 65% to 83%.

7. Williams, Allison, B. Atkinson P.E., K. Garbesi Ph.D., E. Page P.E., and F. Rubenstein, FIES. "Lighting Controls in Commercial Buildings." Luekos Vol. 8, No. 3 (January 2012).

Revision History

Version Number	Date	Description of Change
01	04/2014	Initial TRM entry

Bi Level Controls, High Bay Fixtures

	Measure Details
Measure Master ID	Bi Level Controls, High Bay Fixtures: Gymnasium, 3260 Industrial, 3261 Retail, 3262 Warehouse, 3263 Public Assembly, 3264 Other, 3265
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Controls
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	8[1]
Incremental Cost ($/unit)[2]	$150.00

Measure Description

This measure is bi-level controls for high bay fixtures. Numerous new and existing installations use LED, induction, linear fluorescent, ceramic metal halide, and pulse start metal halide fixtures to light their high bay interiors, commonly in full light output 24 hours a day. Bi level controls and replacement products use ultrasonic and passive infrared sensors to adjust the light output to a safe but energy conserving low level when these spaces become unoccupied. These products save energy by more efficiently lighting the spaces based on occupancy.

Description of Baseline Condition

The baseline condition is LED, induction, fluorescent, ceramic metal halide, and/or pulse start metal halide fixture input wattages with no lighting controls at building interior.

Description of Efficient Condition

The efficient condition is individually controlled light fixtures that may include dimming, stepped dimming, and hi-lo ballast controls. The control must include a passive infrared and/or ultrasonic occupancy sensor with a feature to fail in "on" position in case of failure.

Fixtures must operate in a low-standby light level during vacancy and switch to full light output upon occupancy. The fixture cannot exceed 50% of full wattage during unoccupied periods.

Annual Energy-Savings Algorithm

All algorithms and methodology from: *Focus on Energy Business Programs Deemed Savings Manual V1.0*. March 22, 2010.[2]

The kW savings for this measure are deemed by space type, while kWh savings are deemed by sector and space type. Savings due to occupancy sensor installation are described by the following equations:

kWh_{SAVED} = LtgWatts / 1,000 * % Off * Hours * 50%

Where:

Ltg. Watts = Lighting wattage controlled, deemed (= 237 watts; updated per new wattage table to 310 watts)

1,000 = Kilowatt conversion factor

% Off = Percentage of time lights are controlled (= see table below)

Hours = Baseline hours per year (= see table below)

50% = Bi level factor for fixtures that include dimming, stepped dimming, or hi-lo ballast controls (at least 50% of light source or lamps must be reduced to qualify for incentive)

Percentage Of Values by Space Type (Various Sources)[2]

Space Type	Cal. SPC	RLW Schools	LRC	Maine	Average
Gymnasiums	35%	48%	-	35%	**39%**
Industrial	45%	-	-	-	**45%**
Retail	15%	-	-	-	**15%**
Warehouses	45%	-	65%	50%	**53%**
Public Assembly	35%	59%	-	-	**47%**
Other	-	-	-	-	**40%**

Hours-of-Use by Sector[2]

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

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = LtgWatts / 1,000 * CF

Where:

CF = Coincidence factor (= see table below)

Coincidence Factors by Space Type (Various Sources)[2]

Space Type	Cal. SPC	RLW Schools	Average
Gymnasiums	14%	15%	**15%**
Industrial	18%	-	**18%**
Retail	6%	-	**6%**
Warehouses	18%	-	**18%**
Public	14%	10%	**12%**
Other	-	-	**14%**

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Annual and Lifecycle Deemed Savings in Agriculture and Commercial Sectors

Measure Name	MMID	Agriculture			Commercial		
		kW	kWh	Lifecycle	kW	kWh	Lifecycle
Bi Level Controls, High Bay Fixtures, Gymnasium	3260	0.0465	284	2,274	0.0465	226	1,806
Bi Level Controls, High Bay Fixtures, Industrial	3261	0.0559	328	2,624	0.0559	260	2,083
Bi Level Controls, High Bay Fixtures, Retail	3262	0.0186	109	875	0.0186	87	694
Bi Level Controls, High Bay Fixtures, Warehouse	3263	0.0559	386	3,090	0.0559	307	2,454
Bi Level Controls, High Bay Fixtures, Public Assembly	3264	0.0372	343	2,741	0.0372	272	2,176
Bi Level Controls, High Bay Fixtures, Other	3265	0.0434	292	2,332	0.0434	231	1,852

Annual and Lifecycle Deemed Savings in Industrial and Schools & Government Sectors

Measure Name	MMID	Industrial			Schools & Government		
		kW	kWh	Lifecycle	kW	kWh	Lifecycle
Bi Level Controls, High Bay Fixtures, Gymnasium	3260	0.0465	287	2,297	0.0465	196	1,568
Bi Level Controls, High Bay Fixtures, Industrial	3261	0.0559	331	2,650	0.0559	226	1,809
Bi Level Controls, High Bay Fixtures, Retail	3262	0.0186	110	883	0.0186	75	603
Bi Level Controls, High Bay Fixtures, Warehouse	3263	0.0559	390	3,121	0.0559	266	2,131
Bi Level Controls, High Bay Fixtures, Public Assembly	3264	0.0372	346	2,768	0.0372	236	1,889
Bi Level Controls, High Bay Fixtures, Other	3265	0.0434	294	2,356	0.0434	201	1,608

Assumptions

The annual hours of operation for interior high bay applications is based on sector.

Bi level controls are able to and must achieve at least a 50% reduction in power requirements. Many systems can reduce the light output below 50%.

Product weightings were based on historical project information (gathered October 3, 2013) with a projected increase and prevalence of LED fixtures based on market knowledge. The higher weighting of LED fixtures leads to a more conservative wattage estimate (see table below).

Weighted Average High Bay Lighting Replacement Wattage[2]

Measure	Watts	Agriculture	Commercial	Industrial	Schools & Government	Total
250-399 Watt Replacements	185	13.90%	5.10%	9.70%	18.50%	9.00%
400-699 Watt Replacements	316	73.50%	61.40%	74.90%	70.40%	70.70%
400-999 Watt Replacements	335	12.60%	30.40%	10.30%	9.20%	16.00%
≤ 500 Watts, Replacing ≥ 1,000 Watts	355	0.00%	2.50%	4.40%	1.10%	3.60%
≤ 800 Watts, Replacing ≥ 1,000 Watts	591	0.00%	0.60%	0.70%	0.70%	0.70%
Total		**100%**	**100%**	**100%**	**100%**	**100%**
Average Watts		**300**	**318**	**309**	**295**	**310**

Wattages for LED, induction, fluorescent, ceramic metal halide, and pulse start metal halide fixtures were grouped into five replacement categories based on the existing high bay fluorescent replacement option groups from the deemed savings manual (Table4-204). A weighted average of the wattages per lighting technology was then taken for the four groups based on historical project information (gathered October 3, 2013), with a projected increase and prevalence of LED fixture. Refer to the following table for the technology weightings.

Lighting Technology Weightings

Technology	Weighting
Linear Fluorescent	65%
LED	20%
PSMH/CMH	10%
Induction	5%

Wattage by Fixture Type

Replacing 250-399 Watt HID		Replacing 400 HID < 365 Watt		Replacing 1,000 HID < 800 Watt	
Measure Name	**Wattage**	**Measure Name**	**Wattage**	**Measure Name**	**Wattage**
Induction 120 watt	132	Induction 250 watt	275	Induction 750 watt	825
Induction 125 watt	138	Induction 300 watt	330	PSMH or CMH 575 watt	640
Induction 150 watt	161	PSMH or CMH 250 watt	281	LED	690
Induction 165 watt	174	PSMH or CMH 270 watt	290	T8 or T5HO ≤ 800 watt	535
PSMH or CMH 125 watts	146	PSMH or CMH 315 watt	343		
PSMH or CMH 140 watts	154	PSMH or CMH 320 watt	640		
PSMH or CMH 150 watts	185	LED	296		
LED	119	T8 6 lamp or T5HO 4 lamp	212		
T8 4 lamp or T5HO 2 lamp	144	T8 8 lamp or T5HO 6 lamp	359		
T8 6 lamp or T5HO 4 lamp	212	T8 or T5HO ≤ 500 watt	363		

Replacing 400 HID < 250 Watt		Replacing 1,000 HID < 500 Watt	
Measure Name	**Wattage**	**Measure Name**	**Wattage**
Induction 200 watt	220	LED	338
PSMH or CMH 200 watt	225	T8 8 lamp or T5HO 6 lamp	359
PSMH or CMH 210 watt	229	T8 or T5HO ≤ 500 watt	363
PSMH or CMH 220 watt	242		
LED	169		
T8 6 lamp or T5HO 4 lamp	212		

Sources

1. *Focus on Energy Evaluation Business Programs: Measure Life Study Final Report*. August 25, 2009.
2. *Based on a rounded average of historical project information (gathered October 3, 2013).*
3. *Focus on Energy Business Programs Deemed Savings Manual V1.0. March 22, 2010.*

Revision History

Version Number	Date	Description of Change
01	12/2012	Initial TRM entry
02	10/2013	Changed entry from hybrid to prescriptive (MMID 3115)

Occupancy Sensors for High Bay Fixtures

	Measure Details
Measure Master ID	Occupancy Sensor, High Bay Fixtures: Gymnasium, 3254 Industrial, 3255 Retail, 3256 Warehouse, 3257 Public Assembly, 3258 Other, 3259
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Controls
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by fixture
Peak Demand Reduction (kW)	Varies by fixture
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by fixture
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	8[1]
Incremental Cost ($/unit)[3]	$150.00

Measure Description

This measure is occupancy sensors for high bay fixtures. Numerous new and existing installations use LED, induction, fluorescent, ceramic metal halide, and pulse start metal halide fixtures to light their high bay interiors, commonly in full light output for 24 hours a day. Occupancy controls and replacement products use ultrasonic and passive infrared sensors to turn the fixture off when these spaces become unoccupied. These products save energy by more efficiently lighting the spaces based on occupancy.

Description of Baseline Condition

The baseline condition is LED, induction, fluorescent, ceramic metal halide, and/or pulse start metal halide fixture input wattages with no lighting controls at the building interior.

Description of Efficient Condition

The efficient condition is an indoor wall, ceiling, or fixture mounted occupancy sensor being used to control a high bay fixture. The control must include a passive infrared and/or ultrasonic occupancy sensor with a feature to fail in "on" position in case of failure.

Annual Energy-Savings Algorithm

All algorithms and methodology are from: *Focus on Energy Business Programs Deemed Savings Manual V1.0*. March 22, 2010.[2]

The kW savings for this measure are deemed by space type, while kWh savings are deemed by sector and space type. Savings due to occupancy sensor installation are described by the following equations:

kWh_{SAVED} = LtgWatts / 1,000 * % Off * Hours

Where:

Ltg. Watts = Lighting wattage controlled, deemed (= 237 watts; updated per new wattage table to 310 watts)

1,000 = Kilowatt conversion factor

% Off = Percentage of time lights are controlled (= see table below)

Hours = Baseline hours per year (= see table below)

Percentage Of Values by Space Type (Various Sources)[2]

Space Type	Cal. SPC	RLW Schools	LRC	Maine	Average
Gymnasiums	35%	48%	-	35%	**39%**
Industrial	45%	-	-	-	**45%**
Retail	15%	-	-	-	**15%**
Warehouses	45%	-	65%	50%	**53%**
Public Assembly	35%	59%	-	-	**47%**
Other	-	-	-	-	**40%**

Hours-of-Use by Sector[2]

Sector	Hours
Commercial	3,730
Schools & Gov	3,239
Industrial	4,745
Agriculture	4,698

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = LtgWatts / 1,000 * CF

Where:

CF = Coincidence factor (= see table below)

Coincidence Factors by Space Type (Various Sources)[2]

Space Type	Cal. SPC	RLW Schools	Average
Gymnasiums	14%	15%	**15%**
Industrial	18%	-	**18%**
Retail	6%	-	**6%**
Warehouses	18%	-	**18%**
Public	14%	10%	**12%**
Other	-	-	**14%**

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Annual and Lifecycle Deemed Savings in Agriculture and Commercial Sectors

Measure Name	MMID	Agriculture			Commercial		
		kW	kWh	Lifecycle	kW	kWh	Lifecycle
Occupancy Sensor, High Bay Fixtures, Gymnasium	3254	0.0465	569	4,548	0.0465	451	3,611
Occupancy Sensor, High Bay Fixtures, Industrial	3255	0.0559	656	5,248	0.0559	521	4,167
Occupancy Sensor, High Bay Fixtures, Retail	3256	0.0186	219	1,749	0.0186	174	1,389
Occupancy Sensor, High Bay Fixtures, Warehouse	3257	0.0559	773	6,181	0.0559	613	4,907
Occupancy Sensor, High Bay Fixtures, Public Assembly	3258	0.0372	685	5,481	0.0372	544	4,352
Occupancy Sensor, High Bay Fixtures, Other	3259	0.0434	583	4,665	0.0434	463	3,704

Annual and Lifecycle Deemed Savings in Industrial and Schools & Government Sectors

Measure Name	MMID	Industrial			Schools & Government		
		kW	kWh	Lifecycle	kW	kWh	Lifecycle
Occupancy Sensor, High Bay Fixtures, Gymnasium	3254	0.0465	574	4,594	0.0465	392	3,136
Occupancy Sensor, High Bay Fixtures, Industrial	3255	0.0559	663	5,300	0.0559	452	3,618
Occupancy Sensor, High Bay Fixtures, Retail	3256	0.0186	221	1,767	0.0186	151	1,206
Occupancy Sensor, High Bay Fixtures, Warehouse	3257	0.0559	780	6,243	0.0559	533	4,261
Occupancy Sensor, High Bay Fixtures, Public Assembly	3258	0.0372	692	5,536	0.0372	472	3,779
Occupancy Sensor, High Bay Fixtures, Other	3259	0.0434	589	4,711	0.0434	402	3,216

Assumptions

Product weightings were based on historical project information (gathered October 3, 2013) with a projected increase and prevalence of LED fixtures based on market knowledge. The higher weighting of LED fixtures leads to a more conservative wattage estimate (see table below).

Weighted Average High Bay Lighting Replacement Wattage[2]

Measure	Watts	Agriculture	Commercial	Industrial	Schools & Government	Total
250-399 Watt Replacements	185	13.90%	5.10%	9.70%	18.50%	9.00%
400-699 Watt Replacements	316	73.50%	61.40%	74.90%	70.40%	70.70%
400-999 Watt Replacements	335	12.60%	30.40%	10.30%	9.20%	16.00%
≤ 500 Watts, Replacing ≥ 1,000 Watts	355	0.00%	2.50%	4.40%	1.10%	3.60%
≤ 800 Watts, Replacing ≥ 1,000 Watts	591	0.00%	0.60%	0.70%	0.70%	0.70%
Total		**100%**	**100%**	**100%**	**100%**	**100%**
Average Watts		**300**	**318**	**309**	**295**	**310**

Wattages for LED, induction, fluorescent, ceramic metal halide, and pulse start metal halide fixtures were grouped into five replacement categories based on the existing high bay fluorescent replacement option groups from the deemed savings manual (Table4-204). A weighted average of the wattages per lighting technology was then taken for the four groups based on historical project information (gathered

October 3, 2013), with a projected increase and prevalence of LED fixture. Refer to the following table for the technology weightings.

Lighting Technology Weightings

Technology	Weighting
Linear Fluorescent	65%
LED	20%
PSMH/CMH	10%
Induction	5%

Wattage by Fixture Type

Replacing 250-399 Watt HID		Replacing 400 HID < 365 Watt		Replacing 1,000 HID < 800 Watt	
Measure Name	**Wattage**	**Measure Name**	**Wattage**	**Measure Name**	**Wattage**
Induction 120 watt	132	Induction 250 watt	275	Induction 750 watt	825
Induction 125 watt	138	Induction 300 watt	330	PSMH or CMH 575 watt	640
Induction 150 watt	161	PSMH or CMH 250 watt	281	LED	690
Induction 165 watt	174	PSMH or CMH 270 watt	290	T8 or T5HO ≤ 800 watt	535
PSMH or CMH 125 watts	146	PSMH or CMH 315 watt	343		
PSMH or CMH 140 watts	154	PSMH or CMH 320 watt	640		
PSMH or CMH 150 watts	185	LED	296		
LED	119	T8 6 lamp or T5HO 4 lamp	212		
T8 4 lamp or T5HO 2 lamp	144	T8 8 lamp or T5HO 6 lamp	359		
T8 6 lamp or T5HO 4 lamp	212	T8 or T5HO ≤ 500 watt	363		

Replacing 400 HID < 250 Watt		Replacing 1,000 HID < 500 Watt	
Measure Name	**Wattage**	**Measure Name**	**Wattage**
Induction 200 watt	220	LED	338
PSMH or CMH 200 watt	225	T8 8 lamp or T5HO 6 lamp	359
PSMH or CMH 210 watt	229	T8 or T5HO ≤ 500 watt	363
PSMH or CMH 220 watt	242		
LED	169		
T8 6 lamp or T5HO 4 lamp	212		

Sources

1. *Focus on Energy Evaluation Business Programs: Measure Life Study Final Report*. August 25, 2009.
2. *Focus on Energy Business Programs Deemed Savings Manual V1.0. March 22, 2010.*
3. *Based on a rounded average of historical project information (gathered October 3, 2013).*

Revision History

Version Number	Date	Description of Change
01	10/07/2013	Updated deemed savings and all fixture options and wattages

Occupancy Sensors – Prescriptive

	Measure Details
Measure Master ID	Occupancy Sensor, Ceiling Mount ≤ 500 Watts, 2471 ≥ 1,001 Watts, 2472 501-Watts to 1,000 Watts, 2473 Occupancy Sensor, ≤ 200 Watts Wall Mount, 2483, 3361 Fixture Mount, 2474 Wall or Ceiling Mount, CALP, 3201 Fixture Mount, CALP, 3605 Occupancy Sensor > 200 Watts, Wall Mount, 2484, 3357 Fixture Mount, 2475 Wall or Ceiling Mount, CALP, 3202 Fixture Mount, CALP, 3606 Occupancy Sensor, Fixture Mount ≤ 60 Watts, 3561 > 60 Watts, 3560
Measure Unit	Per sensor
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Controls
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by connected wattage
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by connected wattage
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	8[1]
Incremental Cost ($/unit)	Ceiling Mount: $120.00

	Wall Mount: $35.00 Fixture Mount: $115.00

Measure Description

Occupancy sensors reduce energy consumption by reducing the operating hours for lighting equipment in low occupancy areas, such as hallways, storage rooms, and restrooms. Occupancy sensors automatically turn lights off a preset time after people leave a space, and turn lights on automatically when movement is detected. Occupancy sensors feature a delay adjustment that determines the time that lights are on after no occupancy is detected, as well as a sensitivity adjustment that determines the magnitude of the signal required to trigger the occupied status.

The two primary technologies used for occupancy sensors are passive infrared (PIR) and ultrasonic. PIR sensors determine occupancy by detecting the difference in heat between a body and the background. Ultrasonic sensors detect people using volumetric detectors and broadcast sounds above the range of human hearing, then measure the time it takes the waves to return.

Description of Baseline Condition

The baseline condition is no occupancy sensor, with lighting fixtures being controlled by manual wall switches.

Description of Efficient Condition

The efficient condition is a hard-wired, fixture-, wall-, or ceiling-mounted occupancy sensor, where lighting fixtures are controlled by the sensors based on detected occupancy.

Annual Energy-Savings Algorithm

kWh_{SAVED} = Watts / 1,000 * SF* HOU

Where:

Watts = Controlled lighting wattage (= see table below)

Controlled Lighting Wattage by Measure

Measure Name	Average Connected Wattage
Occupancy Sensor, Ceiling Mount, ≤ 500 Watts	350[2]
Occupancy Sensor, Ceiling Mount, ≥ 1,001 Watts	1,200[2]
Occupancy Sensor, Ceiling Mount, 501-1,000 Watts	750[2]
Occupancy Sensor, Wall Mount, ≤ 200 Watts	150[2]
Occupancy Sensor, Wall Mount, > 200 Watts	350[2]
Occupancy Sensor, Fixture Mount, ≤ 60 Watts	35[3]

Occupancy Sensor, Fixture Mount, > 60 Watts	89[3]

1,000 = Kilowatt conversion factor

SF = Savings factor, deemed (= 41%)[3]

HOU = Annual operating hours (= see table below)

Annual Operating Hours by Sector [3]

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

Summer Coincident Peak Savings Algorithm

There are no deemed summer peak savings for this measure. Although occupancy sensors may reduce load during the peak period, most savings will occur during non-peak hours.

$kW_{SAVED} = Watts / 1,000 * CF$

Where:

CF = Coincidence factor (= 0 kW)

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Deemed Annual Electricity Savings (kWh)

Measure Name	MMID	Multifamily	Commercial	Industrial	Agriculture	Schools & Government
Occupancy Sensor, Ceiling Mount, ≤ 500 Watts	2471	854	535	681	674	465
Occupancy Sensor, Ceiling Mount, ≥ 1,001 Watts	2472	2,927	1835	2335	2311	1594
Occupancy Sensor, Ceiling Mount, 501-1,000 Watts	2473	1,830	1147	1459	1445	996
Occupancy Sensor, Wall Mount, ≤ 200 Watts	2483; 2474; 3201; 3361; 3605	366	229	292	289	199
Occupancy Sensor, Wall Mount, > 200 Watts	2484; 2475; 3202; 3357; 3606	854	535	681	674	465
Occupancy Sensor, Fixture Mount, ≤ 60 Watts	3561	86	52	67	66	46
Occupancy Sensor, Fixture Mount, > 60 Watts	3560	217	133	169	167	115

Deemed Lifecycle Electricity Savings (kWh)

Measure Name	MMID	Multifamily	Commercial	Industrial	Agriculture	Schools & Government
Occupancy Sensor, Ceiling Mount, ≤ 500 Watts	2471	6,831	4282	5447	5393	3718
Occupancy Sensor, Ceiling Mount, ≥ 1,001 Watts	2472	23,419	14681	18676	18491	12749
Occupancy Sensor, Ceiling Mount, 501-1,000 Watts	2473	14,637	9176	11673	11557	7968
Occupancy Sensor, Wall Mount, ≤ 200 Watts	2483; 2474; 3201; 3361; 3605	2,927	1835	2335	2311	1594
Occupancy Sensor, Wall Mount, > 200 Watts	2484; 2475; 3202; 3357; 3606	6,831	4282	5447	5393	3718
Occupancy Sensor, Fixture Mount, ≤ 60 Watts	3561	686	419	534	528	364
Occupancy Sensor, Fixture Mount, > 60 Watts	3560	1,737	1,062	1,351	1,338	922

Assumptions

Occupancy controls at small commercial facilities can be expected achieve a 41% savings[3], based on an average derived from sources that specify the different savings factors in different spaces such as offices, corridors, restrooms, and storage areas.

The deemed summer peak savings is set to zero. Although occupancy sensors may reduce load during the peak period, no savings are assumed because uses are widely variable and most savings will occur during non-peak hours.

Occupancy controls at small commercial facilities can be expected achieve a 50% reduction in power requirements, so a 40% reduction is used as a conservative estimate. No kilowatt savings are estimated because of the variable nature of the uses.

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. Average wattage taken from common pin-based CFL fixtures and 4-foot linear fluorescent fixtures ≤ 60 watts and > 60 watts.
3. PA Consulting Group Inc. and Public Service Commission of Wisconsin. Focus on Energy. Evaluation, Business Programs: Deemed Savings Manual V1.0. March 22, 2010. Hours of Use can be found in Table 3.2. Average connected wattages can be found on Final Report, Page 4-194 and Table 4-163

Revision History

Version Number	Date	Description of Change
01	04/06/2015	Initial TRM entry
02	04/12/2015	Combined workpapers, added comments

CFL Fixture, 12 Hours, CALP

	Measure Details
Measure Master ID	CFL Fixture, 12 Hours, CALP: Interior, 3198 Exterior, 3199
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Compact (CFL)
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	278
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by installation year
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	13[1]
Incremental Cost ($/unit)	$79.00[2]

Measure Description

Hardwired CFL incentives apply only to complete new fixtures or modular (pin or GU-24 based) retrofits with hardwired electronic ballasts. Incentives are for the replacement of incandescent fixtures only, and replacements must result in a net decrease in energy use. CFLs provide the same or better light output than incandescent lamps while using 75% less energy.

Description of Baseline Condition

The baseline equipment is a one or two lamp, 60-watt incandescent fixture on a switch, photocell, or timer that is used for 12 or more hours per day.

Description of Efficient Condition

Hardwired CFL incentives apply only to complete new fixtures or modular (pin or GU-24 based) retrofits with hardwired electronic ballasts. Incentives are for the replacement of incandescent fixtures only.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{INCANDESCENT} – kWh_{CFL}$

Where:

$kWh_{INCANDESCENT}$ = kWh use incandescent fixture (baseline)

kWh_{CFL} = kWh use CFL fixture (new fixture)

Summer Coincident Peak Savings Algorithm

There are no peak savings are this measure.

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

EISA Compliant Lifetime Savings*

Measure	Installation Year			
	2013	2014	2015	2016 and Beyond
Multifamily CALP CFL Fixture, 12 hour	2,411.2 kWh 0.0000 kW	2,306.9 kWh 0.0000 kW	2,254.8 kWh 0.0000 kW	2,254.8 kWh 0.0000 kW

* Pre-EISA savings ended on July 1, 2014; six months after EISA phased out the standard 60-watt A-19 incandescent lamp.

Assumptions

A weighted average of one and two lamp fixtures with 60-watt incandescent lamps being replaced with a fixture containing –one or two 13-watt CFLs operating at least 12 hours per day was used to determine savings. Weighting based on historical project data and estimates.

Sources

1. PA Consulting Group Inc. *Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs: Measure Life Study, Final Report*. August 25, 2009.
2. Michigan DEER Measure Master database. 2013.

Revision History

Version Number	Date	Description of Change
01	06/2013	Initial TRM entry

HPT8, 1-Foot by 4-Foot, Replacing T12 or T8, 2 Lamp

	Measure Details
Measure Master ID	HPT8, 1-Foot by 4-Foot, Replacing T12 or T8, 2 Lamp: SBP After A La Carte, 3390 SBP A La Carte, 3391 SBP Package, 3392
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Linear
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	13[1]
Incremental Cost ($/unit)	$45.00

Measure Description

High performance fixture replacements save energy over standard wattage fluorescent fixtures by increasing the number of lumens per watt and reducing the number of lamps needed to produce appropriate lighting levels. The one-lamp HP 1-foot by 4-foot fixture will replace a 2-lamp or greater T12 or T8 fixture.

Description of Baseline Condition

The baseline measure is EISA-compliant T8 linear fluorescent fixtures with 58 watts and two lamps; or T12 linear fluorescent fixtures with 82 watts and two lamps.

Description of Efficient Condition

The efficient condition is using one 32-watt T8 lamp in a 1-foot by 4-foot fixture combined with a ballast that has a normal ballast factor.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (W_{EX} - W_{HP}) / 1{,}000 * HOURS$

Where:

W_{EX} = Wattage of existing T8 or T12 lamps and ballasts

W_{HP} = Wattage of the of HP 2-lamp 1-foot by 4-foot luminaire

1,000 = Conversion

HOURS = Average annual run hours (= see table below)

Hours-of-Use by Sector[2]

Sector	Hours
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,299

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (W_{Ex} - W_{HP}) / 1{,}000 * CF$

Where:

CF = Demand coincidence factor (= see table below)

Demand Coincidence Factor by Sector

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

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = (kWh_{EX} – kWh_{HP}) * N + (kWh_{EISA} – kWh_{HP}) * (EUL - N)$

$kWh_{EX} = W_{EX} / 1{,}000 * HOURS$

kWh_{HP} = W_{HP} / 1,000 * HOURS

kWh_{EISA} = W_{EISA} / 1,000 * HOURS

Where:

kWh_{EX} = Annual electricity consumption of existing T8 and T12 lamps and ballasts

kWh_{HP} = Annual electricity consumption of HP one-lamp, 1-foot by 4-foot luminaire

N = Number of years until 2016 (2014 = 2, 2015=1)

kWh_{EISA} = Annual electricity consumption of EISA compliant lamps and ballasts

W_{EISA} = Existing wattage of EISA compliant lamps and ballasts

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

This calculation is used to account for the federal legislation stemming from EISA, which dictates the fluorescent fixture efficiency in lumens per watt. As of July 14, 2012, federal standards require that practically all linear fluorescents meet strict performance requirements, such that all consumers will need to upgrade to high performance T8 and T5 lamps and electronic ballasts when purchasing new bulbs. The effect is that first-year savings for T12 to T8 replacements can be assumed only for the remaining useful life of T12 equipment, at which point customers have no choice but to install equipment meeting the new standard.

The calculation above is based on the Illinois TRM, for which the standard is expected to become fully effective 2016. Therefore, the N is set as the number of years until 2016; after that, the remainder of the new fixture EUL will accumulate lifetime savings with the baseline assuming that the EISA regulations are in full effect. As the years between the installed measures and 2016 decreases, the lifetime savings decrease.

Deemed Savings

Average Annual Deemed Savings for HP 1-Lamp, 1-Foot by 4-Foot Fixture Replacement of 2-Lamp 1-Foot by 4-Foot T8 and T12 Fixtures

Measure	Commercial 3,730 (0.77)		Industrial 4,745 (0.77)		Agriculture 4,698 (0.67)		Schools & Gov 3,239 (0.64)	
	kWh	kW	kWh	kW	kWh	kW	kWh	kW
HPT8 1-Foot by 4-Foot Replacement, 2014-2015	156	0.0322	199	0.0322	197	0.0280	136	0.0268
HPT8 1-Foot by 4-Foot Replacement, 2016 and Beyond	111	0.0230	142	0.0230	140	0.0200	97	0.0191

Average Lifecycle Deemed Savings for HP 1-Lamp, 1-Foot by 4-Foot Fixture Replacement of 2-Lamp 1-Foot by 4-Foot T8 and T12 Fixtures

Sector	2014	2015	2016 and Beyond
Commercial	1,536	1,492	1,447
Industrial	1,955	1,898	1,841
Agriculture	1,935	1,879	1,822
Schools & Government	1,334	1,295	1,256

Assumptions

The following table is based on a July 2013 contractor pricing quote from Wesco Distribution for a reflector, lamp, and ballast. The quote is for materials only, and labor was estimated at approximately $25 for this product. The installed cost was rounded to $75.00 total ($50.00 for materials and $25.00 for labor).

Measure Cost Quotes

Item	Price	Brand
TRK14S-T8 with mirror reflector for 2-lamp T12 to 1-lamp T8 conversion	$34.10	Louv
F32T8ADV850/EW/ALTO (28 watt T8 lamp) wesco #28105	$3.15	PHL
IOPA2P32N35I 2-lamp T8 ballast - normal version	$10.40	ADV

The 1-foot by 4-foot HP fixture uses one 32-watt T8 and a ballast with a 0.88 ballast factor. Replaced fixtures are assumed to be 50% T8s and 50% T12s in 2014 and 2015.

The Illinois TRM assumes that this standard will become fully effective in 2016. Their recommendation is due to a realistic expectation that if a customer relamps an existing T12 fixture the day the standard takes effect, they would likely need to upgrade to T8s in less than five years. The Illinois TRM therefore recommends that for T12 systems, the baseline becomes a standard T8 in 2016, regardless of the equipment on the site. In addition, retrofits to T12 systems installed before 2016 have a baseline adjustment applied in 2016 for the remainder of the measure life.

Sources

1. Similar measure MMID 2561 (existing HPT8 one-lamp measure). PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Lighting Hours of Use and Coincidence Factors by Sector. March 22, 2010.
3. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Lighting Hours of Use and Coincidence Factors by Sector. March 22, 2010.

Revision History

Version Number	Date	Description of Change
01	2/2014	Initial TRM entry

8-Foot Linear Fluorescent T8 Replacement System

	Measure Details
Measure Master ID	T8, 2-Lamp, 4-Foot, HPT8 or RWT8: Replacing T12, 1-Lamp, 8-Foot, 0.78 < BF < 1.00, SBP A La Carte, 3307 Replacing T12, 1-Lamp, 8-Foot, 0.78 < BF < 1.00, 3122 Replacing T12, 1-Lamp, 8-Foot, BF ≤ 0.78, 3123 Replacing T12HO, 1-Lamp, 8-Foot, 0.78 < BF < 1.00, SBP A La Carte, 3312 Replacing T12HO, 1-Lamp, 8-Foot, 0.78 < BF < 1.00, 3124 Replacing T12HO, 1-Lamp, 8-Foot, BF ≤ 0.78, 3125 Replacing T12HO, 1-Lamp, 8-Foot, BF > 1.00, 3126 T8, 4-Lamp, 4-Foot, HPT8 or RWT8: Replacing T12, 2-Lamp, 8-Foot, 0.78 < BF < 1.00, SBP A La Carte, 3309 Replacing T12, 2-Lamp, 8-Foot, 0.78 < BF < 1.00, 3127 Replacing T12, 2-Lamp, 8-Foot, BF ≤ 0.78, 3128 Replacing T12HO 1L 8', 0.78 < BF < 1.00, SBP A La Carte, 3312 Replacing T12HO, 2-Lamp, 8-Foot, 0.78 < BF < 1.00, SBP A La Carte, 3314 Replacing T12HO, 2-Lamp, 8-Foot, 0.78 < BF < 1.00, 3129 Replacing T12HO, 2-Lamp, 8-Foot, BF ≤ 0.78, 3130 Replacing T12HO, 2-Lamp, 8-Foot, BF > 1.00, 3131 Replacing T12VHO, 2-Lamp, 8-Foot, 0.78 < BF < 1.00, 3132 Replacing T12VHO, 2-Lamp, 8-Foot, BF ≤ 0.78, 3133 Replacing T12VHO, 2-Lamp, 8-Foot, BF > 1.00, 3134
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Linear
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	Varies by measure
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	Varies by measure[2]

Measure Description

High performance (HP) and reduced wattage (RW) 4-foot linear fluorescent lighting fixtures that use low ballast factors, high wattage lamps, or reduced wattage lamps are an energy-efficient alternative to 8-foot, standard wattage T12, T12HO, and T12VHO linear fluorescent fixtures. These products can be installed on a two-to-one basis to replace 1-lamp or 2-lamp T12 luminaires without sacrificing lighting quality.

Description of Baseline Condition

For existing buildings, the baseline measure is 8-foot, 1-lamp or 2-lamp standard T12, T12HO, and T12VHO linear fluorescent fixtures. High output (HO) 8-foot T12 baseline lamps range from 95 watts to 110 watts, while for very high output (VHO) lamps the range is 185 watts to 215 watts.

Description of Efficient Condition

The efficient measure is 2-lamp or 4-lamp, 4-foot, high performance T8 fixtures with normal and low ballast factor, and reduced wattage, 25-watt and 28-watt T8s with high, normal, and low ballast factors.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{8' T12} - kWh_{HP/RW}$

Where:

$kWh_{8' T12}$ = Annual electricity consumption of an 8-foot T12, T12HO, or T12VHO linear fluorescent lamp fixture

$kWh_{HP/RW}$ = Annual electricity consumption of a 4-foot, linear fluorescent, high performance or reduced wattage fixture

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = Wattage/1{,}000 * CF$

Where:

Wattage = Wattage of installed fixture

1,000 = Conversion

CF = Demand coincidence factor (= see table below)

Demand Coincidence Factor by Sector

Sector	CF[5]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Annual Deemed Savings for 8-FootLinear Fluorescent T8 Replacement System

Measure	MMID	Commercial 3,730 (0.77)		Schools & Gov 3,239 (0.64)		Industrial 4,745 (0.77)		Agriculture 4,698 (0.67)	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW
T8, 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12, 1-Lamp, 8-Foot, 0.78 < BF < 1.00	3122 SBP A La Carte, 3307	112	0.0231	97	0.0192	142	0.0231	141	0.0201
T8, 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12, 1-Lamp, 8-Foot, BF ≤ 0.78	3123	137	0.0283	119	0.0235	174	0.0283	173	0.0246
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12, 2-Lamp, 8-Foot, 0.78 < BF < 1.00	3127 SBP A La Carte, 3309	129	0.0266	112	0.0221	164	0.0266	162	0.0231
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12, 2-Lamp, 8-Foot, BF ≤ 0.78	3128	175	0.0362	152	0.0301	223	0.0362	220	0.0315
T8, 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 1-Lamp, 8-Foot, BF > 1.00	3126	202	0.0416	175	0.0346	257	0.0416	254	0.0362
T8, 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing	3124 SBP A La	269	0.0555	234	0.0461	342	0.0555	339	0.0483

Measure	MMID	Commercial 3,730 (0.77)		Schools & Gov 3,239 (0.64)		Industrial 4,745 (0.77)		Agriculture 4,698 (0.67)	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW
T12HO, 1-Lamp, 8-Foot, 0.78 < BF < 1.00	Carte, 3312								
T8, 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 1-Lamp, 8-Foot, BF ≤ 0.78	3125	294	0.0606	255	0.0504	374	0.0606	370	0.0527
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 2-Lamp, 8-Foot, BF > 1.00	3131	322	0.0665	280	0.0553	410	0.0665	406	0.0579
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 2-Lamp, 8-Foot, 0.78 < BF < 1.00	3129; SBP A La Carte, 3314	461	0.0952	400	0.0791	586	0.0952	581	0.0828
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 2-Lamp, 8-Foot, BF ≤ 0.78	3130	507	0.1047	440	0.0870	645	0.1047	639	0.0911
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO, 2-Lamp, 8-Foot, BF > 1.00	3134	967	0.1997	840	0.1660	1,230	0.1997	1,218	0.1738
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO, 2-Lamp, 8-Foot, 0.78 < BF < 1.00	3132	1,106	0.2284	960	0.1898	1,407	0.2284	1,393	0.1987
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO, 2-Lamp, 8-Foot, BF ≤ 0.78	3133	1,153	0.2379	1,001	0.1977	1,467	0.2379	1,452	0.2070

Lifecycle Deemed Savings for 8-Foot Linear Fluorescent T8 Replacement System

Measure	MMID	Commercial 3,730 (0.77)	Schools & Gov 3,239 (0.64)	Industrial 4,745 (0.77)	Agriculture 4,698 (0.67)
		kWh	kWh	kWh	kWh
T8, 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12, 1-Lamp, 8-Foot, 0.78 < BF < 1.00	3122 SBP A La Carte, 3307	1,680	1,455	2,130	2,115
T8, 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12, 1-Lamp, 8-Foot, BF ≤ 0.78	3123	2,055	1,785	2,610	2,595
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12, 2-Lamp, 8-Foot, 0.78 < BF < 1.00	3127 SBP A La Carte, 3309	1,935	1,680	2,460	2,430
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12, 2-Lamp, 8-Foot, BF ≤ 0.78	3128	2,625	2,280	3,345	3,300
T8, 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 1-Lamp, 8-Foot, BF > 1.00	3126	3,030	2,625	3,855	3,810
T8, 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 1-Lamp, 8-Foot, 0.78 < BF < 1.00	3124 SBP A La Carte, 3312	4,035	3,510	5,130	5,085
T8, 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 1-Lamp, 8-Foot, BF ≤ 0.78	3125	4,410	3,825	5,610	5,550
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 2-Lamp, 8-Foot, BF > 1.00	3131	4,830	4,200	6,150	6,090
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 2-Lamp, 8-Foot, 0.78 < BF < 1.00	3129; SBP A La Carte, 3314	6,915	6,000	8,790	8,715
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 2-Lamp, 8-Foot, BF ≤ 0.78	3130	7,605	6,600	9,675	9,585
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO,	3134	14,505	12,600	18,450	18,270

Measure	MMID	Commercial 3,730 (0.77)	Schools & Gov 3,239 (0.64)	Industrial 4,745 (0.77)	Agriculture 4,698 (0.67)
		kWh	kWh	kWh	kWh
2-Lamp, 8-Foot, BF > 1.00					
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO, 2-Lamp, 8-Foot, 0.78 < BF < 1.00	3132	16,590	14,400	21,105	20,895
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO, 2-Lamp, 8-Foot, BF ≤ 0.78	3133	17,295	15,015	22,005	21,780

Measure Costs for 8-Foot Linear Fluorescent T8 Replacement System[2]

Measure	MMID	Cost ($)
T8, 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12, 1-Lamp, 8-Foot, 0.78 < BF < 1.00	3122; SBP A La Carte, 3307	$41.00
T8, 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12, 1-Lamp, 8-Foot, BF ≤ 0.78	3123	$41.00
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12, 2-Lamp, 8-Foot, 0.78 < BF < 1.00	3127; SBP A La Carte, 3309	$66.00
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12, 2-Lamp, 8-Foot, BF ≤ 0.78	3128	$66.00
T8, 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 1-Lamp, 8-Foot, BF > 1.00	3126	$41.00
T8, 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 1-Lamp, 8-Foot, 0.78 < BF < 1.00	3124; SBP A La Carte, 3312	$41.00
T8, 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 1-Lamp, 8-Foot, BF ≤ 0.78	3125	$41.00
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 2-Lamp, 8-Foot, BF > 1.00	3131	$66.00
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 2-Lamp, 8-Foot, 0.78 < BF < 1.00	3129; SBP A La Carte, 3314	$66.00
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO, 2-Lamp, 8-Foot, BF ≤ 0.78	3130	$66.00
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO, 2-Lamp, 8-Foot, BF > 1.00	3134	$66.00
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO, 2-Lamp, 8-Foot, 0.78 < BF < 1.00	3132	$66.00
T8, 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO, 2-Lamp, 8-Foot, BF ≤ 0.78	3133	$66.00

Sources

1. Focus on Energy Evaluation Business Programs: Measure Life Study Final Report. August 25, 2009. And DEER 2014 EUL Table. http://www.deeresources.com/. Rated ballast life of 70,000 hours, not rated on bulb life. As such the value is capped at 15 years.
2. Focus on Energy EUL Database. April 18, 2013. (Average of 15 years and 13 years)
3. Michigan Master Measure Database. 2011 baselines. Updated May 26, 2011.
4. Focus on Energy Business Programs Deemed Savings Manual V1.0. Commercial Applications. March 22, 2010.
5. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
6. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.

Revision History

Version Number	Date	Description of Change
01	12/2012	Initial TRM entry

Reduced Wattage T5 and T5HO Lamps Replacing Standard T5 Lamps

	Measure Details
Measure Master ID	Reduced Wattage Lamps: Replacing Standard T5, 3023 Replacing Standard T5HO, 3024
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Linear
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	T5 = 6; T5HO = 8[1]
Incremental Cost ($/unit)	T5 = $1.00; T5HO = $15.00[4]

Measure Description

Reduced wattage T5 and T5HO lamps save energy by reducing the total input wattage of the luminaires where they are installed. Reduced wattage T5 and T5HO lamps can be installed in place of existing standard wattage T5 and T5HO lamps where the tasks that take place in the space do not require the light level provided by the existing T5 and T5HO lamps.

Description of Baseline Condition

The baseline equipment is 4-foot, T5 28-watt lamps and 4-foot, 54-watt T5HO lamps.

Description of Efficient Condition

The efficient equipment is 4-foot, 26-watt T5 lamps and 4-foot, 44-watt, 47-watt, 49-watt, or 51-watt T5HO lamps.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{28wattT5\ or\ 54wattT5HO} - kWh_{RWLamp}$

Where:

$kWh_{28wattT5\ or\ 54wattT5HO}$ = Annual electricity consumption of standard 28-watt, 4-foot T5 lamp or 4-foot, 54-watt T5HO lamp

kWh_{RWLamp} = Annual electricity consumption of reduced wattage 4-foot, 26-watt T5 lamp or 44-watt, 47-watt, 49-watt, or 51-watt T5HO lamp

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = Wattage / 1,000 * CF$

Where:

Wattage = Wattage of installed fixture; (= ballast factor * lamp wattage)

1,000 = Conversion

CF = Demand coincidence factor (= see table below)

Demand Coincidence Factor by Sector

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

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = (kWh_{28wattT5\ or\ 54wattT5HO} - kWh_{RWLamp}) * EUL$

Where:

EUL = Effective useful life (= 6 years for T5; = 8 years for T5HO)[1]

Deemed Savings

Average Annual Deemed Savings for Reduced Wattage T5 and T5HO Lamps Replacing Standard T5 and T5HO Lamps

Measure	MMID	Commercial 3,730 (0.77)		Schools & Gov 3,239 (0.64)		Industrial 4,745 (0.77)		Agriculture 4,698 (0.67)	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW
RW T5 Lamp	3023	7	0.0015	6	0.0012	9	0.0015	9	0.0013
RW T5HO Lamp	3024	23	0.0048	20	0.0040	29	0.0048	29	0.0042

Average Lifecycle Deemed Savings for Reduced Wattage T5 and T5HO Lamps Replacing Standard T5 and T5HO Lamps

Measure	MMID	Commercial 3,730 (0.77)	Schools & Gov 3,239 (0.64)	Industrial 4,745 (0.77)	Agriculture 4,698 (0.67)
		kWh	kWh	kWh	kWh
RW T5 Lamp	3023	42	36	54	54
RW T5HO Lamp	3024	184	160	232	232

Assumptions

An average of 25% each of 44-watt, 47-watt, 49-watt, and 51-watt 4-foot T5HO lamps was used to generate the new measure wattage and savings for the T5HO lamp replacement measure.

A 26-watt T5 lamps was used to generate the new measure wattage and savings for the T5 lamp replacement measure.

Sources

1. Multiple manufacturers' product life rating (≈ 25,000 hours for T5 and ≈ 30,000 hours for T5HO lamps.
2. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
3. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.
4. Based on market knowledge. Information gathered December 15, 2012.

Revision History

Version Number	Date	Description of Change
01	12/2012	Initial TRM entry

Reduced Wattage 8-Foot T8 Lamps Replacing 8-Foot Standard T8 Lamps

	Measure Details
Measure Master ID	Reduced Wattage 8-Foot T8 Lamps Replacing 8-Foot Standard T8 Lamps, 2665
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Linear
Sector(s)	Residential - multi family
Annual Energy Savings (kWh)	Varies by wattage
Peak Demand Reduction (kW)	Varies by wattage
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by wattage
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	$8.00[4]

Measure Description

Reduced wattage 8-foot standard wattage T8 lamps save energy by reducing the total input wattage of the luminaires where installed. Reduced wattage 8-foot T8 lamps can be installed in place of existing 59-watt 8-foot T8 lamps where the tasks that take place in the space do not require the light level provided by the existing lamps.

Description of Baseline Condition

The baseline equipment is standard 59-watt 8-foot T8 lamps.

Description of Efficient Condition

The efficient equipment is 49-watt, 50-watt, 51-watt, or 54-watt 8-foot T8 lamps.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{59wattT8} - kWh_{RWLamp}$

Where:

$kWh_{59wattT8}$ = Annual electricity consumption of standard 59-watt 8-foot T8 lamp

kWh_{RWLamp} = Annual electricity consumption of reduced wattage 8-foot T8 lamp

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = Wattage / 1,000 * CF

Where:

Wattage = Wattage of installed fixture; (= ballast factor * lamp wattage)

1,000 = Conversion

CF = Demand coincidence factor (= see table below)

Demand Coincidence Factor by Sector

Sector	CF[3]
Multifamily	0.77

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE}$ = ($kWh_{59wattT8}$ - kWh_{RWLamp}) * EUL

Where:

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

Assumptions

An average of 25% each of 49-watt, 50-watt, 51-watt, and 54-watt 8-foot T8 lamps was used to generate the new measure wattage.

Sources

1. DEER 2014. http://www.deeresources.com/. Rated ballast life of 70,000 hours. Not rated on bulb life. Capped at 15 years.
2. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
3. *Focus on Energy Business Programs Deemed Savings Manual V1.0*. Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.
4. Based on market knowledge.

Revision History

Version Number	Date	Description of Change
01	12/2012	Updated savings values

T8, Low-Watt Relamp

	Measure Details
Measure Master ID	T8, Low-Watt Relamp: 54 Watts, 8-Foot, 2707 8-Foot, 3135
Measure Unit	Per unit
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Linear
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	18
Peak Demand Reduction (kW)	0.0034
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	90
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Incremental Cost ($/unit)	$2.00[2]

Measure Description

Replacing standard T8 lamps with reduced wattage T8 lamps can result in energy savings while still maintaining adequate light levels. This measure is replacing standard replacing standard 59-watt, 8-foot T8 lamps with 54-watt T8 lamps. This measure is for the replacement of lamps only.

Light levels after relamping should meet current Illuminating Engineering Society of North America standards. Reduced-wattage lamps should be CEE listed, and should be used with compatible and existing T8 electronic ballasts. The nominal wattages of the new lamps must be 54 watt.

Description of Baseline Condition

Baseline lamp is 59-watt T8 lamps.

Description of Efficient Condition

54-watt T8 efficient lamps should be used with compatible T8 electronic ballasts:

Annual Energy-Savings Algorithm

$kWh_{SAVED} = [(P_E – P_P) / 1,000] * HOURS$

Where:

P_E = Existing lighting wattage

P_P = Proposed replacement lighting wattage

1,000 = Kilowatt conversion factor

HOURS = Annual operating hours

Summer Coincident Peak Savings Algorithm

$$kW_{SAVED} = [(P_E - P_P) / 1{,}000) * CF$$

Where:

CF = Demand coincident factor

Lifecycle Energy-Savings Algorithm

$$kWh_{LIFECYCLE} = [(P_E - P_P) / 1{,}000) * HOURS * EUL$$

Where:

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

Sources

1. PA Consulting Group Inc. *Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs: Measure Life Study, Final Report*. August 25, 2009.
2. Michigan Public Service Commission. *Michigan Energy Measures Database*. Available online: http://www.michigan.gov/mpsc/0,1607,7-159-52495_55129---,00.html

Revision History

Version Number	Date	Description of Change
01	10/25/2012	Initial draft
02	01/08/2013	Updated to new template
03	03/08/2013	Updated

T8, 2 Lamp, 4-Foot, Recessed Indirect Fixture, HPT8, Replacing 3 Lamp or 4 Lamp T8 or T12

	Measure Details
Measure Master ID	T8, 2 Lamp, 4-Foot, Recessed Indirect Fixture, HPT8, Replacing 3 Lamp or 4 Lamp T8 or T12, 2704
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Linear
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential-multifamily
Annual Energy Savings (kWh)	179.0 kWh T5 fixture, 276.0 kWh T8 fixture
Peak Demand Reduction (kW)	0.0231 kW T5 fixture, 0.0355 kW T8 fixture
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	2,685.0 kWh T5 fixture, 4,140.0 kWh T8 fixture
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[3]
Measure Incremental Cost ($/unit)	$50.00 Existing Buildings, $8.19 New Construction[4]

Measure Description

This measure is replacing 3 lamp or 4 lamp, 4-footstandard T8 and T12 fixtures with 2 lamp F28T5, HPT8, RWT8 2x4 high-efficiency recessed fixtures.

Description of Baseline Condition

The baseline measure is 3 lamp or 4 lamp, 4-foot standard T8 and T12 fixtures.

Description of Efficient Condition

The efficient measure is 2 lamp F28T5, HPT8, RWT8 2x4 high-efficiency recessed fixtures.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{DEEMED} * (HOURS_{MULTIFAMILY} / HOURS_{COMMERCIAL})$

Where:

kWh_{DEEMED} = Annual commercial deemed electricity savings

$HOURS_{MULTIFAMILY}$ = Annual multifamily deemed lighting hours (= 3,730)[2]

$HOURS_{COMMERCIAL}$ = Annual commercial deemed lighting hours (= 5,949.5; 16.3 hours/day * 365 days/year)[1]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = Wattage / 1{,}000 * CF$

Where: CF=0.77 [1]

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Deemed Savings[2]

Measure	Annual Energy Savings (kWh)	Peak Demand Reduction (kW)	Lifecycle Energy Savings (kWh)
4-Foot, 2 Lamp, T5 Fixture	179.0	0.0231	2,685.0
4-Foot, 2 Lamp, T8 Fixture	276.0	0.0355	4,140.0

Sources

5. ACES. *Deemed Savings Desk Review.* Multifamily applications for common areas. November 3, 2010.

Focus on Energy Business Programs Deemed Savings Manual V1.0. Tables 4-185, 4-190, and 4-208, Commercial Applications. March 22, 2010.

CA DEER EUL IDs "ILtg-Lfluor-CommArea" and "Linear Fluorescents - MF Common Area."

2005 DEER D03-852 Database.

Revision History

Version Number	Date	Description of Change
01	01/02/2013	New measure

Ceramic Metal Halide Lamp, ≤ 25 Watts

	Measure Details
Measure Master ID	Ceramic Metal Halide Integral Ballast Lamps, ≤ 25 watts, 2238
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	High Intensity Discharge (HID)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	341
Peak Demand Reduction (kW)	0.0443
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	3,751
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	11[1]
Incremental Cost ($/unit)	$50.00[3]

Measure Description

Integral ballast ceramic metal halide lamps are an energy-saving alternative to standard 70 watt to 100 watt incandescent lamps. These ceramic metal halide lamps can be applied in several common applications without sacrificing any needed performance.

Description of Baseline Condition

The baseline condition is 70 watt to 100 watt incandescent flood or spot lamps.

Description of Efficient Condition

The efficient condition is ceramic metal halide lamps with integrated ballasts.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{DEEMED} * (HOURS_{MULTIFAMILY} / HOURS_{COMMERCIAL})$

Where:

kWh_{DEEMED} = Annual commercial deemed electricity savings

$HOURS_{MULTIFAMILY}$ = Annual multifamily deemed lighting hours(=733.65)[2]

$HOURS_{CCOMMERCIAL}$ = Annual commercial deemed lighting hours (=3,730) [2]

Summer Coincident Peak Savings

$kW_{Demand} = kW_{saved} / HOURS * CF$

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 11 years)[1]

Deemed Savings

Annual deemed savings per CMH integral ballast lamp is 341.0 kWh and 0.0443 kW.

Lifecycle deemed savings per CMH integral ballast lamps is 682 kWh.

Assumptions

- The 214 kWh and 0.0443 kW deemed savings is from: *Focus on Energy Business Programs Deemed Savings Manual V1.0*. Table 4-194 Commercial Applications. March 22, 2010.
- The 3,730 annual operating hours is from: *Focus on Energy Business Programs Deemed Savings Manual V1.0*. Table 4-185 Commercial Applications. March 22, 2010.
- The 5,949.5 annual operating hours (16.3 hours/day * 365 days/year) is from: *Focus on Energy ACES Deemed Savings Desk Review*. Multifamily applications for common areas. November 3, 2010.

Sources

1. Averaged between Cadmus 2013 database, DEER 2008, 2009 Focus study, and Fannie Mae Estimated Useful Life Table: https://www.fanniemae.com/content/guide_form/4099f.pdf .
2. Focus on Energy Business Programs Deemed Savings Manual V1.0. Commercial Applications. March 22, 2010.
3. Based on market knowledge, data gathered December 15, 2012.

Revision History

Version Number	Date	Description of Change
01	01/02/2013	New measure
02	03/11/2013	Revisions per comments

Exterior/Parking LED Fixtures

	Measure Details
Measure Master ID	LED Fixture, Replacing 150-175 Watt HID, Parking Garage: 24 Hour, 3100 Dusk to Dawn, 3101 LED Fixture, Replacing 250 Watt HID, Parking Garage: 24 Hour, 3103 Dusk to Dawn, 3104 LED Fixture, Replacing 70-100 Watt HID, Parking Garage: 24 Hour, 3109 Dusk to Dawn, 3110 LED Fixture, Replacing 320 Watt HID, Parking Garage, 3056
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	Varies by measure
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	16= 3101, 3104, 3110 and 8= 3100, 3103, 3109, 3506 [1]
Incremental Cost	Varies by measure, see Appendix D

Measure Description

Parking garage and exterior LED fixtures are an energy-saving alternative to traditional standard wattage HID light sources used for the same applications. LED light sources can be applied in almost every common application type where HID light sources are currently found.

Description of Baseline Condition

The baseline is standard HID lamps between 70 watts and 400 watts.

Description of Efficient Condition

Replacements must be complete fixtures with a total power reduction of 40% or more. Lamp-only replacements are not eligible for incentive. LEDs must be on the DLC qualifying list.[2]

Annual Energy-Savings Algorithm

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

Where:

$Watts_{BASE}$ = Annual electricity consumption of standard HID fixture (= see table below)

$Watts_{EE}$ = Annual electricity consumption of efficient LED fixture[2]

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 4,380 for dusk to dawn/exterior; = 8,760 for 24 hours)

Baseline HID Lamps	$Watts_{BASE}$
70-watt to 100-watt HID replacement	70-watt HID: 94 watts 100-watt HID: 129 watts
150-watt HID replacement	150-watt HID: 179 watts
175-watt HID replacement	175-watt HID: 210 watts
250-watt HID replacement	250-watt HID: 299 watts
320-watt HID replacement	320-watt HID: 368 watts

Baseline Wattage by HID Lamp Type

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= 0 for exterior lights; = 0 or 1 for garage lights)

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Average Deemed Savings for Exterior LED Fixtures

Annual Savings Measure	MMID	Annual kWh Savings	Lifecycle kWh Savings
Exterior LED replacing 320-watt HID	3056	645	7,737

Average Annual Deemed Savings for Parking LED Fixtures

Measure (hours)	MMID	kWh	kW
Parking LED replacing 70-watt to 100-watt (8,760)	3109	391	0.045
Parking LED replacing 70-watt to 100-watt (4,380)	3110	195	0
Parking LED replacing 150-watt to 175-watt (8,760)	3100	682	0.078
Parking LED replacing 150-watt to 175-watt (4,380)	3101	341	0
Parking LED replacing 250-watt (8,760)	3103	1,048	0.120
Parking LED replacing 250-watt (4,380)	3104	524	0

Average Lifecycle Deemed Savings for Parking LED Fixtures

Measure (hours)	MMID	kWh
Parking LED replacing 70-watt to 100-watt (8,760)	3109	4,688
Parking LED replacing 70-watt to 100-watt (4,380)	3110	2,344
Parking LED replacing 150-watt to 175-watt (8,760)	3100	8,178
Parking LED replacing 150-watt to 175-watt (4,380)	3101	4,089
Parking LED replacing 250-watt (8,760)	3103	12,572
Parking LED replacing 250-watt (4,380)	3104	6,286

Assumptions

- 4,380 and 8,760 hours of annual operation were used for parking garage calculations
- 4,380 hours of annual operation were used for exterior lighting calculations, with dusk to dawn operation. A load factor of 1.0 was used for both parking garage and exterior lighting calculations.
- It was assumed that LED lamps are capable of achieving a 40% reduction in power requirements.[2]

Sources

1. Cadmus review of manufacturers' measure life.
2. Design Lights Consortium. *Qualified Parts List*. Available online: http://www.designlights.org/.

Revision History

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

LED Fixture or PSMH/CMH, Replacing 1,000 Watt HID, Exterior

	Measure Details
Measure Master ID	LED Fixture, Replacing 1,000 Watt HID, Exterior, 3407 PSMH/CMH, Replacing 1,000 Watt HID, Exterior, 3408
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	MMID 3407=20[1]; MMID 3408=15[1]
Incremental Cost	MMID 3407=$1,214.33;[2] MMID 3408=$50.83[2]

Measure Description

LED pole-mount, wall-mount, and flood light luminaires save energy when replacing 1,000-watt HID products by providing a similar lumen output with lower input wattage. These products can be installed on a one-for-one basis to replace 1,000-watt HID luminaires.

CMH and PSMH 575-watt pole-mount, wall-mount, and flood light luminaires save energy when replacing 1,000-watt HID products by providing a similar lumen output with lower input wattage. These products can be installed on a one-for-one basis to replace 1,000-watt HID luminaires.

Description of Baseline Condition

The baseline measure is 1,000-watt metal halide, high-pressure sodium HID luminaires for existing buildings and new construction buildings.

Description of Efficient Condition

The efficient measure is DLC-listed pole, wall, and flood luminaries and complete retrofit kits listed in one of the following DLC categories: 1, 2, 3, 25, 26, 27, or 28, which consumes ≤ 650 watts and has an initial lumen output of ≥ 35,000, 575 watt PSMH or CMH.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{1,000W\ HID} - kWh_{LED}$

$kWh_{SAVED} = kWh_{1,000W\ HID} - kWh_{575W\ PSMH\ or\ CMH}$

Where:

$kWh_{1,000W\ HID}$ = Average annual electricity consumption of 1,000-watt metal halide or high-pressure sodium luminaire

kWh_{LED} = Annual electricity consumption of a DLC listed pole, wall, and flood luminaries and complete retrofit kits listed in one of the following DLC categories: 1, 2, 3, 25, 26, 27, and 28, which consumes ≤ 650 watts and has an initial lumen output ≥ 35,000

$kWh_{575W\ PSMH\ or\ CMH}$ = Annual electricity consumption of a 575-watt PSMH or CMH lamp and ballast system or complete luminaire

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = (kWh_{1,000W\ HID} - kWh_{LED}) * EUL$

$kWh_{LIFECYCLE} = (kWh_{1,000W\ HID} - kWh_{575W\ PSMH\ or\ CMH}) * EUL$

Where:

EUL = Effective useful life (= 20 years for LED fixture;[1] = 15 years for PSMH/CMH fixture)[1]

Deemed Savings

Average Deemed Savings for DLC Listed LED

Savings	MMID	Exterior
Annual kWh	3407	1,841
Lifecycle kWh		20,252

Average Deemed Savings for PSMH or CMH

Savings	MMID	Exterior
Annual kWh	3408	1,364
Lifecycle kWh		20,466

Assumptions

An average of 50% metal halide 1,000-watt luminaires and 50% high-pressure sodium 1,000-watt luminaires was used to generate the baseline wattage.

4,380 hours run time of fixtures based on an annual average of 12 hours per day from NOAA data.[4] This also includes the times when photocells turn on prior to exact sunset and turn off after exact sunrise, accounting for diminished outdoor lighting as well as time clock scheduled lighting.

Applying a controls factor allows for a more conservative estimate of savings. Based on project experience with 1,000-watt HID baselines, less than 30% of the exterior 1,000-watt HID fixtures on the market have additional controls that may operate at conditions other than dusk to dawn.

Sources

1. Cadmus review of manufacturers' measure life.
2. All sources used for gathering pricing data are documented in a calculation workbook titled 1000w HID replacement calculation_FES_BIP_LEU_CSF_SBP_04.01.14.xls.
3. U.S. Department of Commerce National Oceanic & Atmospheric Administration. "NOAA Solar Calculator." http://www.esrl.noaa.gov/gmd/grad/solcalc/.

Revision History

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

LED Fixture Replacing T8/T12 U-Tube Lamps

	Measure Details
Measure Master ID	LED, 2x2, Replacing T12 2 Lamp U-Tube, SBP After A La Carte, 3238 LED, 2x2, Replacing T12 2 Lamp U-Tube, SBP A La Carte, 3323 LED, 2x2, Replacing T12 2 Lamp U-Tube, SBP Package, 3366 LED, 2x2, Replacing T8 2 Lamp U-Tube, 3239
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	$100.00

Measure Description

LED-based troffer replacements save energy over fluorescent fixtures due to the increased number of lumens per watt and increased light quality and distribution. There are varying wattage LED fixtures used to replace 2-foot by 2-foot troffers, which normally have single or dual T8 or T12 U-tube lamps installed. The LED fixture will replace fixtures with either dual (or greater) T12 U-tubes or dual (or greater) T8 U-tubes per 2-foot by 2-foot fixture.

Description of Baseline Condition

The baseline condition is a u-tube fixture, with wattages given in the following table.

U-Tube Fixture Wattages

Measure	MMID	Wattage
LED, 2x2, Replacing T12 2 Lamp U-Tube, SBP After A La Carte	3238	82 watts
LED, 2x2, Replacing T12 2 Lamp U-Tube, SBP A La Carte	3323	82 watts
LED, 2x2, Replacing T12 2 Lamp U-Tube, SBP Package	3366	82 watts
LED, 2x2, Replacing T8 2 Lamp U-Tube	3239	70 watts

Description of Efficient Condition

The efficient condition is DLC-listed, 2x2 LED troffers of 44 watts, luminaires for ambient lighting of interior commercial spaces.[4]

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{EX} – kWh_{LED}$

Where:

kWh_{EX} = Annual electricity consumption of existing T8 or T12 lamps and ballasts

kWh_{LED} = Annual electricity consumption of LED 2x2 luminaire

Summer Coincident Peak Savings Algorithm

First Year Savings

$kW_{SAVED} = (W_{EX} - W_{LED}) / 1,000 * CF$

Where:

W_{EX} = Wattage of existing T8 or T12 lamps and ballasts

W_{LED} = Wattage of the existing LED 2x2 luminaire

1,000 = Kilowatt conversion factor

CF = Demand coincidence factor (= see table below)

Demand Coincidence Factor by Sector

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

Lifecycle Peak Savings

$kW_{LIFECYCLE} = \{(W_{EX} – W_{LED}) * (N) + (W_{EISA} – W_{LED}) * (EUL - N)\} / 1,000$

Where:

N = Number of years until 2016 (= 1 in 2015)

W_{EISA} = Wattage of EISA-compliant lamps and ballasts

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

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = (kWh_{SAVED} * N) + (kWh_{EISA} – kWh_{LED}) * (EUL - N)$

Where:

kWh_{EISA} = Annual electricity consumption of EISA compliant lamps and ballasts

Deemed Savings

Average Annual Deemed Savings

Measure	MMID	Commercial 3,730 (0.77)		Schools & Gov 3,239 (0.64)		Industrial 4,745 (0.77)		Agriculture 4,698 (0.67)	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED, 2x2, Replacing T12 2 Lamp U-Tube, SBP After A La Carte	3238	96.8	0.0200	84.0	0.0166	123.1	0.0200	121.9	0.0174
LED, 2x2, Replacing T12 2 Lamp U-Tube, SBP A La Carte	3323	96.8	0.0200	84.0	0.0166	123.1	0.0200	121.9	0.0174
LED, 2x2, Replacing T12 2 Lamp U-Tube, SBP Package	3366	96.8	0.0200	84.0	0.0166	123.1	0.0200	121.9	0.0174
LED, 2x2, Replacing T8 2 Lamp U-Tube	3239	140.0	0.0289	121.6	0.0240	178.1	0.0289	176.4	0.0252

Average Lifecycle Deemed Savings

Sector	Installation Year							
	2013		2014		2015		2016 and Beyond	
	kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED, 2x2, Replacing T12 2 Lamp U-Tube, SBP After A La Carte, 3238								
Commercial	1,581.2	0.3264	1,537.9	0.3175	1,494.7	0.3085	1,451.4	0.2996
Schools & Govt.	1,373.0	0.2713	1,335.5	0.2639	1,297.9	0.2565	1,260.3	0.2490
Industrial	2,011.5	0.3264	1,956.4	0.3175	1,901.4	0.3085	1,846.3	0.2996
Agriculture	1,991.5	0.2840	1,937.0	0.2762	1,882.5	0.2685	1,828.0	0.2607
LED, 2x2, Replacing T12 2 Lamp U-Tube, SBP A La Carte, 3323								
Commercial	1,581.2	0.3264	1,537.9	0.3175	1,494.7	0.3085	1,451.4	0.2996
Schools & Govt.	1,373.0	0.2713	1,335.5	0.2639	1,297.9	0.2565	1,260.3	0.2490
Industrial	2,011.5	0.3264	1,956.4	0.3175	1,901.4	0.3085	1,846.3	0.2996
Agriculture	1,991.5	0.2840	1,937.0	0.2762	1,882.5	0.2685	1,828.0	0.2607

Sector	Installation Year							
	2013		2014		2015		2016 and Beyond	
	kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED, 2x2, Replacing T12 2 Lamp U-Tube, SBP Package, 3366								
Commercial	1,581.2	0.3264	1,537.9	0.3175	1,494.7	0.3085	1,451.4	0.2996
Schools & Govt.	1,373.0	0.2713	1,335.5	0.2639	1,297.9	0.2565	1,260.3	0.2490
Industrial	2,011.5	0.3264	1,956.4	0.3175	1,901.4	0.3085	1,846.3	0.2996
Agriculture	1,991.5	0.2840	1,937.0	0.2762	1,882.5	0.2685	1,828.0	0.2607
LED, 2x2, Replacing T8 2 Lamp U-Tube, 3239								
Commercial	1,451.4	0.2996	1,451.4	0.2996	1,451.4	0.2996	1,451.4	0.2996
Schools & Govt.	1,260.3	0.2490	1,260.3	0.2490	1,260.3	0.2490	1,260.3	0.2490
Industrial	1,846.3	0.2996	1,846.3	0.2996	1,846.3	0.2996	1,846.3	0.2996
Agriculture	1,828.0	0.2607	1,828.0	0.2607	1,828.0	0.2607	1,828.0	0.2607

Sources

1. Cadmus review of manufacturers’ measure life.
2. *Focus on Energy Business Programs Deemed Savings Manual V1.0*. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
3. *Focus on Energy Business Programs Deemed Savings Manual V1.0*. Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.T
4. *T*he new measure condition assumes an average of the DLC listing as of June 21, 2013.

Revision History

Version Number	Date	Description of Change
01	07/2013	Initial TRM entry

LED Fixture Replacing 2x4 Linear Fluorescent Fixture

	Measure Details
Measure Master ID	LED, 2x4, Replacing T12 2 Lamp, 3232 LED, 2x4, Replacing T8 2 Lamp, SBP After A La Carte, 3235
Measure Unit	Fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	$100.00

Measure Description

LED-based troffer replacements save energy over fluorescent fixtures due to the increased number of lumens per watt and increased light quality and distribution. There are varying wattage LED fixtures used to replace 2-foot by 4-foot troffers, which normally have two, three, or four T12 or T8 lamps with ballast installed. The LED fixture will replace fixtures with either T12 or T8 lamps.

Description of Baseline Condition

The baseline condition measure and wattages are shown in the following table.

Baseline Wattages[4]

Measure	Wattage
T8 Linear Fluorescent Fixtures (EISA compliant)	
2 Lamp T8	58 watts
3 Lamp T8	86 watts
4 Lamp T8	112 watts
T12 Linear Fluorescent Fixtures	
2 Lamp T12	82 watts
3 Lamp T12	130 watts
4 Lamp T12	144 watts

Description of Efficient Condition

The efficient condition is DLC-listed, retrofit kits of 2x4 LED troffers of 50 watts, luminaires for ambient lighting of interior commercial spaces.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{EX} – kWh_{LED}$

Where:

kWh_{EX} = Annual electricity consumption of existing T8 or T12 lamps and ballasts

kWh_{LED} = Annual electricity consumption of LED 2x4 luminaire

Summer Coincident Peak Savings Algorithm

First Year Savings

$kW_{SAVED} = (W_{EX} - W_{LED}) / 1{,}000 * CF$

Where:

W_{EX} = Wattage of existing T8 or T12 lamps and ballasts

W_{LED} = Wattage of LED 2x4 luminaire

1,000 = Kilowatt conversion factor

CF = Demand coincidence factor (= see table below)

Demand Coincidence Factor by Sector

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

Lifecycle Peak Savings

$kW_{LIFECYCLE} = \{kWh_{SAVED} * N + (W_{EISA} - W_{LED}) * (EUL - N)\} / 1{,}000$

Where:

N = Number of years until 2016 (= 1 in 2015)

W_{EISA} = Wattage of EISA compliant lamps and ballasts

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

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = (kWh_{SAVED} * N) + (kWh_{EISA} - kWh_{LED}) * (EUL - N)$

Where:

kWh_{EISA} = Annual electricity consumption of EISA compliant lamps and ballasts

Deemed Savings

Average Annual Deemed Savings for LED Troffer Fixture Replacement of 2-Foot by 4-Foot T8 and T12 Fixtures

Measure	MMID	Commercial 3,730 (0.77)		Schools & Gov 3,239 (0.64)		Industrial 4,745 (0.77)		Agriculture 4,698 (0.67)	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED 2x4 replacement of 2 lamp T12	3232	118.6	0.0245	103.0	0.0204	150.9	0.0245	149.4	0.0213
LED 2x4 replacement of 3 lamp T12	3232	297.7	0.0614	258.5	0.0511	378.7	0.0614	374.9	0.0535
LED 2x4 replacement of 4 lamp T12	3232	349.9	0.0722	303.8	0.0600	445.1	0.0722	440.7	0.0628
LED 2x4 replacement of 2 lamp T8	3235	29.1	0.0060	25.3	0.0050	37.0	0.0060	36.7	0.0052
LED 2x4 replacement of 3 lamp T8	3235	133.5	0.0276	116.0	0.0229	169.9	0.0276	168.2	0.0240
LED 2x4 replacement of 4 lamp T8	3235	230.5	0.0476	200.2	0.0396	293.3	0.0476	290.4	0.0414

Average Lifecycle Deemed Savings for LED Troffer Fixture Replacement of 2-Foot by 4-Foot T8 and T12 Fixtures

Sector	Installation Year							
	2013		2014		2015		2016 and Beyond	
	kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED 2x4 replacement of 2 lamp T12, 3232								
Commercial	705.2	0.1456	615.7	0.1271	526.1	0.1086	436.6	0.0901
Schools & Govt.	612.4	0.1210	534.6	0.1056	456.9	0.0903	379.1	0.0749
Industrial	897.1	0.1456	783.2	0.1271	669.3	0.1086	555.4	0.0901
Agriculture	888.2	0.1267	775.4	0.1106	662.7	0.0945	549.9	0.0784
LED 2x4 replacement of 3 lamp T12, 3232								
Commercial	2,495.6	0.5152	2,331.5	0.4813	2,167.3	0.4474	2,003.2	0.4135
Schools & Govt.	2,167.1	0.4282	2,024.6	0.4000	1,882.0	0.3719	1,739.5	0.3437
Industrial	3,174.7	0.5152	2,965.9	0.4813	2,757.1	0.4474	2,548.3	0.4135
Agriculture	3,143.2	0.4483	2,936.5	0.4188	2,729.8	0.3893	2,523.1	0.3598

Sector	Installation Year							
	2013		2014		2015		2016 and Beyond	
	kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED 2x4 replacement of 4 lamp T12, 3232								
Commercial	3,816.0	0.7878	3,696.6	0.7631	3,577.3	0.7385	3,457.9	0.7138
Schools & Govt.	3,313.7	0.6548	3,210.0	0.6343	3,106.4	0.6138	3,002.7	0.5933
Industrial	4,854.4	0.7878	4,702.6	0.7631	4,550.7	0.7385	4,398.9	0.7138
Agriculture	4,806.3	0.6854	4,656.0	0.6640	4,505.7	0.6426	4,355.3	0.6211
LED 2x4 replacement of 2 lamp T8, 3235								
Commercial	436.6	0.0901	436.6	0.0901	436.6	0.0901	436.6	0.0901
Schools & Govt.	379.1	0.0749	379.1	0.0749	379.1	0.0749	379.1	0.0749
Industrial	555.4	0.0901	555.4	0.0901	555.4	0.0901	555.4	0.0901
Agriculture	549.9	0.0784	549.9	0.0784	549.9	0.0784	549.9	0.0784
LED 2x4 replacement of 3 lamp T8, 3225								
Commercial	2,003.2	0.4135	2,003.2	0.4135	2,003.2	0.4135	2,003.2	0.4135
Schools & Govt.	1,739.5	0.3437	1,739.5	0.3437	1,739.5	0.3437	1,739.5	0.3437
Industrial	2,548.3	0.4135	2,548.3	0.4135	2,548.3	0.4135	2,548.3	0.4135
Agriculture	2,523.1	0.3598	2,523.1	0.3598	2,523.1	0.3598	2,523.1	0.3598
LED 2x4 replacement of 4 lamp T8, 3235								
Commercial	3,457.9	0.7138	3,457.9	0.7138	3,457.9	0.7138	3,457.9	0.7138
Schools & Govt.	3,002.7	0.5933	3,002.7	0.5933	3,002.7	0.5933	3,002.7	0.5933
Industrial	4,398.9	0.7138	4,398.9	0.7138	4,398.9	0.7138	4,398.9	0.7138
Agriculture	4,355.3	0.6211	4,355.3	0.6211	4,355.3	0.6211	4,355.3	0.6211

Sources

1. Cadmus review of manufacturers' measure life.
2. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
3. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.
4. The new measure condition assumes an average of the DLC listing as of June 21, 2013.

Revision History

Version Number	Date	Description of Change
01	07/2013	Initial TRM entry

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

	Measure Details
Measure Master ID	LED Fixture, Bi-Level: Stairwell and Passageway, 3097 Stairwell and Passageway, SBP A La Carte, 3596 Stairwell and Passageway, SBP After A La Carte, 3597 Lighting Controls, Bi-Level: Exterior and Parking Garage Fixtures, Dusk to Dawn, 3251 Parking Garage Fixtures, 24 Hour, 3252
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	MMID 3097, 3596, 3597= Light Emitting Diode (LED) MMIDs 3251, 3252 = Controls
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	9[1]
Incremental Cost	Varies by measure, see Appendix D

Measure Description

Numerous existing installations use LED, induction, fluorescent, CMH, and PSMH fixtures to light their high-bay interiors, exteriors, and parking garages. These fixtures commonly operate in full light output 24 hours a day. Bi-level controls and replacement products use ultrasonic and PIR sensors to adjust the light output to a safe but energy-conserving low light level when these spaces become unoccupied. These products save energy by more efficiently lighting spaces based on occupancy.

Description of Baseline Condition

The baseline condition is LED, induction, fluorescent, CMH, and PSMH fixture input wattages with no lighting controls at building interiors, exteriors, and parking garages.

Description of Efficient Condition

The efficient condition is individually controlled light fixtures that may include dimming, stepped dimming, and/or hi-low ballast controls. Control must include a PIR and/or ultrasonic occupancy sensor with a fail-safe feature (fails in "on" position in case of sensor failure). Fixtures must operate in low-standby light level during vacancy and switch to full light output upon occupancy. The fixture cannot exceed 50% of full wattage during unoccupied periods.

Annual Energy-Savings Algorithm

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

$$kWh_{BASE} = Watts_{FIXTURES} * HOU / 1{,}000$$

$$kWh_{EE} = Watts_{FIXTURES} * HOU * 0.60/1{,}000$$

Where:

kWh_{BASE} = Energy consumption of baseline equipment (standard non-controlled fixture)

kWh_{EE} = Energy consumption of efficient equipment (bi-level controlled fixture)

$Watts_{FIXTURES}$ = Input wattage of fixture(s) being controlled

HOU = Hours-of-use (= 8,760 for parking garages; = 4,380 for exterior; = see table below for interior)

1,000 = Kilowatt conversion factor

0.60 = 40% savings potential from bi-level controls

Interior Hours-of-Use by Sector

Sector	Hours-of-Use[2]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = Watts_{FIXTURES} /1{,}000 * SF * CF$

Where:

SF = Savings factor (= 40%)

CF = Coincidence factor (= 1 for parking; = 0 for exterior; = see table below for interior)

Interior Coincidence Factor by Sector

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

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 9 years)[1]

Deemed Savings

Bi-Level Controls in Parking Garage

Savings per Fixture	MMID	All Sectors
kWh	3252	1,135
kW		0.1296
$kWh_{LIFECYCLE}$		9,082

Bi-Level Controls in Exterior

Savings per Fixture	MMIDs	All Sectors
kWh	3251 and 3343	568
kW		0
$kWh_{LIFECYCLE}$		4,541

Bi-Level Controls in Interior

Savings per Fixture	MMIDs	Commercial	Industrial	Agriculture	Schools & Government
kWh	3097, 3596, 3597 (LED) and 3117 (fluorescent)	483	615	609	420
kW		0.0998	0.0998	0.0868	0.0829
$kWh_{LIFECYCLE}$		3,867	4,920	4,871	3,358

Assumptions

It is assumed that an exterior lamp is on for a nighttime average of 4,380 hours. 8,760 hours are assumed for 24/7 parking garage. Savings for interior are based on the sector for interior high-bay applications.

While bi-level controls can achieve a 50% reduction in power requirements, a 40% reduction is used for Focus on Energy programs as a conservative estimate. No kilowatt savings are assigned to exterior lighting due to reduced hours-of-use for the same wattage.

Sources

1. Cadmus review of manufacturers' measure life.
2. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin. Focus on Energy Business Programs: Deemed Savings Manual V1.0. Table 3.2 Lighting Hours of Use in Commercial Applications. Updated March 22, 2010.
3. The Program directs that wattagage must be reduced by a minimum of 50%, however 40% was is applied to account for any other power factors or unforseen power consumption.

Revision History

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

Delamping, T12 to T8, T8 to T8

	Measure Details
Measure Master ID	Delamping: T12 to T8, 4-Foot, 2276 T8 to T8, 2277 T12 to T8, 8-Foot, 3184, 3320
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	MMIDs 2276 and 2277 = Delamping MMID 3184 and 3320 = Fluorescent, Linear
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	TBA[1]
Incremental Cost	Varies by measure, see Appendix D

Measure Description

This measure is the permanent removal of standard T12 and T8 lamps from two, three, and four lamp 4-foot and 8-foot fixtures. Although the savings are not accounted for here, the measure requires:

- Delamped fixtures must also include upgrading the remaining lamps to HPT8 or RWT8 lamps.
- If a qualifying combination of lamps and ballast are installed, delamped fixtures can also qualify for incentives for HPT8 or RWT8 systems based on the number of lamps in the delamped fixture.

If the existing fixture contains standard T8 ballasts, the ballast is not required to be replaced. Only the lamps must be upgraded. In this case, the project would only qualify for a reduced watt lamp incentive if reduced watt lamps are used. The project would not qualify for a system upgrade incentive.

Description of Baseline Condition

The baseline condition is a weighted average of two, three, and four lamp T12 and T8 fixtures; see the Assumptions section for weighting metrics.

Description of Efficient Condition

The efficient condition is a weighted average of one, two, and three lamp low, normal, and high ballast factor T8 fixtures with 32-watt lamps. See the Assumptions section for weighting metrics.

Annual Energy-Savings Algorithm

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

Where:

$Watts_{BASE}$ = Watts of baseline equipment (existing standard T12 and T8 fixture(s))

$Watts_{EE}$ = Power consumption of efficient measure (delamped T8 fixture(s))

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= see table below)

Hours-of-Use by Sector

Sector	HOU[2]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239
Multifamily	5,950

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= see table below)

Coincidence Factor by Sector

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

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Average Annual Deemed Savings for Linear Fluorescent Delamping

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Gov		Multifamily	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
Delamping T12 to T8 (4-Foot)	2276	192	0.040	244	0.040	242	0.035	167	0.033	306	0.040
Delamping T8 to T8 (4-Foot)	2277	96	0.020	122	0.020	121	0.017	83	0.017	153	0.020
Delamping T12 to T8 (8-Foot)	3184, 3320	357	0.074	454	0.074	450	0.064	310	0.061	N/A	N/A

Average Lifecycle Deemed Savings for Linear Fluorescent Delamping

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Gov	Multifamily
		kWh	kWh	kWh	kWh	kWh
Delamping T12 to T8 (4-Foot)	2276	1,920	2,440	2,420	1,670	3,060
Delamping T8 to T8 (4-Foot)	2277	960	1,220	1,210	830	1,530
Delamping T12 to T8 (8-Foot)	3184, 3320	3,570	4,540	4,500	3,100	N/A

Assumptions

Weighting of delamping quantities is based on historical program data.

The baseline condition is a weighted average of two, three, and four lamp T12 and T8 fixtures:

- Delamping T12 to T8 (4-Foot)
    - 2 Lamp (10%)
    - 3 Lamp (30%)
    - T12 - 4 Lamp (60%)
- Delamping T8 to T8
    - 2 Lamp (10%)

    - 3 Lamp (30%)
    - T8 - 4 Lamp (60%)
- Delamping T12 to T8 (8-Foot)
    - T12 - 2 Lamp (80%)
    - HOT12 - 2 Lamp (20%)

Efficient Condition:

- Delamping T12 to T8 (4-Foot)
    - 2 to 1 Lamp (10%)
    - 3 to 1 Lamp (5%)
    - 3 to 2 Lamp (25%)
    - 4 to 2 Lamp (50%)
    - T8 - 4 to 3 Lamp (10%)
- Delamping T8 to T8
    - 2 to 1 Lamp (10%)
    - 3 to 1 Lamp (5%)
    - 3 to 2 Lamp (25%)
    - 4 to 2 Lamp (50%)
    - T8 - 4 to 3 Lamp (10%)
- Delamping T12 to T8 (8-Foot)
    - T8 – 2 Lamp (8-Foot) to 2 Lamp (4-Foot) (100%)

Sources

1. Early Replacement Calculator spreadsheet.
2. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
3. ACES. *Deemed Savings Desk Review*. November 3, 2010.

Revision History

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

Delamping Light Fixtures

	Measure Details
Measure Master ID	Delamping: 200 - 399 Watt Fixture, 3001, 3321 ≥ 400 Watt Fixture, 3002, 3322
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Delamping
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by wattage and sector
Peak Demand Reduction (kW)	Varies by wattage and sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	TBA[1]
Incremental Cost	$15.00

Measure Description

This measure is to permanently remove existing high-wattage light fixtures from an existing ceiling. De-lamping savings do not include replacements. Customers are responsible for deciding whether de-lamping will maintain adequate light levels.

Description of Baseline Condition

The baseline equipment is 250-watt and 450-watt metal halide light fixtures.

Description of Efficient Condition

The efficient condition is permanent removal of unneeded light fixtures.

Annual Energy-Savings Algorithm

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

Where:

$Watts_{BASE}$ = Watts of high wattage baseline measure light fixture (= 299 for 200-watt or 399-watt light fixture; = 463 for ≥ 400-watt light fixture)[4]

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

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= see table below)

Hours-of-Use by Sector

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

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= see table below)

Coincidence Factor by Sector

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

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

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

	MMID	Commercial	Industrial	Agriculture	Schools & Government
Annual Energy Savings (kWh)	3001 and 3321	1,115	1,419	1,405	968
Peak Demand Reduction (kW)		0.2302	0.2302	0.2003	0.1914
Lifecycle Energy Savings (kWh)		14,499	18,444	18,261	12,590

Deemed Savings for Delamping ≥ 400-Watt Light Fixture

	MMID	Commercial	Industrial	Agriculture	Schools & Government
Annual Energy Savings (kWh)	3002 and 3322	1,727	2,197	2,175	1,500
Peak Demand Reduction (kW)		0.3565	0.3565	0.3102	0.2963
Lifecycle Energy Savings (kWh)		22,451	28,560	28,277	19,496

Sources

1. Early Replacement Calculator spreadsheet.
2. State of Wisconsin Public Service Commission. *Business Programs Deemed Savings Manual V1.0.* Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
3. State of Wisconsin Public Service Commission. *Business Programs Deemed Savings Manual V1.0*. Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.
4. Vermont Energy Investment Corporation. *Ohio Technical Reference Manual*. August 2010.

Revision History

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

T8 2-Foot Lamps Replacing T8 and T12 U-Tube Lamps

	Measure Details
Measure Master ID	T8 2-Foot Lamps: Replacing Single T12 U-Tube Lamp, 3240, 3325 Replacing Double T12 U-Tube Lamp, 3241, 3326 Replacing Single T8 U-Tube, 3242 Replacing Double T8 U-Tube, 3243
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Linear
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	Varies by measure
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	3240, 3241, 3242, 3243= 6[1] and 3325, 3326 =15[2]
Incremental Cost ($/unit)	$40.00 for single U-lamp; $60.00 for double U-lamp

Measure Description

Reduced wattage 2-foot T8 lamps save energy by reducing the total input wattage of the luminaires installed in a fixture. The 2-foot T8 lamps can be installed in varying amounts per fixture as necessary for lighting configurations, with the most common being three lamps in a 2-foot by 2-foot fixture. This measure replaces fixtures with either one or two U-tubes per 2-foot by 2-foot fixture.

Description of Baseline Condition

The wattage of the baseline equipment is shown in the table below.

U-Tube Fixture Wattages

Measure	MMID	Wattage
U-tube T12 1 Lamp	3240, 3325	48 watts
U-tube T12 2 Lamp	3241, 3326	82 watts
U-tube T8 - 1 Lamp (EISA)	3242	35 watts
U-tube T8 - 2 Lamp (EISA)	3243	70 watts

Description of Efficient Condition

The wattages for F17, 2-foot T8 lamps with a ballast factor of 0.82 are shown in the table below. The one exception is a single lamp F17T8, which has a ballast factor of 0.88.

Efficient Fixture Wattages

Measure	Wattage
2-Foot 1 Lamp F17T8	15 watts
2-Foot 2 Lamp F17T8	28 watts
2-Foot 3 Lamp F17T8	42 watts
2-Foot 4 Lamp F17T8	56 watts

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{U} – kWh_{F17T8}$

Where:

kWh_{U} = Annual electricity consumption of existing U-tube lamps and ballasts

kWh_{F17T8} = Annual electricity consumption of F17T8 lamps and ballasts

Summer Coincident Peak Savings Algorithm

First Year Savings

$kW_{SAVED} = (W_{U} - W_{F17T8}) / 1,000 * CF$

Where:

W_{U} = Wattage of existing U-tube lamps and ballasts

W_{F17T8} = Existing wattage of F17T8 lamps and ballasts

1,000 = Conversion

CF = Demand coincidence factor (= see table below)

Demand Coincidence Factor by Sector

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

Subsequent Year Savings

$kW_{SAVED} = \{(W_U – W_{F17T8}) * N + (W_{UEISA} – W_{F17T8}) * (EUL - N)\} / 1,000$

Where:

N = Number of years until 2016 (=1 in 2015)

W_{UEISA} = Existing wattage of EISA-compliant U-tube lamps and ballasts

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

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = (kWh_U – kWh_{F17T8}) * N + (kWh_{UEISA} – kWh_{F17T8}) * (EUL - N)$

Where:

kWh_{UEISA} = Annual electricity consumption of EISA-compliant U-tube lamps and ballasts

Deemed Savings

Average Annual Deemed Savings

Measure	MMID	Commercial 3,730 (0.77)		Schools & Gov 3,239 (0.64)		Industrial 4,745 (0.77)		Agriculture 4,698 (0.67)	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW
F17T8, 2-Foot Lamps Replacing Single T12 U-Tube Lamps	3240, 3325	90.8	0.0187	78.8	0.0156	115.5	0.0187	114.3	0.0163
F17T8, 2-Foot Lamps Replacing Double T12 U-Tube Lamps	3241, 3326	149.2	0.0308	129.6	0.0256	189.8	0.0308	187.9	0.0268
F17T8, 2-Foot Lamps Replacing Single T8 U-Tube Lamps	3242	43.0	0.0089	37.4	0.0074	54.7	0.0089	54.2	0.0077
F17T8, 2-Foot Lamps Replacing Double T8 U-Tube Lamps	3243	105.9	0.0219	92.0	0.0182	134.8	0.0219	133.4	0.0190

Average Lifecycle Deemed kWh Savings

MMID	Commercial 3,730 (0.77)	Schools & Gov 3,239 (0.64)	Industrial 4,745 (0.77)	Agriculture 4,698 (0.67)
	kWh	kWh	kWh	kWh
3240	544.8	472.8	693	685.8
3241	895.2	777.6	1138.8	1127.4
3242	258	224.4	328.2	325.2
3243	635.4	552	808.8	800.4
3325	1362	1182	1732.5	1714.5
3326	2238	1944	2847	2818.5

Assumptions

The replacement of single U-tube fixtures uses an average of 1/3 single F17T8 replacements and 2/3 double F17T8 fixtures to generate the new measure wattage.

The replacement of double U-tube fixtures uses an average of 25% 4-Lamp F17T8, 50% 3-Lamp F17T8, and 25% 2-Lamp F17T8 fixture replacements to generate the new measure wattage.

Sources

1. Multiple Manufacturers Product Life Rating of ~ 24,000 hours.
2. DEER 2014 EUL Table. http://www.deeresources.com. Rated ballast life of 70,000 hours. Not rated on bulb life as such EUL is capped at 15 years.
3. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.

Revision History

Version Number	Date	Description of Change
01	07/2013	Initial TRM entry

Exterior Lighting Optimization

	Measure Details
Measure Master ID	Exterior Lighting Optimization: CMH Lamp: 330 Watts, Replacing 400-Watt HID, 3206 205 Watts, Replacing 250-Watt HID, 3208 CMH Lamp With Controls: 330 Watts, Replacing 400-Watt HID, 3207 205 Watts, Replacing 250-Watt HID, 3209 CMH System: 210-220 Watts, Replacing 400-Watt HID, 3210 140-150 Watts, Replacing 250-Watt HID, 3212 90 Watts, Replacing 150-175 Watt HID, 3214 CMH System With Controls: 210-220 Watts, Replacing 400-Watt HID, 3211 140-150 Watts, Replacing 250-Watt HID, 3213 90 Watts, Replacing 150-175 Watt HID, 3215 LED: ≤ 200 Watts, Replacing 400-Watt HID, 3216 ≤ 125 Watts, Replacing 250-Watt HID, 3218 ≤ 60 Watts, Replacing 150-175 Watt HID, 3220 LED With Controls: ≤ 200 Watts, Replacing 400-Watt HID, 3217 ≤ 125 Watts, Replacing 250-Watt HID, 3219 ≤ 60 Watts, Replacing 150-175 Watt HID, 3221
Measure Unit	Per lamp or fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	High Intensity Discharge (HID)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential-multifamily
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	0

	Measure Details
Annual Therm Savings (Therms)	0
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	3206, 3207, 3208, 3209= 4[1] 3210, 3211, 3212, 3215 = 13[2] 3216, 3217, 3218, 3219, 3220, 3221 =20 [3]
Incremental Cost ($/unit)	$12.91 - $1,295.21[4]

Measure Description

Exterior lighting optimization (ELO) offers three energy-efficient upgrade choices for replacing or retrofitting qualifying exterior pole-mount and wall-mount fixtures. The ELO measures are structured to supply annual savings and set measure cost information for end users.

Description of Baseline Condition

ELO measures target the replacement or retrofit of 150-watt to 175-watt, 250-watt, and 400-watt HID systems that currently operate 4,380 hours per year. Fixtures must be exterior pole mount or wall mount, where the head of the fixture is a minimum of 15-feet above finished grade. There must also be a minimum of 10 pole heads and/or wall packs per location addressed.

Description of Efficient Condition

Facilities with existing 150-watt to 175-watt HIDs have the option to select from a 90-watt ceramic metal halide lamp and ballast replacement or a new LED fixture of ≤ 60 input watts.

Facilities with existing 250-watt HIDs have the option to select from a simple 205-watt direct replacement ceramic metal halide lamp, a 140-watt to 150-watt ceramic metal halide lamp and ballast replacement, or a new LED fixture of ≤ 125 input watts.

Facilities with existing 400-watt HIDs have the option to select from a simple 330-watt direct replacement ceramic metal halide lamp, a 200-watt to 220-watt ceramic metal halide lamp and ballast replacement, or a new LED fixture of ≤ 200 input watts.

When applicable, twistlock fixture-mounted controls with integrated timers will also be an option for each ELO replacement/retrofit conducted.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{HID} – kWh_{ELO}$

Where:

KWh_{HID} = Annual electricity consumption of standard 150-watt, 175-watt, 250-watt, or 400-watt HID

KWh_{ELO} = Annual electricity consumption of ELO measure

Summer Coincident Peak Savings Algorithm

There are no peak savings for this measure.

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= varies by measure; see tables in Deemed Savings section)

For systems with controls:

$kWh_{LIFECYCLE} = (kWh_{SAVED} * EUL) + ((kWh_{SAVED} – kWh_{SAVED\ W/CONTROLS}) * (EUL_{CONTROLS}))$

Where:

$KWh_{SAVED\ W/CONTROLS}$ = Annual electricity consumption of ELO measure with additional controls hours reduction

$EUL_{CONTROLS}$ = Effective useful life of lighting controls (= 8 years)[3]

Deemed Savings

Lamp Replacement Options (from existing metal halide only)*

	400-Watt HID Replacements		250-Watt HID Replacements	
	330-Watt CMH Lamp	330-Watt CMH Lamp w/ Controls	250-Watt CMH Lamp	250-Watt CMH Lamp w/ Controls
Annual kWh Savings	351	905	263	613
EUL (years)[2]	4	4	4	4
Lifecycle kWh Savings	1,404	5,836	1,052	3,852

* This table applies to the following measures:
ELO, CMH Lamp, 330 Watts, Replacing 400-Watt HID, 3206
ELO, CMH Lamp With Controls, 330 Watts, Replacing 400-Watt HID, 3207
ELO, CMH Lamp, 205 Watts, Replacing 250-Watt HID, 3208
ELO, CMH Lamp With Controls, 205 Watts, Replacing 250-Watt HID, 3209

Lamp and Ballast Replacement Options*

	400-Watt HID Replacements		250-Watt HID Replacements		150-Watt to 175-Watt HID Replacements	
	210 Watt and 220 Watt CMH System	210 Watt and 220 Watt CMH System w/ Controls	90-Watt CMH System	90-Watt CMH System	90-Watt CMH System	90-Watt CMH System w/ Controls
Annual kWh Savings	964	1,314	438	438	438	584
EUL (years)[3]	13	13	13	13	13	13
Lifecycle kWh Savings	12,532	15,332	5,694	5,694	5,694	6,862

* This table applies to the following measures:
ELO, CMH System, 210-220 Watts, Replacing 400-Watt HID, 3210
ELO, CMH System With Controls, 210-220 Watts, Replacing 400-Watt HID, 3211
ELO, CMH System, 140-150 Watts, Replacing 250-Watt HID, 3212
ELO, CMH System With Controls, 140-150 Watts, Replacing 250-Watt HID, 3213
ELO, CMH System, 90 Watts, Replacing 150-Watt to 175-Watt HID, 3214
ELO, CMH System With Controls, 90 Watts, Replacing 150-Watt to 175-Watt HID, 3215

Fixture Replacement or Retrofit to LED Options*

	400-Watt HID Replacements		250-Watt HID Replacements		150-Watt 175-Watt HID Replacements	
	LED ≤ 200 Watts	LED ≤ 200 Watts w/ Controls	LED ≤ 125 Watts	LED ≤ 125 Watts w/ Controls	LED ≤ 60 Watts	LED ≤ 60 Watts w/ Controls
Annual kWh Savings	1,358	1,577	920	1,051	701	759
EUL (years)[4]	20	20	20	20	20	20
Lifecycle kWh Savings	27,160	31,540	18,400	21,020	14,020	15,100

* This table applies to the following measures:
ELO, LED ≤ 200 Watts, Replacing 400-Watt HID, 3216
ELO, LED ≤ 200 Watts With Controls, Replacing 400-Watt HID, 3217
ELO, LED ≤ 125 Watts, Replacing 250-Watt HID, 3218
ELO, LED ≤ 125 Watts With Controls, Replacing 250-Watt HID, 3219
ELO, LED ≤ 60 Watts, Replacing 150-Watt to 175-Watt HID, 3220
ELO, LED ≤ 60 Watts With Controls, Replacing 150-Watt to 175-Watt HID, 3221

Assumptions

The 4,380 hours of required minimum run time of fixtures was based on an annual average of 12 hours per day from NOAA data.[5] This includes when photocells turn on prior to exact sunset and turn off after exact sunrise, accounting for diminished outdoor lighting as well as time clock scheduled lighting.

Options that include controls are required to be set to reduce the controlled fixture hours of operation by a minimum of 4 hours per night. This results in a decrease from 4,380 annual run hours 2,920 annual run hours.

Existing and Efficient Wattages by Measure

Measure Description*	MMIDs	Baseline	Existing Wattage	Energy Efficient Wattage
300-Watt CMH Lamp (Replacing Metal Halide Only)	3206 3207	400 Watt HID	458	379.5
200-220 Watt CMH System	3210	400 Watt HID	458	235
LED Option ≤ 200 Watts	3216 3217	400 Watt HID	458	151
205-Watt CHM Lamp (Replacing Metal Halide Only)	3208 3209	250 Watt HID	295	236
140-150 Watt CMH System	3212	250 Watt HID	295	172
LED Option ≤ 125 Watts	3218 3219	250 Watt HID	295	91
90-Watt CMH System	3214 3215	150-175 Watt HID	195	101
LED Option ≤ 60 Watts	3220 3221	150-175 Watt HID	195	42

* Same wattages apply when including controls upgrades.

Sources

1. Cadmus review of manufacturers' measure life.
2. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
3. Cadmus review of manufacturers' measure life.
4. Installed Measure Cost Details.

Installed Measure Cost Table

Measure	MMID	Cost
Ceramic Metal Halide System Measures		
210-Watt and 220-Watt CMH System	3210	$354.00
210-Watt and 220-Watt CMH System w/ Controls	3211	$448.00
140-Watt and 150-Watt CMH System	3212	$279.00
140-Watt and 150-Watt CMH System w/ Controls	3213	$373.00
90-Watt CMH System	3214	$214.00
90-Watt CMH System w/ Controls	3215	$305.00
Ceramic Metal Halide Lamp Measures		
330-Watt CMH Lamp	3206	$106.00
330-Watt CMH Lamp w/ Controls	3207	$197.00
205-Watt CMH Lamp	3208	$97.00
205-Watt CMH Lamp w/ Controls	3209	$188.00
LED Fixture of Retrofit Measures		
LED ≤ 200 Watts	3216	$1,466.00
LED ≤ 200 Watts w/ Controls	3217	$1,565.00
LED ≤ 125 Watts	3218	$878.00
LED ≤ 125 Watts w/ Controls	3219	$977.00
LED ≤ 60 Watts	3220	$421.00
LED ≤ 60 Watts w/ Controls	3221	$520.00

All labor cost data for ceramic metal halide direct replacement reduced wattage lamps and ceramic metal halide lamp and ballast systems was based on data gathered from installation contractors from all four geographical quadrants of the Wisconsin Focus on Energy program territory. Out of 40 installation parties, we contacted 12respondents who completed the questionnaire in time to be included.

Material costs, including standard industry mark-ups for distribution, were collected from all known manufacturers of ceramic metal halide equipment that meets the ELO performance criteria. Internet pricing data was used for LED materials, some HID ballasts, lamp sockets, controls sockets, and photocell/timer controls.

Material Specification Data was collected from the following manufacturers and distributors websites: http://www.venturelighting.com/; http://www.eyelighting.com/; http://www.ripleylightingcontrols.com; http://www.precisionmulticontrols.com; http://www.usa.lighting.philips.com/; and https://www.sylvania.com.

5. U.S. Department of Commerce, National Oceanic & Atmospheric Administration. Solar Calculator. Available online: http://www.esrl.noaa.gov/gmd/grad/solcalc/

Revision History

Version Number	Date	Description of Change
01	08/01/2013	Initial TRM entry
02	08/21/2013	Expanded entry to include wall-mounted HIDs

HID, Reduced Wattage, Replacing HID, Interior, Exterior, Parking Garage

	Measure Details
Measure Master ID	HID, Reduced Wattage: Interior: Replacing 1,000 Watt HID, 3067 Replacing 175 Watt HID, 3068 Replacing 250 Watt HID, 3070 Replacing 320 Watt HID, 3072 Replacing 400 Watt HID, 3073 Exterior: Replacing 1,000 Watt HID, 3036 Replacing 400 Watt HID, 3037 Replacing 320 Watt HID, 3038 Replacing 250 Watt HID, 3039 Replacing 175 Watt HID, 3040 Parking Garage: Replacing 175 Watt HID, 3069 Replacing 250 Watt HID, 3071
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	High Intensity Discharge (HID)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily (exterior measures only)
Annual Energy Savings (kWh)	Varies by baseline and sector
Peak Demand Reduction (kW)	Varies by baseline and sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	4[1]
Incremental Cost	Varies by measure, see Appendix D

Measure Description

RW HID direct replacement lamps save energy by reducing the total input wattage of the luminaire as compared to the same luminaire operating with standard wattage HID lamps. This measure can be applied in spaces where standard wattage HID lamps are being used. These RW HID products have a similar or equivalent lumen output to the lamps that they replace, which allows them to be installed anywhere that standard wattage HID lamps are found.

Description of Baseline Condition

The baseline is standard 175-watt, 250-watt, 320-watt, 400-watt, and 1,000-watt HID lamps.

Description of Efficient Condition

The efficient condition is 145-watt, 150-watt, 205-watt, 220-watt, 260-watt, 330-watt, 360-watt, and 860-watt RW HID lamps.

Annual Energy-Savings Algorithm

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

Where:

$Watts_{BASE}$ = Wattage of baseline standard HID lamp (= see table below)

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

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 4,380 for exterior; = 8,760 for parking garages; = see table below for interior)

Wattages for Deemed Savings Calculations

Measure	$Watts_{BASE}$	$Watts_{EE}$
Exterior RW HID Lamp 1,000-Watt Replacement	1,079	928.8
Interior HID Lamp 1,000-Watt Replacement	1,079	928.8
Exterior RW HID Lamp 400-Watt Replacement	455	396.75
Interior HID Lamp 400-Watt Replacement	455	396.75
Exterior RW HID Lamp 320-Watt Replacement	356	299
Interior HID Lamp 320-Watt Replacement	356	299
Exterior RW HID Lamp 250-Watt Replacement	293	250.75
PG HID Lamp 250-Watt Replacement	293	250.75
Interior HID Lamp 250-Watt Replacement	293	250.75
Exterior RW HID Lamp 175-Watt Replacement	210	177
PG HID Lamp 175-Watt Replacement	210	177
Interior HID Lamp 175-Watt Replacement	210	177

Interior Hours-of-Use by Sector

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

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= 0.00 for exterior; = 1.0 for parking garages; = see table below for interior)

Interior Coincidence Factor by Sector

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

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Average Annual Deemed Savings for Reduced Wattage HID Direct Replacement Lamps

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Gov		Res-Multifamily	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
HID, Reduced Wattage Replacing 1,000-Watt HID, Exterior	3036	658	0	658	0	658	0	658	0	658	0
HID, Reduced Wattage Replacing 1,000-Watt HID, Interior	3067	560	0.1157	713	0.1157	706	0.1006	486	0.0961	N/A	

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Gov		Res-Multifamily	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
HID, Reduced Wattage, Replacing 400-Watt HID, Exterior	3037	255	0	255	0	255	0	255	0	255	0
HID reduced Wattage, Replacing 400-Watt HID, Interior	3073	217	0.0449	276	0.0449	274	0.0390	189	0.0373	N/A	
HID, Reduced Wattage, Replacing Lamp 320-Watt HID, Exterior	3038	250	0	250	0	250	0	250	0	250	0
HID, Reduced Wattage, Replacing Lamp 320-Watt HID, Interior	3072	213	0.0439	270	0.0439	268	0.0382	185	0.0365	N/A	
HID, Reduced Wattage Replacing 250-Watt HID, Exterior	3039	185	0	185	0	185	0	185	0	185	0
HID, Reduced Wattage Replacing 250-Watt HID, Parking Garage	3071	370	0.0423	370	0.0423	370	0.0423	370	0.0423	N/A	
HID, Reduced Wattage Replacing 250-Watt HID, Interior	3070	158	0.0325	200	0.0325	198	0.0283	137	0.0270	N/A	
HID, Reduced Wattage Replacing175-Watt HID, Exterior	3040	145	0	145	0	145	0	145	0	145	0
HID, Reduced Wattage Replacing175-Watt HID, Parking Garage	3069	289	0.0330	289	0.0330	289	0.0330	289	0.0330	N/A	
HID, Reduced Wattage Replacing 175-Watt HID, Interior	3068	123	0.0254	157	0.0254	155	0.0221	107	0.0211	N/A	

Average Lifecycle Deemed Savings for Reduced Wattage HID Direct Replacement Lamps (kWh)

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Gov	Res-Multifamily
HID, Reduced Wattage Replacing 1,000-Watt HID, Exterior	3036	2,632	2,632	2,632	2,632	2,632
HID, Reduced Wattage Replacing 1,000-Watt HID, Interior	3067	2,241	2,851	2,823	1,946	N/A
HID, Reduced Wattage, Replacing 400-Watt HID, Exterior	3037	1,021	1,021	1,021	1,021	1,021
HID reduced Wattage, Replacing 400-Watt HID, Interior	3073	869	1,106	1,095	755	N/A
HID, Reduced Wattage, Replacing Lamp 320-Watt HID, Exterior	3038	999	999	999	999	999
HID, Reduced Wattage, Replacing Lamp	3072	850	1,082	1,071	738	N/A

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Gov	Res-Multifamily
320-Watt HID, Interior						
HID, Reduced Wattage Replacing 250-Watt HID, Exterior	3039	740	740	740	740	740
HID, Reduced Wattage Replacing 250-Watt HID, Parking Garage	3071	1,480	1,480	1,480	1,480	N/A
HID, Reduced Wattage Replacing 250-Watt HID, Interior	3070	630	802	794	547	N/A
HID, Reduced Wattage Replacing175-Watt HID, Exterior	3040	578	578	578	578	578
HID, Reduced Wattage Replacing175-Watt HID, Parking Garage	3069	1,156	1,156	1,156	1,156	N/A
HID, Reduced Wattage Replacing 175-Watt HID, Interior	3068	492	626	620	428	N/A

Assumptions

Same ballast factors were assumed for each replacement watt product (e.g., a 1.18 ballast factor was used for 250-watt products and their replacements). The assumptions for exterior replacement lamps are:

- 400-watt metal halide replacement: An average of 50% each of 360-watt RW and 330-watt RW was used to generate the new measure wattage.
- 250-watt HID replacement: An average of 50% each of 220-watt RW and 205-watt RW was used to generate the new measure wattage.
- 175-watt HID replacement: An average of 50% each of 150-watt RW and 145-watt RW was used to generate the new measure wattage.

Sources

1. Cadmus review of manufacturers' measure life. Multiple manufacturers' product life rating (with a minimum of 20,000 hours / 4,380 hours = 4.5 years, rounded down to 4 years to be conservative).

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

Revision History

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

LED Troffer, 2x4, Replacing 4-Foot, 3-4 Lamp T8 Troffer

	Measure Details
Measure Master ID	LED Troffer, 2x4: Replacing 4-Foot 3-4 Lamp T8 Troffer, SBP Package, 3348 Replacing 4-Foot 3-4 Lamp T8 Troffer, 3111 Replacing 4-Foot 3-4 Lamp T8 Troffer, SBP A La Carte, 3291
Measure Unit	Per luminaire
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	3111= 15 and 3348 and 3291= 13 [1]
Incremental Cost	Varies by measure, see Appendix D

Measure Description

Using LED 2x4 troffers saves energy over 3-lamp or 4-lamp T8 products because they provide a similar lumen output but with lower input wattage. These products can be installed on a one-for-one basis to replace 3-lamp or 4-lamp T8 luminaires.

Description of Baseline Condition

The baseline measure is a four-foot 3-lamp or 4-lamp T8 troffer in an existing building or new construction.

Description of Efficient Condition

The efficient condition is LED fixtures that meet program requirements. Lamp-only replacements are not eligible for an incentive. LEDs must be on the qualified DLC products list.

Annual Energy-Savings Algorithm

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

Where:

Qty_{BASE} = Quantity of baseline equipment

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

Qty_{EE} = Quantity of efficient condition

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

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= see table below)

Hours-of-Use by Sector

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

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= see table below)

Coincidence Factor by Sector

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

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (3111= 15; 3348 and 3291= 13)[1]

Deemed Savings

Average Annual Deemed Savings for DLC-Listed 2x4 Troffers

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Gov	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED Troffer, 2x4, Replacing 4-Foot 3-4 Lamp T8 Troffer	3111, 3291, 3348	248	0.0512	316	0.0512	312	0.0446	215	0.0426

Average Lifecycle Deemed Savings for DLC-Listed 2x4 Troffers

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Gov
		kWh	kWh	kWh	kWh
LED Troffer, 2x4, Replacing 4-Foot 3-4 Lamp T8 Troffer - SBP	3291, 3348	3,224	4,108	4,056	2,795
LED Troffer, 2x4, Replacing 4' 3-4 Lamp T8 Troffer	3111	3,720	4,740	4,680	3,225

Assumptions

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

Sources

1. Cadmus review of manufacturers' measure life.
2. State of Wisconsin Public Service Commission. *Business Programs Deemed Savings Manual V1.0.* Table 3.2 Lighting Hours of Use and Coincidence Factors by Sector. March 22, 2010.

Revision History

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

LED Fixture, ≤ 180 Watts, Replacing 4 Lamp T5 or 6 Lamp T8, High Bay, DLC Listed

	Measure Details
Measure Master ID	LED Fixture, ≤ 180 Watts, Replacing 4 Lamp T5 or 6 Lamp T8, High Bay, DLC Listed, 3393
Measure Unit	Per luminaire
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	16[1]
Incremental Cost	$300.00[2]

Measure Description

LED high bay fixtures save energy when replacing 4 lamp T5 or 6 lamp T8 high bay products by providing a similar lumen output with lower input wattage. These products can be installed on a one-for-one basis to replace 4 lamp T5 or 6 lamp T8 high bay luminaires.

Description of Baseline Condition

The baseline condition is 4-foot 4 lamp T5HO, or 6 lamp T8 high/low bay fixtures for existing buildings and new construction buildings. An average of 50% 4-foot 4 lamp T5HO and 50% 6 lamp T8 high/low bay luminaires was used to generate the baseline wattage.

Description of Efficient Condition

The efficient condition is DLC-listed LED high bay “High-Bay Luminaires for Commercial and Industrial Buildings,” “High-Bay Aisle Luminaires,” or “Retrofit Kits for High-Bay Luminaires for Commercial and Industrial Buildings” that consume ≤ 180 watts.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{LF\ HIGHBAY} - Watts_{LED}) / 1{,}000 * HOU$

Where:

$Watts_{LF\ HIGHBAY}$ = Annual electricity consumption of 4-foot 4 lamp T5HO or 6 lamp T8 high/low bay luminaires (=228 Watts)[5]

$Watts_{LED}$ = Annual electricity consumption of DLC-listed high/low bay luminaire or retrofit kit

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= see table below)

Hours-of-Use by Sector

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

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{LF\ HIGHBAY} - Watts_{LED}) / 1{,}000 * CF$

Where:

CF = Coincidence factor (= see table below)

Coincidence Factor by Sector

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

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Average Annual Deemed Savings for DLC-Listed LED Highbay ≤ 180 Watts

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Gov		Multifamily	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED Fixture, ≤ 180 Watts, Replacing 4 Lamp T5 or 6 Lamp T8, High Bay, DLC Listed	3393	334	0.0689	424	0.0689	420	0.0599	290	0.0572	532	0.0689

Average Lifecycle Deemed Savings for DLC-Listed LED Highbay ≤ 180 Watts (kWh)

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Gov	Multifamily
LED Fixture, ≤180 Watts, Replacing 4 Lamp T5 or 6 Lamp T8, High Bay, DLC Listed	3393	6,006	7,640	7,564	5,215	9,580

Sources

1. Cadmus review of manufacturers' measure life.
2. Market knowledge of accredited lighting experts, trade allies, and cost information gathered from supplier listings. March 1, 2014.
3. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
4. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.
5. The wattage shown is an weighted average of 75% 6 lamp LF and 25% 4 lamp T5HO highbay fixtures.

Revision History

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

LED Downlights Replacing CFL Downlight

	Measure Details
Measure Master ID	LED Fixture, Downlights, ≤ 18 Watts Replacing 1 Lamp Pin-Based CFL Downlight, 3394 LED Fixture, Downlights, > 18 Watts Replacing 2 Lamp Pin-Based CFL Downlight, 3395
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	Business = 11[1]
Incremental Cost	Varies by measures, see Appendix D

Measure Description

LED downlights can be used to replace existing 1 and 2 lamp pin-based CFL downlights without sacrificing performance. LED downlights save energy because they consume less wattage than the 1 and 2 lamp pin-based CFL downlights products they replace.

Description of Baseline Condition

Low Wattage Downlights

The baseline condition is pin-based CFL downlights containing 1 lamp of 26, 32, or 42 watts in existing buildings and new construction or any 1 lamp pin-based CFL downlight between 26 watts and 45 watts. An average of 33.3% each for 1 lamp 26-watt pin-based CFL downlights, 1 lamp 32-watt pin-based CFL downlights, and 1 lamp 42-watt pin-based CFL downlights was used to generate the baseline usage.

High Wattage Downlights

The baseline condition is pin-based CFL downlights containing 2 lamps of 26, 32 or 42 watts each in existing buildings and new construction or any 2 lamp pin-based CFL downlight with 26 watts to 45 watts. An average of 33.3% each for 2 lamp 26-watt pin-based CFL downlights, 2 lamp 32-watt pin-based CFL downlights, and 2 lamp 42-watt pin-based CFL downlights was used to generate the baseline usage.

Description of Efficient Condition

Low Wattage Downlights

Efficient low-wattage downlights are ENERGY STAR-rated and/or Focus on Energy QPL-listed LED downlights that consume ≤ 18 watts.

High Wattage Downlights

Efficient high-wattage downlights are ENERGY STAR-rated and/or Focus on Energy QPL-listed LED downlights that consume > 18 watts.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{PB\ CFL} - Watts_{LED}) /1{,}000 * HOU$

Where:

$Watts_{PB\ CFL}$ = Wattage of 1 or 2 lamp pin-based CFL downlights with 26, 32, or 42 watt lamps

$Watts_{LED}$ = Wattage of LED products

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= see table below)

Hours-of-Use by Sector

Sector	HOU[2]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239
Multifamily	5,950[4]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (W_{PB\ CFL} - W_{LED}) /1{,}000 * CF$

Where:

CF = Coincidence factor (= see table below)

Coincidence Factor by Sector

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

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 10 years for business; = 6 years for multifamily)[1]

Deemed Savings

Average Annual Deemed Savings for LED Downlights Replacing 1 Lamp or 2 Lamp Pin-Based CFL

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Gov		Multifamily	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED downlights that consume ≤ 18 watts replacing 1 lamp pin-based CFL	3394	90	0.0187	115	0.0187	114	0.0162	78	0.0155	144	0.0187
LED downlights that consume > 18 watts replacing 2 lamp pin-based CFL	3395	161	0.0332	204	0.0332	202	0.0289	140	0.0276	256	0.0332

Average Lifecycle Deemed Savings for LED Downlights Replacing 1 Lamp or 2 Lamp Pin-Based CFL (kWh)

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Gov	Multifamily
LED downlights that consume ≤ 18 watts replacing 1 lamp pin-based CFL	3394	904	1,150	1,138	785	865
LED downlights that consume > 18 watts replacing 2 lamp pin-based CFL	3395	1,607	2,044	2,024	1,395	1,538

Sources

1. Cadmus review of manufacturers' measure life.
2. *Focus on Energy Business Programs Deemed Savings Manual V1.0*. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
3. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.
4. ACES. *Focus on Energy Deemed Savings Desk Review Multifamily Applications for Common Areas*. November 3, 2010. (5949.5 annual operating hours based on 16.3 hours/day * 365 days/year)

Revision History

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

LED Fixture, Downlights, ≤ 18 Watts, Replacing Incandescent Downlight, Exterior

	Measure Details
Measure Master ID	LED Fixture, Downlights, ≤ 18 Watts, Replacing Incandescent Downlight, Exterior, 3405
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	193
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	1,932
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	11[1]
Incremental Cost	$66.29

Measure Description

LED downlight luminaires can replace existing incandescent luminaires without sacrificing performance. LED downlights save energy because they consume less wattage than the incandescent luminaires they replace. There is no demand reduction since this measure is used during evening and night lighting hours.

Description of Baseline Condition

The baseline measure is 50 watt to 72 watt incandescent luminaires.

Description of Efficient Condition

The efficient measure is ENERGY STAR-rated LED downlights that consume ≤ 18 watts.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{INC} - Watts_{LED}) /1{,}000 * HOU * Con_{FACT}$

Where:

$Watts_{INC}$ = Wattage of standard incandescent fixture (= 62)

$Watts_{LED}$ = Wattage of LED product (= 13)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 4,380)

Con_{FACT} = Control factor (= 0.90)

Lifecycle Energy-Savings Algorithm

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

Where:

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

Assumptions

A weighted average of 16.66% each for 50 watt, 53 watt, 60 watt, 65 watt, 70 watt, and 72 watt incandescent luminaires was used to generate the baseline wattage.

4,380 hours run time of fixtures based on an annual average of 12 hours per day from NOAA data.[2] This also includes the times when photocells turn on prior to exact sunset and turn off after exact sunrise, accounting for diminished outdoor lighting as well as time clock scheduled lighting.

Applying a controls factor allows for a more conservative estimate of savings. Based on project experience, less than 10% of the exterior fixtures on the market have additional controls that may operate at conditions other than dusk to dawn.

Sources

1. Cadmus review of manufacturers' measure life.
2. U.S. Department of Commerce National Oceanic & Atmospheric Administration.– "NOAA Solar Calculator." http://www.esrl.noaa.gov/gmd/grad/solcalc/.

Revision History

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

Exterior LED Downlights Luminaires > 18 Watts

	Measure Details
Measure Master ID	Exterior LED Downlights Luminaires > 18 Watts, 3404
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	226.3
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	2,263
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	11[1]
Incremental Cost ($/unit)	$84.98

Measure Description

LED downlight luminaires can replace existing incandescent luminaires used for the same application without sacrificing performance. LED downlights save energy because they consume less wattage than the incandescent luminaries they replace.

Description of Baseline Condition

The baseline condition is 80-watt halogen and 50-watt to 100-watt HID luminaires.

Description of Efficient Condition

The efficient condition is ENERGY STAR-rated LED downlights that consume less than 18 watts.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{INC} - kWh_{LED}$

$kWh_{INC} = Wattage_{INC} / 1{,}000 * HOURS * CF$

kWh_{LED} = $Wattage_{LED}$ / 1,000 * HOURS * CF

Where:

kWh_{INC} = Annual electricity consumption of standard wattage incandescent fixtures

kWh_{LED} = Annual electricity consumption of LED products

Wattage = Instantaneous electric consumption of lamp or fixture

1,000 = Kilowatt conversion factor

HOURS = Average annual run hours (= 4,380)[3]

CF = Controls factor that accounts for the small percentage of systems in the market with additional controls (= 0.9)

Summer Coincident Peak Savings Algorithm

There are no peak savings for this measure.

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 11 years)[1]

Deemed Savings

Average Annual Deemed Savings for LED Downlights > 18 Watts

Measure	Exterior 4380 (0.00)	
	Savings (kWh)	Savings (kW)
LED Downlights >18 watts	226.3	0.0

Average Lifecycle Deemed Savings for LED Downlights > 18 Watts

Measure	Exterior 4380 (0.00)
	Savings (kWh)
LED Downlights >18 watts	2,263

Assumptions

A weighted average of 25% each for 80-watt halogen, 50-watt HID, 70-watt HID, and 100-watt HID luminaires was used to generate the baseline wattage.

The 4,380 HOURS was based on an annual average of 12 hours per day from NOAA data.[2] This includes when photocells turn on prior to exact sunset and turn off after exact sunrise, accounting for diminished outdoor lighting as well as time clock scheduled lighting.

Applying a controls factor allows for a more conservative savings estimate. Based on project experience, less than 10% of the exterior fixtures on the market have additional controls that may operate at conditions other than dusk to dawn.

Sources

1. Cadmus review of manufacturers' measure life.
2. U.S. Department of Commerce, National Oceanic & Atmospheric Administration. *NOAA Solar Calculator*. Available online: http://www.esrl.noaa.gov/gmd/grad/solcalc/

Revision History

Version Number	Date	Description of Change
01	04/2014	Initial TRM entry

Exterior LED Fixtures Replacement

	Measure Details
Measure Master ID	LED Fixture, Exterior: Replacing 150-175 Watt HID, 3099, 3289 Replacing 250 Watt HID, 3102, 3301 Replacing 320 Watt HID, 3105 Replacing 320-400 Watt HID, 3106 Replacing 400 Watt HID, 3107, 3303 Replacing 70-100 Watt HID, 3108,3304
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by wattage
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by wattage
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Incremental Cost	Varies by measure, see Appendix D

Measure Description

Exterior LED fixtures are an energy-saving alternative to traditional standard wattage HID light sources that have been used for the same applications. LED light sources can be applied in almost every common application type where HID light sources are currently found. This measure is only for replacing existing HID fixtures.

Description of Baseline Condition

The baseline condition is existing HID lamps between 70 watts and 400 watts.[2]

Description of Efficient Condition

The efficient condition is LED fixtures that meet program requirements. Replacements must be complete fixtures or a retrofit of interior components with a total power reduction of 40% or more. Lamp-only replacements are not eligible for an incentive. LEDs must be on the qualifying DLC list.[3]

Annual Energy-Savings Algorithm

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

Where:

$Watts_{BASE}$ = Wattage of standard HID fixture

$Watts_{EE}$ = Wattage of LED fixture

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 4,380)

Wattages Used for Deemed Savings Calculations

Measure	$Watts_{BASE}$ [5]	$Watts_{EE}$ [4]
Exterior LED replacing 70-watt to 100-watt HID Average	111.5	31
Exterior LED replacing 150-watt to 175-watt HID Average	194.5	59
Exterior LED replacing 250-watt HID Average	299.0	94
Exterior LED replacing 320-watt HID	368.0	160
Exterior LED replacing 400-watt HID	463.0	178

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Average Annual Deemed Savings for Exterior LED Fixtures

Measure	MMID	kWh	kW
Exterior LED replacing 70-watt to 100-watt HID Average	3108, 3304	344	0
Exterior LED replacing 150-watt to 175-watt HID Average	3099, 3289	594	0
Exterior LED replacing 250-watt HID Average	3102, 3301	870	0
Exterior LED replacing 320-watt HID	3105	859	0
Exterior LED replacing 400-watt HID	3106, 3107, 3290, 3303	1,215	0

Average Lifecycle Deemed Savings for Exterior LED Fixtures

Measure	MMID	kWh
Exterior LED replacing 70-watt to 100-watt HID Average	3108, 3304	4,131
Exterior LED replacing 150-watt to 175-watt HID Average	3099, 3289	7,127
Exterior LED replacing 250-watt HID Average	3102, 3301	10,438
Exterior LED replacing 320-watt HID	3105	10,312
Exterior LED replacing 400-watt HID	3106, 3107, 3290, 3303	14,575

Assumptions

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

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

Sources

1. Cadmus review of manufacturers’ measure life.
2. Based on market research.
3. Design Lights Consortium. *Qualified Products List*.
4. Focus on Energy Default Wattage Guide 2013, Version 1.0.
5. Focus on Energy Default Wattage Guide 2013, Version 1.0.

Revision History

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

LED Replacing Incandescent, Exterior

	Measure Details
Measure Master ID	LED Lamp, ENERGY STAR, Exterior: Replacing Incandescent Lamp ≤ 40 Watts, 3402 Replacing Incandescent Lamp > 40 Watts, 3403
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by baseline
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by baseline
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	7[1]
Incremental Cost	$15.00[2]

Measure Description

ENERGY STAR-rated LED replacement lamps save energy by reducing the total input wattage of the luminaire as compared to the same luminaire operating with standard wattage incandescent lamps. This measure provides an energy-efficient alternative to using incandescent lamps in several exterior applications.

Description of Baseline Condition

Less than or equal to 40 watts

One baseline condition is for standard incandescent lamps. The baseline wattage is generated using an average of 50% 25-watt incandescents and 50% 40-watt incandescents.

Greater than 40 watts

Another baseline condition is for standard and EISA compliant incandescent lamps of 53 watts, 60 watts, 65 watts, 70 watts, 72 watts, and 80 watts. The baseline wattage is generated using an average of 16.66% each of 53-watt incandescent, 60-watt incandescent and halogen, 65-watt incandescent, 70-watt halogen, 72-watt halogen, and 80-watt halogen lamps.

Description of Efficient Condition

The efficient equipment must be an ENERGY STAR-rated LED lamp. The efficient wattage is generated using an average of 33% each of 11.68 watt, 16.70 watt, and 17.81 watt ENERGY STAR-rated LEDs.

Annual Energy-Savings Algorithm[3]

$kWh_{SAVED} = (Watts_{INCANDESCENT} - Watts_{EXT\ LED}) / 1{,}000 * HOU$

Where:

$Watts_{INCANDESCENT}$ = Wattage of standard incandescent lamps = 67 if > 40 watts; = 32.5 if ≤ 40 watts)

$Watts_{EXT\ LED}$ = Wattage of ENERGY STAR-rated LED lamp with a lumen output rating equivalent to the lumen output of incandescent being replaced (= 15.4)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 4,380)

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 7 years)[1]

Deemed Savings

Average Annual Deemed Savings for LED Lamp Replacing Incandescent

Measure	MMID	kWh Saved
LED Lamp, ENERGY STAR, Replacing Incandescent Lamp ≤ 40 Watts, Exterior	3402	106
LED Lamp, ENERGY STAR, Replacing Incandescent Lamp > 40 Watts, Exterior	3403	202

Average Lifecycle Deemed Savings for LED Lamp Replacing Incandescent

Measure	MMID	kWh Saved
LED Lamp, ENERGY STAR, Replacing Incandescent Lamp ≤ 40 Watts, Exterior	3402	742
LED Lamp, ENERGY STAR, Replacing Incandescent Lamp > 40 Watts, Exterior	3403	1,414

Assumptions

4,380 hours run time of fixtures based on an annual average of 12 hours per day from NOAA data.[3] This also includes the times when photocells turn on prior to exact sunset and turn off after exact sunrise, accounting for diminished outdoor lighting as well as time clock scheduled lighting.

Sources

1. Cadmus review of manufacturers' measure life.
2. Market knowledge of accredited lighting experts, trade allies, and cost information gathered from supplier listings. March 1, 2014.
3. U.S. Department of Commerce National Oceanic & Atmospheric Administration. "NOAA Solar Calculator." http://www.esrl.noaa.gov/gmd/grad/solcalc/.

Revision History

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

LED Fixtures, High Bay

	Measure Details
Measure Master ID	LED Fixture, High Bay < 155 Watts, Replacing 250 Watt HID, 3091, 3285 < 250 Watts, Replacing 320-400 Watt HID, 3092 < 250 Watts, Replacing 400 Watt HID, 3093, 3287 < 365 Watts, Replacing 400 Watt HID, 3094, 3288 < 500 Watts, Replacing 1,000 Watt HID, 3095 < 800 Watts, Replacing 1,000 Watt HID, 3096
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by wattage and sector
Peak Demand Reduction (kW)	Varies by wattage and sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by measure and sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Incremental Cost	Varies by measure, see Appendix D

Measure Description

High bay LED fixtures are an energy-saving alternative to traditional standard wattage HID light sources used for the same applications. LED light sources can be used in almost every common type of application where HID light sources are currently found.

Description of Baseline Condition

The baseline is standard HID lamps that range from 250 watts to 1,000 watts.

Description of Efficient Condition

To meet program requirements, the LED replacements must be complete fixtures that result in a total power reduction of 40% or more. The LEDs must also be on the qualifying DLC list. Lamp-only replacements are not eligible for incentive.

Annual Energy-Savings Algorithm

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

Where:

Qty_{BASE} = Quantity of standard HID fixture

$Watts_{BASE}$ = Baseline consumption of standard HID fixture (= see table below)

Qty_{EE} = Quantity of LED fixture

$Watts_{EE}$ = Efficient consumption of LED fixture (= see table below)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= see table below)

Hours-of-Use by Sector

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

Baseline and Efficient Lamp Consumption

Measure	$Watts_{BASE}$	$Watts_{EE}$
LED Fixture, High Bay, < 155 Watts Replacing 250-Watt HID	293	119
LED Fixture, High Bay, < 250 Watts Replacing 400-Watt HID	455	169
LED Fixture, High Bay, < 250 Watts Replacing 320-Watt to 400-Watt HID	356	169
LED Fixture, High Bay, < 365 Watts Replacing 400-Watt HID	455	296
LED Fixture, High Bay, < 800 Watts Replacing 1,000-Watt HID	1,079	690
LED Fixture, High Bay, < 500 Watts Replacing 1,000-Watt HID	1,079	500

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= see table below)

Coincidence Factor by Sector

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

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Average Annual Deemed Savings for High Bay LED Fixtures

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Gov	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED Fixture, High Bay, < 155 Watts Replacing 250-Watt HID	3091, 3285	649	0.1340	826	0.1340	817	0.1166	564	0.1114
LED Fixture, High Bay, < 250 Watts Replacing 400-Watt HID	3093	1,067	0.2202	1,357	0.2202	1,344	0.1916	926	0.1830
LED Fixture, High Bay, < 250 Watts Replacing 320-Watt to 400-Watt HID	3092, 3287	698	0.1440	887	0.1440	879	0.1253	606	0.1197
Fixture, High Bay, < 365 Watts Replacing 400-Watt HID	3094, 3288	593	0.1224	754	0.1224	747	0.1065	515	0.1018
LED Fixture, High Bay, < 800 Watts Replacing 1,000-Watt HID	3096	1,451	0.2995	1,846	0.2995	1,828	0.2606	1,260	0.2490
LED Fixture, High Bay, < 500 Watts Replacing 1,000-Watt HID	3095	2,160	0.4458	2,747	0.4458	2,720	0.3879	1,875	0.3706

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

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Gov
LED Fixture, High Bay, < 155 Watts Replacing 250-Watt HID	3091, 3285	11,682	14,861	14,714	10,145
LED Fixture, High Bay, < 250 Watts Replacing 400-Watt HID	3093	19,202	24,427	24,185	16,674
LED Fixture, High Bay, < 250 Watts Replacing 320-Watt to 400-Watt HID	3092, 3287	12,555	15,972	15,813	10,902
Fixture, High Bay, < 365 Watts Replacing 400-Watt HID	3094, 3288	10,675	13,580	13,446	9,270
LED Fixture, High Bay, < 800 Watts Replacing 1,000-Watt HID	3096	26,117	33,224	32,895	22,679
LED Fixture, High Bay, < 500 Watts Replacing 1,000-Watt HID	3095	38,874	49,452	48,963	33,757

Assumptions

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

Sources

1. Cadmus review of manufacturers’ measure life.
2. State of Wisconsin Public Service Commission of Wisconsin. *Focus on Energy Evaluation, Business Programs Deemed Savings Manual V1.0*. Table 3.2 Lighting Hours of Use and Coincidence Factors by Sector. March 22, 2010.
3. *Focus on Energy Default Wattage Guide*. 2013. All values are based on metal halide fixtures, except as otherwise noted.

Revision History

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

LED, Horizontal Case Lighting

	Measure Details
Measure Master ID	LED, Horizontal Case Lighting, 3114, 3335
Measure Unit	Per linear foot
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	55
Peak Demand Reduction (kW)	0.0063
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	1,100
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	3114=20[1] 3335=16[2]
Incremental Cost	$86.00 per installation

Measure Description

This measure is horizontal LED case lighting replacing existing fluorescent case lighting in both freezers and cooler applications. The measure incentives are based on the feet of lamp replaced.

Description of Baseline Condition

The baseline is a mix of fluorescent T8 lamps, T12 lamps, and HOT12 lamps in a multideck refrigerated or freezer case. The deemed value of the existing fluorescent lamps is 10.93 watts per linear foot of lamp. This estimate represents the assumed base case technology of F32 T8 fluorescent lamps with electronic ballasts, F40 T12 fluorescent lamps with energy-saving magnetic ballasts, and F48 HOT12 fluorescent lamps with energy-saving magnetic ballasts. A weighting of 60% for F32 T8 fixtures, 20% for F40 T12 fixtures, and 20% for F48 HOT12 fixtures was used based on industry market research. The deemed wattage value was taken from specifications for a standard refrigeration multideck case.[3,4]

Description of Efficient Condition

The efficient equipment is LED fixtures in a multideck refrigerated or freezer case. The deemed value for the LED replacement lamp is 6.29 watts per linear foot of multideck case, based on DLC qualifying products. The deemed wattage value was taken from specifications for a standard refrigeration multideck case with LED lighting.[3,4]

Annual Energy-Savings Algorithm

$kWh_{SAVED} = [P_E - P_P + ((P_E * F_{FH} - P_P * F_{LH})/COP_{COOLING})] * HOU$

Where:

P_E = Existing fluorescent lighting wattage per linear foot (= 0.01093 kW)
P_P = Replacement LED lighting wattage per linear foot (= 0.00629 kW)
F_{FH} = Fluorescent lighting to heat factor (= 79%)[5]
F_{LH} = LED lighting to heat factor (= 80%)[5]
$COP_{COOLING}$ = Coefficient of performance of refrigeration system (= 2.22)[5]
HOU = Hours-of-use (= 8,760)[6]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = [P_E - P_P + ((P_E * F_{FH} - P_P * F_{LH})/COP_{COOLING})] * CF$

Where:

CF = Coincidence factor (= 1)

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (3114=20[1] 3335=16[2])

Assumptions

The deemed value for the fluorescent lighting to heat factor is 79%, based on an analysis stating that 21% of the power to a fluorescent light is converted to light while the remainder (79%) is infrared radiation or direct heat.[5]

The deemed value for the LED lighting to heat factor is 80%, as the midpoint based on an analysis stating that 15-25% of the power to an LED light is converted to light, while the remainder (75-85%) is converted directly to heat.[6]

The deemed value of the COP for a refrigeration system is 2.5 for coolers and 1.3 for freezers. The COP was weighted 77% to coolers and 23% to freezers, for an overall value of 2.22.[6]

The deemed annual operating hours is 8,760, the number of hours in a year.[6]

Sources

1. Cadmus review of manufacturers' measure life, similar measures MMIDs 2456-2457.
2. DEER 2008 and Regional Technical Forum http://www.energy.ca.gov/deer/ and http://rtf.nwcouncil.org/
3. Arthur D. Little, Inc. *Energy Savings Potential for Commercial Refrigeration Equipment – Final Report.* 1996.
4. Navigant Consulting, Inc. *Energy Savings Potential and R&D Opportunities for Commercial Refrigeration*. 2009.
5. United States Department of Energy Office of Energy Efficiency & Renewable Energy. The calculation assumes that 100% of the thermal energy produced by the lights is removed by the refrigeration system.
6. PA Consulting Group Inc. *State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation Business Programs: Deemed Savings Manual v1.0*. Updated March 22, 2010.

Revision History

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

LED, Direct Install

	Measure Details
Measure Master ID	LED, Direct Install: 12 Watts, 3274, 3347 12 Watts, SBP A La Carte, 3631 > 12 Watts, 3577, 3578 > 12 Watts, SBP A La Carte, 3629 > 16 Watt, 3579, 3580 > 16 Watt, SBP A La Carte, 3630
Measure Unit	Per LED
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by wattage and sector
Peak Demand Reduction (kW)	Varies by wattage and sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by wattage and sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	7[1]
Incremental Cost	Varies by measure, see Appendix D

Measure Description

This measure is an ENERGY STAR-qualified LED screw-in bulb installed by a qualified Small Business Program trade ally to replace an incandescent screw-in bulb. Assumptions are based on a direct installation, not a time-of-sale purchase. Replacement involves a functioning bulb.

Description of Baseline Condition

The baseline equipment is assumed to be the EISA requirements (see table below).[2]

Baseline Wattage by Measure

Measure	Baseline Wattage
LED, > 16 Watt, DI	72
LED, > 12 Watt, DI	53
LED, 12 Watt, DI	43
LED, 8 Watt, DI	29

Description of Efficient Condition

The efficient measure is a standard screw-based LED lamp. Based on experiences for the 2014 Small Business Program, the following table shows the most common wattages installed.

Efficient Wattages by Measure

Measure	LED Wattage
LED, > 16 Watt, DI	18.0
LED, > 12 Watt, DI	12.5
LED, 12 Watt, DI	10.5
LED, 8 Watt, DI	8.0

Annual Energy-Savings Algorithm

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

Where:

$Watts_{BASE}$ = Baseline wattage (= see table above)

$Watts_{EE}$ = Efficient wattage (= see table above)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= see table below)

Hours-of-Use by Sector

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

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= see table below)

Coincidence Factor by Sector

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

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (=7 years)[1]

Deemed Savings

Annual Savings

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Government	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED, > 16 Watt	3580, 3630	201	0.0416	256	0.0416	254	0.0362	175	0.0346
LED, > 12 Watt	3577, 3578, 3629	151	0.0312	192	0.0312	190	0.0271	131	0.0259
LED, 12 Watt	3274, 3347, 3631	121	0.0250	154	0.0250	153	0.0218	105	0.0208
LED, 8 Watt	3273	78	0.0162	100	0.0162	99	0.0141	68	0.0134

Lifecycle Savings

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Government
LED, > 16 Watt	3580, 3630	1,407	1,792	1,778	1,225
LED, > 12 Watt	3577, 3578, 3629	1,057	1,344	1,330	917
LED, 12 Watt	3274, 3347, 3631	847	1,078	1,071	735
LED, <=8 Watt	3273	546	700	693	476

Sources

1. Cadmus review of manufacturers' measure life.
2. Focus on Energy. Approach to Accounting for Changes in Lighting Baseline. May 2013.

3. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
4. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.

Revision History

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

LED Exit Signs

	Measure Details
Measure Master ID	LED Exit Sign, Retrofit, 2768
Measure Unit	Per sign
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by baseline
Peak Demand Reduction (kW)	Varies by baseline
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by baseline
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	8 MESP, 16 Small Business[4]
Incremental Cost	$91.61

Measure Description

Exit signs that have earned the ENERGY STAR label use 5 watts or less, compared to standard signs that use up to 40 watts. Savings result from replacing incandescent or fluorescent exit signs with LED exit signs, which use significantly less electricity. The savings estimate assumes that both incandescent and fluorescent exit signs undergo early replacement rather than replacement at failure.

Description of Baseline Condition

The baseline condition is an incandescent (40 watt) or CFL (16 watt) exit sign with one or two bulbs.

Description of Efficient Condition

The efficient condition is an LED exit sign. The fixture must meet ENERGY STAR v2.0 specifications.

Annual Energy-Savings Algorithm

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

Where:

$Watts_{BASE}$ = Wattage of baseline measure (= 16 for CFL exit sign; = 40 for incandescent exit sign)[2]

$Watts_{EE}$ = Wattage of LED exit sign (= 2.9)[1]

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 8,760)[3]

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= 1)[3]

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 8 years MESP; = 16 years small business)[4]

Deemed Savings

The default assumption is generated using 50% CFL replacements and 50% incandescent replacements.

Deemed Savings for LED Exit Signs

Type of Savings	MMID	Baseline Measure Type		
		CFL	Incandescent	Default
Annual Energy Savings (kWh)	2768	115	325	220
Peak Demand Reduction (kW)		0.013	0.037	0.025
Lifecycle Energy Savings (kWh) - MESP		918	2,600	1,759
Lifecycle Energy Savings (kWh) – Small Business		1,836	5,200	3,518

Sources

1. ENERGY STAR. "Exit Signs." ENERGY STAR Savings Calculator. http://www.energystar.gov/index.cfm?c=exit_signs.pr_exit_signs.
2. ENERGY STAR. "Save Energy, Money and Prevent Pollution with Light-Emitting Diode Exit Signs." http://www.energystar.gov/ia/business/small_business/led_exitsigns_techsheet.pdf.
3. *Mid-Atlantic Technical Reference Manual, Version 3*. March 2013.
4. *PA* Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf

Revision History

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

LED Fixture, Downlights, Accent Lights, and Monopoint ≤ 18 Watts

	Measure Details
Measure Master ID	LED Fixture, Downlights, Accent Lights, and Monopoint ≤ 18 Watts: Common Area, 2984 In Unit, 3158
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by location
Peak Demand Reduction (kW)	Varies by location
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by location
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	2984=11 and 3158=20[1]
Incremental Cost	MMID 2984 = $80.13; MMID 3158 = $88.38

Measure Description

LED downlights, accent lights, and monopoint fixtures can replace existing incandescent fixtures without sacrificing performance, and save energy because they consume less wattage than the incandescent products they replace.

Description of Baseline Condition

The baseline is a 60-watt to 100-watt incandescent fixture.

Description of Efficient Condition

The efficient equipment is a monopoint fixture that consumes ≤ 18 watts, an ENERGY STAR-rated LED downlight that consumes ≤ 18 watts, and an ENERGY STAR-rated LED accent lights that consumes ≤ 18 watts.

Annual Energy-Savings Algorithm

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

Where:

$Watts_{BASE}$ = Power consumption of baseline incandescent fixtures (see table below)

$Watts_{EE}$ = Power consumption of efficient LED products (see table below)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 5,950 in common area;[2] = 829 in unit)[6]

Wattage by Location and Lumen Output

Location	Lumen Output	Typical Wattage	$Watts_{BASE}$[3]	$Watts_{EFFICIENT}$[4]
In Unit	750-1,049	60	49	13
	1,050-1,489	75	58	16
Common Area	750-1,049	60	49	13
	1,050-1,489	75	58	16

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= 0.77 in common area;[5] = 0.11 in unit)[7]

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (MMIDS 2984=11 and 3158=20)[1]

Assumptions

The baseline for this measure is a combination of halogen and incandescent efficiencies for 2014. The weighted average is based on estimated sales percentages: 0-309 lumens = 20%; 310-749 lumens = 30%; 750-1,049 lumens = 40%; 1,050-1,489 lumens = 10%.

Sources

1. Cadmus review of manufacturers’ measure life.
2. ACES. *Deemed Savings Desk Review*. November 3, 2010.

3. United States Environmental Protection Agency. “Next Generation Lighting Programs: Opportunities to Advance Efficient Lighting for a Cleaner Environment.” EPA-430-R-11-115, pg. 27. October 2011. http://www.energystar.gov/lightingresources.
4. Predominant wattage in each category.
5. *Focus on Energy Business Programs Deemed Savings Manual V1.0*. Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.
6. Cadmus. Field Study Research: Residential Lighting. October 18, 2013. Conducted regarding CFL and incandescent bulbs.
7. Cadmus. Field Study Research: Residential Lighting. October 25, 2013. Conducted regarding CFL and incandescent bulbs.

Revision History

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

LED Fixture, Downlights, ≤ 100 Watts, ≥ 4,000 Lumens, Exterior, Interior

	Measure Details
Measure Master ID	LED Fixture, Downlights ≤ 100 Watts, ≥ 4,000 Lumens: Interior, 3396 Exterior, 3397
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	11[1]
Incremental Cost	$60.00[2]

LED Fixture, Downlights, ≥ 6,000 Lumens, Exterior, Interior

	Measure Details
Measure Master ID	LED Fixture, Downlights ≥ 6,000 Lumens: Interior, 3398 Exterior, 3399
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0

	Measure Details
Effective Useful Life (years)	11[1]
Incremental Cost	$60.00[2]

Measure Description

LED downlights can replace existing interior and exterior 150-watt to 250-watt HID fixtures without sacrificing performance. LED downlights save energy because they consume less wattage than the HID products they replace.

Description of Baseline Condition

An average of 50% each 150-watt and 175-watt HID fixtures was used to generate the baseline usage.

≥ 4,000 Lumen ≤ 100 Watt LED Downlights

The baseline measure is 150-watt to 175-watt HID fixtures for existing buildings and new construction. 100% 250-watt HID fixtures were used to generate the baseline usage.

≥ 6,000 Lumen LED Downlights

The baseline measure is 176-watt to 250-watt HID fixtures for existing buildings and new construction.

Description of Efficient Condition

Replacement of 150-175 Watt HID

The efficient measure is an ENERGY STAR-rated and/or Focus on Energy QPL-listed LED downlight that produces ≥ 4,000 lumens and consumes ≤ 100 watts.

Replacement of 176-250 Watt HID

The efficient measure is an ENERGY STAR-rated and/or Focus on Energy QPL-listed LED downlight that produces ≥ 6,000 lumens.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{HID} - Watts_{LED}) / 1{,}000 * HOU * Con_{FACT}$

Where:

$Watts_{HID}$ = Wattage of standard HID fixtures

$Watts_{LED}$ = Wattage of LED products

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 4,380 for exterior; = see table below for interior)

Con_{FACT} = Control factor (= 0.90), exterior only

Interior Hours-of-Use by Sector

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

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor, interior fixtures only (= see table below)

Interior Coincidence Factor by Sector

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

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Average Annual Deemed Savings for Interior LED Downlights ≥ 4,000 Lumens and Consume ≤ 100 Watts

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Gov		Multifamily	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED Fixture, Downlights ≤ 100 Watts, ≥ 4,000 Lumens, Interior	3396	372	0.0767	473	0.0767	468	0.0668	323	0.0638	593	0.0767

Average Lifecycle Deemed Savings for Interior LED Downlights ≥ 4,000 Lumens and Consume ≤ 100 Watts (kWh)

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Gov	Multifamily
LED Fixture, Downlights ≤ 100 Watts, ≥ 4,000 Lumens, Interior	3396	3,717	4,729	4,682	3,228	5,930

Average Annual Deemed Savings for Exterior LED Downlights ≥ 4,000 Lumens and Consume ≤ 100 Watts

Measure	MMID	Exterior	
		kWh	kW
LED Fixture, Downlights ≤ 100 Watts, ≥ 4,000 Lumens, Exterior	3397	393	N/A

Average Lifecycle Deemed Savings for Exterior LED Downlights ≥ 4,000 Lumens and Consume ≤ 100 Watts (kWh)

Measure	MMID	Exterior
LED Fixture, Downlights ≤ 100 Watts, ≥ 4,000 Lumens, Exterior	3397	3,929

Average Annual Deemed Savings for Interior LED Downlights ≥ 6,000 Lumens

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Gov		Multifamily	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED Fixture, Downlights ≥ 6,000 Lumens, Interior	3398	518	0.1069	658	0.1069	652	0.0930	449	0.0888	826	0.1069

Average Lifecycle Deemed Savings for Interior LED Downlights ≥ 6,000 Lumens (kWh)

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Gov	Multifamily
LED Fixture, Downlights ≥ 6,000 Lumens, Interior	3398	5,176	6,585	6519	4,495	8,257

Average Annual Deemed Savings for Exterior LED Downlights ≥ 6,000 Lumens

Measure	MMID	Exterior	
		kWh	kW
LED Fixture, Downlights ≥ 6,000 Lumens, Exterior	3399	547	N/A

Average Lifecycle Deemed Savings for Exterior LED Downlights ≥ 6,000 Lumens (kWh)

Measure	MMID	Exterior
LED Fixture, Downlights ≥ 6,000 Lumens, Exterior	3399	5,470

Assumptions

4,380 hours run time of exterior fixtures based on an annual average of 12 hours per day from NOAA data.[5] This also includes the times when photocells turn on prior to exact sunset and turn off after exact sunrise, accounting for diminished outdoor lighting as well as time clock scheduled lighting.

Applying a controls factor allows for a more conservative estimate of savings. Based on project experience, less than 10% of the exterior fixtures on the market have additional controls that may operate at conditions other than dusk to dawn.

Sources

1. Cadmus review of manufacturers' measure life.
2. Market knowledge of accredited lighting experts, trade allies, and cost information gathered from supplier listings. March 1, 2014.
3. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
4. *Focus on Energy Business Programs Deemed Savings Manual V1.0*. Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.
5. U.S. Department of Commerce National Oceanic & Atmospheric Administration.– "NOAA Solar Calculator." http://www.esrl.noaa.gov/gmd/grad/solcalc/.

Revision History

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

LED Fixture, Replacing HID, Exterior

	Measure Details
Measure Master ID	LED Fixture, Exterior: Replacing 70-100 Watt HID, 3108 Replacing 150-175 Watt HID, 3099 Replacing 250 Watt HID, 3102 Replacing 320 Watt HID, 3105 Replacing 400 Watt HID, 3107
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by baseline
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by baseline
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Incremental Cost	Varies by measure, see Appendix D

Measure Description

Exterior LED fixtures are an energy-saving alternative to traditional standard wattage HID light sources that have been used for the same applications. LED light sources can be applied in almost every common application type where HID light sources are currently found.

Description of Baseline Condition

The baseline condition is standard HID lamps between 70 watts and 400 watts.

Description of Efficient Condition

The efficient condition is LED fixtures that meet program requirements. Replacements must be complete fixtures with a total power reduction of 40% or more. Lamp-only replacements are not eligible for an incentive. LEDs must be on the qualifying DLC list.[2]

Annual Energy-Savings Algorithm

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

Where:

$Watts_{BASE}$ = Wattage of standard HID fixture (= varies by measure)

$Watts_{EE}$ = Wattage of LED fixture (= varies by measure)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 4,380)

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Average Deemed Savings for Exterior LED Fixtures

Measure	MMID	Annual kWh Savings	Lifecycle kWh Savings
LED Fixture, Replacing 70-100 Watt HID Exterior	3108	317	3,804
LED Fixture, Replacing 150-175 watt HID, Exterior	3099	534	6,408
LED Fixture, Replacing 250 Watt HID, Exterior	3102	808	9,696
LED Fixture, Replacing 320 Watt HID, Exterior	3105	820	9,840
LED Fixture, Replacing 400 Watt HID, Exterior	3107	1,123	13,476

Assumptions

Calculations are based on exterior lighting that operates 4,380 hours annually, dusk to dawn. LED lamps can achieve a 40% reduction in power requirements.

Sources

1. Cadmus review of manufacturers’ measure life.
2. Design Lights Consortium. *Qualified Parts List*.

Revision History

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

LED 1-Foot by 4-Foot Replacing 2 Lamp Linear Fluorescent

Measure Master ID	LED, 1x4, Replacing T8 or T12, 2-Lamp, 3387,3388, 3389
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	16[1]
Incremental Cost	$110.00

Measure Description

LED-based fixture replacements or complete LED retrofits save energy over fluorescent fixtures by increasing the number of lumens per watt and increasing the light quality and distribution. There are varying wattage LED fixtures used to replace 1’x4’ dimension fixtures, which normally have two T12 or T8 lamps with ballast installed. While not in the savings calculations, this measure can be used for replacing specialty 1’x4’ fixtures that have three T12 or T8 lamps. The 1’x4’ LED fixture will replace a 2 lamp or greater T12 or T8 fixture.

LED fixtures are counted on a per-fixture basis. A partial retrofit of the fixture is not allowed, including linear LED tubes and LED luminaires that adhere to the interior of the existing fixture housing.

Description of Baseline Condition

T8 Linear Fluorescent Fixtures (EISA compliant)

2 Lamp T8	58 watts

T12 Linear Fluorescent Fixtures

2 Lamp T12	82 watts

The baseline is a 2 lamp T8 fixture. 3 Lamp replacements are allowed, although not included in the calculation because of the expected limited number applied in the field.

This measure does not include replacing 1 lamp T12 or T8 1-foot by 4-foot fixtures.

Description of Efficient Condition

The DLC provides a listing of qualified LED products. The efficient condition uses the listing for 1'x4' Luminaires for Ambient Lighting of Interior Commercial Spaces. The new measure condition assumes an average of the DLC listing on December 2, 2013.

Average of DLC Listing

1'x4' LED troffer	36 watts

DLC-listed equipment in the following categories are not acceptable as replacements.

- Four-Foot Linear Replacement Lamps
- Two-Foot Linear Replacement Lamps

Replacing T8 or T12 fixtures use the DLC listing of 1'x4' Luminaires for Ambient Lighting of Interior Commercial Spaces. The new measure condition assumes an average of the DLC listing on December 2, 2013. The efficient condition wattage and hours of operation are an average of the listing on this date.

Annual Energy-Savings Algorithm

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

Where:

$Watts_{EX}$ = Wattage of existing T8 or T12 lamps and ballasts
$Watts_{LED}$ = Wattage of LED 1-foot by 4-foot luminaire
1,000 = Kilowatt conversion factor
HOU = Hours-of-use (= see table below)

Hours-of-Use by Sector

Sector	HOU[1]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239
Multifamily	5,950

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= see table below)

Coincidence Factor by Sector

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

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Average Annual Savings

Measure	kWh Savings	kW Savings
Commercial	81	0.0168
Industrial	104	0.0168
Agriculture	102	0.0146
Schools & Government	71	0.0140

Average Lifecycle Savings

Measure	kWh Savings
Commercial	1,296
Industrial	1,664
Agriculture	1,632
Schools & Government	1,136

Assumptions

This measure does not include the replacement of 1-lamp T12 or T8 1’x4’ fixtures. This calculation is used to account for the federal legislation stemming from EISA, which dictates the fluorescent fixture efficiency in lumens per watt. Initiated on July 14, 2012, federal standards will require that practically all linear fluorescents meet strict performance requirements that will essentially require all T12 users to upgrade to high performance T8 and T5 lamps and electronic ballasts when purchasing new bulbs. The effect is that first-year savings for T12 to T8 replacements can be assumed only for the remaining useful life of T12 equipment, at which point customers have no choice but to install equipment meeting the new standard.

Cost Assumptions: Cost is expected to be $10 less for materials than the 2’x4’ LED replacements based on preliminary quotes from suppliers. Labor costs are the same as for 2’x4’ LED replacements. Labor is estimated at approximately $40 for the troffer replacement and $20 for the troffer retrofit. The installed cost was rounded to $150.00 ($110.00 materials + $40.00 labor or $130.00 material + $20.00 labor).This price is expected to drop over time.

Sources

1. Cadmus review of manufacturers’ measure life.
2. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Lighting Hours of Use and Coincidence Factors by Sector. March 22, 2010.

Revision History

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

LED 8-Foot, Replacing T12 or T8, 1 or 2 Lamp

	Measure Details
Measure Master ID	LED, 8-Foot, Replacing T12 or T8: 1 Lamp, 3425, 3426, 3427 2 Lamp, 3428, 3429, 3430 LED, 8-Foot, Replacing T12HO or T8HO: 1 Lamp, 3432, 3433 2 Lamp, 3435, 3436 LED, 4-Foot, 2 Lamp, < 20 Watts, Replacing 8-Foot, 1 Lamp T12 or T8, SBP A La Carte, 3616 LED, 4-Foot, 4 Lamp, < 20 Watts, Replacing 8-Foot, 2 Lamp T12 or T8, SBP A La Carte, 3617
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	16[1]
Incremental Cost	Varies by measure

Measure Description

This measure is replacing an 8-foot T12 or T8 linear fluorescent fixture with an 8-foot LED-based (or equivalent) fixture. Energy savings result from the decrease in fixture wattage, and the increased lumens per watt improves light quality and distribution. There are varying wattages LED fixtures used to replace 8-foot fixtures, and normally install one or two 8-foot T12 or T8 lamps with ballasts.

Four different measures will be used depending on the configuration of the existing fixture. These are for 1 and 2 lamp standard output 8-foot T8 or T12 fixtures and 1 and 2 lamp high output T8 or T12 fixtures. A partial retrofit of a fixture does not qualify, which include linear LED tubes and LED luminaires that adhere to the interior of the existing fixture housing. A retrofit that includes two fixtures combined to create the equivalent of an 8-foot fixture (such as two 4-foot fixtures) is acceptable.

Description of Baseline Condition

The baseline condition wattage is outlined in the following table.

T8 Linear 8-Foot Fluorescent Fixture Baseline Conditions (EISA compliant)

Measure	Wattage
8-foot 1 Lamp T8	65
8-foot 2 Lamp T8	110
8-foot 1 Lamp T8HO	91
8-foot 2 Lamp T8HO	145
4-Foot, 2 Lamp, < 20 Watts	N/A
4-Foot, 4 Lamp, < 20 Watts	N/A

Replaced standard output 1 and 2 lamp fixtures are assumed to be 80% T12 and 20% T8. Replaced high output 1 and 2 lamp fixtures are assumed to be 95% T12 and 5% T8. The Illinois TRM assumes that EISA standards will become fully effective in 2016.

Description of Efficient Condition

DLC provides a listing of qualified LED products. The efficient condition uses an average from a filtered listing of luminaires for Low-Bay Commercial and Industrial Building applications (V2.0) and similar products from other reputable manufacturers. The new measure condition assumes an average of five models on the DLC listing on December 10, 2013 and six models from two additional manufacturers that are intending to be DLC listed. These models were included because of the low number of DLC-qualified products at the time of this analysis.

Efficient Condition Wattage by Measure

Measure	Wattage
8-foot LED Fixture Standard Output	60
8-foot LED Fixture Standard Output	84
8-foot LED Fixture 1 Lamp High Output	84
8-foot LED Fixture 2 Lamp High Output	125
4-Foot, 2 Lamp, < 20 Watts	N/A
4-Foot, 4 Lamp, < 20 Watts	N/A

In order to guide the marketplace and ensure that future qualified products meet the intentions of this work paper, the following maximum wattages for the efficient condition are allowable.

Maximum Wattages Allowable for Efficient Condition

Existing Fixture	Maximum Efficient Specification
8-foot LED Fixture Standard Output	70 watts
8-foot LED Fixture Standard Output	95 watts
8-foot LED Fixture 1 Lamp High Output	95 watts
8-foot LED Fixture 2 Lamp High Output	145 watts
4-Foot, 2 Lamp, < 20 Watts	N/A
4-Foot, 4 Lamp, < 20 Watts	N/A

Replaced standard output 1 and 2 lamp fixtures are assumed to be 80% T12 and 20% T8. Replaced high output 1 and 2 lamp fixtures are assumed to be 95% T12 and 5% T8.

Annual Energy-Savings Algorithm

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

Where:

$Watts_{EX}$ = Wattage of existing T8 and T12 lamps and ballasts

$Watts_{LED}$ = Wattage of LED 8-foot luminaire

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= see table below)

Hours-of-Use by Sector

Sector	HOU[1]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= see table below)

Coincidence Factor by Sector

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

Lifecycle Energy-Savings Algorithm

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

Where:

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

Assumptions

For MMIDs 3428-3435: Labor to install the fixture is estimated at approximately $20.00. The installed cost is estimated as $480.00 ($460.00 materials + $20.00 labor), and is expected to drop over time.

The incremental cost was determined as the difference between the standard replacement of the fixture ($110.00) and the energy-efficient fixture replacement ($480.00), for a total of $370.00.

Sources

1. Cadmus review of manufacturers' measure life.
2. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.

Revision History

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

LED, Recessed Downlight, ENERGY STAR

	Measure Details
Measure Master ID	LED, Recessed Downlight, Replacing CFL, ENERGY STAR: Common Area, 3464 In Unit, 3463 LED, Recessed Downlight, Replacing Incandescent, ENERGY STAR: Common Area, 3462 In Unit, 3461
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by measure and location
Peak Demand Reduction (kW)	Varies by measure and location
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by measure and location
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	11[1]
Incremental Cost	$46.00[6]

Measure Description

This measure is for replacing incandescent or CFL downlights with qualified LED fixtures.

Description of Baseline Condition

The baseline is an incandescent (65 watt) or CFL (16 watt) downlight.[3]

Description of Efficient Condition

The efficient condition is replacing a complete luminaire unit. The downlight (12 watt)[3] must be ENERGY STAR rated and replace the trim, reflector, lens, heat sink, driver, and light source.

Annual Energy-Savings Algorithm

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

Where:

$Watts_{BASE}$ = Power consumption of baseline measure (= 65 watts if incandescent; = 16 watts if CFL)[3]

$Watts_{EE}$ = Power consumption of efficient LED downlight (= 12 watts)[3]

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 5,950 for multifamily common areas;[4] = 829 for in-residence lighting)[2]

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (=0.77 for multifamily common areas;[5] = 0.11 for in-residence lighting)[2]

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Baseline Technology	Area Type	MMID	$Watts_{BASE}$	$Watts_{EFFICIENT}$	Annual kWh_{SAVED}	kW_{SAVED}	Lifecycle kWh_{SAVED}
Incandescent	In Unit	3461	65	12	50	0.006	754
CFL		3463	16	12	4	0.000	57
Incandescent	Common Area	3462	65	12	315	0.041	4730
CFL		3464	16	12	24	0.003	357

Assumptions

Incremental cost assumed to be the same as MMID 2458.

Sources

1. Cadmus review of manufacturers' measure life.

2. Cadmus. Field Study Research: Residential Lighting. October 18, 2013. (Report based on using CFL bulbs to replace incandescent bulbs. LEDs will initially be treated the same as CFLs, pending further research)
3. Mid-Atlantic TRM Version 3. March 2013.
4. ACES. *Focus on Energy Deemed Savings Desk Review*. Multifamily Applications for Common Areas. November 3, 2010.
5. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.
6. Assumed to be the same as MMID 2458.

Revision History

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

LED Replacement of 4-Foot T8 Lamps Using Existing Ballast

	Measure Details
Measure Master ID	LED Replacement of 4-Foot T8 Lamps Using Existing Ballast, 3512
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	16[1]
Incremental Cost	$30.00[4]

Measure Description

Four-foot T8 LEDs are an energy-efficient alternative to standard 4-foot 32/28/25 watt T8 fluorescent lamps found commonly throughout commercial, industrial, agriculture, school, government, and multifamily spaces. These products can replace 32/28/25 watt T8 lamps one-for-one operating off the existing fluorescent ballast.

Description of Baseline Condition

The baseline condition is 4-foot standard 32/28/25 watt T8 lamps on low (0.78), normal (0.88), and high (1.15) ballast factor ballasts. Lamps are weighted 60%, 30%, and 10%, respectively, in the savings calculations. 32-watt lamps are weighted 10%, 70%, and 20% with respect to low, normal, and high ballast factors; while 28-watt and 25-watt lamps are weighted 5%, 90%, and 5% for the same ballast factors in the savings calculations.[5]

Description of Efficient Condition

Equipment must be DLC-listed with less than 24 watts based on a normal ballast factor (0.88) and operate off the existing fluorescent ballast. This measure is not intended to be used in refrigerated case lighting applications. Products must carry a safety certification from a NRTL, such as UL or ETL.

Annual Energy-Savings Algorithm

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

Where:

$Watts_{BASE}$ = Weighted annual electricity consumption of standard 4-foot 32/28/25 watt T8 fluorescent lamp operating on low/normal/high ballast factor ballasts

$Watts_{LED}$ = Weighted average annual electricity consumption of DLC-listed 4-foot linear LED < 24 watts, operating off existing ballast

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= see table below)

Hours-of-Use by Sector

Sector	HOU[2]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239
Multifamily	5,950

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= see table below)

Coincidence Factor by Sector

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

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Annual Savings

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Gov		Multifamily	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED Replacement of 4-Foot T8 Lamps Using Existing Ballast	3512	24	0.0049	30	0.0049	30	0.0043	21	0.0041	37	0.0048

Lifecycle Savings (kWh)

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Gov	Multifamily
LED Replacement of 4-Foot T8 Lamps Using Existing Ballast	3512	384	480	480	336	592

Sources

1. Cadmus review of manufacturers' measure life.
2. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
3. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.
4. Pricing research from market sources.
5. Weights are estimated based on general market knowledge and historical application data.

Revision History

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

LED Replacement of 4-Foot T8 Lamps with Integral or External Driver

	Measure Details
Measure Master ID	LED Replacement of 4-Foot T8 Lamps with Integral or External Driver, 3511
Measure Unit	Per lamp
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Measure Type	Prescriptive
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential - multifamily
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	16[1]
Incremental Cost	$73.00[4]

Measure Description

Dual 4-foot T8 LEDs are an energy-efficient alternative to standard 8-foot fluorescent lamps found commonly throughout multifamily, commercial, industrial, agriculture, and schools and government facilities. These products can replace 96-watt T12 and 75-watt T8 lamps two-for-one when replacing the existing fluorescent lamp(s) and ballast(s).

Description of Baseline Condition

Because 8-foot standard 96-watt T12 lamps are required to be replaced by 8-foot T8 lamps, the baseline is an 8-foot T8 with 75 watts per lamp. These are generally operated on low (0.78), normal (0.88), and high (1.15) ballast factor ballasts within their fixtures. Lamps are weighted 10%, 70%, and 20%, respectively, in the savings calculations.[5]

Description of Efficient Condition

Efficient equipment must be DLC-listed, less than 20 watts, and use a new external driver not operate off the existing fluorescent ballast(s). This measure is not intended to be used in refrigerated case lighting applications or in products intended to bring line voltage to existing sockets. Products must carry a safety certification from a NTRL, such as UL or ETL.

Annual Energy-Savings Algorithm

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

Where:

$Watts_{FLUORESCENT}$ = Weighted annual electricity consumption of standard 8-foot 75-watt T8 fluorescent lamp operating on low/normal/high ballast factor ballasts

$Watts_{LED}$ = Weighted average annual electricity consumption of two DLC-listed 4-foot linear LEDs < 20 watts, noted w/external driver

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= see table below)

Hours-of-Use by Sector

Sector	HOU[2]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239
Multifamily	5,950

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= see table below)

Coincidence Factor by Sector

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

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Annual Savings

Annual Savings	MMID	Commercial		Industrial		Agriculture		Schools & Gov		Multifamily	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED Replacement of 4-Foot T8 Lamps w/External Driver	3511	131	0.0270	166	0.0270	165	0.0235	113	0.0224	327	0.2510

Lifecycle Savings

Lifecycle Savings (kWh)	MMID	Commercial	Industrial	Agriculture	Schools & Gov	Multifamily
LED Replacement of 4-Foot T8 Lamps w/External Driver	3511	2,096	2,656	2,640	1,808	5,232

Sources

1. Cadmus review of manufacturers' measure life.
2. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
3. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.
4. Pricing research from market sources.
5. Weights are estimated based on general market knowledge and historical application data.

Revision History

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

LED Lamp Replacing Incandescent Lamp ≤ 40 Watts

	Measure Details
Measure Master ID	LED, ≤ 40 Watt, ENERGY STAR, Replacing Incandescent, 3112
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	7[1]
Incremental Cost	$12.75

Measure Description

ENERGY STAR-rated LED replacement lamps save energy by reducing the total input wattage of the luminaire as compared to the same luminaire operating with standard wattage incandescent lamps. This measure will provide an energy-efficient alternative to using incandescent lamps in several applications.

Description of Baseline Condition

The baseline condition is standard 25-watt and 40-watt incandescent lamps.

Description of Efficient Condition

Efficient equipment must be an ENERGY STAR-rated LED lamp.

Annual Energy-Savings Algorithm

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

Where:

$Watts_{BASE}$ = Average consumption of standard 25-watt or 40-watt incandescent lamp (= 32.5 watts)

$Watts_{EE}$ = Consumption of reduced ENERGY STAR-rated lamp of equivalent lumen output to ≤ 40-watt incandescent (= 6 watts)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= see table below)

Hours-of-Use by Sector

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

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= see table below)

Coincidence Factor by Sector

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

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 7 years)[1]

Deemed Savings

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

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Gov	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED Lamps ENERGY STAR ≤ 40 Watts	3112	100	0.0204	127	0.0204	126	0.0178	87	0.0169

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

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Gov
		kWh	kWh	kWh	kWh
LED Lamps ENERGY STAR ≤ 40 Watts	3112	700	889	882	609

Assumptions

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

Assumes that average ENERGY STAR-rated LED of 5.64 watts for ≤ 40-watt replacement products.

Sources

1. Cadmus review of manufacturers' measure life.
2. State of Wisconsin Public Service Commission. *Business Programs Deemed Savings Manual V1.0.* Table 3.2 Lighting Hours of Use and Coincidence Factors by Sector. March 22, 2010.
3. State of Wisconsin Public Service Commission. *Business Programs Deemed Savings Manual V1.0.* Table 3.2 Lighting Hours of Use and Coincidence Factors by Sector. March 22, 2010.

Revision History

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

LED Lamp Replacing Incandescent Lamp > 40 Watts

	Measure Details
Measure Master ID	LED, > 40 Watt, ENERGY STAR, Replacing Incandescent, 3113
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	7[1]
Incremental Cost	$20.00

Measure Description

ENERGY STAR-rated LED replacement lamps save energy by reducing the total input wattage of the luminaire as compared to the same luminaire operating with standard wattage incandescent lamps. This measure will provide an energy-efficient alternative to using incandescent lamps in several applications.

Description of Baseline Condition

The baseline condition is standard 53-watt, 60-watt, 65-watt, 70-watt, 72-watt, and 80-watt incandescent lamps.

Description of Efficient Condition

Efficient equipment must be an ENERGY STAR-rated LED lamp.

Annual Energy-Savings Algorithm

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

Where:

$Watts_{BASE}$ = Average power consumption of standard incandescent lamps (= 66.7 watts)

$Watts_{EE}$ = Power consumption of ENERGY STAR-rated LED lamp with a lumen output rating equivalent to a > 40-watt incandescent (= 14.2 watts)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= see table below)

Hours-of-Use by Sector

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

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= see table below)

Coincidence Factor by Sector

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

Lifecycle Energy-Savings Algorithm

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

Where:

EUL = Effective useful life (= 7 years)[1]

Deemed Savings

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

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Gov	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW
LED Lamps ENERGY STAR > 40 Watts	3113	196	0.0404	249	0.0404	247	0.0352	170	0.0336

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

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Gov
		kWh	kWh	kWh	kWh
LED Lamps ENERGY STAR > 40 Watts	3113	1,372	1,743	1,729	1,190

Assumptions

An average of 16.67% each of 53-watt incandescent, 60-watt incandescent and halogens, 65-watt incandescent, 70-watt halogens, 80-watt halogens, and 100-watt halogen lamps was used to generate the baseline wattage.[3]

An average of 20% each of 9-watt, 11-watt, 13-watt, 18-watt, and 20-watt ENERGY STAR-rated LED lamps was used to generate the new wattage.[3]

Sources

1. Cadmus review of manufacturers' measure life.
2. State of Wisconsin Public Service Commission. *Business Programs Deemed Savings Manual V1.0.* March 22, 2010.
3. Based on market knowledge.

Revision History

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

LED Tube Retrofit of 4-Foot T12 or T8 Fixtures

	Measure Details
Measure Master ID	T8 LED < 20 Watts, 2L, Replacing 3L or 4L T12/T8, SBP After A La Carte, 3582
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	16[1]
Incremental Cost	MMID 3581= $94.00;[5] MMID 3582=$62.00[6]

Measure Description

Four-foot T8 LEDs are an energy-efficient alternative to standard 4-foot 32/28/25 watt T8 fluorescent lamps found commonly throughout small commercial facilities. These products can replace 32/28/25 watt T8 lamps one-for-one, incorporating replacing the existing fluorescent lamp(s) and ballast(s).

Description of Baseline Condition

The baseline condition is 4-foot standard 32/28/25 watt T8 lamps on low (0.78), normal (0.88), and high (1.15) ballast factor ballasts. Lamps are weighted 60%, 30%, and 10%, respectively, in the savings calculations. 32-watt lamps are weighted 10%, 70%, and 20% with respect to low, normal, and high ballast factors, while 28-watt and 25-watt lamp ballast factors are weighted 5%, 90%, and 5% for those same ballast factors in the savings calculations.[3]

Description of Efficient Condition

Efficient equipment must be DLC-listed, less than 20 watts, and use a new external driver or operate on a new fluorescent ballast(s). This measure is not intended to be used in refrigerated case lighting applications and those products which intend to bring line voltage to existing sockets. Products must carry a safety certification from a NRTL, such as UL or ETL.

Annual Energy-Savings Algorithm

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

Where:

$Watts_{BASE}$ = Power consumption of baseline measure based on ballast factor

$Watts_{EE}$ = Power consumption of efficient equipment based on ballast factor

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= see table below)

Hours-of-Use by Sector

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

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= see table below)

Coincidence Factor by Sector

Sector	CF^4
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Annual Savings

Measure	Commercial		Industrial		Agriculture		Schools & Gov	
	kWh	kW	kWh	kW	kWh	kW	kWh	kW
T8 LED < 20W, 3L, replace 3 or 4L T12/T8	166	0.0342	211	0.0342	209	0.0297	144	0.0284
T8 LED < 20W, 2L, replace 3 or 4L T12/T8	230	0.0474	292	0.0474	289	0.0413	199	0.0394

Lifecycle Savings

Measure	Commercial	Industrial	Agriculture	Schools & Gov
	kWh	kWh	kWh	kWh
T8 LED < 20W, 3L, replace 3 or 4L T12/T8	2,656	3,376	3,344	2,304
T8 LED < 20W, 2L, replace 3 or 4L T12/T8	3,680	4,672	4,624	3,184

Sources

1. Cadmus review of manufacturers' measure life.
2. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
3. Weights estimated based on general market knowledge and historical application data.
4. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.
5. Market research documented in Excel spreadsheet Four-foot Linear LED replacing 4-foot T8 flour 4to3 calculation_GDS_SBP_12_26_14.

Revision History

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

LED Lamp Replacing Neon Sign

	Measure Details
Measure Master ID	LED, Replacing Neon Sign, 3353
Measure Unit	Per fixture (or per sign)
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost	$55.00

Measure Description

This measure is installing a new LED open sign to replace an old neon sign with high voltage magnetic transformers. All new open signs must meet UL-84 requirements.

Traditionally, these signs consist of 5 or 6 millimeter (roughly 1/2 inch) diameter neon tubing with a 3,000 to 15,000 magnetic high-voltage transformer. The tubing length varies by the sign size, but averages 10 feet. Electrical drive levels vary by brightness, but neon tubing of this diameter typically operates at 6 watts to 8 watts per linear foot.

The high voltage neon transformers that drive the neon tubing are designed to provide a limited and reasonably constant current of 20 to 30 mill amperes. One of the consequences of this transformer design is an extremely poor normal power factor. Normal power factors range from 45% to 50%, while high power factors range from 85% to 90%.

Improvements in solid-state electronics over the last two decades have led to the availability of electronic neon transformers and LED alternatives to neon tube technology. Electronic neon transformers can supply the needed current limitation and regulation with roughly twice the efficiency of magnetic transformers, while providing a high power factor. LED technology can provide a neon-like appearance at the same or higher brightness levels, with six to eight times the efficiency of neon tubes that use magnetic transformers. LEDs also have the advantage of being powered by inherently safe low-voltage drivers in lieu of high voltage neon transformers.

LED drivers can be either electronic switching or linear magnetic, with the supplies for electronic switching being the most efficient. The on-off power switch may be on either the power line or load side of the driver, with the line side location providing significantly lower standby losses when the sign is turned off.

Description of Baseline Condition

The baseline condition is a neon open sign with a normal magnetic ballast neon sign power factor.

Description of Efficient Condition

The efficient equipment is the new LED open sign.

Annual Energy-Savings Algorithm

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

Where:

$Watts_{BASE}$ = Wattage of neon sign with magnetic high voltage transformer (= 189)

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

1,000 = Kilowatt conversion factor

HOU = Hours-of-use, estimated as 80% of that listed in the Deemed Savings Manual to account for when the facility is occupied but not open (= see table below)

Hours-of-Use by Sector

Sector	HOU[4]
Commercial	80% of 3,730 = 2,984
Industrial	80% of 4,745 = 3,796
Agriculture	80% of 4,698 = 3,758
Schools & Government	80% of 3,239 = 2,591

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= 1.0 for commercial, industrial, and agriculture; = 0.59 for schools & government)

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Deemed Savings by Sector

Savings	MMIDs	Commercial	Industrial	Agriculture	Schools & Government
kWh	3003 and 3353	504	642	635	438
kW		0.1690	0.1690	0.1690	0.0997
Lifecycle kWh		7,564	9,623	9,527	6,568

Assumptions

The peak demand coincidence factor varies from the typical weighted average factors because it is assumed that the open sign (if owned by the facility) will be on during peak times. Therefore, the demand coincidence factor is set to 1.0 or 0.59.

The baseline wattage of the fixtures has two components: the real power and the reactive power. Neon open signs have low-grade magnetic ballasts that create a very low power factor and increase the apparent power from the grid. The 2004 Core Program LED Open Sign Pilot findings (in California) revealed a power factor of 0.41. In order for the grid to supply the power, the wattage draw of the neon signs must be divided by the power factor. In other words, the wattage draw is only 41% of the power that needs to be supplied from the grid to operate the neon sign.

The baseline is 189 watts to account for varying real power requirements between 90 and 100 watts.

Sources

1. Cadmus review of manufacturers' measure life.
2. Itron. 2004-2005 DEER Update Study Final Report. Table 3-8, pg. 3-12. December 2005.
3. Pacific Gas & Electric. Lighting Rebate Catalog and Application. 2007. Retrieved February 2008.
4. State of Wisconsin Public Service Commission. *Business Programs Deemed Savings Manual V1.0.* Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
5. U.S. Department of Energy. (n.d.). *Save Energy, Money, and Prevent Pollution with Light-Emitting Diode Exit Signs.* February 2008. Available online: http://www.energystar.gov/ia/business/small_business/led_exitsigns_techsheet.pdf.
6. GDS Associates. LED Open Signs. Work Paper PGEPLTG018. August 20, 2009.

Revision History

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

LED Fixture, 2x2, Low and High Output, DLC Listed

	Measure Details
Measure Master ID	LED Fixture, 2x2, Low Output, DLC Listed, 3400 LED Fixture, 2x2, High Output, DLC Listed, 3401
Measure Unit	Per luminaire
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	16[1]
Incremental Cost	$23.16

Measure Description

LED 2x2 troffers save energy when replacing 2-4 lamp T8 products and 2-4 FT lamps by providing a similar lumen output with lower input wattage. These products can be installed on a one-for-one basis to replace 2x2 2-4 lamp T8, T12, or FT lamp luminaires.

Description of Baseline Condition

The baseline condition is 2-foot 2, 3, and 4 lamp T8 or FT lamp troffers for existing buildings and new construction buildings.

Low Output 2x2

An average of 2% 2 lamp, 40% 2 lamp U bend, 38% 3 lamp, and 20% 4 lamp troffers was used to generate the baseline wattage.

High Output 2x2

An average of 50% 3 lamp and 50% 4 lamp troffers was used to generate the baseline wattage.

Description of Efficient Condition

Low Output 2x2

The efficient condition is a DLC-listed 2x2 “Linear Panel (2x2 troffer),” which consumes ≤ 36 watts and has an output of ≥ 2,000 initial lumens.

High Output 2x2

The efficient condition is DLC-listed 2x2 “Linear Panel (2x2 troffer),” which consumes ≤ 85 watts and has an output of ≥ 4,000 initial lumens.

Annual Energy-Savings Algorithm

Low Output 2x2

$kWh_{SAVED} = (Watts_{2\text{-}4L\ 2'\ T8} - Watts_{LED\ LOW\ OUTPUT\ 2x2})\ /1{,}000 * HOU$

High Output 2x2

$kWh_{SAVED} = (Watts_{2\text{-}4L\ 4'\ FT} - Watts_{LED\ HIGH\ OUTPUT\ 2x2})\ /1{,}000 * HOU$

Where:

$Watts_{2\text{-}4L\ 2'\ T8}$ = Annual electricity consumption of 2 or 4 lamp T8 troffer luminaires

$Watts_{LED\ LOW\ OUTPUT\ 2x2}$ = Wattage of DLC-listed 2x2 troffer that consumes ≤ 36 watts and has an initial lumen output ≥ 2,000

$Watts_{2\text{-}4L\ 4'\ FT\ -}$ = Annual electricity consumption of 2 to 4 lamp FT troffer luminaires

$Watts_{LED\ HIGH\ OUTPUT\ 2x2}$ = Annual electricity consumption of a DLC-listed 2x2 troffer that consumes ≤ 85 watts and has an initial lumen output ≥ 4,000

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= see table below)

Hours-of-Use by Sector

Sector	HOU[2]
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239
Multifamily	5,950

Summer Coincident Peak Savings Algorithm

Low Output 2x2

$kW_{SAVED} = (Watts_{2\text{-}4L\ 4'\ FT} - Watts_{LED\ LOW\ OUTPUT\ 2x2}) / 1{,}000 * CF$

High Output 2x2

$kW_{SAVED} = (Watts_{2\text{-}4L\ 4'\ FT} - Watts_{LED\ HIGH\ OUTPUT\ 2x2}) / 1{,}000 * CF$

Where:

CF = Coincidence factor (= see table below)

Coincidence factor by Sector

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

Lifecycle Energy-Savings Algorithm

Low Output 2x2

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

High Output 2x2

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

Where:

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

Deemed Savings

Average Annual Deemed Savings for DLC-Listed 2x2 Troffer

Measure	MMID	Commercial		Industrial		Agriculture		Schools & Gov		Multifamily	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
Low Output 2x2 Qualifying DLC-Listed HPT Fixtures	3400	94	0.0193	119	0.0193	118	0.0168	81	0.0161	149	0.0193
High Output 2x2 Qualifying DLC-Listed HPT Fixtures	3401	345	0.0713	439	0.0713	435	0.0620	300	0.0593	551	0.0713

Average Lifecycle Deemed Savings for DLC-Listed 2x2 Troffer (kWh)

Measure	MMID	Commercial	Industrial	Agriculture	Schools & Gov	Multifamily
Low Output 2x2 Qualifying DLC-Listed HPT Fixtures	3400	1,504	1,904	1,888	1,296	2,384
High Output 2x2 Qualifying DLC-Listed HPT Fixtures	3401	5,520	7,024	6,960	4,800	8,816

Sources

1. Cadmus review of manufacturers’ measure life.
2. Focus on Energy. *Business Programs Deemed Savings Manual V1.0*. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
3. Focus on Energy. *Business Programs Deemed Savings Manual V1.0.* Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.

Revision History

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

High Bay Fluorescent Lighting

	Measure Details
Measure Master ID	High Bay Fluorescent Lighting: T8 4L Replacing 250-399 W HID, 2884, 3329 T8 6L Replacing 400-999 W HID, 2885, 3331 T8 8L Replacing 400-999 W HID, 2886 T8 8L ≤ 500 W, Replacing ≥ 1,000 W HID, 2887, 3333 T8 10L ≤ 500 W, Replacing ≥ 1,000 W HID, 2888 T8 (2) 6L ≤ 500 W, Replacing ≥ 1,000 W HID, 2889 T5HO 2L Replacing 250-399 W HID, 2890, 3330 T5HO 3L Replacing 250-399 W HID, 2891 T5HO 4L Replacing 400-999 W HID, 2892, 3332 T5HO 6L Replacing 400-999 W HID, 2893 T5HO 6L ≤ 500 W, Replacing ≥ 1,000 W HID, 2894, 3334 T5HO 8L ≤ 500 W, Replacing ≥ 1,000 W HID, 2895 T5HO (2) 4L ≤ 500 W, Replacing ≥ 1,000 W HID, 2896 T5HO (2) 6L ≤ 800 W, Replacing ≥ 1,000 W HID, 2897
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Linear
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	Varies by measure
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	2884, 2885, 2886, 2887, 2888, 2889, 2890, 2891, 2892, 2893, 2894, 2895, 2896, 2897 =14[1] and 3329, 3330, 3331, 3332, 3333, 3334 = 15[2]
Incremental Cost	Varies by measure, see Appendix D

Measure Description

In high-bay lighting applications (ceiling heights generally over 15 feet), HID fixtures have typically been used due to their high lumen output. In recent years, however, improvements in fluorescent lamps and the emergence of new high-intensity fluorescent fixtures have made fluorescent lighting the most cost-effective choice for lighting high indoor spaces. These high-intensity fluorescent systems are more energy efficient than HID solutions and feature lower lumen depreciation rates, better dimming options, virtually instant start-up and re-strike, better color rendition, and reduced glare. Similar high-intensity fluorescent lighting fixtures are also available for low bay applications, generally with equipment available in the same product family as the manufacturers' high bay products.

Description of Baseline Condition

The baseline condition is HID fixtures and lamps.

Description of Efficient Condition

The efficient condition varies by the wattage of the baseline lamp. See table below.

Annual Energy-Savings Algorithm

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

Where:

$Watts_{BASE}$ = Wattage of a HID lamp (= see table below)

$Watts_{EE}$ = Wattage of HOT5 or HOT8 lamp (= see table below)

Wattages Used for Deemed Savings Calculations

Measure	$Watts_{BASE}$	$Watts_{EE}$
2L HOT5	293	117
3L HOT5	293	179
4L T8	293	151
4L HOT5	356	234
6L T8	356	224
4L HOT5	455	234
6L HOT5	455	355
6L T8	455	224
8L T8	455	291
6L HOT5	1,079	355
8L HOT5	1,079	585
(2) 4L HOT5	1,079	468
(2) 6L HOT5	1,079	709
8L T8	1,079	291
10L T8	1,079	366
(2) 6L T8	1,079	447

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= see table below)

Hours-of-Use by Sector

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

Summer Coincident Peak Savings Algorithm

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

Where:

CF = Coincidence factor (= see table below)

Coincidence Factor by Sector

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

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Annual Electric Savings (kWh/year/lamp removed)

Existing Wattage	New Fixture Type	MMID	Commercial	Industrial	Agriculture	Schools & Government
250 watts - 399 watts	2L HOT5	2890, 3330	656	835	827	570
	3L HOT5	2891	425	541	536	369
	4L T8	2884, 3329	532	676	669	462
400 watts - 999 watts	4L HOT5	2892, 3332	824	1,049	1,038	716
	6L HOT5	2893	375	477	472	326
	6L T8	2885, 3331	863	1,098	1,088	750
	8L T8	2886	612	778	770	531
1,000 watts	6L HOT5	2894, 3334	2,701	3,435	3,401	2,345
	8L HOT5	2895	1,841	2,342	2,318	1,598
	(2) 4L HOT5	2896	2,277	2,897	2,868	1,977
	(2) 6L HOT5	2897	1,378	1,753	1,736	1,197
	8L T8	2887, 3333	2,937	3,737	3,700	2,551
	10L T8	2888	2,658	3,381	3,347	2,308
	(2) 6L T8	2889	2,355	2,996	2,967	2,045

Summer Peak Savings

Existing Wattage	New Fixture Type	MMID	Commercial	Industrial	Agriculture	Schools & Government
250 watts – 399 watts	2L HOT5	2890, 3330	0.136	0.136	0.118	0.113
	3L HOT5	2891	0.088	0.088	0.076	0.073
	4L T8	2884, 3329	0.11	0.11	0.095	0.091
400 watts - 999 watts	4L HOT5	2892, 3332	0.17	0.17	0.148	0.141
	6L HOT5	2893	0.077	0.077	0.067	0.064
	6L T8	2885, 3331	0.178	0.178	0.155	0.148
	8L T8	2886	0.126	0.126	0.11	0.105
1,000 watts	6L HOT5	2894, 3334	0.557	0.557	0.485	0.463
	8L HOT5	2895	0.38	0.38	0.331	0.316
	(2) 4L HOT5	2896	0.47	0.47	0.409	0.391
	(2) 6L HOT5	2897	0.285	0.285	0.248	0.236
	8L T8	2887, 3333	0.606	0.606	0.528	0.504
	10L T8	2888	0.549	0.549	0.477	0.456
	(2) 6L T8	2889	0.486	0.486	0.423	0.404

Lifecycle Savings (kWh)

Existing Wattage	New Fixture Type	MMID	Commercial	Industrial	Agriculture	Schools & Government
250 watts - 399 watts	2L HOT5	2890, 3330	9,191	11,692	11,576	7,981
	3L HOT5	2891	5,953	7,573	7,498	5,169
	4L T8	2884, 3329	7,441	9,466	9,373	6,462
400 watts - 999 watts	4L HOT5	2892, 3332	11,541	14,681	14,536	10,021
	6L HOT5	2893	5,248	6,676	6,610	4,557
	6L T8	2885, 3331	12,089	15,379	15,226	10,498
	8L T8	2886	8,564	10,895	10,787	7,437
1,000 watts	6L HOT5	2894, 3334	37,807	48,095	47,619	32,831
	8L HOT5	2895	25,771	32,783	32,458	22,378
	(2) 4L HOT5	2896	31,880	40,556	40,154	27,684
	(2) 6L HOT5	2897	19,295	24,546	24,303	16,755
	8L T8	2887, 3333	41,123	52,314	51,795	35,710
	10L T8	2888	37,207	47,331	46,863	32,309
	(2) 6L T8	2889	32,977	41,951	41,535	28,636

Sources

1. Average of: Cadmus 2013 database; 2007 GDS residential measure life report: http://www.iar.unicamp.br/lab/luz/ld/Arquitetural/interiores/ilumina%E7%E3o%20industrial/measure_life_GDS.pdf; California Energy Commission and California Public Utilities Commission. Database for Energy Efficient Resources (DEER) 2008. http://www.energy.ca.gov/deer/ ; and PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation Business Programs: Deemed Savings Manual v1.0. Updated March 22, 2010.

2. DEER 2014 EUL Table. http://www.deeresources.com/. Rated ballast life of 70,000 hours. Not rated on bulb life as such capped at 15 years.

3. PA Consulting Group Inc. *State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation Business Programs: Deemed Savings Manual v1.0.* Updated March 22, 2010.

Revision History

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

Exterior – Induction, PSMH, CMH, Linear Florescent Fixtures

	Measure Details
Measure Master ID	Induction, PSMH/CMF or Linear Fluorescent, Exterior: Replacing 150-175 Watt HID, 3078 Replacing 250 Watt HID, 3081 Replacing 320 -Watt HID, 3084 Replacing 400 Watt HID, 3086 Replacing 70-100 Watt HID, 3087
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Other
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by fixture
Peak Demand Reduction (kW)	Varies by fixture
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by fixture
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost	Varies by measure, see Appendix D

Measure Description

Induction, PSMH, CMH, and linear fluorescent lighting fixtures save energy by reducing the light fixture wattage compared to standard metal halide fixtures, without sacrificing illumination quality and safety. These lighting technologies are appropriate for exterior applications.

Description of Baseline Condition

The baseline measure is standard HID lamps between 70 watts and 400 watts, located on exterior poles or high canopies.

Description of Efficient Condition

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

Annual Energy-Savings Algorithm

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

Where:

$Watts_{BASE}$ = Wattage of baseline HID fixture

$Watts_{EE}$ = Wattage of efficient induction fixture, PSMH fixture, CMH fixture, or linear fluorescent fixture

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 4,380)

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Deemed Savings by Measure

Measure	MMID	Annual Savings (kWh)	Peak Demand Reduction (kW)	Lifecycle Savings (kWh)
Induction, PSMH/CMH, or Linear Fluorescent, Replacing 70-Watt to 100-Watt HID, Exterior	3087	247	0	3,712
Induction, PSMH/CMH, or Linear Fluorescent, Replacing 150-Watt to 175-Watt HID, Exterior	3078	329	0	4,938
Induction, PSMH, CMH, or Linear Fluorescent Replacing 250-Watt HID, Exterior	3081	605	0	9,076
Induction, PSMH, CMH, or Linear Fluorescent Replacing 320-Watt HID, Exterior	3084	556	0	8,344
Induction, PSMH, CMH, or Linear Fluorescent Replacing 400-Watt HID, Exterior	3086	972	0	14,585

Assumptions

The induction wattages shown below include the ballast wattage, which was calculated as 10% of the lamp wattage based on the manufacturer specifications.

All exterior replacement calculations use 4,380 hours of annual operation, half the total hours in a year.

70-watt to 100-watt HID exterior replacements are weighted as follows:

- Baseline = 50% 70-watt HID and 50% 100-watt HID (= 111.5 watts)
- Eligible Replacements = 50% linear fluorescent ≤ 60 watts, 25% 35-watt induction, and 25% 55-watt induction (= 55 watts)

150-watt to 175-watt HID exterior replacements are weighted as follows:

- Baseline = 50% 150-watt HID and 50% 175-watt HID (= 194.5 watts)
- Eligible Replacements = 33.33% 100-watt induction, 33.33% 100-watt PSMH or CMH, and 33.33% ≤ 120-watt linear fluorescent (= 119 watts)

250-watt HID exterior replacements are weighted as follows:

- Baseline = 100% 250-watt HID (= 299 watts)
- Eligible Replacements = 14.3% 120-watt to 125-watt induction, 14.3% 150-watt induction, 14.3% 165-watt induction, 14.3% 125-watt PSMH or CMH, 14.3% 140-watt PSMH or CMH, 14.3% 150-watt PSMH or CMH, and 14.3% ≤ 155-watts linear fluorescent (= 161 watts)

320-watt HID exterior replacements are weighted as follows:

- Baseline = 100% 320-watt HID (= 368 watts)
- Eligible Replacements = 16.6% 200-watt induction, 16.6% 225-watt induction, 16.6% 250-watt induction, 16.6% 200-watt PSMH or CMH, 16.6% 210-watt PSMH or CMH, and 16.6% 220-watt PSMH or CMH (= 241 watts)

400-watt HID exterior replacements are weighted as follows:

- Baseline = 100% 400-watt HID (= 463 watts)
- Eligible Replacements = 16.6% 200-watt induction, 16.6% 225-watt induction, 16.6% 250-watt induction, 16.6% 200-watt PSMH or CMH, 16.6% 210-watt PSMH or CMH, and 16.6% 220-watt PSMH or CMH (= 241 watts)

Sources

1. Similar measure MMID 2419.

Revision History

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

Parking Garage Induction PSMH CMH LF Fixtures

	Measure Details
Measure Master ID	Induction, PSMH/CMH, or Linear Fluorescent, Parking Garage: Replacing 150-175 Watt HID, 24 Hour, 3079 Replacing 150-175 Watt HID, Dusk to Dawn, 3080 Replacing 250 Watt HID, 24 Hour, 3082 Replacing 250 Watt HID, Dusk to Dawn, 3083 Replacing 70-100 Watt HID, 24 Hour, 3088 Replacing 70-100 Watt HID, Dusk to Dawn, 3089
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Other
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by fixture
Peak Demand Reduction (kW)	Varies by fixture
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by fixture
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost	Varies by measure, see Appendix D

Measure Description

Induction, PSMH, CMH, and linear fluorescent lighting fixtures save energy by reducing the light fixture wattage compared to standard metal halide fixtures, without sacrificing illumination quality and safety. These lighting technologies are appropriate for parking garage applications.

Description of Baseline Condition

The baseline is standard HID lamps between 70 watts and 400 watts located in parking garages.

Description of Efficient Condition

The efficient condition is induction, PSMH, CMH, and linear fluorescent fixtures between 35 watts and 250 watts.

Annual Energy-Savings Algorithm

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

Where:

$Watts_{BASE}$ = Wattage of baseline HID fixture

$Watts_{EE}$ = Wattage of efficient induction fixture, PSMH fixture, CMH fixture, or linear fluorescent fixture

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (varies by hours of operation; = 4,380 for night run only; = 8,760 if on continuously)

Lifecycle Energy-Savings Algorithm

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

Where:

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

Deemed Savings

Average Annual Deemed Savings

Measure	MMID	kWh	kW
Induction, PSMH/CMH, or Linear Fluorescent, Replacing 70 Watt to 100 Watt HID, Parking Garage, 24 Hour	3088	495	0.057
Induction, PSMH, CMH, or Linear Fluorescent, Replacing 70 Watt to 100 Watt, Parking Garage, Dusk to Dawn	3089	247	0
Induction PSMH, CMH, or Linear Fluorescent, 150 Watt to 175 Watt Parking Garage, 24 Hour	3079	658	0.075
Induction, PSMH/CMH, or Linear Fluorescent, Replacing 150 Watt to 175 Watt HID, Parking Garage, Dusk to Dawn	3080	329	0
Induction PSMH, CMH, or Linear Fluorescent, 250 Watt, Parking Garage, 24-hour	3082	1.210	0.141
Induction PSMH, CMH, or Linear Fluorescent, 250 Watt, Parking Garage, Dusk to Dawn	3083	605	0

Average Lifecycle Deemed Savings

Measure	MMID	kWh
Induction, PSMH/CMH, or Linear Fluorescent, Replacing 70 Watt to 100 Watt HID, Parking Garage, 24 Hour	3088	7,424
Induction, PSMH, CMH, or Linear Fluorescent, Replacing 70 Watt to 100 Watt, Parking Garage, Dusk to Dawn	3089	3,712
Induction PSMH, CMH, or Linear Fluorescent, 150 Watt to 175 Watt, Parking Garage, 24 Hour	3079	9,877
Induction, PSMH/CMH, or Linear Fluorescent, Replacing 150 Watt to 175 Watt HID, Parking Garage, Dusk to Dawn	3080	4,938
Induction PSMH, CMH, or Linear Fluorescent, 250 Watt, Parking Garage, 24-hour	3082	18,152
Induction PSMH, CMH, or Linear Fluorescent, 250 Watt, Parking Garage, Dusk to Dawn	3083	9,076

Assumptions

The induction wattages shown below include the ballast wattages, which was calculated as 10% of the lamp wattage based on the manufacturer specifications.

All garage replacement calculations use 8,760 or 4,380 hours of annual operation.

70-watt to 100-watt HID parking garage replacements are weighted as follows:

- Baseline = 50% 70-watt HID and 50% 100-watt HID (= 111.5 watts)
- Eligible Replacements = 25% 35-watt induction, 25% 55-watt induction, and 50% ≤ 60-watt linear fluorescent (= 55 watts)

150-watt to 175-watt HID parking garage replacements are weighted as follows:

- Baseline = 50% 150-watt HID and 50% 175-watt HID (= 194.5 watts)
- Eligible Replacements = 33.33% 100-watt induction, 33.33% 100-watt PSMH or CMH, and 33.33% ≤ 120-watt linear fluorescent (= 119 watts)

250-watt HID parking garage replacements are weighted as follows:

- Baseline = 100% 250-watt HID (= 299 watts)
- Eligible Replacements = 14.3% 120-watt to 125-watt induction, 14.3% 150-watt induction, 14.3% 165-watt induction, 14.3% 125-watt PSMH or CMH, 14.3% 140-watt PSMH or CMH, 14.3% 150-watt PSMH or CMH, and 14.3% ≤ 155-watt linear fluorescent (= 161 watts)

Sources

1. *PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf*

Revision History

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

High Bay – Induction, PSMH, CMH Fixtures

	Measure Details
Measure Master ID	High Bay – Induction, PSMH, CMH Fixtures: ≤ 250 Watt, Replacing 320-400 Watt HID, 3075 ≤ 250 Watt, Replacing 400 Watt HID, 3076 ≤ 365 Watt, Replacing 400 Watt HID, 3077 Replacing 250 Watt HID, 3090 Induction, 750 Watt, Replacing 1000 Watt HID, High Bay, 3074
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Other
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	Varies by measure
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1] 27 (for 750-watt induction)[2]
Incremental Cost ($/unit)	Varies by measure[2]

Measure Description

Induction, pulse-start metal halide, and ceramic metal halide lighting fixtures save energy by reducing the light fixture wattage compared to standard metal halide fixtures, without sacrificing illumination quality and safety. These lighting technologies are appropriate for high bay applications.

Description of Baseline Condition

The baseline condition is standard HID lamps between 250 watts and 1,000 watts, located in a parking garage.

Description of Efficient Condition

The efficient condition is induction, pulse-start metal halide, and ceramic metal halide fixtures between 120 watts and 750 watts.

Annual Energy-Savings Algorithm

$kWh_{SAVED\ IND} = kWh_{HID} - kWh_{IND}$

$kWh_{SAVED\ PSMH} = kWh_{HID} - kWh_{PSMH}$

$kWh_{SAVED\ CMH} = kWh_{HID} - kWhc_{MH}$

Where:

kWh_{HID} = Annual electricity consumption of standard HID fixture
kWh_{IND} = Annual electricity consumption of induction lighting fixture
kWh_{PSMH} = Annual electricity consumption of pulse start metal halide fixture
kWh_{CMH} = Annual electricity consumption of ceramic metal halide fixture

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = Wattage / 1{,}000 * CF$

$kW_{IND} = kW_{PEAK\ HID} – kW_{PEAK\ IND}$

$kW_{PSMH} = kW_{PEAK\ HID} – kW_{PEAK\ PSMH}$

$kW_{CMH} = kW_{PEAK\ HID} – kW_{PEAK\ CMH}$

Where:

$kW_{PEAK\ HID}$ = Peak demand of existing HID system
$kW_{PEAK\ IND}$ = Peak demand of new induction lighting system
$kW_{PEAK\ PSMH}$ = Peak demand of new pulse start metal halide lighting system
$kW_{PEAK\ CMH}$ = Peak demand of new ceramic metal halide lighting system
HOURS = Hours-of-use (= see table below)

Hours-of-Use by Sector

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

CF = Demand coincidence factor (= see table below)

Demand Coincidence Factor by Sector

Sector	CF[4]
Commercial	0.77
Industrial	0.77
Agriculture	0.67
Schools & Government	0.64

Lifecycle Energy-Savings Algorithm

$$kWh_{LIFECYCLE\ IND} = (kWh_{HID} - kWh_{IND}) * EUL$$

$$kWh_{LIFECYCLE\ PSMH} = (kWh_{HID} - kWh_{PSMH}) * EUL$$

$$kWh_{LIFECYCLE\ CMH} = (kWh_{HID} – kWh_{CMH}) * EUL$$

Where:

EUL = Effective useful life (= 15 years;[1] = 27 years for 750-watt induction)[2]

Deemed Savings

Average Annual Deemed Savings for High Bay Induction PSMH/CMH Fixtures

Measure	MMID	Commercial 3,730 (0.77)		Schools & Gov 3,239 (0.64)		Industrial 4,745 (0.77)		Agriculture 4,698 (0.67)	
		kWh	kW	kWh	kW	kWh	kW	kWh	kW
HB PSMH, CMH, IND Replacing 250 Watt HID	3090	510	0.1053	443	0.0875	649	0.1053	642	0.0916
HB PSMH, CMH, IND (250 Watt or Less) Replacing 400 Watt HID	3076	827	0.1706	718	0.1418	1,052	0.1706	1,042	0.1484
HB PSMH, CMH, IND (250 Watt or Less) Replacing 320-400 Watt HID NC (Based on 320 watt savings)	3075	499	0.1031	433	0.0857	635	0.1031	628	0.0897
HB PSMH, CMH, IND (365 Watt or Less) Replacing 400 Watt HID	3077	546	0.1128	474	0.0938	695	0.1128	688	0.0982
HB IND 750 Watt High Bay Replacing 1,000 Watt HID	3074	970	0.2002	842	0.1664	1,234	0.2002	1,222	0.1742

Average Lifecycle Deemed Savings for High Bay Induction PSMH/CMH Fixtures

Measure	MMID	Commercial 3,730 (0.77)	Schools & Gov 3,239 (0.64)	Industrial 4,745 (0.77)	Agriculture 4,698 (0.67)
		kWh	kWh	kWh	kWh
HB PSMH, CMH, IND Replacing 250 Watt HID	3090	7,650	6,645	9,735	9,630
HB PSMH, CMH, IND (250 Watt or Less) Replacing 400 Watt HID	3076	12,405	10,770	15,780	15,630
HB PSMH, CMH, IND (250 Watt or Less) Replacing 320-400 Watt HID NC (Based on 320 watt savings)	3075	7,485	6,495	9,525	9,420
HB PSMH, CMH, IND (365 Watt or Less) Replacing 400 Watt HID	3077	8,190	7,110	10,425	10,320
HB IND 750 Watt High Bay Replacing 1,000 Watt HID	3074	26,190	22,734	33,318	32,994

Measure Costs for High Bay Induction PSMH/CMH Fixtures

Measure	MMID	Cost ($)
HB PSMH, CMH, IND Replacing 250 Watt HID	3090	$100.00
HB PSMH, CMH, IND (250 Watt or Less) Replacing 400 Watt HID	3076	$240.00
HB PSMH, CMH, IND (250 Watt or Less) Replacing 320-400 Watt HID NC (Based on 320 watt savings)	3075	$290.00
HB PSMH, CMH, IND (365 Watt or Less) Replacing 400 Watt HID	3077	$240.00
HB IND 750 Watt High Bay Replacing 1,000 Watt HID	3074	$750.00

Assumptions

Hours of operation and coincidence factor based on sector. Induction wattage shown includes ballast wattage, which was calculated as 10% of lamp wattage based on the manufacturer specifications. 250-watt HID high bay replacements of ≤ 155 watts weighted as follows:

- Baseline = 100% 250-watt HID
- Eligible Replacements = 16.6% 120-watt to 125-watt induction, 16.6% 150-watt induction, 16.6% 165-watt induction,16.6% 125-watt PSMH or CMH, 16.6% 140-watt PSMH or CMH, and 16.6% 150-watt PSMH or CMH

320-watt HID high bay replacements of ≤ 250 watts weighted as follows:

- Baseline = 100% 320-watt HID
- Eligible Replacements = 16.6% 200-watt induction, 16.6% 225-watt induction, 16.6% 165-watt induction, 16.6% 200-watt PSMH or CMH, 16.6% 210-watt PSMH or CMH, and 16.6% 220-watt PSMH or CMH

400-watt HID high bay replacements of ≤ 365 watts weighted as follows:

- Baseline = 100% 400-watt HID
- Eligible Replacements = 16.6% 250-watt induction, 16.6% 300-watt induction, 16.6% 250-watt PSMH or CMH, 16.6% 270-watt PSMH or CMH, 16.6% 315-watt PSMH or CMH, and 16.6% 320-watt PSMH

1,000-watt HID high bay replacements of ≤ 800 watts weighted as follows:

- Baseline = 100% 1,000-watt HID
- Eligible Replacements = 50% 750-watt induction, and 50% 575-watt PSMH or CMH

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. Based on market research.
3. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.
4. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.

Revision History

Version Number	Date	Description of Change
01	12/2012	Initial TRM entry
02	09/2015	Updates and revisions

Other

DEET Behavioral Savings

	Measure Details
Measure Master ID	DEET, Savings Period 1, 3652 DEET, Savings Period 2, 3653 DEET, Savings Period 3, 3654 DEET, Savings Period 4, 3655 DEET, Savings Period 5, 3656 DEET, Savings Period 6, 3657 DEET, Savings Persistence, 3658
Measure Unit	Per building
Measure Type	Hybrid
Measure Group	Other
Measure Category	Whole Building
Sector(s)	Schools & Government
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	Varies by measure
Annual Therm Savings (Therms)	Varies by measure
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	Varies by measure
Water Savings (gal/yr)	0
Effective Useful Life (years)	3[1]
Incremental Cost ($/unit)	$12,000.00[2]

Measure Description

According to the U.S. Environmental Protection Agency, 30% of a district's total energy may be used inefficiently or unnecessarily.[3] Schools have a considerable opportunity to reduce energy consumption and district energy costs. Recommended behavior changes that will conserve energy include turning off unnecessary lights, shutting down computers, reducing phantom loads, and disseminating regular energy conservation reminders.

This measure is a series of behavioral incentives based on savings measured directly from utility bills in K-12 schools every six months for three years. The amount of kW, kWh, and therm savings incentives is determined by comparing reporting period utility bills to an established baseline (12 months prior to starting the initiative). Program/sector kW, kWh, and therms savings are determined by comparing reporting period consumption to previous year consumption using utility bills.

Description of Baseline Condition

The baseline condition is a school building that has not completed any measures incented by Focus on Energy within 12 months. In addition, participating buildings must not be planning for major renovations and/or energy upgrades within three years from the start of initiative.

Description of Efficient Condition

DEET participants will use less energy than their baseline by expanding management-driven savings to include occupant behavioral energy savings, sustaining energy reductions, increasing occupancy involvement in energy reduction initiatives, and increasing occupants' realization of the financial and environmental impact of individual and group energy consumption.

Annual Energy-Savings Algorithm

kWh and therms savings are calculated every six months for three years (for a total of six calculation/reporting periods). Measured savings will use the previous year consumption as a baseline.

$$kWh_{SAVED} = kWh_{BP} - kWh_{RP}$$

Where:

kWh_{BP} = Electrical consumption during baseline period (= varies by building)
kWh_{RP} = Electrical consumption during reporting period (= varies by building)

$$Therms_{SAVED} = Therms_{BP} - Therms_{RP}$$

$$Therms_{BP} = (Therms_{BPACT}) * (HDD_{30YRAVG} / HDD_{BP})$$

$$Therms_{RP} = Therms_{NORM} = (Therms_{RPACT}) * (HDD_{30YRAVG} / HDD_{RP})$$

Where:

$Therms_{BP}$ = Natural gas consumption during baseline period (= varies by building)
$Therms_{RP}$ = Natural gas consumption during reporting period (= varies by building)
$Therms_{BPACT}$ = Actual natural gas consumption during baseline period (= varies by building)
$HDD_{30YRAVG}$ = 30-year average heating degree days
HDD_{BP} = Heating degree days during baseline period (= varies by year)
$Therms_{NORM}$ = Natural gas consumption normalized for heating loads (= varies by building)

$Therms_{RPACT}$ = Actual natural gas consumption for reporting period (= directly from utility bill; varies by building)

HDD_{RP} = Heating degree days during reporting period (= varies by year)

Summer Coincident Peak Savings Algorithm

There will be no peak savings for Periods 1, 3, and 5. For Periods 2, 4, and 6, the monthly kW for June, July, and August of the reporting year is averaged and used as the kW_{RP}.

$$kW_{SAVED} = kW_{BP} - kW_{RP}$$

Where:

kW_{BP} = Average monthly kW usage for baseline year (= average of kW_{JUNE} + kW_{JULY} + kW_{AUG}; varies by building)

kW_{RP} = Average monthly kW usage for reporting year (= average of kW_{JUNE} + kW_{JULY} + kW_{AUG}; varies by building)

Lifecycle Energy-Savings Algorithm

$$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$$

$$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$$

Where:

EUL = Effective useful life (= 3 years)[1]

Assumptions

The 30-year average HDDs per month by Wisconsin city are provided in the table below.

30-Year HDD[4] Values Per Month by Wisconsin City

Month	Milwaukee	Green Bay	Wausau	Madison	La Crosse	Minocqua	Rice Lake
January	1,443	1,591	1,440	1,561	1,623	1,632	1,623
February	1,211	1,238	1,313	1,272	1,200	1,293	1,455
March	934	1,019	1,278	844	911	1,222	1,125
April	595	630	550	607	514	574	531
May	358	265	460	217	242	321	414
June	126	87	39	105	80	124	84
July	29	38	33	18	10	73	45
August	36	74	54	45	40	97	64
September	116	182	143	233	186	294	185
October	471	560	568	568	522	528	571

Month	Milwaukee	Green Bay	Wausau	Madison	La Crosse	Minocqua	Rice Lake
November	817	932	844	916	861	969	1,007
December	1,262	1,288	1,261	1,404	1,373	1,665	1,624
Total	**7,398**	**7,903**	**7,982**	**7,791**	**7,561**	**8,793**	**8,726**

The incremental cost of $12,000 per building was based on the following assumptions:

- According to project experience, we assumed that staff will spend approximately 45 minutes per month on the DEET Initiative, doing activities such as reviewing DEET-related emails and reports, addressing energy topics in staff meetings, and discussing energy with students.
- We assumed an average staff wage of $30/hour based on working 1,500 hours for the median teacher salary of $45,227 in La Crosse, Wisconsin.[5] (Note: administrators have a higher salary and support staff will have a lower salary). The total, at $30/hour multiplied by 0.75 hour/month and 9 months/year, is $202.50 (rounded to $200).
- We assumed an average of 50 staff per building based on field experience ($200 multiplied by 50 staff/building = $10,000/building).
- Finally, based on rough estimates from general data available to the program, we assumed each building would spend an average of $2,000 in buildings and grounds discretionary funds on small energy projects (such as replacing incandescent/CFLs with LEDs, installing timers and/or power strips, and adding LED task lighting or vending misers). Since this is the first time an initiative like DEET has been proposed in Wisconsin, we concluded that an incremental cost of $10,000 for staff time and $2,000 for energy projects per building is reasonable and appropriate.

Sources

1. Skumatz, Lisa A. “Measuring the Impacts of Behavior Change Programs: Filling in the Blanks.” 2012 ACEEE Summer Study on Energy Efficiency in Buildings. Available online: http://beccconference.org/wp-content/uploads/2013/12/Hannah-Arnold_BECC-Presentation-FINAL-2013-11-20.pdf
2. This includes a $2,000.00 estimate for annual expenditures on small energy projects, such as replacing incandescent/CFLs with LEDs, installing timers and/or power strips, or installing LED task lighting or vending misers. In addition, the incremental cost accounts for the average staff time needed to ensure that DEET is a success, at 50 staff/building and $200/staff (= $10,000; larger buildings will have more staff, smaller building will have fewer staff).
3. United States Environmental Protection Agency. *Schools: An Overview of Energy Use and Energy Efficiency Opportunities*. 2006. Available online: http://www.energystar.gov/ia/partners/publications/pubdocs/Schools.pdf

4. Renewable Resource Data Center, National Renewable Resource Laboratory. *National Solar Radiation Database (Base of 65°F) Typical Meteorological Year 3*. Available online: http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html
5. Public School Teacher Salaries, La Crosse, WI. Available online: http://www1.salary.com/WI/La-Crosse/Public-School-Teacher-salary.html on August 10, 2015.

Revision History

Version Number	Date	Description of Change
01	09/2015	Initial release

Process

Process Exhaust Filtration

	Measure Details
Measure Master ID	Process Exhaust Filtration, 3244
Measure Unit	Per CFM
Measure Type	Hybrid
Measure Group	Process
Measure Category	Filtration
Sector(s)	Industrial, Commercial
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Varies by project
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	Varies by project
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1,2,3]
Incremental Cost ($/unit)	N/A

Measure Description

Process exhaust air filtration systems save energy by reducing the heat load on a make-up air system by recirculating filtered process air instead of bringing in colder outdoor make-up air during the heating season. Energy savings result from the reduced temperature difference through the heat exchanger of the supply air system. The temperature difference between the filtered indoor air and the indoor supply air temperature is much lower than the difference between outdoor air and indoor supply air temperature. This reduction in heat load results in natural gas savings.

Exhaust filtration systems typically use cartridge filters and are frequently found in welding fume exhaust and paint booth exhaust applications. This measure is incented per CFM of make-up air eliminated and savings will be realized in industrial and service facilities. Systems must run a minimum of 2,000 hours annually in order to be eligible.

Description of Baseline Condition

The baseline condition is 100% of process exhaust fumes being evacuated from the space associated with the industrial process, with ventilation provided by 100% outside air with heating provided by a natural gas fired make-up air unit.

Description of Efficient Condition

The efficient condition is a filtration system that reduces or eliminates the need to discharge 100% of process exhaust by filtering and recirculating the air and thereby reducing or eliminating make-up air demand and associated heating energy.

Annual Energy-Savings Algorithm

Btu/°F = CFM * Specific Heat

$\text{Btu}_{\text{SAVED}}$ = Btu/°F * ΔT * HOURS

$\text{Therm}_{\text{SAVED}}$ = $\text{BTU}_{\text{SAVED}}$ / (System Efficiency * 100,000)

Note: Fan energy savings are neglected for this measure, as eliminating the makeup air fan is offset by the increased energy usage of the exhaust fan due to static pressure increases.

Where:

BTU/°F = Energy required to heat volume of make-up air for each additional degree Fahrenheit

CFM = Volumetric flow rate of eliminated make-up air unit (= actual)

Specific Heat = 1.08 Btu/hr/CFM-°F (dry air)

$\text{BTU}_{\text{SAVED}}$ = Total energy required to heat eliminated make-up air

ΔT = Difference between average indoor temperature and average outside winter temperature

HOURS = Annual hours requiring exhaust (= actual)

$\text{Therm}_{\text{SAVED}}$ = Natural gas energy required to heat make-up air before eliminated

System Efficiency = Heating efficiency of make-up air system (= actual)

100,000 = Conversion from Btu to therm

Summer Coincident Peak Savings Algorithm

There are no peak savings associated with this measure.

Lifecycle Energy-Savings Algorithm

$\text{Therm}_{\text{LIFECYCLE}}$ = $\text{Therm}_{\text{SAVED}}$ * EUL

Where:

EUL = Effective useful life (15 years)[1,2,3]

Assumptions

The average inside temperature, 65°F, assumed to equal design temperature. Average outdoor winter temperature of 30.8°F.[5] (Therefore ΔT = 65°F – 30.8°F = 34.2°F).

Sources

1. Using current EULs, rooftop units are very similar to the industrial ventilation system but without a heating or cooling coil. Focus on Energy currently uses a 15 year EUL for rooftop units.
6. Chartered Institution of Building Services Engineers. "Probabilistic Estimation Of Service Life." http://www.cibse.org/knowledge/cibse-technical-symposium-2011/probabilistic-estimation-of-service-life. The industrial ventilation system would consist of a fan and a set of filters; fan EUL is 15 to 20 years depending on type and filter EUL is 15 to 20 years depending on type.
7. Wisconsin DOA guideline document for lifecycle costing of state building projects. Page 36 lists 10 to 20 years for rooftop units and 15 to 30 years for fans depending on type.
8. SPECTRUM historical projects (custom projects that implemented comparable measures).
9. *Focus on Energy Deemed Savings Manual*.

Revision History

Version Number	Date	Description of Change
01	07/2015	Initial TRM entry

Pressure Screen Rotor

	Measure Details
Measure Master ID	Pressure Screen Rotor, 2496
Measure Unit	Per horsepower
Measure Type	Hybrid
Measure Group	Process
Measure Category	Specialty Pulp & Paper
Sector(s)	Industrial
Annual Energy Savings (kWh)	Varies by horsepower
Peak Demand Reduction (kW)	Varies by horsepower
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by horsepower
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[2]
Incremental Cost ($/unit)	Varies by measure

Measure Description

Paper mills use pressure screens to separate contaminants from the pulp produced from recycled products. A motor is used to spin the rotor at a high velocity, forcing the pulp through narrow slots or apertures that are a barrier to debris, stickies, contaminates, and uncooked or undeveloped bundles of wood fibers (shives). This makes contaminate-free pulp available for further processing.

Pressure screen rotors are an energy-efficient method of removing large contaminants from pulp stock. The new dual element foil design more efficiently removes the contaminants while using less power.

Description of Baseline Condition

The baseline technology for removing contaminants is with a narrow slotted screen.

Description of Efficient Condition

The efficient condition is a pressure screen rotor design.

Annual Energy-Savings Algorithm

There are two methods for estimating savings. The first method relies on pre-retrofit and post-retrofit amp measurements from the participant application; the second method determines deemed savings using an energy savings factor of 30% based on Focus on Energy project history.

Method #1: Custom Approach (Amps Known)

$kWh_{SAVED} = (Amps_{PRE} - Amps_{POST}) * 1.73 * V * PF * Hrs/wk * Weeks$

Method #2: Deemed Approach (Amps Unknown)

$kWh_{SAVED} = HP * LF / Eff * 0.746 * S * Hrs/wk * Weeks$

Where:

$Amps_{PRE}$ = Pre-retrofit pulper amps (= actual; requested in program application or measured)

$Amps_{POST}$ = Post-retrofit pulper amps (= actual; requested in program application or measured)

1.73 = Constant to calculate kWh

V = Voltage of pulper (= actual; requested in program application or reported by customer)

PF = Power factor (= actual reported by customer or deemed 0.75)

Hrs/wk = Hours per week (= actual; requested in program application or reported by customer)

Weeks = Weeks of operation per year (= actual; requested in program application or reported by customer)

HP = Motor horsepower (= actual; reported by customer)

LF = Motor load factor (= actual reported by customer or deemed 65%)

Eff = Estimated motor efficiency (= actual reported by customer or deemed 92%)

0.746 = Conversion HP to Watts

S = Deemed savings factor (= 30%)[1]

Summer Coincident Peak Savings Algorithm

Method #1: Custom Approach (Amps Known)

$kW = (Amps_{PRE} - Amps_{POST}) * 1.73 * V * PF$

Method #2: Deemed Approach (Amps Unknown)

$kW = HP * LF / Eff * 0.746 * S$

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)

Sources

1. Focus on Energy industrial sector project history.
2. Engineering Judgement

Revision History

Version Number	Date	Description of Change
01	05/2015	Initial TRM entry

Repulper Rotor

	Measure Details
Measure Master ID	Repulper Rotor, 2538
Measure Unit	Per horsepower
Measure Type	Hybrid
Measure Group	Process
Measure Category	Specialty Pulp & Paper
Sector(s)	Industrial
Annual Energy Savings (kWh)	Varies by amperage
Peak Demand Reduction (kW)	Varies by amperage
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by amperage
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15 [3]
Incremental Cost ($/unit)	Varies by amperage

Measure Description

A repulper is a large tank with a mixer, or rotor, on the bottom. Pulping rotors are rebuilt or replaced periodically, providing facility managers with the opportunity to investigate new repulper rotors for their facility. Manufacturers of paper process equipment designed new energy-efficient repulper rotors to help offset rising energy costs, including energy-efficient repulper rotors (HM rotors, new energy efficient repulping blades) replacing conventional HOG-type rotors (bexisiting conventional repulping blades, baseline). HM rotors have a tall, swept-back blade design that provides effective turbulence of the fiber suspension product and maximizes rotor fiber contact while consuming less horsepower than conventional rotors.

Description of Baseline Equipment

The baseline technology is a HOG rotor.

Description of Efficient Equipment

The efficient condition is a HM rotor.

Annual Energy-Saving Algorithm

There are two methods for estimating savings. The first method relies on pre-retrofit and post-retrofit amp measurements as provided in the participant application or obtained; the second method uses deemed savings using an energy savings factor of 23%.[1]

Method #1: Custom Approach (Amps Known)

$kWh_{SAVED} = (Amps_{PRE} - Amps_{POST}) * 1.73 * V * PF * Bwk * t * Weeks$

Method #2: Deemed Approach (Amps Unknown)

$kWh_{SAVED} = HP * LF / Eff * 0.746 * S * Bwk * t * Weeks$

Where:

$Amps_{PRE}$ = Pre-retrofit pulper amps (= actual; from program application or measured)

$Amps_{POST}$ = Post-retrofit pulper amps (= actual; from program application or measured)

1.73 = Constant to calculate kWh

V = Voltage of pulper (= actual; from program application or reported by customer)

PF = Power factor (= actual reported by customer or deemed 0.75)

Bwk = Batches per week (= actual; from program application or reported by customer)

t = Time per pulp batch in minutes (= actual; from program application or reported by customer)

Weeks = Weeks of pulping per year (= actual; from program application or reported by customer)

HP = Motor horsepower (= actual; reported by customer)

LF = Motor load factor (= actual reported by customer or deemed 65%)

Eff = Estimated motor efficiency (=actual reported by customer or deemed 92%)

0.746 = Conversion HP to Watts

S = Savings factor (= deemed 23%)[2]

Summer Concident Peak Savings Algorithm

Method #1: Custom Approach (Amps Known)

$kW = (Amps_{PRE} - Amps_{POST}) * 1.73 * V * PF$

Method #2: Deemed Approach (Amps Unknown)

$kW = HP * LF / Eff * 0.746 * S$

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)

Sources

1. As determined from the pilot study performed in 2005 by Wisconsin Focus on Energy in partnership with an in-state towel, tissue, and paper manufacturing company based in Wisconsin. Voith High Efficiency HM Rotor Energy Data A Repulper Rotor Design Case Study. 2005. http://oaktrust.library.tamu.edu/bitstream/handle/1969.1/5580/ESL-IE-05-05-21.pdf?sequence=4&isAllowed=y. Accessed 05/ 2015.
2. *Focus on Energy Business Programs - Industrial Sector*. December 16, 2005. Repulper rotor reduces energy costs by 23%.
3. Engineering Judgement

Revision History

Version Number	Date	Description of Change
01	05/2015	Initial TRM entry

Variable Frequency Drive (Variable Torque and Constant Torque)

	Measure Details
Measure Master ID	Variable Frequency Drive, Process Fan, 2647 Variable Frequency Drive, Process Pump, 2648 Variable Frequency Drive, Constant Torque, 3280
Measure Unit	Per motor
Measure Type	Hybrid
Measure Group	Process
Measure Category	Variable Speed Drive
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	Varies by motor
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by motor
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost	Varies by measure, see Appendix D

Measure Description

Fans, pumps, conveyors, and other motor-driven equipment require controls to vary their operation to produce the desired output (sufficient airflow to cool a building, deliver hot water for heating, or move product down a conveyor). Traditionally, flow rates have been reduced by increasing the head and riding the pump (or fan) curve back to a new flow rate (throttling control). Alternately, some systems have bypasses that divert a portion of the flow back to the pump or fan inlet to reduce system flow (bypass control). Other systems simply start and stop the motor to meet the given load (on/off control). An alternate way to provide control of motor systems is to use VFDs, which physically slow the motors driving pumps, fans, and other equipment in order to achieve reduced flow rates at considerable energy savings.

There are three categories of motor applications, but only two (variable torque and constant torque) have the potential for energy savings when adding VFDs. The categories of motor applications are as follows:[2]

Variable Torque Loads – This category consists of centrifugal pumps and fans. For these applications, the motors follow the fan or affinity laws, resulting in the input power varying with the pump or fan rotational speed. This means that small reductions in flow (20%, for example) can produce large input power savings (50%).

Constant Torque Loads – This category consists of equipment where the torque requirement is independent of speed. Examples include cranes, hoists, conveyors, extruders, mixers, and positive displacement pumps. The input power varies linearly with the rotational speed (e.g., a 20% reduction in speed equals a 20% reduction in input power).

Constant Horsepower Loads[3] – For equipment in this category, the torque varies inversely with the speed of the motor. Therefore, the power requirement does not vary, regardless of speed. Examples include lathes, drilling, and milling equipment. This equipment category does not offer energy savings for installing VFDs, and is therefore ineligible for VFD incentives.

The following rules and requirements apply to the VFD application:

- VFD must be used in conjunction with a process (non HVAC) pumping application.
- Redundant or back-up units do not qualify.
- Routine replacement of existing VFDs does not qualify.
- VFD speed (for variable torque applications) must be automatically controlled by differential pressure, flow, temperature, or other variable signal.
- VFD speed (for constant torque applications) may be either automatically or manually controlled.
- The system controlled must have significant load diversity that will result in savings through motor speed variation. Conditions requiring the motor to be loaded consistently above 80% or consistently loaded below 30% are not eligible for this incentive, as these operating conditions may not realize sufficient savings from a VFD.
- Copies of invoices that clearly show the drive’s size are required.
- Incremental cost assumed to equal measure installed cost. HVAC and process systems either have equipment described under the Description of Baseline Condition section or have a VFD. Baseline condition equipment is required for operation, so VFD is a replacement technology, not an incremental improvement in efficiency (like for a chiller or boiler).

Description of Baseline Condition

The baseline condition is a motor for a variable torque or constant torque application operating at full speed and using throttling, bypass, or on/off control to handle variable outputs from the driven device (pump, fan, etc.).

Description of Efficient Condition

The efficient condition is adding a VFD to the motor to vary the electric frequency (i.e., Hertz) going to the motor, which will allow the speed of the motor to be varied. For variable torque (pump and fan) applications, the VFD must be automatically controlled by a variable input signal. Constant torque applications have the option to be manually controlled to vary the speed of equipment associated with production in a manufacturing environment.

Annual Energy-Savings Algorithm

Energy savings for this measure are custom calculated using a spreadsheet tool,[4] which is based on an engineering bulletin[5] and savings calculators[6] from two different VFD manufacturers. This spreadsheet tool uses power curves developed from data obtained by measuring the operating characteristics of various fans and pumps. The curves are representative of typical VFD operation.

- Equation used in the software tool:
- Power at Design GPM [CFM] = Nameplate Horsepower * Conversion Constant (kW/hp) * Motor Load at Design GPM [CFM] / Nameplate Efficiency

Computed for each capacity level:

- Percentage of Design kW = A1 + (A2 * Capacity) + (A3 * (Capacity)^2) + (A4 * (Capacity)^3)
- Percentage of Design kW for VSD = A1 + (A2 * Capacity) + (A3 * (Capacity)^2) + (A4 * (Capacity)^3)
  - Where A1, A2, A3, and A4 are variables unique to each "before VFD" control type, allowing a quadratic equation to be created to represent the load profile. The next table shows values for A1, A2, A3, and A4.

Equation Variables: Before VFD

Control	A1	A2	A3	A4	CF
Pumps					
Outlet Control Valve	55.21240	0.63700	0.00190	0.00000	0.9
Eddy Current Clutch	16.39683	-0.05647	0.01237	-0.00003	0.9
Torque Converter	13.51137	0.34467	0.01269	-0.00007	0.9
Bypass Valve	102.00000	0.00000	0.00000	0.00000	0.9
VFD_Pump	27.44751	-1.00853	0.01762	0.00000	0.9
On/Off	100.00000	0.00000	0.00000	0.00000	0.9

Control	A1	A2	A3	A4	CF
Fans					
Inlet Guide Vane, FC Fans	20.00000	0.06808	0.00128	0.00009	0.9
Inlet Guide Vanes	47.26190	0.67944	0.01554	0.00014	0.9
Inlet Damper Box	50.25833	0.71648	0.01452	0.00013	0.9
Outlet Damper, FC Fans	20.41905	0.10983	0.00745	0.00000	0.9
Discharge Damper	55.92857	-0.56905	0.02462	-0.00014	0.9
Eddy Current Drives	16.39683	-0.05647	0.01237	-0.00003	0.9
VFD_Fan	5.90000	-0.19567	0.00766	0.00004	0.9
Constant Torque VFD					
Constant_Torque_VFD	0.00000	1.00000	0.00000	0.00000	0.78

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} / HOURS * CF$

Where:

HOURS = Annual hours of operation for the system controlled by the VFD

CF = Coincidence factor (= varies by VFD use; see table below)

Coincidence Factor by VFD Use

VFD Use	CF	Source
Hot Water Pump	0.00	Heating pumps operate in winter (off peak)
Equipment type = Other Pump, Other Fan Baseline flow controls = Fan with Inlet Damper Box, Eddy Current Drives, Torque Converter	0.00	Assume no demand reduction
Chilled Water Pump	0.90	DEER model runs are weather normalized for statewide use by population density.
Constant Volume Fan (on/off control)	0.90	
Air foil / inlet guide vanes	0.90	
Forward curved fan with discharge damper	0.90	
Forward curved inlet guide vanes	0.90	
Inlet guide vanes, fan type unknown	0.90	
Cooling tower fan	0.90	
Process pump	0.78	Per Michigan Energy Measures Database[7]
Process fan	0.78	
Constant torque process applications	0.78	Assume same CF as other process equipment
Pool pump	0.78	Assume same CF as process equipment

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Expected useful life (= 15 years)[1]

Sources

1. 2013 Vermont TRM. http://www.greenmountainpower.com/upload/photos/371TRM_User_Manual_No_2013-82-5-protected.pdf
2. Office of Energy Efficiency and Renewable Energy Advanced Manufacturing Office. Motor Systems Tip Sheet #11, Adjustable Speed Drive Part Load Efficiency.
3. Smart Energy Design Assistance Center. *SEDAC Tech Note – Variable Frequency Drives*. November 2011.
4. Focus on Energy. *VFD calculation spreadsheet.* Modified to handle constant torque loads.
5. "Flow Control." Westinghouse publication, Bulletin B-851, F/86/Rev-CMS 8121.
6. ABB and Toshiba energy saving spreadsheet tools.
   ABB Pump Save (use version 4.4): http://www.abb.com/product/seitp322/5fcd62536739a42bc12574b70043c53a.aspx
   ABB Fan Save (use version 4.4): http://www.abb.com/product/seitp322/5b6810a0e20d157fc1256f2d00338395.aspx
   Toshiba (set filters to product family=drives and download type=software, look for "Cost Savings Estimator"): http://www.toshiba.com/ind/downloads_main.jsp.
7. "Michigan Energy Measures Database." 2013. Available online: http://www.michigan.gov/mpsc/0,4639,7-159-52495_55129---,00.html. Refer to "VFD 1.5 to 50 hp Process Pumping" and "VFD for Process Fans Under 50 hp" measures.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

Refrigeration

Cooler Evaporator Fan Control

	Measure Details
Measure Master ID	Cooler Evaporator Fan Control, 2269
Measure Unit	Per fan motor
Measure Type	Prescriptive
Measure Group	Refrigeration
Measure Category	Controls
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	2,051
Peak Demand Reduction (kW)	0.234
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	32,817
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	16[1]
Incremental Cost	$275.00

Measure Description

Walk-in cooler and freezer refrigeration systems typically operate 24 hours per day, 365 days per year. These systems must run when the compressor is running to provide cooling, and they must run when the compressor is not running to provide air circulation, thus preventing the coil from freezing. The only time these fans do not operate is during the defrost cycle.

Significant energy savings can be realized by installing a more efficient evaporator fan motor and control fan system, which regulates the speed of the evaporator fan motor to meet the need during each phase of the refrigeration cycle. These systems save energy in two ways: (1) the evaporator fans consume less energy, and (2) the system results in less heat being introduced to the refrigerated chamber from the evaporator fan motors, which decreases the overall box load, thereby reducing the compressor/condenser on-duty cycle.

This measure is a single motor and a controller that could control multiple fan motors.

Description of Baseline Condition

The baseline condition is a refrigeration system with a SP or PSC motor without an evaporator fan controller. Existing ECMs are not eligible for replacement under this measure. It is assumed that these fans run at a constant speed for 8,578 hours per year.

Description of Efficient Condition

The efficient condition is a two-speed ECM replacing a SP or PSC motor on an evaporator fan unit and a controller to switch the fan to lower speed when the temperature of the unit or refrigerant is determined to need lower air movement. Only upgraded motors connected to the control unit are allowable under this measure.

Controls must meet the requirements of the ECM fan motor control measures.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{BASE\,-}\ kWh_{EE}$

$kWh_{BASE} = [(kWevap * DCevap) * BF] * HOURS$

$kWh_{EE} = \{[(kWcircH*(1-LS)+ kWcircH*LS) * BF\} *HOURS$

Where:

kWh_{BASE} = Annual existing base kWh consumed
kWh_{EE} = Proposed annual kWh consumed
kWevap = Connected load kW of each evaporator fan
DCevap = Duty cycle of evaporator fan (= 97%)[3]
BF = Bonus factor to account for a reduced cooling load on the compressor, thus refrigeration savings.[3]
HOURS = Annual operating hours of fans (= 8,578)
kWcircH = Connected load kW of the normal speed ECM evaporator fan
LS = Fraction of time at low-speed setting (= 32%)[7]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} / (8{,}760) * CF$

Where:

8,760 = Total annual operating hours of building
CF = Coincidence factor (= 1)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 16 years)[1]

Assumptions

A 60% SP motor and 40% PSC motor were assumed for the baseline. An equal mix of 1/10, 1/15, and 1/20 HP motors were assumed for the motor sizes being replaced. It is assumed that there is a 70% load factor, 20% SP motor efficiency, and 40% PSC motor efficiency. It is assumed that the fan size is equal to the horsepower replaced for walk in coolers and freezers. It is assumed that there is a 70% load factor for full operation and 70% motor efficiency. Low-speed operation assumes a 10% load factor and 50% motor efficiency. The assumed bonus factor for coolers is 1.3 and for freezers is 1.5.

Bonus Factor assumes that the application of this measure would occur 50% of the time in a cooler and 50% of the time in a freezer. Thus the assumed bonus factor for coolers is 1.3 and for freezers is 1.5.

Annual operating hours, assumes that the application of this measure would occur 50% of the time in a cooler and 50% of the time in a freezer. The assumed number of operating hours for coolers is 8,760 per year and for freezers is 8,273 per year (with for 4 x 20-minute defrost cycles per day).

The Connected load kW of the normal speed ECM evaporator fan is based on 100% ECM evaporator fan types. It is assumed that the fan size is equal to the horsepower replaced for walk in coolers and freezers. It is assumed that there is a 70% load factor for full operation and 70% motor efficiency. Low-speed operation assumes a 10% load factor and 50% motor efficiency.

It is assumed that application of this measure would occur 50% of the time in a cooler and 50% of the time in a freezer. The associated duty cycle assumed for coolers is 100% and for freezers is 100% and 94%.

Sources

1. California Energy Commission and California Public Utilities Commission. Database for Energy Efficient Resources (DEER) 2008. http://www.energy.ca.gov/deer/ .
2. Efficiency Maine. *Commercial Technical Reference Manual, Version 2013.1.* Pg. 67. January 1, 2013.
3. Regional Technical Forum. *Evaporator Fan Controls and Evaporator Fan Uniform Energy Savings Measures Calculations*. 2010. Estimated as conservative average of a Medium Temperature Low Speed at 42% and a Low Temperature Low Speed at 32%.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

ECM Compressor Fan Motor

	Measure Details
Measure Master ID	ECM Compressor Fan Motor, 2306
Measure Unit	Per motor
Measure Type	Prescriptive
Measure Group	Refrigeration
Measure Category	Motor
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	396
Peak Demand Reduction (kW)	0.0792
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	5,940
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost	$80.00

Measure Description

Compressor and condenser packaged unit fans typically run 4,500 hours per year to blow air across the compressor and condenser to cool the equipment and refrigerant. The long-time standard in refrigeration equipment is SP fan motors, which are highly inefficient and generate excessive heat. Higher-efficiency ECMs use 75% less energy to run and generate less heat. ECMs or brushless AC fan motors are used in conjunction with air-cooled condensers and/or compressors.

Incentives are available for ECMs replacing SP motors or PSC motors on existing packaged condenser/compressor fans. This measure does not apply to evaporator fan motors.

Description of Baseline Condition

The baseline condition is an SP or PSC packaged compressor/condenser unit fan motor.

Description of Efficient Condition

The efficient condition is an ECM replacing a SP motor or PSC motor on a compressor/condenser unit.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1,000 * HOURS$

Where:

$Watts_{BASE}$ = Wattage of the existing SP fan motor (= 142 average)[2]
$Watts_{EE}$ = Wattage of the proposed motor (= 54)[2]
1,000 = Kilowatt conversion factor
HOURS = Average annual run hours (= 4,500)[3]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1,000 * CF$

Where:

CF = Coincidence factor (= 0.90)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[1]

Assumptions

A 50% SP motor and 50% PSC motor were assumed for the baseline.

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. Pennsylvania Public Utility Commission. *Technical Reference Manual*. June 2013.
3. Operating hours based on compressor/condenser run time and Wisconsin weather. This value is between 4,000 – 5,000 hours, so 4,500 hours was used.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Reach In Refrigerated Case w/ Doors Replacing Open Multi Deck Case

	Measure Details
Measure Master ID	Reach In Refrigerated Case w/ Doors Replacing Open Multi Deck Case, 2509
Measure Unit	Per linear foot
Measure Type	Prescriptive
Measure Group	Refrigeration
Measure Category	Refrigerated Case Door
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	847
Peak Demand Reduction (kW)	0.0966
Annual Therm Savings (Therms)	98
Lifecycle Energy Savings (kWh)	12,697
Lifecycle Therm Savings (Therms)	847
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[8]
Incremental Cost	$700.00[9]

Measure Description

This measure is replacing existing open multi-deck cases with equivalent storage (in cubic feet or linear feet) of reach-in cases with doors. The estimated measure savings are conservative because case replacements use equivalent linear feet, but reach-in cases are designed to hold more cubic feet of product per linear foot (side-to-side measure) than multi-deck cases.

Description of Baseline Condition

The baseline is a 95% to 5% mix of cooler to freezer open multi-deck style cases.

Description of Efficient Condition

The replacement cases must have doors, be tied into a central refrigeration system, and be purchased new. New case upgrades that simply enclose and/or add doors to an existing multi-deck do not qualify for this incentive. New cases must be DOE 2012 Energy Compliant.

Annual Energy-Savings Algorithm

$$kWh_{SAVED} = [((P_{CE} - P_{LE} - P_{ME} - (P_{CE}F_{CR})) - (((P_{CP} * (1 - F_I) - P_{LP} - P_{MP} - P_{CP}F_{CR} (1 - F_I)))] * [((LF * (1/3{,}412) * HOURS) / COP_{REFRIG}) - ((24 * (CDD / (T_S - T_R)) * (12/3{,}412) * COP_{ROOFTOP} * (1/12{,}000))]$$

$$Therm_{SAVED} = [((P_{CE} - P_{LE} - P_{ME} - (P_{CE}F_{CR})) - (((P_{CP} * (1 - F_I) - P_{LP} - P_{MP} - (P_{CP}F_{CR} (1 - F_I)))] * [24 * (HDD / (T_S - T_R)) * (1/eff) * (1/100{,}000)]$$

Where:

P_{CE} = Total load of multideck case (= 1,500 Btuh per linear foot for coolers;[1] = 1,850 Btuh per linear foot for freezers)[2]

P_{LE} = Lighting load of existing case (= 6.7 Btuh per linear foot)[2]

P_{ME} = Motor load of existing case (= 7.3 Btuh per linear foot)[2]

F_{CR} = Amount of case load associated with conduction and radiation (= 13%)[5]

P_{CP} = Total load of new enclosed case (= 332 Btuh per linear foot for coolers; = 528 Btuh per linear foot for freezers)[3]

F_I = Amount of case load associated with infiltration reduction (= 68%)[4]

P_{LP} = Lighting load of new case (= 8.2 Btuh per linear foot)[3]

P_{MP} = Motor load of new case (= 2.7 Btuh per linear foot for coolers; = 3.5 Btuh per linear foot for freezers)[3]

LF = Case load factor, the compressor duty cycle needed to maintain case temperatures, deemed (= 62% for coolers; = 80% for freezers)[6]

3,412 = Conversion from kilowatt-hours to Btu

HOURS = Average annual operating hours of the light fixture measured in hours per year, deemed (= 8,760)[6]

COP_{REFRIG} = Coefficient of performance of refrigeration system: a measure of the refrigeration system efficiency equal to the ratio of net heat removal to total energy input, deemed (= 2.5 for coolers; = 1.3 for freezers)[1]

24 = Hours per day

CDD = Cooling degree days, the sum of the number of degrees the average daily temperature is greater than a base temperature for a given time period, deemed (= 535)[6]

T_S = Temperature of store, deemed (= 65°F)[6]

T_R = Temperature of refrigerated case that needs to be maintained (= 36.5°F for coolers; = -11°F for freezers)[7]

12 = COP conversion factor

$COP_{ROOFTOP}$ = Coefficient of performance of rooftop system: a measure of the efficiency of the rooftop system equal to the ratio of net heat removal to total energy input (= 3.2)[7]

12,000 = Btu to ton conversion factor

HDD = Heating degree days, the sum of the number of degrees the average daily temperature is less than a base temperature for a given time period, deemed (= 7,699)[6]

eff = Heating system efficiency, the average combustion efficiency of the boiler (= 78%)[7]

100,000 = Conversion factor from Btu to Dth

Summer Coincident Peak Savings Algorithm

$$kW_{SAVED} = [((P_{CE} – P_{LE} – P_{ME} – (P_{CE}F_{CR})) – (((P_{CP} * (1 – F_{I}) – P_{LP} – P_{MP} – P_{CP}F_{CR} (1 – F_{I})))] * [(((LF * (1/3{,}412) * HOURS) / COP_{REFRIG}) – ((24 * (CDD / (T_{S} – T_{R})) * (12/3{,}412) * COP_{ROOFTOP} * (1/12{,}000))] * (1/8{,}760)$$

Where:

8,760 = Total annual operating hours of building

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[8]

Assumptions

Refrigerated case temperatures were calculated as the average of the most commonly used settings for cooler and freezer cases: 35°F to 38°F and -14°F to -8°F, respectively.[7]

Sources

1. Arthur D. Little, Inc. *Energy Savings Potential for Commercial Refrigeration Equipment – Final Report*. 1996.
2. Manufacturer's specification sheet for open multideck style freezer case. Hussmann Excel F6L. November 2010.

3. Manufacturer's specification sheet for enclosed reach-in cases. Zero Zone RVCC30 and RVZC30. 2012.
4. California Edison Research and Thermal Test Center.
5. ASHRAE RP-1402.
6. PA Consulting Group Inc. *State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0.* Updated March 22, 2010.
7. National Renewable Energy Lab. U.S. Department of Energy Building Technology Program. *Advanced Energy Retrofit Guide: Practical Ways to Improve Energy Performance, Grocery Stores*. June 2012.
8. California Energy Commission and California Public Utilities Commission. Database for Energy Efficient Resources (DEER) 2008. http://www.energy.ca.gov/deer/ .
9. Project bid data based on Focus on Energy project history.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

Retrofit Open Multi-Deck Cases with Doors

	Measure Details
Measure Master ID	Retrofit Open Refrigerated Cases with Doors, 3409
Measure Unit	Per linear foot
Measure Type	Prescriptive
Measure Group	Refrigeration
Measure Category	Refrigerated Case Door
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	615
Peak Demand Reduction (kW)	0.0702
Annual Therm Savings (Therms)	11
Lifecycle Energy Savings (kWh)	7,378
Lifecycle Therm Savings (Therms)	129
Water Savings (gal/yr)	0
Effective Useful Life (years)	12[7]
Incremental Cost	$126.53

Measure Description

Existing open multi-deck style cases can be retrofitted with doors. The doors are designed to fit right onto the open multi-deck style cases with minimal case modification. The measure incentives are based on a per-foot-case enclosed.

Description of Baseline Condition

The baseline is a 95% to 5% mix of cooler to freezer open multi-deck style cases.

Description of Efficient Condition

The efficient condition is installing doors on the cooler or freezer multi-deck style cases.

Annual Energy-Savings Algorithm

$$kWh_{SAVED} = (P_C F_I - P_L - P_M - (P_C F_{CR} F_I)) * (LF * (1/3{,}412) * HOURS * COP_{REFRIG}) - ((24 * (CDD / (T_S - T_R)) * (12/3{,}412) * COP_{ROOFTOP} * (1/12{,}000))$$

$$Therm_{SAVED} = P_C F_{CR} F_I * ((24 * (HDD / (T_S - T_R)) * (1/eff) * (1/100{,}000))$$

Where:

P_C = Total case load, the average energy consumption of the refrigerated case (= 1,500 Btuh for coolers;[1] = 1,850 Btuh for freezers)[2]

F_I = Amount of infiltration reduction, the fraction of the case energy associated with infiltration (= 68%)[3]

P_L = Lighting load of case, the average energy consumption of the lighting in the case (= 6.7 Btuh)[2]

P_M = Motor load of case, the average energy consumption of the evaporator motors in the case (= 5 Btuh)[2]

F_{CR} = Amount of case load energy associated with conduction and radiation (= 13%)[4]

LF = Case load factor, the compressor duty cycle needed to maintain case temperatures, deemed (= 62% for coolers; = 80% for freezers)[5]

3,412 = Conversion factor from kilowatt-hours to Btu

HOURS = Average annual operating hours of the light fixture, deemed (= 8,760)[5]

COP_{REFRIG} = Coefficient of performance of refrigeration system, a measure of the refrigeration system efficiency equal to the ratio of net heat removal to the total energy input, deemed (= 2.5 for coolers; = 1.3 for freezers)[1]

24 = Hours per day

CDD = Cooling degree days, the sum of the number of degrees that the average daily temperature is greater than a base temperature for a given time period (the State of Wisconsin uses a base temperature of 65°F, which is a standard value used in the HVAC industry), deemed (= 535)[5]

T_S = Temperature of store, deemed (= 65°F)[5]

T_R = Temperature of case, the refrigerated case temperature that needs to be maintained (= 36.5°F for coolers; = -11°F for freezers)[6]

12 = COP conversion factor

$COP_{ROOFTOP}$ = Coefficient of performance of rooftop system, a measure of the efficiency of the rooftop system equal to the ratio of net heat removal to the total energy input (= 3.2)[6]

12,000 = Btu to ton conversion factor

HDD = Heating degree days, the sum of the number of degrees that the average daily temperature is less than a base temperature for a given time period (the State of Wisconsin uses a base temperature of 65°F, which is a standard value used in the HVAC industry), deemed (= 7,699)[5]

eff = Heating system efficiency, the average combustion efficiency of the boiler (= 78%)[6]

100,000 = Conversion factor from Btu to Dth

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (P_C F_I - P_L - P_M - (P_C F_{CR} F_I)) * (LF * (1/3{,}412) * HOURS * (1/COP_{REFRIG})) - ((24 * (CDD / (T_S - T_R)) * (12/3{,}412) * COP_{ROOFTOP} * (1/12{,}000)) * 1/8{,}760$

Where:

100,000 = Conversion factor from Btu to Dth

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 12 years)[7]

Assumptions

Refrigerated case temperatures were calculated as the average of the most commonly used settings for cooler and freezer cases, 35°F to 38°F and -14°F to -8°F, respectively.[6]

Sources

1. Arthur D. Little, Inc. *Energy Savings Potential for Commercial refrigeration Equipment – Final Report.* 1996.
2. Manufacturer’s specification sheet for open multideck style freezer case. Hussmann Excel F6L. November 2010.
3. California Edison Research and Thermal Test Center.

4. ASHRAE RP-1402.
5. PA Consulting Group Inc. *State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0.* Updated March 22, 2010.
6. U.S. Department of Energy Building Technology Program. *Advanced Energy Retrofit Guide: Practical Ways to Improve Energy Performance, Grocery Stores.* National Renewable Energy Laboratory. June 2012.
7. California Energy Commission and California Public Utilities Commission. Database for Energy Efficient Resources (DEER) 2008. http://www.energy.ca.gov/deer/ .Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

Strip Curtains for Walk-In Freezers and Coolers

	Measure Details
Measure Master ID	Strip Curtains for Walk-In Freezers and Coolers, 3183 Strip Curtains for Walk-In Freezers and Coolers, SBP A La Carte, 3284
Measure Unit	Per linear foot
Measure Type	Prescriptive
Measure Group	Refrigeration
Measure Category	Strip Curtain
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government
Annual Energy Savings (kWh)	315 per linear foot
Peak Demand Reduction (kW)	0.036 per linear foot
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	1,260 per linear foot
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	4[1]
Incremental Cost ($/unit)	$50.00

Measure Description

Strip curtains reduce the refrigeration load associated with the infiltration of non-refrigerated air into the refrigerated spaces of walk-in coolers or freezers. The most likely areas of application are grocery stores, supermarkets, restaurants, and refrigerated warehouse.

Description of Baseline Condition

The baseline condition is a walk-in cooler or freezer that with no strip curtain or an old, ineffective strip curtain installed.

Description of Efficient Condition

The efficient condition is adding a strip curtain or replacing the ineffective strip curtain on a walk-in cooler or freezer. Strip curtains must be at least 0.06 inches thick. Low temperature strip curtains must be used for low temperature applications.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = \Delta kWh/LF * LF$

Where:

LF = Linear feet of door width of installation

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = \Delta kW/LF * LF$

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 4 years)[1]

Deemed Savings

The annual deemed savings is calculated based on methods and deemed savings included in the 2013 Pennsylvania TRM.[2] For the Small Business Program, a single deemed measure is developed using the expected mix of program customers and situations.

In order to create the Small Business Program measure mix, the following assumptions based on facility type are assumed. See the Assumptions section for more background.

- Facility Types
  - Supermarket = 10%
  - Convenience Store = 30%
  - Restaurant = 60%
- Cooler and Freezer Mix
  - Coolers = 75%
  - Freezers = 25%
- Facilities that have existing ineffective strip curtains
  - 25% (75% have no existing strip curtains)

Comparison of Pennsylvania TRM to Focus on Energy Values by Facility Type*

Facility Type	PA TRM 2013 (Source 1)			Focus on Energy		
	Pre-Existing Curtains	Energy Savings (per sqft)**	Demand Reduction (per sqft)***	Measure Mix	Weighted Energy Savings (per sqft)	Weighted Demand Reduction (per sqft)
Supermarket - Cooler	Yes	37	0.0042	1.88%	0.69	0.00008
	No	108	0.0123	5.63%	6.08	0.00069
	Unknown	108	0.0123	0.00%	0.00	0.00000
Supermarket - Freezer	Yes	119	0.0136	0.63%	0.74	0.00009
	No	349	0.0398	1.88%	6.54	0.00075

Facility Type	PA TRM 2013 (Source 1)			Focus on Energy		
	Pre-Existing Curtains	Energy Savings (per sqft)**	Demand Reduction (per sqft)***	Measure Mix	Weighted Energy Savings (per sqft)	Weighted Demand Reduction (per sqft)
	Unknown	349	0.0398	0.00%	0.00	0.00000
Convenience Store - Cooler	Yes	5	0.0006	5.63%	0.28	0.00003
	No	20	0.0023	16.88%	3.38	0.00039
	Unknown	11	0.0013	0.00%	0.00	0.00000
Convenience Store - Freezer	Yes	8	0.0009	1.88%	0.15	0.00002
	No	27	0.0031	5.63%	1.52	0.00017
	Unknown	17	0.002	0.00%	0.00	0.00000
Restaurant - Cooler	Yes	8	0.0009	11.25%	0.90	0.00010
	No	30	0.0034	33.75%	10.13	0.00115
	Unknown	18	0.002	0.00%	0.00	0.00000
Restaurant - Freezer	Yes	34	0.0039	3.75%	1.28	0.00015
	No	119	0.0136	11.25%	13.39	0.00153
	Unknown	81	0.0092	0.00%	0.00	0.00000
Refrigerated Warehouse	Yes	254	0.029	0.00%	0.00	0.00000
	No	729	0.0832	0.00%	0.00	0.00000
	Unknown	287	0.0327	0.00%	0.00	0.00000
Focus on Energy Small Business Program Savings Values (per sqft)					**45.00**	**0.00514**

* Sum values may differ due to rounding.

* The 2013 Pennsylvania TRM uses the Tamm Equation to determine electricity savings: kWh = 365 x topen x (ηnew - ηold) x 20CD x A x {[(Ti - Tr)/Ti]gH}0.5 x 60 x (ρihi – ρrhr) / (3413 x COPadj)

*** $kW_{SAVED} = kWh_{SAVED} / 8{,}760$

The unit of measurement for strip curtains is per linear foot of doorway width. It is assumed that all walk-in unit doors are 7 feet tall. The table below shows the energy savings per square foot to linear foot comparison for determining deemed savings.

Conversion of Energy Savings

Savings Type	Savings (per sqft)	Door Height (Ft)	Deemed Value per Linear Foot
Annual Electricity Savings (kWh/yr)	45	7	315
Demand Reduction (kW)	0.0051	7	0.036
Annual Natural Gas Savings (therms/yr)	0	7	0

Using the EUL, the table below shows updated savings values for strip curtains.

Deemed Annual Savings

Savings Type	Annual Savings	EUL	Lifecycle Savings
Annual Electricity Savings (kWh/yr)	315	4	1,260
Annual Natural Gas Savings (therms/yr)	0	4	0

Assumptions

The primary cause of air infiltration into walk-in coolers and freezers is the air density difference between two adjacent spaces of different temperatures. The total refrigeration load due to infiltration through the main door into the unit depends on the temperature differential between the refrigerated and non-refrigerated airs, the door area and height, and the duration and frequency of door openings.

The avoided infiltration depends on the barrier efficacy of the newly installed strip curtains, and on the efficacy of the supplanted infiltration barriers, if applicable. The calculation of the refrigeration load due to air infiltration and the energy required to meet that load is rather straightforward, but relies on critical assumptions regarding the aforementioned operating parameters. The calculation for this measure follows the Pennsylvania TRM[1] calculation for Measure 3.17: Strip Curtains for Walk-In Freezers and Coolers. The assumptions in that protocol are based on values that were determined by direct measurement and monitoring of over 100 walk-in units in the 2006-2008 evaluation for the California Public Utility Commission.

Within the TRM calculation, the kW demand reduction is simplistic, but should be noted as a major assumption. The below quote is from Page 259 of the 2013 Pennsylvania TRM;

> "The peak demand reduction is quantified by multiplying savings per square foot by area. The source algorithm is the annual energy savings divided by 8760. This assumption is based on general observation that refrigeration is constant for food storage, even outside of normal operating conditions. This is the most conservative approach in lieu of a more sophisticated model.
>
> $$\Delta kW_{PEAK} = \Delta kWh / 8760"$$

There is no code requiring strip curtains for remodeling walk-in coolers and freezers.

Assumptions for Facility Types and Technology

The assumed levels of facility types within the Small Business Program for Focus on Energy are based on the Program Implementer's experience between July 2012 and April 2013 (Staples Energy). Although data was not collected on existing walk-in coolers and freezers from the existing customer list, that list was categorized to differentiate restaurants, convenience stores (including liquor stores and florists), and supermarkets (including meat markets and fish markets).

The table below details the number of customers the Program Implementer visited in each category and the estimated number that will have walk-in refrigeration. The customer size in the small business sector indicates the amount of facilities that have walk-in refrigeration, and does not represent the standard mix for the total marketplace.

Percentage of Walk-In Refrigerators by Facility Type

Facility Type	Customer Visits	Percentage with Walk-In Refrigeration	Number with Walk-In Refrigeration	Percentage of Total Facilities
Restaurant	424	33%	139.92	59%
Convenience Store	96	70%	67.2	28%
Supermarket	39	80%	31.2	13%
Total	**559**		**238.32**	**100%**

The calculation uses a slightly more conservative number by reducing the supermarket total to 10% and increasing the convenience store and restaurant totals slightly.

The assumptions for the refrigerator/freezer mix were roughly determined from the same list of customers, broken out by type of facility. The assumptions included determining the numbers of freezers present at the following restaurant types: fast food, Asian cuisine, and fry kitchens. The supermarket freezer components are meat markets, fish markets, and an estimated amount of rural groceries.

Percentage of Walk-In Freezers by Facility Type*

Facility Type	Customer Visits	Number with Walk-In Freezer	Percentage with Walk-In Freezer	Percentage of Total Facilities
Restaurant	424	123	30%	22%
Convenience Store	96	0	0%	0%
Supermarket	39	19	50%	3%
Total	**559**	**142**		**25%**

*Percentages are rounded up

Sources

1. GDS Associates, Inc. The Measure Life Report for Residential and Commercial/Industrial Lighting and HVAC Measures. June 2007.
2. *Pennsylvania Technical Reference Manual*. 2013. Available online: http://www.puc.state.pa.us/filing_resources/issues_laws_regulations/act_129_information/technical_reference_manual.aspx

3. Commercial Facilities Contract Group. *2006-2008 Direct Impact Evaluation.* Available online: http://www.calmac.org/publications/ComFac_Evaluation_V1_Final_Report_02-18-2010.pdf

Revision History

Version Number	Date	Description of Change
01	04/22/2013	Initial submittal

Renewable Energy

Ground Source Heat Pump, Natural Gas and Electric Backup

	Measure Details
Measure Master ID	Ground Source Heat Pump, 2820 (Electric Back-up) and 2821 (NG Back-Up)
Measure Unit	Per heat pump
Measure Type	Prescriptive
Measure Group	Renewable Energy
Measure Category	Geothermal
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	3,476
Peak Demand Reduction (kW)	0.8277
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	62,568
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	18[1]
Incremental Cost	Varies by project

Measure Description

This measure is installing residential-sized geothermal (ground-source) heat pump systems in non-residential applications. Geothermal heat pump systems use the earth as a source of heating and cooling through the installation of an exterior underground loop working in combination with an interior heat pump unit. The measure provides a centralized heating and cooling system, similar to that of a standard air-source heat pump.

Description of Baseline Condition

The baseline condition is an air-source heat pump of 13 SEER and 7.7 HSPF.[4]

Description of Efficient Condition

The efficient condition is a ground-source heat pump of 3.5 COP and 15 EER with either a multi-compressor or a multi-stage compressor, as well as an ECM air handler. Additionally, the procedures followed when installing the equipment must conform to the ACCA Standard 5 Quality Installation requirements.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (FLH_{COOL} * Btu/h_{COOL} * (1/SEER_{BASE} – 1/(EER_{EE} * 1.02)))/1,000 + (FLH_{HEAT} * Btu/h_{HEAT} * (1/HSPF_{BASE} – 1/(COP_{EE} * 3.412)))/1,000$

Where:

FLH_{COOL} = Full-load cooling hours (= 599)[5]

Btu/h_{COOL} = Cooling capacity of equipment (= 40,089 Btu/hour)[3]

$SEER_{BASE}$ = Seasonal energy efficiency ratio of baseline equipment (= 13)[4]

EER_{EE} = Energy efficiency ratio of efficient equipment (= 22.43 kBtu/kWh)[3]

1.02 = Factor to determine SEER based on its EER

1,000 = Conversion

FLH_{HEAT} = Full-load heating hours (= 1,466)[6]

Btu/h_{HEAT} = Heating capacity of equipment (= 30,579 Btu/hour)[3]

$HSPF_{BASE}$ = Heating seasonal performance factor of baseline equipment (= 7.7 kBtu/kWh)[4]

COP_{EE} = Coefficient of performance of efficient equipment (= 4.18)[3]

3.412 = Conversion from Watt to Btu

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Btu/h_{COOL} * (1/EER_{BASE} – 1/EER_{EE})) / 1,000 * CF$

Where:

EER_{BASE} = Energy efficiency ratio of baseline equipment (= 12.75)[4]

CF = Coincidence factor (= 0.61)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 18 years)[1]

Assumptions

This system life expectancy is generally constrained by the heat pump exchanger and compressor equipment. The actual ground loop installation often has a much longer life expectancy.

The run-time differs for non-residential and residential applications due to internal heat gains, additional ventilation requirements for non-residential buildings, times of occupancy, and occupancy numbers. Heating run-times from the TRM for Pennsylvania 2013 Draft for Commercial HVAC were used and adjusted using EFLH from the U.S. DOE ENERGY STAR Air Source Heat Pump Calculator[5] to account for differences in weather conditions. This resulted in a 42% reduction in hours from ENERGY STAR – or 1,466 hours.

Full Load Heating Hours from Pennsylvania TRM and ENERGY STAR

City	PE TRM (hours)[4]	ENERGY STAR (hours)[8]
Allentown	1,098	2,492
Erie	1,720	2,901
Harrisburg	1,406	2,371
Philadelphia	1,461	2,328
Pittsburgh	1,411	2,380
Scranton	1,501	2,532
Williamsport	1,483	2,502
Average	**1,440**	**2,501**

Full Load Heating Hours from Wisconsin TRM and ENERGY STAR

City	ENERGY STAR (hours)[8]	WI TRM (hours)
Green Bay	2,641	1,521
La Crosse	2,445	1,408
Madison	2,547	1,467
Milwaukee	2,548	1,467
Average	**2,545**	**1,466**

Full Load Heating and Cooling Hours for Average Commercial Building

Building Type	FLH_{HEAT}[6]	FLH_{COOL}[5]
Average Commercial	**1,466**	**599**

The installation of a ground-source heat pump is more likely to happen in the northern part of the state due to the lack of available natural gas. A lower coincidence factor than residential (0.68)[5] and non-residential (0.80)[7] air conditioning is used to account for the reduced occurrence of operation.

Coincidence Factors by Sector

Sector	Air Conditioner	GSHP
Residential	0.68[5]	0.50[3]
Non-Residential	0.80[7]	0.61

Sources

1. 2012 Illinois TRM. http://www.ilsag.info/technical-reference-manual.html
2. Energy Center of Wisconsin. *Update of Geothermal Analysis.* Pg. 19-21. August 31 2009.
3. California Energy Commission and California Public Utilities Commission. Database for Energy Efficient Resources (DEER) 2008. http://www.energy.ca.gov/deer/ .Revision History DEER model runs that were weather normalized for statewide use by population density.
4. International Energy Conservation Code. Table 503.2.3(1). 2009.
5. See similar measures A/C Split System, ≤ 65 MBh: SEER 14, 2194; SEER 15, 2192; and SEER 16+, 2193.
6. Technical Reference Manual for Pennsylvania 2013 Draft for Commercial HVAC were used and adjusted using EFLH from the U.S. DOE ENERGY STAR Air Source Heat Pump Calculator to account for differences in weather conditions.
7. See similar measures A/C Split System, ≤ 65 MBh: SEER 14, 2194; SEER 15, 2192; and SEER 16+, 2193.
8. See similar measure Natural Gas Boilers (≤ 300 MBh) 90%+ AFUE, 2743
9. U.S. Department of Energy. *ENERGY STAR Calculator.*

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

Residential Measures

Through the Residential Portfolio, Wisconsin Focus on Energy delivers information, incentives, and implementation support to help residential customers access energy-efficient technologies that help them control their electricity and natural gas use. These efficient technologies include, but are not limited to, lighting, heating and cooling systems, home appliances, insulation and air sealing services, and residential renewable energy systems.

The Mass Markets portfolio for 2016 includes 9 core programs that Focus on Energy designed to help different types of residential customers access these technologies, using different approaches to offer outreach and financial support.

All types of residential homeowners can take advantage of the **Residential Lighting and Appliance Program**, in which they receive in-store discounts for purchasing high-efficiency light bulbs and home appliances.

Residential customers that live in single-family homes[3] can participate in the following programs and obtain incentives for different types of energy-saving measures:

- The **Appliance Recycling Program** offers a financial incentive for residents to recycle old refrigerators and freezers, as well as free pickup and disposal.
- The **Home Performance with ENERGY STAR Program** offers comprehensive energy audits, incentives for whole-house energy-savings measures, such as insulation and air sealing, and incentives for customers to install energy-efficient furnaces and other heating equipment.
- The Assisted Home Performance with ENERGY STAR Program offers enhanced incentives for income-qualified participants.
- A new program, unnamed at the time of this publication, will provide free kits with energy-saving measures to customers.
- The **Renewable Rewards Program** connects customers with experts that help them determine whether their property could effectively support a renewable energy system, and offers financial incentives for customers who proceed to install these systems.

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[3] Including single-family detached homes, mobile homes, and single-family attached homes with three or fewer units.

Owners, managers, and residents of multifamily buildings (such as apartments and condominiums) are served through two related programs.

1. The **Multifamily Direct Install Program** offers free installation of CFLs, LEDs, low-flow showerheads, and other energy-savings measures in tenant units, as well as walk-through assessments of the whole building.
2. Those assessments can identify additional incentives that property owners and managers can take advantage of through the **Multifamily Energy Savings Program**, which provides information, financial incentives, and implementation support to install measures in resident units and common areas.

Residential customers who are building a new home can receive assistance through the **New Homes Program**, in which Focus on Energy works with owners, builders, and energy experts to construct homes that are more energy efficient than required by Wisconsin building codes.

Boilers & Burners

Hot Water Boiler, 95%+ AFUE

	Measure Details
Measure Master ID	Hot Water Boiler, 95%+ AFUE, 1983
Measure Unit	Per boiler
Measure Type	Prescriptive
Measure Group	Boilers & Burners
Measure Category	Boiler
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	151
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	3,011
Effective Useful Life (years)	20[1]
Incremental Cost	$3,105.00

Measure Description

Space heating boilers are pressure vessels that transfer heat to water for use primarily in space heating applications. Boilers either heat water using a heat exchanger that works like an instantaneous water heater, or by the addition of a separate tank with an internal heat exchanger that is connected to the boiler.

High-efficiency space heating boilers are applicable to any residential boiler used for space heating. They are not applicable to boilers used for process end uses, DHW, pools, or spas. The space heating boiler qualifications are listed in the table below.

Qualifications for Space Heating Boilers

Type	Input Rating	Required Efficiency
95% Efficient Boiler	≤ 300 MBh	AFUE ≥ 95%

Description of Baseline Condition

The baseline equipment is a hot water boiler with 82% AFUE.[2]

Description of Efficient Condition

Energy-efficient space heating boilers often feature high-efficiency and/or low-Nox burners, and typically have features such as forced air burners, relatively large heat exchange surfaces, and/or use heat recovery from stack gases.

Annual Energy-Savings Algorithm

$Therm_{SAVED} = EFLH * (1 - EFF_{BASELINE} / EFF_{EE})$

Where:

$EFLH$ = Equivalent full-load hours (= 1,000)[3]

$EFF_{BASELINE}$ = AFUE of baseline measure (= 82%)

EFF_{EE} = AFUE of efficient measure (= 95%)

Lifecycle Energy-Savings Algorithm

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 20 years)[1]

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. Energy Efficiency and Renewable Energy Office. *Annual Fuel Utilization Efficiency.* Section 10 CFR 430.23(n)(2). Available online: http://www.regulations.gov/#!documentDetail;D=EERE-2006-STD-0102-0009.
3. 800 therms consumed by 90% AFUE furnaces (i.e., 720 therms output) for all residential natural gas measures estimate from: Pigg and Nevius. *Electricity Use by New Furnaces.* 2000. Available online: http://www.ecw.org/sites/d3efault/files/230-1.pdf. Using average furnace size of 72,000 Btu (from 2012 SPECTRUM database of 13,000 furnaces), 1,000 full-load heating hours are estimated.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry
02	01/2015	MMIDs 1982 and 1978 deactivated and removed

Boiler, Natural Gas

	Measure Details
Measure Master ID	Boiler, ≥ 90% AFUE, NG, 2747
Measure Unit	Per MBh
Measure Type	Custom
Measure Group	Boilers & Burners
Measure Category	Boiler
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	1.56
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	31.27
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Incremental Cost	Varies by project

Measure Description

High efficiency sealed combustion, condensing, and modulating boilers operate by taking advantage of condensing to lower energy consumption. Condensing boilers are designed to capture the latent heat of condensation in the form of water vapor in the exhaust stream. Capturing this latent heat produces high efficiency levels. For a boiler to operate in condensing mode, its return water temperature should be kept below 120°F. In order to capture as much latent heat as possible, condensing boilers are made from stainless steel or other corrosion resistant materials. Chimney liners must be installed for boilers that are replacing a naturally drafting unit that was vented through the same flue as a water heater. Flue closure protocols must be followed when the chimney that will used by the replacement unit was not in use for the previous equipment.

Description of Baseline Condition

The baseline equipment is an 82% AFUE boiler.[2]

Description of Efficient Condition

The efficient equipment is a 85-90%+ AFUE boiler[3] that is capable of modulating the firing rate, has integrated input/output reset control, and is used for space heating. Industrial process or DHW applications do not qualify. Redundant or backup boilers do not qualify.

Annual Energy-Savings Algorithm

These savings are per Mbh of input boiler capacity.

$$Therm_{SAVED} = BC * EFLH * (1 - EFF_{BASELINE} / EFF_{EE}) / 100)$$

Where:

BC = Boiler capacity in MBh (=1)

EFLH = Equivalent full-load hours (= 1,759)[3]

$EFF_{BASELINE}$ = AFUE of baseline measure (=82%)

EFF_{EE} = AFUE of efficient measure (=85-90%)

100 = Conversion factor from MBtu to therms

Lifecycle Energy-Savings Algorithm

$$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$$

Where:

EUL = Effective useful life (= 20 years)[1]

Assumptions

The boiler baseline efficiency is based on the EISA requirements of 82%.

Sources

1. California Energy Commission and California Public Utilities Commission. Database for Energy Efficient Resources (DEER) 2008. http://www.energy.ca.gov/deer/ .
2. Energy Efficiency and Renewable Energy Office. *Annual Fuel Utilization Efficiency*. Section 10 CFR 430.23(n)(2). Available online: http://www.regulations.gov/#!documentDetail;D=EERE-2006-STD-0102-0009.
3. Full load hours for all residential natural gas measures estimate from: Pigg and Nevius. *Electricity Use by New Furnaces.* 2000. Available online: http://www.ecw.org/sites/d3efault/files/230-1.pdf

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry
02	01/2015	Savings changed from per unit to per MBh

Boiler Control, Outside Air Temperature Reset/Cutout Control

	Measure Details
Measure Master ID	Boiler, Outside Temperature Reset/Cutout Control, 2221
Measure Unit	Per MBh
Measure Type	Prescriptive
Measure Group	Boilers & Burners
Measure Category	Controls
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	1.48
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	7.41
Water Savings (gal/yr)	0
Effective Useful Life (years)	5
Incremental Cost	$612.00 per unit

Measure Description

Boiler reset controls automatically control the boiler water temperature based on outdoor temperature. This allows the water to run a little cooler during the fall and spring, and a little hotter during the coldest parts of the winter, improving boiler efficiency and indoor comfort by providing a better match between boiler output and space heating needs. Boiler cutout controls prevent a boiler from firing at a predetermined outside temperature set point to prevent overheating.

Description of Baseline Condition

The baseline condition is no input/output reset with an 87% TE boiler.

Description of Efficient Condition

Outside air temperature reset or cutout control incentives are for existing space heating boilers only. A new boiler with integrated boiler reset controls is not eligible. New boilers not equipped with these controls are eligible for retrofit. The system must be set so that the minimum temperature is not more than 10°F above the manufacturer’s recommended minimum return temperature, unless unusual circumstances require a higher setting. The system must have an outdoor air temperature sensor in a shaded location on the north side of the building. For controls on multiple boilers to qualify, a control strategy must stage the lag boiler(s) only after the first boiler stage(s) fail to maintain the boiler water temperature called for by the reset control.

Annual Energy-Savings Algorithm

$Therm_{SAVED}$ = BC * EFLH / (Eff * 100) * SF

Where:

BC = Boiler capacity in MBh (= 1)

EFLH = Equivalent full-load hours (Multifamily residential= 1,759; Commercial, Industrial, Agriculture, Schools & Government = see table below)[3,4]

Effective Full Load Heating and Cooling Hours by City

City	EFLHheating
Green Bay	1,852
La Crosse	1,966
Madison	1,934
Milwaukee	1,883

Eff = Combustion efficiency of the boiler (= 87%)

100 = Conversion factor from therm to MBtu

SF = Savings factor (= 8%)[2]

Lifecycle Energy-Savings Algorithm

$Therm_{LIFECYCLE}$ = $Therm_{SAVED}$ * EUL

Where:

EUL = Effective useful life (= 5 years)[1]

Sources

1. Average of Cadmus database March 2013 and Fannie Mae Estimated Useful Life Table: https://www.fanniemae.com/content/guide_form/4099f.pdf .
2. Michigan Energy Measures Database. Available online: http://www.michigan.gov/mpsc/0,1607,7-159-52495_55129---,00.html.
3. Pigg and Nevius. *Electricity Use by New Furnaces.* 2000. Available online: http://www.ecw.org/sites/d3efault/files/230-1.pdf
4. Several Cadmus metering studies reveal that the ENERGY STAR calculator EFLH are over-estimated by 25%. The heating EFLH were adjusted by population-weighted HDD and TMY-3 values.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry
02	01/2015	Savings changed from per unit to per MBh

Boiler Tune-Up

	Measure Details
Measure Master ID	Boiler Tune-Up, 2744
Measure Unit	Per tune-up
Measure Type	Prescriptive
Measure Group	Boilers & Burners
Measure Category	Tune-up / Repair / Commissioning
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	129
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	258
Water Savings (gal/yr)	0
Effective Useful Life (years)	2[1]
Incremental Cost	$119.95 per tune-up

Measure Description

Tune-ups are required for boilers to maintain optimal combustion efficiency. Boiler tune-ups must be completed according to the boiler tune-up checklist. This measure applies to non-process-related boilers. A boiler tune-up includes reducing excess air and stack temperature; cleaning burners, burner nozzles, combustion chamber, and boiler tubes; sealing the combustion chamber; and recalibrating boiler controls.

The inspector also checks combustion air intake. The proper combustion air-to-fuel ratio directly affects combustion efficiency. Inadequate air supply yields unburned combustibles (fuel, soot, smoke, and carbon monoxide) while excess air causes heat loss from increased flue gas flow, which lowers the boiler efficiency.

Description of Baseline Condition

The baseline measure is 82% boiler efficiency.

Description of Efficient Condition

The minimum burner size for measure eligibility is 110,000 Btu per hour. The incentive is available once in a 24-month period. The service provider must perform before and after combustion efficiency tests and record the results on the boiler tune-up incentive application. The burner must be adjusted to improve combustion efficiency as needed. The incentives are only available for space and water heating equipment.

Annual Energy-Savings Algorithm

$Therm_{SAVED} = 0.346 * \text{Boiler Size}$

Where:

0.346 = Therms savings per input MBh[2]

Boiler Size = Size of the boiler being tuned and cleaned (= 373 MBtu/hour)[3]

Lifecycle Energy-Savings Algorithm

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 2 years)[1]

Sources

1. 2012 NYSERDA Natural Gas Database. http://www.nyserda.ny.gov/-/media/Files/Publications/PPSER/Program-Evaluation/2012ContractorReports/2012-CI-Natural-Gas-Report.pdf .
2. State of Wisconsin Public Service Commission. *Business Programs Deemed Savings Manual V1.0*. March 22, 2010. (based on an updated baseline efficiency of 82%).
3. Average boiler size of boilers tuned and cleaned in the ACES program 2008-2010.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Combination Boiler, Natural Gas, AFUE ≤ 0.95

	Measure Details
Measure Master ID	Boiler, 95%+ AFUE, With DHW, NG, 3559
Measure Unit	Per combination boiler
Measure Type	Prescriptive
Measure Group	Boilers & Burners
Measure Category	Boiler
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	277
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	5,540
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Incremental Cost ($/unit)	$3,521.72[2]

Measure Description

Space heating boilers are pressure vessels that transfer heat to water for use in space heating. Boilers either heat water using a heat exchanger that works like an instantaneous water heater or by adding/connecting a separate tank with an internal heat exchanger to the boiler. A combination boiler contains a separate heat exchanger that heats water for domestic hot water use.

Qualifying combination boilers must be whole-house units used for both space conditioning (boiler) and hot water heating with one appliance and energy source. Only participants who have a natural gas account with a participating natural gas utility are eligible for this rebate.

Description of Baseline Condition

The baseline condition is a boiler with the federal minimum of 82% AFUE[2] and a residential, natural gas-fueled, 0.575 EF storage water heater.[3] New federal efficiency standards that took effect in April 2015 raised the minimum EF for baseline units from 0.575 to 0.600. The criteria date was rounded to January 1, 2016 since the code took affect mid-year 2015.

Description of Efficient Condition

The efficient condition is a combination boiler unit with boiler AFUE of 95% or greater. The combination boiler must have a sealed combustion unit and be capable of modulating the firing rate. Measures that do not qualify for this incentive include boilers with a storage tank and redundant or backup boilers.

Annual Energy-Savings Algorithm

$Therm_{SAVED} = Therm_{SAVED\text{ - }BOILER} + Therm_{SAVED – WH}$

$Therm_{SAVED\text{ - }BOILER} = BC * EFLH\ (1 – EFF_{BASE} / EFF_{EE}) / 100$

$$Therm_{SAVED – WH} = ((GPD * 365 * 8.33 * 1 * \Delta T_w)/100{,}000) * ((1/RE_{BASE}) – (1/E_{C,EE})) + ((UA_{BASE} / RE_{BASE}) – (UA_{EE} / E_{C,EE})) * (\Delta T_s * 8{,}760)/100{,}000$$

Where:

BC	=	Boiler capacity (= 110 MBtu/hour)[3]
EFLH	=	Effective full-load hours (= 1,000)[4]
EFF_{BASE}	=	Baseline AFUE (= 82%)[5]
EFF_{EE}	=	Efficient AFUE (= 95%)
100	=	Conversion
GPD	=	Gallons of hot water used by the home (= 51.5 per day)[6]
365	=	Days per year
8.33	=	Density of water (lb/gal)
1	=	Specific heat of water (Btu/lb °F)
ΔT_w	=	Average difference between cold water inlet temperature (52.3°F) and hot water delivery temperature (125°F) (= 72.7°F)[7]
100,000	=	Conversion from Btu to therm
RE_{BASE}	=	Recovery efficiency of the baseline tank type water heater (= 76%)[8]
$E_{C,EE}$	=	Combustion efficiency of combination boiler used to provide DHW (= 95%)[9]
UA_{BASE}	=	Overall heat loss coefficient of baseline tank-type water heater (= 14.0 Btu/hr-°F) [10]
UA_{EE}	=	Overall heat loss coefficient of combination boiler (=0 Btu/hr-°F)
ΔT_S	=	Temperature difference between stored hot water (125°F) and ambient indoor temperature (65°F) (= 60°F)
8,760	=	Hours per year

Summer Coincident Peak Savings Algorithm

There are no peak demand savings for this measure.

Lifecycle Energy-Savings Algorithm

$\text{Therm}_{\text{LIFECYCLE}} = \text{Therm}_{\text{SAVED}} * \text{EUL}$

Where:

EUL = Effective useful life (= 20 years)[1]

Assumptions

Because the efficiency of a residential water heater is measured in EF, the true thermal efficiency and overall heat loss coefficient (UA_{BASE}) is not available. A TE of 76% and a UA_{BASE} of 14 is assumed.

The overall heat loss of the combination heater is assumed to be 0 Btu/hr-°F due to the minimal amount of domestic hot water stored within the unit. The average difference of 60°F assumes pipe and ambient air temperatures of 125°F and 65°F, respectively.

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. Northeast Energy Efficiency Partnerships. *Incremental Cost Study Report*. September 23, 2011. Incremental measure cost of $2,791.00 for a combination boiler and $2,461.00 for a high-efficiency boiler sized at 110 Mbh. The percentage increase is applied to the current boiler incremental cost to provide a combination boiler cost of $3,521.72.
3. Average input capacity of boilers under 300 Mbh in the 2013 SPECTRUM Database.
4. 800 therms consumed by 90% AFUE furnaces (i.e., 720 therms output) for all residential natural gas measures estimate from: Pigg and Nevius. Electricity Use by New Furnaces. 2000. Available online: http://www.ecw.org/sites/d3efault/files/230-1.pdf. Using average furnace size of 72,000 Btu (from 2012 SPECTRUM database of 13,000 furnaces), 1,000 full-load heating hours are estimated.
5. Title 42 - THE PUBLIC HEALTH AND WELFARE - 42 U.S.C. 6291-6309 (http://www.gpo.gov/fdsys/pkg/USCODE-2010-title42/html/USCODE-2010-title42-chap77-subchapIII-partA-sec6291.htm)
6. Calculated by using the linear relationship of y = 16.286 x + 13, where x is the average number of people per home and y is the average gallons of hot water used per day. An average value of 2.361 people/home was used for Wisconsin, based on RECS 2009 data (http://www.eia.gov/consumption/residential/data/2009/). The linear relationship is used in

the 2012 Indiana TRM (http://aceee.org/files/pdf/2012-indiana-emv-report.pdf) and the 2010 NY TRM (http://aceee.org/files/pdf/2012-indiana-emv-report.pdf).

7. Public Service Commission of Wisconsin. Request for Proposals. Issued for Mass Markets Portfolio Residential Energy Efficiency Program Implementation. July 26, 2011.
8. Air-Conditioning, Heating, and Refrigeration Institute. “RWH Search.” http://www.ahridirectory.org/ahridirectory/pages/rwh/defaultSearch.aspx. Most common RE for non-heat pump water heaters.
9. ENERGY STAR. “ENERGY STAR Most Efficient 2015 — Boilers.” https://www.energystar.gov/index.cfm?c=most_efficient.me_boilers
10. United States Department of Energy. Technical Support Document: Energy Efficiency Standards for Consumer Products, Residential Water Heaters, Including Regulatory Impact Analysis. 2000.

Revision History

Version Number	Date	Description of Change
01	11/03/2014	Original
02	12/17/2014	Changed ΔT_S to match residential indirect, provided assumptions for value used in calculation, and provided justification for UA_{EE} value

Building Shell

Air Sealing

	Measure Details
Measure Master ID	Air Sealing, 2745
Measure Unit	Per CFM leakage
Measure Type	Custom
Measure Group	Building Shell
Measure Category	Air Sealing
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by heating and cooling system
Peak Demand Reduction (kW)	Varies by heating and cooling system
Annual Therm Savings (Therms)	Varies by heating system
Lifecycle Energy Savings (kWh)	Varies by heating and cooling system
Lifecycle Therm Savings (Therms)	Varies by heating system
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Incremental Cost	Varies by project

Measure Description

Air sealing is the sealing of cracks, gaps, or other penetrations that allow unwanted outside air to enter or exit conditioned spaces. Air sealing reduces the load on heating and cooling equipment, and can increase comfort. Typical areas to seal are attics, basements, crawlspaces, and around doors and windows. Blower door tests may be required to estimate the CFM of leaks before and after air sealing is performed. Savings are determined either by pre- and post-blower door testing or pre- and post-billing analysis.

Description of Baseline Condition

The baseline condition is no air sealing.

Description of Efficient Condition

The efficient condition is air sealing of cracks, gaps, or other penetrations that allow unwanted outside air to enter or exit conditioned spaces.

Annual Energy-Savings Algorithm[2]

$$kWh_{SAVED} = kWh_{SAVED\ COOL} + kWh_{SAVED\ HEAT}$$

For systems with cooling installed:

$$kWh_{SAVED\ COOL} = [\{((CFM50_{PRE} – CFM50_{POST}))/N_{COOL}) * 60 * 24 * CDD * 0.018\} /(1{,}000 * Cool_{EFF})] * LM$$

For systems with electric heat:

$$kWh_{SAVED\ HEAT} = [((CFM50_{PRE} – CFM50_{POST})/N_{HEAT}) * 60 * 24 * HDD * 0.018] /(3{,}412 * Heat_{EFF})$$

For systems with natural gas heat:

$$Therm_{SAVED} = [((CFM50_{PRE} – CFM50_{POST})/N_{HEAT}) * 60 * 24 * HDD * 0.018] /(100{,}000 * Heat_{EFF})$$

Where:

$CFM50_{PRE}$ = Blower door test result before air sealing is performed

$CFM50_{POST}$ = Blower door test result after air sealing is performed

N_{COOL} = Conversion factor for CFM from 50 Pascal to natural conditions (= 18.5 assuming normal shielding)

60 = Constant to convert minutes to hours

24 = Hours per day

CDD = Cooling degree days (= 565; see table below)

0.018 = Specific heat capacity of air (Btu/cubic feet – ^{o}F)

1,000 = Conversion factor from kW to W

$Cool_{EFF}$ = Cooling system efficiency, BTW/W - hr (= 10 SEER if manufactured before 2006; = 13 SEER if manufactured in 2006 or later)

LM = Latent multiplier to convert the calculated sensible cooling savings to a value representing sensible and latent cooling loads (= 6.6 as an average of Chicago and Minneapolis)[2]

N_{HEAT} = Conversion factor for CFM from 50 Pascal to natural conditions, assuming normal shielding (= 18.5 if 1-story; = 16.5 if 1.5 stories; = 15.0 if 2 stories; = 14.1 if 2.5 stories; = 13.3 if 3-stories)[3]

HDD = Heating degree days (= 7,616; see table below)

Cooling Degree Days and Heating Degree Days by Location

Location	HDD[4]	CDD[4]
Milwaukee	7,276	548
Green Bay	7,725	516
Wausau	7,805	654
Madison	7,599	630
La Crosse	7,397	729
Minocqua	8,616	423
Rice Lake	8,552	438
Statewide Weighted	**7,616**	**565**

3,412 = Conversion factor from kW-hr to Btu

$Heat_{EFF}$ = Heating system efficiency (fraction of heat output per unit of energy input expressed as a decimal)

100,000 = Conversion factor from Btu to therms

For systems with electric heat, $Heat_{EFF}$ = HSPF/3.412

Heat pumps manufactured before 2006, $Heat_{EFF}$ = 6.8/3.412 = 1.99

Heat pumps manufactured in 2006 or later, $Heat_{EFF}$ = 7.7/3.412 = 2.26

Electric resistance, $Heat_{EFF}$ = 1.0

Installed AFUE for systems with natural gas heat:

$Heat_{EFF}$ = 0.92 for condensing systems

$Heat_{EFF}$ = 0.78 for non-condensing systems

Summer Coincident Peak Savings Algorithm

For systems with central air conditioning:

$kW_{SAVED} = (kWh_{SAVED\ COOL}/EFLH_{COOL}) * CF$

Where:

$EFLH_{COOL}$ = Equivalent full load cooling hours (= 380; see table below)

Supporting Inputs for Load Hours in Several Wisconsin Cities[5]

Location	$EFLH_{COOL}$
Green Bay	344
La Crosse	323
Madison	395
Milwaukee	457
Wisconsin Average	**380**

CF = Coincidence factor (= 0.66)[6]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 20 years)[1]

Sources

1. 2007 GDS residential measure life report: http://www.iar.unicamp.br/lab/luz/ld/Arquitetural/interiores/ilumina%E7%E3o%20industrial/measure_life_GDS.pdf
2. Harriman et al. "Dehumidification and Cooling Loads From Ventilation Air." ASHRAE Journal. (Added the latent and sensible loads to determine the total (using averages from Chicago and Minneapolis to represent Wisconsin), then divided by the sensible load.
3. Lawrence Berkeley National Laboratory. Building Performance Institute Building Analyst Technical Standards. Available online: http://www.bpi.org/tools_downloads.aspx?selectedTypeID=1&selectedID=2.
4. ASHRAE Estimation of Degree-Days: Fundamentals, Chapter 14. (Calculated from TMY3 weather files of the seven Wisconsin locations using statewide weighted values calculated from 2010 U.S. Census data for Wisconsin.)
5. Illinois Statewide Technical Reference Manual. (used average FLH/CDD and applied to Wisconsin CDD.)
6. Opinion Dynamics Corporation. Delaware Technical Resource Manual. April 30, 2012. Available online: http://www.dnrec.delaware.gov/energy/information/otherinfo/Documents/EM-and-V-guidance-documents/DELAWARE_TRM_August%202012.pdf.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Insulation, Attic, R-11 or R-19 to R-38

	Measure Details
Measure Master ID	Insulation and Air Sealing, Attic, R-11 to R-38, 3570 Insulation, Attic, R-19 to R-38, 3558
Measure Unit	Per residence
Measure Type	Prescriptive
Measure Group	Building Shell
Measure Category	Insulation
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	Varies by baseline
Peak Demand Reduction (kW)	Varies by baseline
Annual Therm Savings (Therms)	Varies by baseline
Lifecycle Energy Savings (kWh)	Varies by baseline
Lifecycle Therm Savings (Therms)	Varies by baseline
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Incremental Cost	$2,647.71[2,3]

Measure Description

This measure is installing attic insulation in an existing single-family residence, prefaced by sealing the attic to reduce air infiltration. The associated insulation measure characteristics are from the Focus on Energy single-family residential proposal calculator as provided in 2011,[4] and the air sealing characteristics are based on modeling of a house with the same assumed characteristics—natural gas heating and electric cooling—with kWh savings reduced by 7.5% based on a Cadmus survey revealing that 92.5% of Wisconsin homes have central cooling.[6]

An additional requirement of this measure is that the existing condition of the space have less than or equal to an effective insulation of R-11 (excluding assembly section) for tier 1, or R-19 for tier 2; and the space should be insulated to a minimum level of R-38. This specific measure detail was not provided in the Focus on Energy calculator, but was determined through additional analysis and calculations in reference to the Illinois TRM attic insulation methodologies.[5] In absence of measure detail, specific program installation guidelines developed by Focus on Energy for its Home Performance with ENERGY STAR Program will be referenced to ensure consistency.

Data from the Energy Center of Wisconsin, the U.S. Census Bureau, and the American Housing Survey were used to calculate best estimates of energy savings for installing attic insulation in single-family Wisconsin residences.

Description of Baseline Condition

The baseline is an attic insulated to R-11 or below for tier 1, and up to R-19 for tier 2. Based on adjustments for projects expected in Wisconsin, the baseline is assumed to be a CFM50 (cubic feet per minute air leakage, at a pressure of 50 Pascal) of 3,684.

Description of Efficient Condition

The efficient condition is an attic insulated to a minimum of R-38, with air sealing techniques (e.g., caulk) of attic leaks to a CFM50 of 3,377.

Annual Energy-Savings Algorithm

The following equations are used to determine savings from attic insulation.

For Cooling

$kWh_{SAVED} = ((1 / R_{BASE} – 1 / R_{EE}) * CDD * 24 * area) / 1,000 / SEER * AC\%$

For heating:

$Therm_{SAVED} = ((1 / R_{BASE} – 1 / R_{EE}) * HDD * 24 * area) / 100,000 / AFUE$

Where:

R_{BASE} = Existing R-value of attic (= 11 for tier 1; = 19 for tier 2)

R_{EE} = Proposed R-value of attic (= 38)

CDD = Cooling degree days (= 565; see table below)

24 = Hours per day

Area = Attic area to be insulated (= 1,209 square feet)

1,000 = Conversion from W to kW

SEER = Cooling system efficiency (= 12)

AC% = Amount of homes with central cooling systems (=92.5%)[6]

HDD = Heating degree days (= 7,616; see table below)

Cooling and Heating Degree Days by Location

Location	HDD[7]	CDD[7]
Milwaukee	7,276	548
Green Bay	7,725	516
Wausau	7,805	654
Madison	7,599	630
La Crosse	7,397	729
Minocqua	8,616	423
Rice Lake	8,552	438
Statewide Weighted	**7,616**	**565**

100,000 = Conversion from Btu to therms

AFUE = Natural gas heating system efficiency (= 80%)

Annual Energy-Savings Algorithm (Air Sealing)[8]

For cooling:

$kWh_{SAVED} = [\{((CFM50_{EXISTING} – CFM50_{NEW}) / N) * 60 * 24 * CDD * 0.018\} / 1,000 * SEER] * LM * AC\%$

For heating:

$Therm_{SAVED} = [((CFM50_{EXISTING} – CFM50_{NEW}) / N) * 60 * 24 * HDD * 0.018] / (100,000 * AFUE)$

Where:

$CFM50_{EXISTING}$ = Existing airflow rate in cubic feet per minute (= 3,683.6)[9]

$CFM50_{NEW}$ = New airflow rate post-air sealing (= 3,377.0)[9]

N = Conversion factor for CFM from 50 Pascal to natural conditions (= 18.5 assuming normal shielding)

60 = Constant to convert minutes to hours

0.018 = Specific heat capacity of air (Btu/cubic feet –°F)

LM = Latent multiplier used to convert the calculated sensible cooling savings to a value representing sensible and latent cooling loads (= see table below)[10]

Latent Multiplier by Location

Location	LM
Eau Claire	8.0
Green Bay	7.7
La Crosse	8.0
Madison	6.5
Milwaukee	8.3

Summer Coincident Peak Savings Algorithm[8]

$kW_{SAVED} = (kWh_{SAVED} / EFLH_{COOLING}) * CF$

Where:

$EFLH_{COOLING}$ = Equivalent full-load hours of air conditioning (= 410)[6]

CF = Coincidence factor (=0.68)[6]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 20 years)[1]

Deemed Savings

Deemed Savings by Baseline R-Value

Baseline	MMID	Annual kWh	Annual Therms	Peak Coincident kW	Lifecycle kWh	Lifecycle Therms
R-11 (tier 1)	3570	231	219	0.3831	4,620	4,380
R-19 (tier 2)	3558	183	114	0.3035	3,660	2,280

Assumptions

The assumed attic area of 1,209 square feet represents the average across all residential attic insulation projects undertaken in the Residential Rewards Program in 2012 and 2013. The previous value of 922 was based on a weighted average of housing unit areas and number of floors from a 2011 American Housing Survey day for Milwaukee.

Federal AFUE standard is 78%, but most new furnaces installed are 90% and higher, so we increased the assumption slightly to 80% (only a slight adjustment since these are likely older homes without many other improvements). SEER 12 is the assumption used for the ECM measure through the Focus on Energy Single Family Residential Program.

The default savings are based on existing heating and cooling equipment efficiencies of 80% AFUE and SEER 12, respectively.

Baseline and efficient R-values are conservative estimates based on the minimum program requirements. Where possible, savings should be calculated based on the square footage of actual existing and final R-values.

Sources

1. Wisconsin PSC EUL Database. 2013. See Appendix C. Attic insulation has an EUL of 25 and air sealing an EUL of 20, so 20 years was used to avoid over-counting lifecycle savings.
2. Wisconsin Public Service Commission. Incremental Cost Database. December 2014. (Attic Insulation incremental cost of $0.99 per square foot.)
3. National Renewable Energy Laboratory. “National Residential Efficiency Measures Database.” Air Leakage and Ceiling/Roof. http://www.nrel.gov/ap/retrofits/about.cfm (Air sealing cost for going from 15ACH50 to 10ACH50 is $1.20 per square foot.)
4. Wisconsin Focus on Energy. Cost-Effectiveness Calculator, Mass Markets – Residential SF Program. July 2011.
5. Illinois Energy Efficiency Statewide Advisory Group. Illinois Statewide Technical Reference Manual. Section 5.6.4 Wall and Ceiling/Attic Insulation. February 2014.
6. Wisconsin Focus on Energy. Evaluated Deemed Savings Changes. October 21, 2014.
7. ASHRAE Estimation of Degree –Days: Fundamentals, Chapter 14. (Calculated from TMY3 weather files of the seven Wisconsin locations, with statewide weighted values calculated using 2010 U.S. Census data for Wisconsin.)
8. Illinois Energy Efficiency Statewide Advisory Group. Illinois Statewide Technical Reference Manual. Section 5.6.1 Air Sealing. February 2014.
9. Calculated from EnergyGauge modeling completed using data from a survey of 136 existing homes in Illinois that participated in a CLEAResult home performance program. The model showed CFM50 of 3,683.635 pre-blower door test and 2,588.414 post-test, for a home of 1,209 square feet. To guard against overly aggressive savings estimates, CFM reduction was decreased by 72%, leading to a post-test figure of 3,376.973.

10. Harriman et al. "Dehumidification and Cooling Loads from Ventilation Air." ASHRAE Journal. . (Added the latent and sensible loads to determine the total (using averages from Chicago and Minneapolis to represent Wisconsin), then divided by the sensible load.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

Domestic Hot Water

Kitchen Aerators, Single-Family

	Measure Details
Measure Master ID	Faucet Aerator, 1.5 GPM, Kitchen: NG, 2120, 2136 Electric, 2126
Measure Unit	Per aerator
Measure Type	Prescriptive
Measure Group	Domestic Hot Water
Measure Category	Aeration
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	294
Peak Demand Reduction (kW)	0.014
Annual Therm Savings (Therms)	13
Lifecycle Energy Savings (kWh)	2136 and 2126 =2,940; 2120= 5,880
Lifecycle Therm Savings (Therms)	2136 and 2126 =130; 2120= 260
Water Savings (gal/yr)	2,897
Effective Useful Life (years)	2136, 2126= 10 [1] and 2120= 20 [9]
Incremental Cost	$5.00

Bathroom Aerators

	Measure Details
Measure Master ID	Faucet Aerator, 1.0 GPM, Bathroom, Residential: NG, 2121, 2137 Electric, 2127
Measure Unit	Per aerator
Measure Type	Prescriptive
Measure Group	Domestic Hot Water
Measure Category	Aeration
Sector(s)	Residential- multifamily, Residential- single family
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	Varies by sector
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	Varies by sector
Water Savings (gal/yr)	829
Effective Useful Life (years)	2127 and 2137=10[1] 2121= 20[9]

	Measure Details
Incremental Cost	\$3.00

Shower Aerators, Single-Family

	Measure Details
Measure Master ID	Showerhead, Direct Install, 1.5 GPM: NG, 2123 Electric, 2129
Measure Unit	Per showerhead
Measure Type	Prescriptive
Measure Group	Domestic Hot Water
Measure Category	Showerhead
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	360
Peak Demand Reduction (kW)	0.0090
Annual Therm Savings (Therms)	16
Lifecycle Energy Savings (kWh)	3,600
Lifecycle Therm Savings (Therms)	158
Water Savings (gal/yr)	2,967
Effective Useful Life (years)	10[7]
Incremental Cost	\$5.00

Measure Description

This measure is the Program Implementer or a subcontractor of the Program Implementer installing a 1.75, 1.5, or 1.0 GPM faucet or shower aerator in place of a higher flow rate aerator. Assumptions are based on a direct installation, not a time-of-sale purchase.

Description of Baseline Condition

The baseline equipment is a higher flow rate aerator (above 1.5 GPM).

Description of Efficient Condition

This measure applies to standard 1.5 and 1.0 GPM low-flow aerators.

Annual Energy-Savings Algorithm

Aerators:

$kWh_{SAVED} = \Delta Gallons\ * 8.33 * 1 * (T_{POINT\ OF\ USE} - T_{ENTERING})) / RE_{ELECTRIC} / 3,412)$

$$Therm_{SAVED} = \Delta Gallons * 8.33 * 1 * (T_{POINT\ OF\ USE} - T_{ENTERING}))/ RE_{GAS} / 100{,}000)$$

$$\Delta Gallons = (GPM_{EXISTING} - GPM_{NEW}) * PH / FH * LU * 365$$

Showerheads:

$$kWh_{SAVED} = \Delta Gallons * 8.33 * 1 * (T_{POINT\ OF\ USE} - T_{ENTERING})) / RE_{ELECTRIC} / 3{,}412)*ISR$$

$$Therm_{SAVED} = \Delta Gallons * 8.33 * 1 * (T_{POINT\ OF\ USE} - T_{ENTERING}))/ RE_{GAS} / 100{,}000) *ISR$$

$$\Delta Gallons = (GPM_{EXISTING} - GPM_{NEW})) * PH * SPD / FH * SLU * 365)*ISR$$

Where:

$\Delta Gallons$ = First-year water savings, gallons

8.33 = Density of water, lbs/gallon

1 = Specific heat of water, Btu/lb °F

$T_{POINT\ OF\ USE}$ = Temperature of water at point of use (= 93°F for kitchen aerators; = 86°F for bathroom aerators; = 101°F for showerheads)[5]

$T_{ENTERING}$ = Temperature of water entering water heater (= 52.3°F)[2]

$RE_{ELECTRIC}$ = Recovery efficiency of electric water heater (= 98%)[3]

3,412 = Conversion from Btus to kWhs

RE_{GAS} = Recovery efficiency of natural gas water heater (= 76%)[3]

100,000 = Conversion from Btus to therms

PH = Single-family persons per house (= 2.52)[1] / multifamily unit (=1.93)[1]

FH = Single-family fixtures per house (= 1.0 for kitchen aerator; = 2.13 for bathroom aerators; = 1.64 for showerheads)[1] / multifamily unit (= 1.0 for kitchen aerators; = 1.11 for bathroom aerators; = 1.0 for showerheads)[1]

LU = Length of use in minutes per person per day (= 4.5 for kitchen aerators; = 1.6 for bathroom aerators)[5]

365 = Conversion from days to years

ISR = In-service rate (=0.90)[8]

Summer Coincident Peak Savings Algorithm

Aerators:

$$kW_{SAVED} = \Delta kWh * CF / (PH * LU * 365 / 60 / FH)$$

$CF = \%Peak_{AERATOR} * LU / 180$

Showerheads:

$kW_{SAVED} = \Delta kWh * CF / (PH * SPD * SLU * 365 / 60 / FH) * ISR$

$CF = \%Peak_{SHOWER} * SLU * SPD / 180$

Where:

CF = Coincidence factor (= 0.0033 for kitchen aerators; = 0.0012 for bathroom aerators; = 0.0023 for showerheads)

60 = Conversion from second to minutes

$\%Peak_{AERATOR}$ = Amount of time faucet aerators used during peak period (= 13%)[6]

180 = Number of minutes during peak period

$\%Peak_{SHOWER}$ = Amount of time showers used during peak period (= 9%)[6]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 10 years)[7]

Sources

1. DEER 2014 and GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts. Prepared for GasNetworks; Table B-2a, measure C-WH-15. Found online here: http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx and http://ma-eeac.org/wordpress/wp-content/uploads/5_Natural-Gas-EE-Potenial-in-MA.pdf
2. U.S. Department of Energy. *Domestic Hot Water Scheduler*. Average water main temperature of all locations measured in Wisconsin by scheduler, weighted by city populations.
3. National Renewable Energy Laboratory. *Building America Research Benchmark Definition*. pg. 12. 2009. Available online: http://www.nrel.gov/docs/fy10osti/47246.pdf.
4. Federal minimum at 80 psi.
5. Cadmus. *Michigan Water Meter Study.* 2012.
6. DeOreo, William B. *The End Uses of Hot Water in Single Family Homes From Flow Trace Analysis*. Figure 2, pg. 10. Available online: http://s3.amazonaws.com/zanran_storage/www.aquacraft.com/ContentPages/4776806

7.pdf. The peak percentage values of 9% and 13% for showerheads and aerators, respectively, determined from the load shape in Figure 2 for the hours between 1:00 p.m. and 4:00 p.m.

7. New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs Selected Residential & Small Commercial Gas Measures; March 2009. New York Department of Public Service. http://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/766a83dce56eca35852576da006d79a7/$FILE/60_DAy_Gas_TecMarket_Energy_Savings_Manual_Final_1-0.pdf
8. Cadmus. *Focus on Energy Evaluated Deemed Savings Changes*. September 14, 2015. https://focusonenergy.com/sites/default/files/FoE_Deemed%20Savings%20Report_%20CY%2015_final.pdf
9. Wisconsin Department of Natural Resources and EPA planning years

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry
02	01/2015	Combined separate entries

Kitchen, Bath, and Shower Aerators

	Measure Details
Measure Master ID	Faucet Aerator: 1.5 GPM, Kitchen, 3026 (Electric), 3025 (NG) 1.0 GPM, Kitchen, 3506 (Electric), 3507 (NG) 0.5 GPM, Kitchen, 3509 (Electric), 3510 (NG) 1.5 GPM, Bathroom, 3028 (Electric), 3027 (NG) 1.0 GPM, Bathroom, 2143 (Electric), 2137 (NG) 0.5 GPM, Bathroom, 3508 (NG) 1.5 GPM, Shower, 3030 (Electric), 3029 (NG)
Measure Unit	Per aerator
Measure Type	Prescriptive
Measure Group	Domestic Hot Water
Measure Category	Aeration
Sector(s)	Residential – single family; Residential- multi family
Annual Energy Savings (kWh)	Varies by location and sector
Peak Demand Reduction (kW)	Varies by location and sector
Annual Therm Savings (Therms)	Varies by location and sector
Lifecycle Energy Savings (kWh)	Varies by location and sector
Lifecycle Therm Savings (Therms)	Varies by location and sector
Water Savings (gal/yr)	Varies by location
Effective Useful Life (years)	10[7]
Incremental Cost	Varies by measure, see Appendix D

Measure Description

This measure is installing low-flow kitchen, bathroom, and/or shower aerators in existing buildings or new construction. It saves either natural gas or electric consumption depending on the water heating fuel source. It also saves on total water consumption.

Description of Baseline Condition

The baseline equipment is a kitchen aerator at 2.2 GPM, a bathroom aerator at 2.2 GPM, and a showerhead at 2.5 GPM.

Description of Efficient Condition

The efficient condition is a kitchen aerator at 1.5, 1.0, or 0.5 GPM, a bathroom aerator at 1.5, 1.0, or 0.5 GPM, and showerhead at 1.5 GPM.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = ((\Delta Gallons * 8.33 * 1 * (T_{POINT\ OF\ USE} - T_{ENTERING}))/ RE_{ELECTRIC})/3{,}412$

$Therm_{SAVED} = ((\Delta Gallons * 8.33 * 1 * (T_{POINT\ OF\ USE} - T_{ENTERING}))/ RE_{GAS})/100{,}000$

For Aerators:

$Gallon_{SAVED} = (GPM_{EXISTING} - GPM_{NEW}) * (PH/FH) * FLU * 365$

For Showerheads:

$Gallon_{SAVED} = (GPM_{EXISTING} - GPM_{NEW}) * ((PH * SPD)/FH) * SLU * 365$

Where:

$\Delta Gallons$ = First-year water savings, gallons

8.33 = Density of water, lbs/gallon

1 = Specific heat of water, Btu/lb °F

$T_{POINT\ OF\ USE}$ = Temperature of water at point of use (= 93°F for kitchen aerators; = 86°F for bathroom aerators; = 101°F for showerheads)[5]

$T_{ENTERING}$ = Temperature of water entering water heater (= 52.3°F)[2]

$RE_{ELECTRIC}$ = Recovery efficiency of electric water heater (= 98%)[3]

3,412 = Conversion from Btus to kWhs

RE_{GAS} = Recovery efficiency of natural gas water heater (= 76%)[3]

100,000 = Conversion from Btus to therms

$GPM_{EXISTING}$ = Baseline flow rate (= 2.2 GPM for kitchen and bathroom aerators; = 2.5 GPM for showerheads)[4]

GPM_{NEW} = Efficient flow rate (= 1.5, 1.0, or 0.5 GPM for kitchen and bathroom aerators; = 1.5 GPM for showerheads)

PH = Single-family persons per house (= 2.52)[1] / multifamily unit (=1.93)[1]

FH = Single-family fixtures per house (= 1.0 for kitchen aerator; = 2.13 for bathroom aerators; = 1.64 for showerheads)[1] / multifamily unit (= 1.0 for kitchen aerators; = 1.11 for bathroom aerators; = 1.0 for showerheads)[1]

FLU = Length of use in minutes per person per day (= 4.5 for kitchen aerators; = 1.6 for bathroom aerators)[5]

365 = Conversion from days to years

SPD = Showers per person per day (= 0.6)[5]

SLU = Shower length of use (= 7.8 minutes/shower)[5]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} * CF / (PH * LU * 365 \text{ days} / (60 \text{ mins/hr}) / FH)$

Where:

CF = Coincidence factor (= 0.0032 for kitchen aerators; = 0.0011 for bathroom aerators; = 0.0039 for showerheads)[6]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 10 years)[7]

Sources

1. DEER 2014 and GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts. Prepared for GasNetworks; Table B-2a, measure C-WH-15. Online here: http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx and http://ma-eeac.org/wordpress/wp-content/uploads/5_Natural-Gas-EE-Potenial-in-MA.pdf
2. U.S. Department of Energy. Domestic Hot Water Scheduler. Average water main temperature of all locations measured in Wisconsin by scheduler, weighted by city populations.
3. National Renewable Energy Laboratory. Building America Research Benchmark Definition. Pg. 12. 2009. Available online: http://www.nrel.gov/docs/fy10osti/47246.pdf.
4. Federal minimum at 80 psi.
5. Cadmus. Michigan Water Meter Study. 2012.
6. DeOreo, William B. The End Uses of Hot Water in Single Family Homes From Flow Trace Analysis. Figure 2, pg. 10. Available online: http://s3.amazonaws.com/zanran_storage/www.aquacraft.com/ContentPages/47768067.pdf The peak percentage values of 9% and 13% for showerheads and aerators, respectively, determined from the load shape in Figure 2 for the hours between 1:00 p.m. and 4:00 p.m.
7. Wisconsin PSC EUL Database. 2013. See Appendix C.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry
02	01/2015	Added measures/flow rates

DHW Temperature Turn Down, Direct Install, Electric and Natural Gas

	Measure Details
Measure Master ID	DHW Temperature Turn Down, Direct Install: NG, 2125, 2141 Electric, 2131, 2147
Measure Unit	Per turn down
Measure Type	Prescriptive
Measure Group	Domestic Hot Water
Measure Category	Controls
Sector(s)	Residential – single family; Residential- multi family
Annual Energy Savings (kWh)	743
Peak Demand Reduction (kW)	0.085
Annual Therm Savings (Therms)	68
Lifecycle Energy Savings (kWh)	11,145
Lifecycle Therm Savings (Therms)	748
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]

Measure Description

The measure is the Program Implementer or a subcontractor of the Program Implementer turning the water heater temperature down to 120°F. Assumptions are based on direct installation, not on a time-of-sale purchase.

There are two main effects of hot water storage temperature on energy use. The primary effect is due to standby loss, which increases with hot water temperature. The secondary effect is that hotter stored water affects hot water end-uses. This happens in two ways. For batch appliances, such as most clothes washers, more energy is used for hot and warm wash cycles because a fixed number of gallons is drawn for each load. For mixed end-uses (showers, sinks, bathtubs), when the stored water is hotter, less of it is mixed with cold water to achieve the target use temperature. Since the majority of hot water use is mixed temperature, a modest change in the hot water temperature (of 10°F to 20°F) has a relatively small impact on the energy required to heat the delivered hot water.

The reduction in standby loss also affects internal gains. For electric hot water, the reduction in internal gains from a turn-down results in slightly smaller cooling load; assuming that most water heaters in Wisconsin are in basements, and that basements have little or no direct air conditioning, this effect can be ignored. Heating effects are ignored for electric water heaters, assuming a predominance of natural gas heat; however, it should be accounted for at an appropriate efficiency in residence with a heat pump or electric resistance heat.

Description of Baseline Condition

The baseline is a hot water temperature set above 120°F.

Description of Efficient Condition

The efficient condition is for residential electric water heaters serving single residential units and multiple dwelling units to be set to 120°F.

Annual Energy-Savings Algorithm

Electric Measures

$$kWh_{SAVED} = [(HW_{BASE} + SB_{BASE}) - (HW_{EFF} + SB_{EFF})] * 365 * (1/3{,}412) * Units$$

$$HW = GPD * C_P * (T_{WH} - T_{ENTERING}) * 1/RE * [1 - UA * (T_{WH} - T_{ROOM}/Input)] * Units$$

$$SB = UA * 24 * (T_{WH} - T_{ROOM}) * Units$$

$$UA = [(1/EF)\text{-}(1/RE)]/[67.5 * ((24/Q_{OUT}) - (1/(RE * Input)))]$$

Where:

HW_{BASE} = Hot water baseline load (= 24,912 Btu/day)
SB_{BASE} = Standby baseline load (= 4,125 Btu/day)
HW_{EFF} = Hot water efficient load (= 24,111 Btu/day)
SB_{EFF} = Standby efficient load (= 3,536 Btu/day)
365 = Number of days per year
3,412 = Conversion from Btu to kWh
Units = Number of dwelling units served by water heater (= 1 single family, = 5 multifamily central unit)
GPD = Gallons of hot water use per day (= 38.1 for baseline measure; = 42.3 for efficient measure)
C_P = Heat capacity of water (= 8.33 Btu/gallon/°F)
T_{WH} = Temperature in tank (= 130°F for baseline measure; = 120°F for efficient measure)
$T_{ENTERING}$ = Cold water mains temperature (= 52.3°F)[2]
RE = Water heater recovery efficiency (=0.98)[3]
UA = Water heater equivalent heat loss factor (= 2.45 Btu/hr-°F)
T_{ROOM} = Ambient temperature surrounding tank (= 65°F)

Input = Firing rate (= 15,350 Btu/hr)

24 = Number of hours per day

EF = Energy factor (= 0.904)[4]

67.5 = Ambient Air Temperature

Q_{OUT} = Energy content of water drawn from water heater during 24 hour test (= 41,094 Btu/day)[4]

Therm Measures

$$Therm_{SAVED} = [(HW_{BASE} + SB_{BASE}) – (HW_{EFF} + SB_{EFF})] * 365 * 1/1,000 * Units$$

$$HW = GPD * C_P * (T_{WH} – T_{ENTERING}) * 1/RE * [1 – UA * (T_{WH} – T_{ROOM}/Input)] * Units$$

$$SB = UA * 24 * (T_{WH} – T_{ROOM}) * Units$$

$$UA = [(1/EF)-(1/RE)] / [67.5 * ((24/Q_{OUT}) – (1/ (RE * Input)))]$$

Where:

HW_{BASE} = Hot water baseline load (= 31,887 Btu/day)

SB_{BASE} = Standby baseload (= 17,752 Btu/day)

HW_{EFF} = Hot water efficient load (= 30,900 Btu/day)

SB_{EFF} = Standby efficient load (= 15,021 Btu/day)

RE = Water heater recovery efficiency (=0.76)[3]

UA = Water heater equivalent heat loss factor (= 11.38 Btu/hr-°F)

Input = Firing rate (= 40,000 Btu/hr)[4]

EF = Energy factor (= 0.575)[4]

Summer Coincident Peak Savings Algorithm

$$kW_{SAVED} = (kWh_{SAVED} / 8,760) * CF * Units$$

Where:

8,760 = Number of hours in one year

CF = Coincidence factor (= 1)

Lifecycle Energy-Savings Algorithm

$$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$$

$$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$$

Where:

EUL = Effective useful life (= 15 years)[1]

Assumptions

The gallons per day assumptions were as follows:

- Total hot water use at the tap = 51.5 GPD.[4] The hot water use is broken into two components: unmixed (primarily for clothes washers and dishwashers) and mixed (for showers and sinks). It is assumed that 10 GPD is unmixed and 41.5 GPD is mixed (unmixed is direct draw from the water heater, and does not vary with stored hot water temperature; mixed is delivered at the fixture at 105°F, so the total draw from the water heater varies with stored water temperature).
- The water heater draw is given as:
  - GPD_{BASE} = 10 + 41.5 * (105 - 52.3)/(130 - 52.3) = 38.1 GPD
  - GPD_{EFF} = 10 + 41.5 * (105 - 52.3)/(120 - 52.3) = 42.3 GPD
- As the set temperature goes down, the hot water consumption at the tank goes up. As the stored temperature is reduced, more hot and less cold must be mixed to reach the target of 105°F at the showerhead or sink.
- An average value of 2.36 people per home was used for Wisconsin, based on RECS 2009 data and calculated using the linear relationship from the 2012 Indiana TRM and the 2010 NY TRM of y = 16.286 x + 13, where x is the average number of people per home (2.36) and y is the average gallons of hot water used per day.
- For multifamily central DHW units, the BTU input size was changed from 40,000 to 200,000 based on field experience and a one-year project sample of DHW heater replacements for multifamily buildings from December 1, 2012 through December 1, 2013. The overall average size was 217,000 BTUs, with the most common size of 200,000 BTUs, which was used as a conservative estimate.
- Based on an individual water heater size of 40,000 BTUs, five dwelling units were used as the average units per water heater (200,000 / 40,000 = 5 units). This number of units was used as a multiplier for the single unit pre- and post- GPD numbers.

Sources

1. 2007 GDS study for New England working group: http://www.iar.unicamp.br/lab/luz/ld/Arquitetural/interiores/ilumina%E7%E3o%20industrial/measure_life_GDS.pdf .
2. U.S. Department of Energy. *DHW Scheduler*. Used average water main temperature of all Wisconsin locations, weighted by city population.

3. National Renewable Energy Laboratory. *Building America Research Benchmark Definition*. Pg. 12. 2009. Available online: http://www.nrel.gov/docs/fy10osti/47246.pdf.
4. Lawrence Berkley National Laboratory. *Water Heater Energy Consumption*. http://hes-documentation.lbl.gov/calculation-methodology/calculation-of-energy-consumption/water-heater-energy-consumption
5. U.S. Department of Energy. Federal standard for residential water heaters effective in 2004.

Revision History

Version Number	Date	Description of Change
01	01/01/2012	New measure
02	03/09/2013	Updated to new template and added lifecycle savings
03	04/22/2013	Revisions/comments
04	12/15/2013	Added multifamily sector and larger DHW heater savings

Insulation, Direct Install, Pipe, Electric

	Measure Details
Measure Master ID	Insulation, Direct Install, 6-Foot Pipe, Electric, 2128
Measure Unit	Per unit of pipe insulation
Measure Type	Prescriptive
Measure Group	Domestic Hot Water
Measure Category	Insulation
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	Depends on length of insulation
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Depends on length of insulation
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	2128= 15[1]
Incremental Cost	$3.96 per foot; $23.76 for all

Measure Description

This measure is the Program Implementer or a subcontractor of the Program Implementer insulating non-insulated water heater pipes for 6-feet or 3-feet.

Pipe insulation near the tank saves energy by reducing standby losses from pipes that are hot from conducting heat from the storage tank. This happens by convective currents within the pipe(s), or by eventually drawing and using hot water in the pipe.

In the following calculations, the reduction in electric hot water internal gains from pipe insulation is ignored, assuming that most water heaters in Wisconsin are in basements, and that basements have little or no direct air conditioning. For natural gas hot water, the regain from reduced pipe heat loss (for the duration of the heating season) is subtracted from the direct savings to arrive at the net natural gas savings.

Heating effects are ignored for electric water heaters, assuming a predominance of natural gas heat. For heat pump or electric resistance heat, the heating effects should account for an appropriate efficiency, as with natural gas heat.

Description of Baseline Condition

The baseline condition is no pipe insulation.

Description of Efficient Condition

The efficient condition is pipe insulation on a residential electric water heater.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = Btu_{SAVED} / 3{,}412$

$Btu_{SAVED} = ((1/R_{EXIST} – 1/R_{NEW}) * (L * C) * \Delta T * 8{,}760 / RE$

Where:

R_{EXIST} = Pipe heat loss coefficient of existing uninsulated pipe (= 1 Btu/hr-°F-ft)

R_{NEW} = Pipe heat loss coefficient of new insulated pipe (= 1/4 Btu/hr-°F-ft)

L = Length of pipe from water heating source covered by pipe wrap (= 6 feet or 3 feet)

C = Circumference of pipe (= inches of outer diameter * π * 0.083, or 0.229 feet)

ΔT = Average temperature difference from pipe to ambient air (= 60°F)

8,760 = Conversion for hours per year

RE = Water heater recovery efficiency (= 0.98)[2]

3,412 = Conversion factor from Btu to kWh

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[1]

Assumptions

Assumptions are based on a direct installation, not a time-of-sale purchase.

The average difference of 60°F assumes pipe and ambient air temperatures of 125°F and 65°F, respectively.

The pipe inner and outer diameters are assumed to be 3/4-inch and 7/8-inch, respectively.

Sources

1. 2007 GDS study for New England working group: http://www.iar.unicamp.br/lab/luz/ld/Arquitetural/interiores/ilumina%E7%E3o%20industrial/measure_life_GDS.pdf .

2. National Renewable Energy Laboratory. *Building America Research Benchmark Definition*. Pg. 12. 2009. Available online: http://www.nrel.gov/docs/fy10osti/47246.pdf.
3. DEER 2014 and GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts. Prepared for GasNetworks; Table B- 2a, measure C-WH-15. http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx and http://ma-eeac.org/wordpress/wp-content/uploads/5_Natural-Gas-EE-Potenial-in-MA.pdf

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Insulation, Direct Install, Pipe, NG

	Measure Details
Measure Master ID	Insulation Direct Install, 6-Foot Pipe, NG, 2122, 2138
Measure Unit	Per unit of pipe insulation
Measure Type	Prescriptive
Measure Group	Domestic Hot Water
Measure Category	Insulation
Sector(s)	Residential – single family; Residential- multi family
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	Depends on length of insulation
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	Depends on length of insulation
Water Savings (gal/yr)	0
Effective Useful Life (years)	2122 and 2138 = 12[1]
Incremental Cost	$3.96 per foot; $23.76 for all

Measure Description

This measure the Program Implementer or a subcontractor of the Program Implementer insulating non-insulated water heater pipes for 6-feet.

Pipe insulation near the tank saves energy by reducing standby losses from pipes that are hot from conducting heat from the storage tank. This happens by convective currents within the pipe(s), or by eventually drawing and using hot water in the pipe.

In the following calculations, the reduction in electric hot water internal gains from pipe insulation is ignored, assuming that most water heaters in Wisconsin are in basements, and that basements have little or no direct air conditioning. For natural gas hot water, the regain from reduced pipe heat loss (for the duration of the heating season) is subtracted from the direct savings to arrive at the net natural gas savings.

Heating effects are ignored for electric water heaters, assuming a predominance of natural gas heat. For heat pump or electric resistance heat, the heating effects should account for an appropriate efficiency, as with natural gas heat.

Description of Baseline Condition

The baseline condition is no pipe insulation.

Description of Efficient Condition

The efficient condition is pipe insulation on a residential natural gas water heater.

Annual Energy-Savings Algorithm

$\text{Therm}_{\text{SAVED}} = \text{Btu}_{\text{SAVED}} * (1 - \text{PCT}_{\text{HEAT}}) * \text{RE} / \text{HE} / 100{,}000$

$\text{Btu}_{\text{SAVED}} = ((1/\text{R}_{\text{EXIST}} - 1/\text{R}_{\text{NEW}}) * (\text{L} * \text{C}) * \Delta\text{T} * 8{,}760 / \text{RE}$

Where:

R_{EXIST} = Pipe heat loss coefficient of existing uninsulated pipe (= 1 Btu/hr-°F-ft)

R_{NEW} = Pipe heat loss coefficient of new insulated pipe (= 1/4 Btu/hr-°F-ft)

L = Length of pipe from water heating source covered by pipe wrap (= 6 feet or 3 feet)

C = Circumference of pipe (= inches of outer diameter * π * 0.083, or 0.229 feet)

ΔT = Average temperature difference from pipe to ambient air (= 60°F)

8,760 = Conversion for hours per year

RE = Water heater recovery efficiency (= 0.76)[2]

PCT_{HEAT} = Portion of year the house / unit that is mechanically heated (= 0.54)

HE = Natural gas system heating efficiency (= 0.8)

100,000 = Btu to therm conversion

Lifecycle Energy-Savings Algorithm

$\text{Therm}_{\text{LIFECYCLE}} = \text{Therm}_{\text{SAVED}} * \text{EUL}$

Where:

EUL = Effective useful life (2122 and 2138 = 12)[1]

Assumptions

Assumptions are based on a direct installation, not a time-of-sale purchase.

The average difference of 60°F assumes pipe and ambient air temperatures of 125°F and 65°F, respectively.

The pipe inner and outer diameters are assumed to be 3/4-inch and 7/8-inch, respectively.

Sources

1. California Energy Commission and California Public Utilities Commission. Database for Energy Efficient Resources (DEER) 2008. http://www.energy.ca.gov/deer/ .
2. National Renewable Energy Laboratory. *Building America Research Benchmark Definition*. Pg. 12. 2009. Available online: http://www.nrel.gov/docs/fy10osti/47246.pdf.
3. DEER 2014 and GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts. Prepared for GasNetworks; Table B- 2a, measure C-WH-15. http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx and http://ma-eeac.org/wordpress/wp-content/uploads/5_Natural-Gas-EE-Potenial-in-MA.pdf

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Retail Store Markdown, Low-Flow Showerheads

	Measure Details
Measure Master ID	Showerheads, Retail Store Markdown, 3017
Measure Unit	Per showerhead
Measure Type	Prescriptive
Measure Group	Domestic Hot Water
Measure Category	Showerhead
Sector(s)	Residential- multifamily, Residential- single family
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	Varies by sector
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	Varies by sector
Water Savings (gal/yr)	2,632
Effective Useful Life (years)	10[1]
Incremental Cost	$5.00

Measure Description

This measure is installing a showerhead with a flow rate of 1.75 GPM or less in a residential location, based on a time-of-sale purchase.

The energy and therm savings were adjusted based on the saturation of fuel types for water heating in Wisconsin (30% electric and 61% natural gas). Therefore, the savings values do not reflect the actual energy or natural gas savings on a per-unit basis.

Description of Baseline Condition

The baseline equipment is a showerhead with flow rate of 2.5 GPM.

Description of Efficient Condition

The efficient equipment is low-flow showerhead (≤ 1.75 GPM) installed in a residential location. The GPM used for the efficient showerhead in the calculations is a weighted average from sales data as of October 2013.

Annual Energy-Savings Algorithm

Water Savings:

$\text{Gallon}_{\text{SAVED}} = (\text{GPM}_{\text{BASE}} - \text{GPM}_{\text{EE}}) * ((\text{PH} * \text{SPD})/\text{FH}) * \text{SLU} * 365$

Electric Water Heaters:

$\text{kWh}_{\text{SAVED}} = (((\text{Gallon}_{\text{SAVED}} * 8.33 * 1 * (\text{T}_{\text{POINT OF USE}} - \text{T}_{\text{ENTERING}}))/\text{RE})/3{,}412) * \text{WHS}$

Natural Gas Water Heaters:

$\text{Therm}_{\text{SAVED}} = (((\text{Gallon}_{\text{SAVED}} * 8.33 * 1 * (\text{T}_{\text{POINT OF USE}} - \text{T}_{\text{ENTERING}}))/\text{RE})/100{,}000) * \text{WHS}$

Where:

GPM_{BASE} = Baseline flow rate (= 2.5 GPM)[2]

GPM_{EE} = Efficient flow rate (= 1.54 GPM)

PH = Single-family persons per house (= 2.52)[7] / multifamily unit (=1.93)[7]

SPD = Showers per person per day (= 0.6)[4]

365 = Number of days per year

8.33 = Density of water, lbs/gallon

1 = Specific heat of water, Btu/lb °F

$\text{T}_{\text{POINT OF USE}}$ = Temperature of water at point of use (= 101°F)[4]

$\text{T}_{\text{ENTERING}}$ = Temperature of water entering water heater (= 52.3°F)[5]

RE = Average estimated recovery efficiency of electric water heater (= 98%)[6]

3,412 = Conversion from Btu to kWh

WHS = Water heater saturation (= 30% for electric;= 61% for natural gas)[3]

FH = Fixtures/house (= 1.47)[3]SLU = Shower length in minutes (= 7.8)[4]

100,000 = Conversion from Btu to therms

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} * CF / (PH * SLU * 365 * SPD) / 60 / FH)$

Where:

CF = Coincidence factor (= 0.0039%)[7]
SLU = Shower length in minutes (= 7.8)[4]
60 = Number of minutes per hour
FH = Fixtures/house (= 1.47)[3]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 10 years)[1]

Sources

1. Based on the effective useful life of 10 years, in California Joint Utility Low Income Energy Efficiency Program Costs and Bill Savings Standardization Report Final Report February 1, 2001 (Revised as of March 5, 2001). The effective useful life (EUL) is defined as the median number of years that a measure is in place and operable. See also Measure Life Report Residential and Commercial/Industrial Lighting and HVAC Measures, prepared for The New England State Program Working Group (SPWG) for use as an Energy Efficiency Measures/Programs Reference Document for the ISO Forward Capacity Market (FCM) by GDS Associates, Inc., June 2007 Federal minimum at 80 psi. Available online here: http://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/766a83dce56eca35852576da006d79a7/$FILE/60_DAy_Gas_TecMarket_Energy_Savings_Manual_Final_1-0.pdf and http://www.calmac.org/%5C/publications/Bill_Savings_Final_Report_revised_3-12-01.pdf and http://www.iar.unicamp.br/lab/luz/ld/Arquitetural/interiores/ilumina%E7%E3o%20industrial/measure_life_GDS.pdf
2. Residential Energy Consumption Survey. 2009 RECS Micro Survey Data. Structural and Geographic Characteristics, Wisconsin.
3. Cadmus. Michigan Water Meter Study. 2012.
4. U.S. Department of Energy. *DHW Scheduler*. Average water main temperature of all locations measured in Wisconsin by scheduler, weighted by city populations.

5. National Renewable Energy Laboratory. *Building America Research Benchmark Definition*. Pg. 12. 2009. Available online: http://www.nrel.gov/docs/fy10osti/47246.pdf.
6. Calculated assuming 9% of showers take place during peak hours (9% * 7.8 minutes per day / 180 minutes in peak period) = 0.0039.
7. DEER 2014 and GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts. Prepared for GasNetworks; Table B-2a, measure C-WH-15. Found online here: http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx and http://ma-eeac.org/wordpress/wp-content/uploads/5_Natural-Gas-EE-Potenial-in-MA.pdf

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Domestic Hot Water Plant Replacement

	Measure Details
Measure Master ID	DHW Plant Replacement, 2760
Measure Unit	Per plant (or per apartment)
Measure Type	Hybrid
Measure Group	Domestic Hot Water
Measure Category	Other
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	324 (reference savings)
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	3,564
Water Savings (gal/yr)	0
Effective Useful Life	15[1]
Incremental Cost	$27.07 per MBH

Measure Description

This measure is upgrading an entire DHW plant in a building with central DHW.

Commercial water heaters with greater than 75,000 Btu/hour have a TE rating, which typically varies from around 80% for standard efficiency natural gas water heaters to 90% or greater for condensing water heaters.

Description of Baseline Condition

The baseline condition is a DHW plant with TE of 80%.

Description of Efficient Condition

The efficient condition is installing new water heater, which must be:

- A commercially sized HESCCM,
- An HESCC stand-alone water heater, or
- An indirect storage tank off a HESCCM boiler(s).

The new commercial water heaters must have a TE of 90% or greater. Fuel switching is not included in this measure. The additional requirements are:

- Building must have a central DHW system.
- Entire DHW system must be replaced: single water heater replacement in a multiple water heater system do not qualify.

Annual Energy-Savings Algorithm

The Building America Multi-Family Central Water Heating Evaluation Tool[2] was used to determine the deemed savings for this measure. With the exception of the inputs listed below, the tool's default values were used to calculate savings:

$$Therm_{SAVED} = Therm_{BASE} - Therm_{EE}$$

$$Therm_{BASE} = [(GPD * N_{APTS} * 8.33 * C_P * \Delta T * 365)/(\eta_{BASE} * 100{,}000)] + [(Q_{LOSS\text{-}BASE} * N_{WH} * 24 * 365)/(100{,}000)]$$

$$Therm_{EE} = [(GPD * N_{APTS} * 8.33 * C_P * \Delta T * 365)/(\eta_{EE} * 100{,}000)] + [(Q_{LOSS\text{-}EE} * N_{WH} * 24 * 365)/(100{,}000)]$$

Where:

GPD = Gallons per day (= 43.9)[3]

N_{APTS} = Total number of dwelling units served by system (= 11.5)[4]

8.33 = Conversion from gallons to mass

C_P = Specific heat constant pressure (= 1.0 Btu/lb-°F)

ΔT = Hot water setpoint of 125°F minus inlet water temperature of 52.3°F (= 72.7°F)[5]

365 = Number of days per year

η_{BASE} = Baseline TE (= 80%)

100,000 = Conversion from Btu to therm

$Q_{LOSS\text{-}BASE}$ = Baseline standby heat loss (= 1,233 Btu/hour)[6]

N_{WH} = Total number of DWH tanks (= 1)

24 = Number of hours per day

η_{EE} = Efficient TE (=90%)

$Q_{LOSS\text{-}EE}$ = Efficient standby heat loss (=929 Btu/hour)[7]

Lifecycle Energy-Savings Algorithm

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[1]

Assumptions

The water usage and recirculation loop condition parameters of the Building America Evaluation Tool were set to “medium” and “normal,” respectively, to represent typical applications and reflect the prescriptive nature of the measure. The total heating capacity and standby losses were scaled from the default value of 600,000 Btuh and 15,000 Btuh to 230,000 Btuh and 5,750 Btuh, respectively, to reflect the change in number of apartment units from the default of 30 to 11.5.

Sources

1. Engineering Judgement
2. National Renewable Energy Laboratory. *Strategy Guideline: Proper Water Heater Selection*. August 2012. Available online: http://www.nrel.gov/docs/fy12osti/55074.pdf. Evaluation tool described in report is online: http://apps1.eere.energy.gov/buildings/publications/docs/building_america/multifamily_central_dhw_evaluationtool_v1-0.xls
3. The gallons per day is calculated by using the linear relationship of y = 16.286x + 13, where x is the average number of people per home and y is the average gallons of hot water used per day. An average value of 1.9 people per home was used for Wisconsin, based on RECS 2009 data. The linear relationship is used in the 2012 Indiana TRM and the 2010 NY TRM.
4. The Wisconsin multifamily number of units per apartment was estimated at 11.5 units based on: 2009 U.S. Census, table 989. Housing Units by Units in Structure and State. Available online: https://www.census.gov/compendia/statab/cats/construction_housing/housing_units_and_characteristics.html.
5. United States Department of Energy. *DHW Scheduler.* Average water main temperature of all locations measured in Wisconsin by scheduler, weighted by city populations. The water heater set point is assumed to be 125°F. Wisconsin building code 704.06 requires landlords to set water heaters to 125°F: https://docs.legis.wisconsin.gov/statutes/statutes/704/06. Water heater setpoints typically range between 120°F and 140°F, because temperatures below 120°F are susceptible to Legionella bacteria (which lead to Legionnaires Disease) and heaters set to temperatures above 140°F can quickly scald users: http://www.nrel.gov/docs/fy12osti/55074.pdf. Most TRMs assume water heater

setpoints of 120°F, 125°F, or 130°F, though most of these are unsourced engineering assumptions.

6. Federal standard for natural gas storage water heater with 80 gallon storage and 199 kBtu/hour heat input.
7. Average standby loss of AHRI certified natural gas storage water heaters with TE > 94%, storage volume between 80 and 100 gallons, and heat input less than 200 kBtu/hour.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Condensing Water Heater, NG, 90%+

	Measure Details
Measure Master ID	Condensing Water Heater, NG, 90%+, 1986 Condensing Water Heater, NG, 90%+, Claim Only, 3584
Measure Unit	Per water heater
Measure Type	Prescriptive
Measure Group	Domestic Hot Water
Measure Category	Water Heater
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	-50
Peak Demand Reduction (kW)	-0.0050
Annual Therm Savings (Therms)	46
Lifecycle Energy Savings (kWh)	-600
Lifecycle Therm Savings (Therms)	552
Water Savings (gal/yr)	0
Effective Useful Life (years)	15
Incremental Cost	$1,120.00

Measure Description

This measure is installing high-efficiency, commercial-sized, condensing tank-type water heaters. These heaters are used for whole-house domestic water heating in the residential sector. Commercial-sized water heaters have a minimum input rating of 75,000 Btuh and have a TE rating of 80%. While these appliances have a commercial rating, they are often installed in residential homes.

The rebate is for customers who install condensing water heaters with a TE rating of at least 90% in a residential home.

Description of Baseline Condition

Savings are calculated using the federal code standard minimum of 0.600 if purchased after January 1, 2016. This updated baseline reflects the new federal standard that took effect April 2015, with the criteria date rounded to January 1, 2016.2 The calculation assumes a 50 gallon tank.

Description of Efficient Condition

The efficient condition is upgrading from the code-standard minimum natural gas storage residential water heater to a higher efficiency 90% TE commercial natural gas storage-type water heater. Natural gas storage water heaters are used to supply DHW.

Annual Energy-Savings Algorithm

Because the efficiency of traditional natural gas storage water heaters is measured using an EF and the efficiency of condensing water heaters is measured using the TE, different algorithms are used to calculate the baseline energy use and efficient energy use.

$\text{Therm}_{\text{SAVED}} = \text{Therm}_{\text{BASELINE}} - \text{Therm}_{\text{MEASURE}}$

$\text{Therm}_{\text{BASELINE}} = [\dot{M} * C_P * (T_{\text{TANK}} – T_{\text{INLET}})/\text{EF}] * (365/100{,}000)$

Where:

$\dot{M}$ = Mass of water drawn (= 429 lbs/day)

c_P = Specific heat of water (= 1 Btu/lb-°F)

T_{TANK} = Water heater thermostat set point temperature (= 125°F)[3]

T_{INLET} = Inlet water temperature (= 52.3°F)[4]

EF = Energy factor (= 0.600 after January 1, 2016)

365 = Number of days per year

100,000 = Conversion factor from Btu to therms

The following shows this equation solved for the post January 1, 2016 scenario:

ThermBASELINE = [(429 lbs/day * 1 Btu/lb°F * (125°F – 52.3°F))/0.600] * (365 / 100,000)

Mass flow was calculated as the product of the density of water and the gallons of water used per day: 8.33 lbs/gal * 51.5 GPD = 429 lbs/day. The gallons per day was calculated using the linear relationship of y = 16.286 x + 13, where x is the average number of people per home and y is the average gallons of hot water used per day. The linear relationship is used in the 2012 Indiana TRM and the 2010 NY TRM. An average value of 2.365 people per home was used for Wisconsin, based on RECS 2009 data.

Measure Case Energy Usage

While residential storage water heater efficiency is measured in EF, which includes standby losses, commercial-sized storage water heater efficiency is measured in TE. While the efficiency equation for TE is similar to EF, it only measures the amount of energy used to heat the water consumed, and not the amount of energy needed for standby losses. The total energy usage a water heater consumes can be defined as:

ThermMEASURE = QUSAGE + QSTANDBY

QUSAGE = [$\dot{M}$ * CP * (TTANK – TINLET)]/TE

QSTANDBY = UA * (TTANK – TAMB) * [24 – ((QUSAGE/(RE*PON))] (source 5)

The amount of energy used to heat the water consumed is solved for below:

QUSAGE = [(429 lbs/day * 1 Btu/lb°F * (125°F – 52.3°F))/0.90] * (365 / 100,000)

Where:

TE = Thermal efficiency of measure (= 0.90)
UA = Standby heat loss coefficient (= 3.319 Btu/hr- °F)
T_{AMB} = Ambient temperature (= 65°F)
24 = Number of hours per day
RE = Recovery efficiency (= 0.90, assume TE as a proxy)[6]
P_{ON} = Rated input power (= 76,000 Btu/hour, conservative)

The standby loses are solved for below:

QSTANDBY = 3.319 Btu/hr-°F * (125°F - 65°F) * [24 – ((133 therms /(0.90 * 76,000 Btu/hr) * (365 /100,000)]

Combining these equations, the total energy usage a water heater consumes is solved for below:

ThermMEASURE = 126 therms/year + 17 therms/year = 144 therms/year

The measure savings is the difference in energy used by the baseline case and the efficient case:

ThermSAVED = 198 therms – 144 therms = 54 therms/year

Electrical Energy Savings

The condensing water heaters must be power vented to qualify for a program incentive. Power-vented equipment include an electrical fan to exhaust flue gases, which therefore has a negative electrical impact. As shown in the RFP TRC calculator, the estimated electrical impact of power-vented equipment is 50 kWh and 0.005 kW per year.

Summer Coincident Peak Savings Algorithm

The estimated electrical peak impact of power-vented equipment is 0.0050 kW for single family.

Lifecycle Energy-Savings Algorithm

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (=Singlefamily 15; Multifamily 12)[1]

Assumptions

The electric values (kWh and kW) were reviewed from the supplied RFP calculator, which align with expected savings.

Sources

1. *Single family*: CALMAC 2000 workshop report. Available online here: http://www.cpuc.ca.gov/NR/rdonlyres/7E3A4773-6D35-4D21-A7A2-9895C1E04A01/0/EEPolicyManualV5forPDF.pdf. *Multifamily*: Fannie Mae Estimated Useful Life Table: https://www.fanniemae.com/content/guide_form/4099f.pdf and PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf

2. The water heater setpoint is assumed to be 125°F, as Wisconsin building code 704.06 requires landlords to set water heaters to 125°F: https://docs.legis.wisconsin.gov/statutes/statutes/704/06. Water heater setpoints typically range between 120°F and 140°F because temperatures below 120°F are susceptible to Legionella bacteria (which lead to Legionnaires Disease) and heaters set to temperatures above 140°F can quickly scald users: http://www.nrel.gov/docs/fy12osti/55074.pdf. Additionally, a review of TRMs from geographically similar regions (including Connecticut 2012, Mid-Atlantic v3.0, Illinois v2.0, and Indiana v1.0) found assumed hot water setpoints between 120°F and 130°F.
3. U.S. Department of Energy. *DHW Scheduler*. (The average water main temperature is for all locations measured in Wisconsin, weighted by city population.)
4. U.S. Department of Energy, Energy Efficiency and Renewable Energy. *Residential Water Heater Technical Support Document for the January 17, 2001, Final Rule.* Appendix D-2: Water Heater Analysis Model. Last updated October 17, 2013. Available online: http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/water_heater_fr.pdf.
5. Pacific Gas and Electric Company. *Applied Technology Services Performance Testing and Analysis Unit ATS Report #: 491-08.5, PY2008 Emerging Technologies Program.* Pg. 8. 2008. Available online: http://www.etcc-ca.com/sites/default/files/OLD/images/stories/reswhtestreport1.pdf.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Water Heater, ≥ 0.82 EF, Tankless, Residential, Natural Gas

	Measure Details
Measure Master ID	Water Heater, ≥ 0.82 EF, Tankless, Residential, NG, 2652 Water Heater, ≥ 0.82 EF, Tankless, Residential, NG, Claim Only, 3588
Measure Unit	Per water heater
Measure Type	Prescriptive
Measure Group	Domestic Hot Water
Measure Category	Water Heater
Sector(s)	Residential- multi family; Residential – single family
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	44
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	572
Water Savings (gal/yr)	0
Effective Useful Life (years)	13 [1]
Incremental Cost	$605.00

Measure Description

This measure is installing an ENERGY STAR-qualified, small tankless water heater with an EF of 0.82 or greater and an input rating less than or equal to 75,000 Btu/hour. In addition, qualifying tankless water heaters must be whole-house units used for domestic water heating, and must be natural gas fueled.

Residential tankless water heaters are defined as equipment having a nominal input between 50,000 and 200,000 Btu/hour and a rated storage volume of 2 gallons or less.

Description of Baseline Condition

New federal efficiency standards that take effect in April 2015 raise the minimum EF for baseline units from 0.575 to 0.600. The criteria date was rounded to January 1, 2016 since the code takes affect mid-year 2015.

Description of Efficient Condition

Qualifying tankless water heaters must meet the qualifications listed in the table below.

Qualification Requirements for Tankless Water Heaters

Sector	Input Rating	EF
Multifamily	≤ 75,000 Btu/hour	≥ 0.82
Single Family	≥ 50,000 Btu/hour ≤ 200,000 Btu/hour	≥ 0.82

Annual Energy-Savings Algorithm

$\text{Therm}_{\text{SAVED}} = (T_{\text{WH}} - T_{\text{ENTERING}}) * \text{GPD} * 8.33 * 1 * 365 * [(1/\text{EF}_{\text{BASE}}) - (1/\text{EF}_{\text{EFF}})] * (1/100{,}000)$

Where:

T_{WH} = Water heater temperature set point (= 125°F)[2]

T_{ENTERING} = Temperature of water entering water heater (= 52.3°F)[3]

GPD = Gallons of hot water used by the home per day (= 44.4 for multifamily; = 51.5 for single family)[4]

8.33 = Density of water, lbs/gal

1 = Specific heat of water, Btu/lb-°F

365 = Days per year

EF_{BASE} = Baseline energy factor (= 0.575 for units sold before January 1, 2016; = 0.600 for units sold after January 1, 2016)[5]

EF_{EFF} = Efficiency energy factor (= 0.820)

100,000 = Conversion from Btu to therms

Lifecycle Energy-Savings Algorithm

$\text{Therm}_{\text{LIFECYCLE}} = \text{Therm}_{\text{SAVED}} * \text{EUL}$

Where:

EUL = Effective useful life (= 13 years)[1]

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf

2. The water heater setpoint is assumed to be 125°F, as Wisconsin building code 704.06 requires landlords to set water heaters to 125°F: https://docs.legis.wisconsin.gov/statutes/statutes/704/06. Water heater setpoints typically range between 120°F and 140°F because temperatures below 120°F are susceptible to Legionella bacteria (which lead to Legionnaires Disease) and heaters set to temperatures above 140°F can quickly scald users: http://www.nrel.gov/docs/fy12osti/55074.pdf. Most TRMs assume water heater set points of 120°F, 125°F, or 130°F, though most of these are unsourced engineering assumptions. (Residential water heater setpoint resources include: Connecticut 2012 TRM PSD: 130°F for natural gas DWH and 125°F for tank wrap, HPWH, and temperature reduction; Mid-Atlantic TRM v3.0: 130°F for tank wrap and pipe insulation; Illinois TRM v2.0: 125°F for pipe insulation, natural gas water heater, HPWH, and tank wrap and 120°F for temperature reduction; and Indiana TRM v1.0: 130°F for pipe insulation.)
3. United States Department of Energy. *DHW Scheduler*. (Average water main temperature for all Wisconsin locations as measured by scheduler and weighted by city population).
4. The gallons per day was calculated by using the linear relationship of y = 16.286 x + 13, where x is the average number of people per home and y is the average gallons of hot water used per day. An average value of 1.93 people per home was used for Wisconsin multifamily and 2.36 for single family, based on RECS 2009 data. The linear relationship is used in the 2012 Indiana TRM and the 2010 NY TRM.
5. Calculated as 0.67 - 0.0019 * 50 = 0.575, per the 2001 federal standard that took effect in 2004. The new federal standard baseline was adopted in 2010 and took effect in April 2015; this was calculated as 0.675 - 0.0015 * 50 = 0.600. Both calculations assume a 50 gallon tank.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Water Heater, Indirect

	Measure Details
Measure Master ID	Water Heater: Indirect, 95% or greater, 1988 Electric, EF ≥ 0.93, 1989 Indirect, Claim Only, 3585 Electric, EF ≥ 0.93, Claim Only, 3586
Measure Unit	Per water heater
Measure Type	Prescriptive
Measure Group	Domestic Hot Water
Measure Category	Water Heater
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	0
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	93
Lifecycle Energy Savings (kWh)	0
Lifecycle Therm Savings (Therms)	1,395
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost	$204.88[2]
Important Comments	

Measure Description

Indirect water heaters are applicable to any indirectly fueled water heater, and must be paired with a high-efficiency boiler. In addition, qualifying indirect water heaters must be whole-house units or used for domestic water heating.

Unlike other water heaters, indirect water heaters use a boiler as the heat source. The water heater may also have a direct energy source for non-heating seasons when the boiler is shut off and thus not able to meet the water heating demands.[3]

Description of Baseline Condition

The base case is a residential, gas-fueled, storage water heater with an EF of 0.575.[4] New federal efficiency standards that took effect in April 2015 raised the minimum EF for baseline units from 0.575 to 0.600. The criteria date was rounded to January 1, 2016 since the code takes affect mid-year 2015.

Description of Efficient Condition

Indirect water heaters must be connected to a boiler with an AFUE of 95% or greater.

Annual Energy-Savings Algorithm

$$Therms_{SAVED} = ((GPD * 365 * 8.33 * 1 * \Delta T_{w})/100{,}000) * ((1/RE_{BASE}) - (1/E_{C,EE})) + ((UA_{BASE} / RE_{BASE}) - (UA_{EE} / E_{C,EE})) * (\Delta T_{s} * 8{,}760)/100{,}000$$

Where:

GPD = Average daily hot water consumption (= 51.5 gallons per day)[5]

365 = Days per year

8.33 = Density of water (lb/gallon)

1 = Specific heat of water (Btu/lb °F)

ΔT_{w} = Average difference between the cold water inlet temperatures (52.3°F) and the hot water delivery temperature (125°F) (= 72.7°F)[6]

100,000 = Conversion factor (Btu/therm)

RE_{BASE} = Recovery efficiency of the baseline tank type water heater (= 76%)[6]

$E_{C,EE}$ = Combustion efficiency of energy-efficient boiler used to heat indirect water heater (= 95%)[7]

UA_{BASE} = Overall heat loss coefficient of base tank type water heater (= 14.0 Btu/hr-°F)[8]

UA_{EE} = Overall heat loss coefficient of indirect water heater storage tank (= 6.1 Btu/hr-°F; see table below)[9]

Typical Values for UA_{EE}

Volume (gal)	H (bare tank) inches	Diameter (bare tank) inches	Insulation	UA (Btu/hr-°F)
40	44	17	1 in foam	4.1
			2 in foam	2.1
80	44	24	1 in foam	6.1
			2 in foam	3.1
120	65	24	1 in foam	8.4
			2 in foam	5.4

ΔT_{S} = Temperature difference between the stored hot water temperature (125°F) and the ambient indoor temperature (65°F) (= 60°F)

8,760 = Conversion factor (hours/year)

Summer Coincident Peak Savings Algorithm

Indirect water heaters consume no electrical energy; therefore, they have no impact on demand savings.

Lifecycle Energy-Savings Algorithm

$\text{Therms}_{\text{LIFECYCLE}} = \text{Therms}_{\text{SAVED}} * \text{EUL}$

Where:

EUL = Effective useful life (15 years)[1]

Assumptions

Because the efficiency of residential water heater is measured in EF, the true EF and UA_{BASE} is not available. A thermal efficiency of 76% and a UA_{BASE} of 14 is assumed.

The average difference of 60°F assumes pipe and ambient air temperatures of 125°F and 65°F, respectively.

Sources

1. 2009 GDS Residential Study,MA Natural Gas Potential http://ma-eeac.org/wordpress/wp-content/uploads/5_Natural-Gas-EE-Potenial-in-MA.pdf .
2. Focus on Energy. Request for Proposals. Issued for Mass Markets Portfolio Residential Energy Efficiency Program Implementation. July 26, 2011.
3. Public Service Commission of Wisconsin. Focus on Energy Evaluation, Residential Programs: CY09 Deemed Savings Review. March 26, 2010.
4. U.S. Department of Energy. Federal standard for residential water heaters effective in 2004.
5. Calculated by using the linear relationship of y=16.286x + 13, where x is the average number of people per home and y is the average gallons of hot water used per day. An average value of 2.361 people/home was used for Wisconsin, based on RECS 2009 data. The linear relationship is used in the 2012 Indiana TRM and the 2010 NY TRM.
6. Air-Conditioning, Heating, and Refrigeration Institute. "RWH Search." Most common RE for non-heat pump water heaters. http://www.ahridirectory.org/ahridirectory/pages/rwh/defaultSearch.aspx
7. Assumed the combustion efficiency is a proxy for AFUE, where the program minimum is 95% AFUE.
8. United States Department of Energy. Technical Support Document: Energy Efficiency Standards for Consumer Products, Residential Water Heaters, Including Regulatory Impact Analysis. 2000.

9. New York Technical Reference Manual. Indirect Water Heaters, pg. 87. 2010.

Revision History

Version Number	Date	Description of Change
01	01/01/2012	New measure
02	10/30/2014	Updated therms based off 72.7°F temperature

HVAC

Smart Thermostat

	Measure Details
Measure Master ID	Smart Thermostat: Existing NG Boiler, 3609 Existing NG Furnace, 3610 Existing Air Source Heat Pump, 3611
Measure Unit	Per thermostat
Measure Type	Prescriptive
Measure Group	HVAC
Measure Category	Controls
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	Varies by existing heating system
Peak Demand Reduction (kW)	Varies by existing heating system
Annual Therm Savings (Therms)	Varies by existing heating system
Lifecycle Energy Savings (kWh)	Varies by existing heating system
Lifecycle Therm Savings (Therms)	Varies by existing heating system
Water Savings (gal/yr)	0
Effective Useful Life (years)	10[1]
Measure Incremental Cost ($/unit)	$250.00

Measure Description

Users can set standard programmable thermostats to adjust temperature setpoints at different times of the day, changing temperatures during unoccupied periods to allow for energy savings. The user can also communicate remotely with a smart thermostat through Wi-Fi, which allows for remote programming and can detect when the house is unoccupied through sensors or an application that tracks the homeowner’s location through their phone. This occupancy sensor capacity allows the thermostat to reduce energy use without requiring active programming or regular attention from the user, thus optimizing thermostat-based energy savings independent of user interaction. Some smart thermostats can also optimize efficiency through auto-adjustments based on outdoor temperature and humidity, and “learning” standard occupancy behaviors and temperature preferences (eliminating the need for programming).

Description of Baseline Condition

The baseline condition is a manual or standard programmable thermostat installed in a home with an existing natural gas furnace, natural gas boiler, or air-source heat pump.

See the Assumptions section for detail on weighted averages applied to savings to account for the combination of manual and programmable thermostats in the baseline Wisconsin population.

Description of Efficient Condition

The efficient condition is a smart thermostat installed in a home to replace the existing thermostat. To qualify as a “smart,” the thermostat must be Wi-Fi capable (with the Wi-Fi connection established by the customer), and have occupancy-sensing capability, such as motion sensors and/or geofencing.

Annual Energy-Savings Algorithm

The savings algorithms associated with this measure involve calculating the heating and cooling energy use, then applying a percentage savings achieved by installing a smart thermostat.[2]

$$Therm_{SAVED} = HOURS_{HEATING} * CAP / AFUE / 100 * ESF_{HEATING}$$

$$kWh_{SAVED\ HEATING} = EFLH_{HEATING} * CAP / HSPF / 3.412 * ESF_{HEATING}$$

$$kWh_{SAVED\ COOLING} = (1/SEER) * EFLH_{COOLING} * MBtuH * AC\% * ESF_{COOLING}$$

Where:

$HOURS_{HEATING}$ = Annual home heating hours (= 1,158 hours for natural gas furnace and furnace/AC;[5] = 1,000 hours for boiler)[6]

CAP = Heating system capacity (= 72 MBtuH for furnace;[3] = 110 MBtuH for boiler;[4] = 37.2 MBtuH for ASHP)

AFUE = AFUE of system (= 90% for natural gas furnace; = 80% for boiler)

100 = Conversion

$ESF_{HEATING}$ = Heating energy savings fraction (= 9.9% for furnace and boiler;[8] = 12.0% for ASHP)[9]

$EFLH_{HEATING}$ = Effective full-load heating hours (= 1,890)[7]

HSPF = Heating seasonal performance factor (= 7.1)

3.412 = Btu to Watt

SEER = Seasonal energy efficiency rating (= 12)

$EFLH_{COOLING}$ = Effective full-load cooling hours (= 410 for natural gas furnace;[6] = 321 for ASHP)

MBtuH = Cooling system capacity (=29.1 MBtuH)[10]

AC% = Air conditioner efficiency % (= 92.5% for natural gas furnace;[5] = 100% for ASHP; = 0% for boiler)

$ESF_{COOLING}$ = Cooling energy savings fraction (= 8.3%)[8]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} / EFLH_{COOLING} * CF$

Where:

CF = Coincidence factor (=68%)[5]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 10 years)[1]

Deemed Savings

Annual and Lifecycle Electric Savings by Measure

Type of Savings (kWh)	Measure (with existing heating equipment)		
	Smart Thermostat Installed in Home Heated by Natural Gas Boiler, MMID 3609	Smart Thermostat Installed in Home Heated by Natural Gas Furnace, MMID 3610	Smart Thermostat Installed in Home Heated by Air Source Heat Pump, MMID 3611
Annual	0	76.33	430.87
Lifecycle	0	763.3	4,308.7

Annual and Lifecycle Natural Gas Savings by Measure

Type of Savings (kWh)	Measure (with existing heating equipment)		
	Smart Thermostat Installed in Home Heated by Natural Gas Boiler, MMID 3609	Smart Thermostat Installed in Home Heated by Natural Gas Furnace, MMID 3610	Smart Thermostat Installed in Home Heated by Air Source Heat Pump, MMID 3611
Annual	136.13	91.71	0
Lifecycle	1,361.3	917.1	0

Annual Summer Coincident Peak Savings by Measure

Type of Savings (kWh)	Measure (with existing heating equipment)		
	Smart Thermostat Installed in Home Heated by Natural Gas Boiler, MMID 3609	Smart Thermostat Installed in Home Heated by Natural Gas Furnace, MMID 3610	Smart Thermostat Installed in Home Heated by Air Source Heat Pump, MMID 3611
Annual	0	0.127	0.175

Assumptions

Measure cost and savings assume a tech-based upgrade as opposed to end-of-life replacement, so the baseline condition would have continued with existing equipment.

The GDS Associates document cited for EUL is also used by the Illinois TRM for programmable thermostats.

The $250 incremental measure cost was based on typical online and retail stores prices for Nest, Ecobee3, and Honeywell Lyric thermostats.

As a proxy for the Wisconsin service territory, the percentages of Indiana homes with a manual thermostat and a programmable thermostat identified in a Cadmus study[8] was used.

Percentages of Indiana Homes with Manual Versus Programmable Thermostat

Type of Thermostat	Percentage of Population	
	Heating	Cooling
Manual	48.5%	47.1%
Programmable	51.5%	52.9%

This savings for a programmable thermostat baseline was estimated by averaging the savings found by the Cadmus Indiana study[8] with that found by a 2007 study in Connecticut;[12] then calculating the additional percentage savings a smart thermostat would achieve using the smart thermostat savings from the Indiana study.

Heating and Cooling Energy Savings Fractions by Thermostat Replacement Type

Thermostat Replacement Type	$ESF_{HEATING}$	$ESF_{COOLING}$
Manual to Smart[8]	13.4%	16.1%
Manual to Programmable[8]	7.8%	15.0%
Manual to Programmable[12]	6.8%	N/A
Averaged Manual to Programmable	7.3%	15.0%
Programmable to Smart	6.6%	1.3%

The savings percentages are a weighted average to represent the combination of manual and programmable thermostats that comprise the baseline population in Wisconsin. This was achieved by multiplying the percentage of homes with a manual thermostat by the energy savings fraction achieved by a smart thermostat (over a manual) and the percentage of homes with a programmable thermostat, then multiplying by the energy savings fraction estimated for a smart thermostat replacing a programmable thermostat.

Weighted Heating and Cooling Energy Savings Fractions

Type of Energy Savings Fraction	Weighted Percentage
$ESF_{HEATING}$	9.9%
$ESF_{COOLING}$	8.3%

For ASHPs, the *Oregon Heat Pump Control Pilot Evaluation*[9] revealed savings of 12.0%, which is assumed to be correct. This may be evaluated in the future based on additional studies as they become available.

As the region most similar to Wisconsin, the Northern Indiana pilot study was used as the primary source for savings values used in this workpaper.

The capacity of residential heat pumps installed in Wisconsin is assumed to be 3.1 tons, based on an analysis of 75 ASHPs installed between 2013 and 2015 for the Focus on Energy Residential Prescriptive Program. At 12,000 Btu per hour per ton, the assumed average capacity is 37,200 Btu per hour.

The default efficiency levels are based on existing heating and cooling equipment efficiencies of 80% AFUE boilers, 90% AFUE natural gas furnaces, SEER 12 central ACs, and HSPF 7.1 ASHPs. Current baselines for boilers, furnaces, AC systems, and ASHPs assume 82% AFUE, 92% AFUE, SEER 13, and HSPF 7.7, respectively, based on current installation standards in Wisconsin (and assuming that the average customer in Wisconsin is slightly below the baseline due to some homes still using older equipment).

The peak kW savings algorithm was based on the Attic Air Sealing measure in the Illinois TRM. This is because all other kW algorithms used for Focus on Energy residential prescriptive measures are based on efficiency changes, while the Attic Air Sealing measure, like this Smart Thermostat measure, involves decreasing the HVAC system run time.

Supporting inputs for cooling load hours (furnaces) in several Wisconsin cities are shown in the table below. Cooling hours are based on an air conditioner in the *Deemed Savings Report,*[5] adjusted for the larger capacity system (e.g., 410 hours at 2.425 tons is equivalent to 321 hours at 3.1 tons).

Supporting Inputs for Effective Full Load Cooling Hours by City

Location	$EFLH_{COOLING}$	Weighting by Participant
Green Bay	344	22%
Lacrosse	323	3%
Madison	395	18%
Milwaukee	457	48%
Wisconsin Average	380	9%
Weighted Average	**410**	**100%**

Supporting inputs for heating load hours (ASHPs) in several Wisconsin cities are shown in the table below.

Supporting Inputs for Effective Full Load Heating Hours by City[13]

Location	$EFLH_{HEATING}$	Weighting by Participant
Green Bay	1,852	22%
Lacrosse	1,966	3%
Madison	1,934	18%
Milwaukee	1,883	48%
Wisconsin Average	1,909	9%
Weighted Average	**1,890**	**100%**

Sources

1. GDS Associates. *Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures*. Table 1, HVAC Controls. 2007. Used programmable thermostat EUL as the closest proxy for smart thermostats.
2. *Indiana Technical Resource Manual, Version 1.0.* Programmable Thermostats (Time of Sale, Direct Install). January 10, 2013.
3. SPECTRUM Focus Prescriptive Database. 2012. Average furnace size of 13,000 lb.
4. SPECTRUM Focus Prescriptive Database. 2013. Average input capacity of boilers under 300 Mbh.

5. *Focus on Energy Deemed Savings Report: Evaluated Deemed Savings Changes*. November 14, 2014.
6. 800 therms consumed by 90% AFUE furnaces (i.e., 720 therms output) for all residential natural gas measures estimate from: Pigg and Nevius. Electricity Use by New Furnaces. 2000. Available online: http://www.ecw.org/sites/d3efault/files/230-1.pdf. Using average furnace size of 72,000 Btu (from 2012 SPECTRUM database of 13,000 furnaces), 1,000 full-load heating hours are estimated.
7. Focus on Energy. *Technical Reference Manual*. August 15, 2014. (Several Cadmus metering studies reveal that ENERGY STAR calculator overestimates EFLH by 25%. The heating EFLH are adjusted by population-weighted HDD and TMY-3 values.)
8. Cadmus. *Evaluation of the 2013-2014 Programmable and Smart Thermostat Program*. Prepared for Northern Indiana Public Service Company. January 22, 2015.
9. Apex Analytics. *Nest Thermostat Heat Pump Control Pilot Evaluation*. Prepared for Energy Trust of Oregon. October 10, 2014.
10. P.A. Consulting Group. *Focus on Energy Evaluation, Residential Programs: CY09 Deemed Savings Review*. March 26, 2010. Available online: https://focusonenergy.com/sites/default/files/cy09residentialdeemedsavingsreview_evaluationreport.pdf
11. Illinois Energy Efficiency Statewide Advisory Group. *Illinois Statewide Technical Reference Manual.* Section 5.6.1 Air Sealing. February 2014.
12. RLW Analytics. *Validating the Impact of Programmable Thermostats.* Prepared for GasNetworks. January 2007.
13. Several Cadmus metering studies reveal that the ENERGY STAR calculator EFLH are over-estimated by 25%. The heating EFLH were adjusted by population-weighted HDD and TMY-3 values.

Revision History

Version Number	Date	Description of Change
01	03/2015	Initial TRM entry

Smart Thermostat, Installed with Home Heating Measure

	Measure Details
Measure Master ID	Smart Thermostat: Installed with 95% AFUE NG Furnace, 3612 Installed with 95% AFUE NG Boiler, 3613 Installed with Furnace and A/C, 3614 Installed with Air-Source Heat Pump, 3615
Measure Unit	Per thermostat
Measure Type	Prescriptive
Measure Group	HVAC
Measure Category	Controls
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	Varies by heating system installed
Peak Demand Reduction (kW)	Varies by heating system installed
Annual Therm Savings (Therms)	Varies by heating system installed
Lifecycle Energy Savings (kWh)	Varies by heating system installed
Lifecycle Therm Savings (Therms)	Varies by heating system installed
Water Savings (gal/yr)	0
Effective Useful Life (years)	10[1]
Incremental Cost ($/unit)	$250.00

Measure Description

Users can set standard programmable thermostats to adjust temperature setpoints at different times of the day, changing temperatures during unoccupied periods to allow for energy savings. The user can also communicate remotely with a smart thermostat through Wi-Fi, which allows for remote programming and can detect when the house is unoccupied through sensors or an application that tracks the homeowner’s location through their phone. This occupancy sensor capacity allows the thermostat to reduce energy use without requiring active programming or regular attention from the user, thus optimizing thermostat-based energy savings independent of user interaction. Some smart thermostats can also optimize efficiency through auto-adjustments based on outdoor temperature and humidity, and “learning” standard occupancy behaviors and temperature preferences (eliminating the need for programming).

Description of Baseline Condition

The baseline condition is a manual or standard programmable thermostat installed in a home with new, program qualified, natural gas furnace, natural gas boiler, furnace/AC combo, or air-source heat pump.

See the Assumptions section for detail on weighted averages applied to savings to account for the combination of manual and programmable thermostats in the baseline Wisconsin population.

Description of Efficient Condition

The efficient condition is a smart thermostat installed in a home to replace the existing thermostat. To qualify as a “smart,” the thermostat must be Wi-Fi capable (with the Wi-Fi connection established by the customer), and have occupancy-sensing capability, such as motion sensors and/or geofencing.

Annual Energy-Savings Algorithm

The savings algorithms associated with this measure involve calculating the heating and cooling energy use, then applying a percentage savings achieved by installing a smart thermostat.[2]

$$\text{Therm}_{\text{SAVED}} = \text{HOURS}_{\text{HEATING}} * \text{CAP} / \text{AFUE} / 100 * \text{ESF}_{\text{HEATING}}$$

$$\text{kWh}_{\text{SAVED HEATING}} = \text{EFLH}_{\text{HEATING}} * \text{CAP} / \text{HSPF} / 3.412 * \text{ESF}_{\text{HEATING}}$$

$$\text{kWh}_{\text{SAVED COOLING}} = (1/\text{SEER}) * \text{EFLH}_{\text{COOLING}} * \text{MBtuH} * \text{AC\%} * \text{ESF}_{\text{COOLING}}$$

Where:

$\text{HOURS}_{\text{HEATING}}$ = Home heating hours (= 1,158 hours for natural gas furnace and furnace/AC;[5] = 1,000 hours for boiler)[6]

CAP = Heating system capacity (= 72 MBtuH for furnace;[3] = 110 MBtuH for boiler;[4] = 37.2 MBtuH for ASHP)

AFUE = AFUE of system if natural gas furnace or furnace/AC

100 = Conversion

$\text{ESF}_{\text{HEATING}}$ = Heating energy savings fraction (= 9.9% for furnace and boiler;[8] = 12.0% for ASHP)[9]

$\text{EFLH}_{\text{HEATING}}$ = Effective full-load heating hours (= 1,890)[7]

HSPF = Heating seasonal performance factor (= 8.4)

3.412 = Watt to Btu conversion

SEER = Seasonal energy efficiency rating (= 13 for 95% natural gas furnace; = 16 for furnace/AC)

$\text{EFLH}_{\text{COOLING}}$ = Effective full-load cooling hours (= 410 for natural gas furnace and furnace/AC;[5] = 321 for ASHP)

MBtuH = Cooling system capacity (=29.1 MBtuH)[10]

AC% = Air Conditioner efficiency (= 92.5% for 95% natural gas furnace;[5] = 100% for furnace/AC or ASHP; = 0% for boiler)

$ESF_{COOLING}$ = Cooling energy savings fraction (= 8.3%)[8]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} / EFLH_{COOLING} * CF$

Where:

CF = Coincidence factor (=68%)[5,11]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 10 years)[1]

Deemed Savings

Annual and Lifecycle Electric Savings by Measure

Type of Savings (kWh)	Measure			
	Smart Thermostat Installed with 95% Natural Gas Boiler, MMID 3613	Smart Thermostat Installed with 95% AFUE Natural Gas Furnace, MMID 3612	Smart Thermostat Installed with Furnace/AC Combo, MMID 3614	Smart Thermostat Installed with Air Source Heat Pump, MMID 3615
Annual	0	70.46	61.89	356.32
Lifecycle	0	704.6	618.9	3,563.2

Annual and Lifecycle Natural Gas Savings by Measure

Type of Savings (therms)	Measure			
	Smart Thermostat Installed with 95% Natural Gas Boiler, MMID 3613	Smart Thermostat Installed with 95% AFUE Natural Gas Furnace, MMID 3612	Smart Thermostat Installed with Furnace/AC Combo, MMID 3614	Smart Thermostat Installed with Air Source Heat Pump, MMID 3615
Annual	114.63	86.89	86.89	0
Lifecycle	1,146.3	868.9	868.9	0

Annual Summer Coincident Peak Savings by Measure

Type of Savings (kW)	Measure			
	Smart Thermostat Installed with 95% Natural Gas Boiler, MMID 3613	Smart Thermostat Installed with 95% AFUE Natural Gas Furnace, MMID 3612	Smart Thermostat Installed with Furnace/AC Combo, MMID 3614	Smart Thermostat Installed with Air Source Heat Pump, MMID 3615
Annual	0	0.117	0.103	0.131

Assumptions

The GDS Associates document cited for EUL is also used by the Illinois TRM for programmable thermostats.

The $250 incremental measure cost was based on typical online and retail stores prices for Nest, Ecobee3, and Honeywell Lyric thermostats.

As a proxy for the Wisconsin service territory, the percentages of Indiana homes with a manual thermostat and a programmable thermostat identified in a Cadmus study[8] was used.

Percentages of Indiana Homes with Manual Versus Programmable Thermostat

Type of Thermostat	Percentage of Population	
	Heating	Cooling
Manual	48.5%	47.1%
Programmable	51.5%	52.9%

This savings for a programmable thermostat baseline was estimated by averaging the programmable savings found by the Cadmus Indiana study[8] with that found by a 2007 study in Connecticut;[12] then calculating the additional percentage savings a smart thermostat would achieve using the smart thermostat savings from the Indiana study.

Heating and Cooling Energy Savings Fractions by Thermostat Replacement Type

Thermostat Replacement Type	$ESF_{HEATING}$	$ESF_{COOLING}$
Manual to Smart[8]	13.4%	16.1%
Manual to Programmable[8]	7.8%	15.0%
Manual to Programmable[12]	6.8%	N/A
Averaged Manual to Programmable	7.3%	15.0%
Programmable to Smart	6.6%	1.3%

The savings percentages are a weighted average to represent the combination of manual and programmable thermostats that comprise the baseline population in Wisconsin. This was achieved by multiplying the percentage of homes with a manual thermostat by the energy savings fraction achieved by a smart thermostat (over a manual) and the percentage of homes with a programmable thermostat, then multiplying by the energy savings fraction estimated for a smart thermostat replacing a programmable thermostat.

Weighted Heating and Cooling Energy Savings Fractions

Type of Energy Savings Fraction	Weighted Percentage
$ESF_{HEATING}$	9.9%
$ESF_{COOLING}$	8.3%

For ASHPs, the *Oregon Heat Pump Control Pilot Evaluation*[9] revealed savings of 12.0%, which is assumed to be correct. This may be evaluated in the future based on additional studies as they become available.

As the region most similar to Wisconsin, the Northern Indiana pilot study was used as the primary source for savings values used in this workpaper.

The capacity of residential heat pumps installed in Wisconsin is assumed to be 3.1 tons, based on an analysis of 75 ASHPs installed between 2013 and 2015 for the Focus on Energy Residential Prescriptive Program. At 12,000 Btu per hour per ton, the assumed average capacity is 37,200 Btu per hour.

Installed furnace/AC combos are required to have a SEER 16 AC rating, while installed natural gas furnaces are assumed to have central AC rated at the federal minimum of 13 SEER.

As the 2014 *Focus on Energy Deemed Savings Report* revealed that 92.5% of customers with natural gas furnaces also have central air conditioning, the $kWh_{SAVED\ COOLING}$ and kW_{SAVED} values are multiplied by 0.925 for customers installing a smart thermostat with their new natural gas furnace without a 16 SEER AC.

Customers with boilers are not assumed to have central air conditioning on the same thermostat, and thus no kWh or kW savings are associated with a smart thermostat installed with a 95% boiler.

The peak kW savings algorithm was based on the Attic Air Sealing measure in the Illinois TRM. This is because all other kW algorithms used for Focus on Energy residential prescriptive measures are based on efficiency changes, while the Attic Air Sealing measure, like this Smart Thermostat measure, involves decreasing the HVAC system run time.

Supporting inputs for cooling load hours (furnaces) in several Wisconsin cities are shown in the table below. Cooling hours are based on an air conditioner in the *Deemed Savings Report,*[5] adjusted for the larger capacity system (e.g., 410 hours at 2.425 tons is equivalent to 321 hours at 3.1 tons).

Supporting Inputs for Effective Full Load Cooling Hours by City

Location	$EFLH_{COOLING}$	Weighting by Participant
Green Bay	344	22%
Lacrosse	323	3%
Madison	395	18%
Milwaukee	457	48%
Wisconsin Average	380	9%
Weighted Average	**410**	**100%**

Supporting inputs for heating load hours (ASHPs) in several Wisconsin cities are shown in the table below.

Supporting Inputs for Effective Full Load Heating Hours by City

Location	$EFLH_{HEATING}$	Weighting by Participant
Green Bay	1,852	22%
Lacrosse	1,966	3%
Madison	1,934	18%
Milwaukee	1,883	48%
Wisconsin Average	1,909	9%
Weighted Average	**1,890**	**100%**

Sources

1. GDS Associates. *Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures.* Table 1, HVAC Controls. 2007. Used programmable thermostat EUL as the closest proxy for smart thermostats.
2. *Indiana Technical Resource Manual, Version 1.0*. Programmable Thermostats (Time of Sale, Direct Install). January 10, 2013.
3. SPECTRUM Focus Prescriptive Database. 2012. Average furnace size of 13,000 lb.
4. SPECTRUM Focus Prescriptive Database. 2013. Average input capacity of boilers under 300 Mbh.
5. *Focus on Energy Deemed Savings Report: Evaluated Deemed Savings Changes.* November 14, 2014.
6. 800 therms consumed by 90% AFUE furnaces (i.e., 720 therms output) for all residential natural gas measures estimate from: Pigg and Nevius. Electricity Use by New Furnaces. 2000. Available

online: http://www.ecw.org/sites/d3efault/files/230-1.pdf. Using average furnace size of 72,000 Btu (from 2012 SPECTRUM database of 13,000 furnaces), 1,000 full-load heating hours are estimated.

7. Focus on Energy. *Technical Reference Manual*. August 15, 2014. (Several Cadmus metering studies reveal that ENERGY STAR calculator overestimates EFLH by 25%. The heating EFLH are adjusted by population-weighted HDD and TMY-3 values.)
8. Cadmus. *Evaluation of the 2013-2014 Programmable and Smart Thermostat Program*. Prepared for Northern Indiana Public Service Company. January 22, 2015.
9. Apex Analytics. *Nest Thermostat Heat Pump Control Pilot Evaluation*. Prepared for Energy Trust of Oregon. October 10, 2014.
10. PA Consulting Group. *Focus on Energy Evaluation, Residential Programs: CY09 Deemed Savings Review*. March 26, 2010. Available online: https://focusonenergy.com/sites/default/files/cy09residentialdeemedsavingsreview_evaluationreport.pdf
11. Illinois Energy Efficiency Statewide Advisory Group. *Illinois Statewide Technical Reference Manual.* Section 5.6.1 Air Sealing. February 2014.
12. RLW Analytics. *Validating the Impact of Programmable Thermostats.* Prepared for GasNetworks. January 2007.

Revision History

Version Number	Date	Description of Change
01	03/2015	Initial TRM entry

Gas Furnace

	Measure Details
Measure Master ID	LP Furnace with ECM, 90%+ AFUE (Existing), 3679 Natural Gas Furnace: 95% AFUE, 3441 With ECM, 95+ AFUE (Existing), Enhanced Rewards, 3443
Measure Unit	Per furnace
Measure Type	Prescriptive
Measure Group	HVAC
Measure Category	Furnace
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily, Residential- single family
Annual Energy Savings (kWh)	415 (excluding non-ECM)
Peak Demand Reduction (kW)	0.0792 (excluding non-ECM)
Annual Therm Savings (Therms)	Varies by AFUE and fuel type
Lifecycle Energy Savings (kWh)	9,545 (excluding non-ECM)
Lifecycle Therm Savings (Therms)	Varies by AFUE and fuel type
Water Savings (gal/yr)	0
Effective Useful Life (years)	23[1]
Incremental Cost	Varies by measure, see Appendix D

Measure Description

Conventional natural gas furnaces produce by-products, such as water vapor and carbon dioxide, which are usually vented out through a chimney along with a considerable amount of heat. This occurs not only when the furnace is in use, but also when it is turned off. Newer designs increase energy efficiency by reducing the amount of heat that escapes and by extracting heat from the flue gas before it is vented. These furnaces use much less energy than conventional furnaces.

Description of Baseline Condition

The current federal furnace standard is 78% AFUE without an ECM. However, the Residential Rewards Program uses 92% AFUE furnace without an ECM as the baseline due to market trends in Wisconsin,[2] while the Enhanced Rewards Program maintains the 78% AFUE baseline due to income restraints for participating consumers. A baseline of 92% AFUE is used for nonresidential and multifamily applications.

Description of Efficient Condition

The efficient condition varies by measure-specific requirements; the measure master name largely explains the efficient condition for each measure. For all measures, the efficient condition pertains to a furnace used for space heating only.

Annual Energy-Savings Algorithm

$Therm_{SAVED} = CAP * hours_{HEATING} * (1/\eta_{BASE} - 1/\eta_{EE}) * (1/100)$

$kWh_{SAVED} = kWh_{SAVED\ COOLING} + kWh_{SAVED\ HEATING} + kWh_{SAVED\ CIRC}$

$kWh_{SAVED\ COOLING} = tons * EFLH_{COOLING} * 12\ kBtu/ton * (1/SEER_{BASE} - 1/SEER_{ECM}) * AC\%$

$kWh_{SAVED\ HEATING} = hours_{HEATING} * \Delta kW_{HEAT}$

$kWh_{SAVED\ CIRC} = hours_{CIRC} * \Delta kW_{CIRC}$

Where:

CAP = Heating capacity (= 72 MBtu/h)[3]

$hours_{HEATING}$ = Annual heating hours (= 1,158 hours)[3]

η_{BASE} = Baseline unit efficiency (= 78% AFUE for Enhanced Rewards and LP furnaces; = 92% AFUE for Residential Rewards, multifamily, and nonresidential application)

η_{EE} = Energy efficient unit efficiency (= 90% AFUE for LP or 95% AFUE forNG)

100 = Conversion

tons = Cooling capacity (=2.425 tons)

$EFLH_{COOLING}$ = Equivalent full-load hours of cooling (= 410; see table below)[4]

$SEER_{BASE}$ = Seasonal energy efficiency rating of baseline unit (= 12)[3]

$SEER_{ECM}$ = Seasonal energy efficiency rating of efficient unit (= 13)[3]

AC% = Air Conditioner efficiency (= 92.5%)[3]

ΔkW_{HEAT} = Heating demand (= 0.116 kW)[3]

$hours_{CIRC}$ = Annual hours on circulate setting (= 1,020 hours)[3]

ΔkW_{CIRC} = Demand on circulate setting (= 0.207 kW)[3]

Equivalent Full-Load Cooling Hours by Location

Location	$EFLH_{COOLING}$	Weighting by Participant
Green Bay	344	22%
Lacrosse	323	3%
Madison	395	18%
Milwaukee	457	48%
Wisconsin Average	380	9%
Overall	**410**	

Summer Coincident Peak Savings Algorithm

Peak electrical energy savings for the ECM changed based on the Focus on Energy ECM Study[3] and is deemed as 0.0792 kW/unit.

$kW_{SAVED} = tons * 12\ kBtu/ton * (1/EER_{BASE} - 1/EER_{ECM}) * CF * AC\%$

Where:

EER_{BASE} = Energy efficiency rating of baseline unit (= 10.5)[3]

EER_{ECM} = Energy efficiency rating of efficient unit (= 11)[3]

CF = Coincidence factor (= 68%)[3]

Lifecycle Energy-Savings Algorithm

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (=18)[1]

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. Cadmus. *Focus on Energy Calendar Year 2013 Baseline Market Study*. November 26, 2013. Available online: https://focusonenergy.com/sites/default/files/FOC_XC_Baseline%20Evaluation%20Report%20CY%202013.pdf
3. *Focus on Energy Deemed Savings Report*. October 27, 2014.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

Joint Furnace & Central AC with ECM

	Measure Details
Measure Master ID	Furnace and A/C, with ECM, 95%+ AFUE, ≥ 16 SEER, 2990 Furnace and A/C, with ECM, 95% + AFUE, ≥ 16 SEER, Enhanced Rewards, 3569
Measure Unit	Per system
Measure Type	Prescriptive
Measure Group	HVAC
Measure Category	Other
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	518
Peak Demand Reduction (kW)	0.277
Annual Therm Savings (Therms)	Varies by baseline
Lifecycle Energy Savings (kWh)	11,914
Lifecycle Therm Savings (Therms)	Varies by baseline
Water Savings (gal/yr)	0
Effective Useful Life (years)	23[1]
Incremental Cost	$1,451.66 for Residential Rewards[2] $2,238.73 for Enhanced Rewards[2]

Measure Description

This is the joint measures of a high-efficiency furnace with an ECM and a central air conditioner.

Description of Baseline Condition[2]

The baseline condition for Residential Rewards is a 92% AFUE[3] natural gas furnace without an ECM and a 13 SEER central air conditioner, and the baseline condition for Enhanced Rewards is a 78% AFUE natural gas furnace without an ECM and a 13 SEER central air conditioner.

Description of Efficient Condition

The efficient condition is a 95% AFUE natural gas furnace with an ECM and a 16 SEER central AC.

Annual Energy-Savings Algorithm

$$\text{Therm}_{\text{SAVED}} = \text{CAP} * \text{HOURS}_{\text{HEAT}} * (1/\ \text{AFUE}_{\text{BASE}} - 1/\text{AFUE}_{\text{EE}}) * (1/100)$$

$$\text{kWh}_{\text{SAVED}} = \text{kWh}_{\text{SAVED COOLING}} + \text{kWh}_{\text{SAVED HEATING}} + \text{kWh}_{\text{SAVED CIRC}}$$

$$\text{kWh}_{\text{SAVED COOLING}} = \text{tons} * \text{EFLH}_{\text{COOL}} * 12\ \text{kBtu/ton} * (1/\text{SEER}_{\text{BASE}} - 1/\text{SEER}_{\text{EE}})$$

$kWh_{SAVED\ HEATING} = HOURS_{HEAT} * kW_{SAVED\ HEATING}$

$kWh_{SAVED\ CIRC} = HOURS_{CIRC} * kW_{SAVED\ CIRC}$

Where:

CAP = Heating capacity (= 72 MBtu/h)[4]

$HOURS_{HEAT}$ = Hours of heating operation (= 1,158)[3]

$AFUE_{BASE}$ = Efficiency rating of standard efficiency furnace, deemed (= 78% AFUE for Enhanced Rewards; = 92% AFUE for Residential Rewards)

$AFUE_{EE}$ = Efficiency rating of efficient furnace, deemed (= 95% or 97%)

100 = Conversion

$kWh_{SAVED\ COOLING}$ = kWh saved from AC with ECM (= 173; see algorithm above)

$kWh_{SAVED\ HEATING}$ = kWh saved in heating mode, deemed (= 134)[3]

$kWh_{SAVED\ CIRC}$ = kWh saved in heating mode, deemed (= 211)[3]

tons = Cooling capacity (= 2.425 tons)[3]

$EFLH_{COOL}$ = Equivalent full-load cooling hours (= 410; see table below)[3]

Equivalent Full-Load Cooling Hours by Location

Location	$EFLH_{COOL}$	Weighting by Participant
Green Bay	344	22%
La Crosse	323	3%
Madison	395	18%
Milwaukee	457	48%
Wisconsin Average	380	9%
Overall	**410**	

$SEER_{BASE}$ = Federal minimum seasonal energy efficiency ratio (= 13)

$SEER_{EE}$ = Efficient measure seasonal energy efficiency ratio (= 16)

$kW_{SAVED\ HEATING}$ = Average power saved in heating mode (= 0.116 kW)[3]

$HOURS_{CIRC}$ = Circulation hours of operation (= 1,020 hours)[3]

$kW_{SAVED\ CIRC}$ = Average power saved in circulation mode (= 0.207 kW)[3]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = tons * 12\ kBtu/ton * (1/EER_{BASE} – 1/EER_{ECM}) * CF$

Where:

EER_{BASE} = Baseline energy efficiency ratio (= 11.0)[5]

EER_{ECM} = Efficient measure energy efficiency ratio (= 13)[5]

CF = Coincidence factor (= 68%)[3]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (=18 years)[1]

Deemed Savings

Deemed Savings by Program

Program	MMID	Annual Electric Energy Savings (kWh/yr)	Peak Demand Reduction (kW)	Lifecycle Electric Energy Savings (kWh)	Annual Natural Gas Savings (therms/yr)	Lifecycle Natural Gas Savings (therms)
Enhanced Rewards	3569	518	0.277	9,324	191	3,438
Residential Rewards	2990	518	0.277	9,324	29	522

Assumptions

- The current federal furnace standard is a 78% AFUE furnace without an ECM. However, the Residential Rewards Program uses a 92% AFUE furnace without an ECM as the baseline due to market trends in Wisconsin, while the Enhanced Rewards Program maintains the 78% AFUE baseline due to income restraints for participating consumers.
- Electrical energy savings for the ECM were established in a State of Wisconsin Department of Administration Division of Energy Impact Assessment Report, and later revised in a 2009 Impact Assessment Report, to be 733 kWh/furnace.[7] Upon receiving feedback from Cadmus, the ECM electric savings were adjusted downward to 500 kWh/furnace in 2012. The ECM savings were revised in 2014 to 415 kWh/furnace for the 2015 program year.

- AHRI ratings reveal that 76% of 16 SEER combinations have an EER rating of 13 or higher. This seems consistent with federal tax credits given to 13 EER / 16 SEER equipment in 2006, 2007, and 2009 through 2013.
- AHRI combination ratings reveal that EER rating is approximately 2 less than SEER rating.[6] This is very close to the U.S. DOE guideline of EER = -0.02 x SEER^2 + 1.12 x SEER (http://www.nrel.gov/docs/fy11osti/49246.pdf), obtained using an equation first proposed in: Wassmer, M. *A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations.* Masters Thesis, University of Colorado at Boulder. 2003.

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdfIncremental costs based on Fall 2014 review of Residential Prescriptive trade allies. IMCs are different for the two programs because the measures use different baselines.
2. Cadmus. Focus on Energy Calendar Year 2013 Baseline Market Study. November 26, 2013. Available online: https://focusonenergy.com/sites/default/files/Appendix%20B%20-%20FOC_XC_Deemed_WriteUp_12122013%20(2).pdf
3. Average size of 13,000 furnaces in the 2012 SPECTRUM Focus Prescriptive Database.
4. PA Consulting Group. Focus on Energy Evaluation, Residential Programs: CY09 Deemed Savings Review. March 26, 2010. Available online: https://focusonenergy.com/sites/default/files/cy09residentialdeemedsavingsreview_evaluationreport.pdf
5. Cadmus. Focus on Energy Evaluated Deemed Savings Changes. November 14, 2014. https://focusonenergy.com/sites/default/files/FoE_Deemed_WriteUp%20CY14%20Final.pdf
6. Focus on Energy Evaluation, ECM Furnace Impact Assessment Report: Final Report. January 12, 2009.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

Laundry

ENERGY STAR Multifamily Common Area Clothes Washers

	Measure Details
Measure Master ID	Clothes Washer, Common Area, ENERGY STAR, 2756 (Electric), 2757 (NG)
Measure Unit	Per clothes washer
Measure Type	Prescriptive
Measure Group	Laundry
Measure Category	Clothes Washer
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by fuel source
Peak Demand Reduction (kW)	Varies by fuel source
Annual Therm Savings (Therms)	Varies by fuel source
Lifecycle Energy Savings (kWh)	Varies by fuel source
Lifecycle Therm Savings (Therms)	Varies by fuel source
Water Savings (gal/yr)	13,978
Effective Useful Life (years)	11[1]
Incremental Cost	$325.40

Measure Description

ENERGY STAR is a standard for energy-efficient consumer appliances. This standard increases savings for clothes washers in multifamily buildings, which are derived from factors such as hot water fuel, dryer type, and location (in-unit or common area).

This measure describes clothes washers in common areas. For washers installed in individual units of a multifamily building, see the residential single-family clothes washer measure.

Description of Baseline Condition

The baseline condition is a non-ENERGY STAR commercial clothes washer.

Description of Efficient Condition

The efficient condition is an ENERGY STAR commercial clothes washer.

Annual Energy-Savings Algorithm

Clothes washer with electric DHW:

kWh_{SAVED} = [ΔkWh(EG) * %EG + ΔkWh(EE) * %EE + ΔkWh(EnD) * %EnD] * Cycles/year

$Therm_{SAVED}$ = [ΔTherm(EG) * %EG] * Cycles/year

Clothes washer with natural gas DHW:

$$kWh_{SAVED} = [\Delta kWh(GE) * \%GE + \Delta kWh(GG) * \%GG + \Delta kWh(GnD) * \%GnD] * Cycles/year$$

$$Therm_{SAVED} = [\Delta Therm(GG) * \%GG + \Delta Therm(GE) * \%GE + \Delta Therm(GnD) * \%GnD\ ] * Cycles/year$$

Where:

Mix of dryers for clothes washers with electric DHW[2]

EG = Electric DHW and natural gas dryer (= 8.0%)

EE = Electric DHW and electric dryer (= 92.0%)

EnD = Electric DHW with no dryer (= 0.0%)

Cycles/year = Wash cycles per year (= 1,241)[2]

Mix of dryers for clothes washers with natural gas DHW[2]

GG = Natural gas DHW and natural gas dryer (= 26.5%)

GE = Natural gas DHW and electric dryer (= 74.5%)

Gnd = Natural gas DHW with no dryer (=0.0%)

Cycles/year = Wash cycles per year (= 1,241)[2]

Electric and natural gas savings for mixes of dryer and DHW types[2]

$\Delta kWh(GE)$ = Electric savings per cycle in kWh (= 1.45)

$\Delta kWh(EG)$ = Electric savings per cycle in kWh (= 0.25)

$\Delta kWh(EE)$ = Electric savings per cycle in kWh (= 1.70)

$\Delta kWh(EnD)$ = Electric savings per cycle in kWh (=1.70)

$\Delta Therm(GG)$ = Natural gas savings per cycle in therms (= 0.066)

$\Delta Therm(GE)$ = Natural gas savings per cycle in therms (= 0.011)

$\Delta Therm(EG)$ = Natural gas savings per cycle in therms (= 0.055)

$\Delta Therm(GnD)$ = Natural gas Savings per cycle in therms (= 0.011)

Summer Coincident Peak Savings Algorithm

$$kW_{SAVED} = kWh_{SAVED}/(Cycles/year * Hours/cycle) * CF$$

Where:

Hours/cycle = 1 (estimated)

CF = Coincidence factor (= 0.045)[2]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

$Therm_{LIFECYCLE} = Therm_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 11 years)[1]

Deemed Savings

Deemed Savings by Measure

	CAE (MMID 2756)	CAG (MMID 2757)
Annual Deemed Electricity Savings (kWh)	1,971	1,331
Deemed Summer Peak Electricity Demand Reduction (kW)	0.071	0.048
Lifecycle Deemed Electricity Energy Savings (kWh)	21,681	14,641
Annual Deemed Natural Gas Energy Savings (therms)	5.3	31.9
Lifecycle Deemed Natural Gas Energy Savings (Therms)	58	351
Annual Demand Water Savings (gallons)	13,978	13,978
Lifecycle Deemed Water Savings (gallons)	195,692	195,692

Sources

1. Energy Savings Potential and RD&D Opportunities for Commercial Building Appliances: U.S. Department of Energy Energy Efficiency and Renewable Energy Building Technologies Program, Navigant Consulting, Inc. 2009. http://apps1.eere.energy.gov/buildings/publications/pdfs/corporate/commercial_appliances_report_12-09.pdf
2. California Public Utilities District. *Res Retro HIM Evaluation Report*. Weighted by quantity of each efficiency level from MESP Spectrum.
3. RECs Database - Wisconsin Multifamily unit counts.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Lighting

CFL, Reduced Wattage, Pin Based, Replacing CFL

	Measure Details
Measure Master ID	CFL, Reduced Wattage, Pin Based: 18 Watt, Replacing CFL, 3031 26 Watt, Replacing CFL, 3032 32 Watt, Replacing CFL, 3033 42 Watt, Replacing CFL, 3034
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Compact (CFL)
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential- multifamily
Annual Energy Savings (kWh)	Varies by wattage and sector
Peak Demand Reduction (kW)	Varies by wattage and sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by wattage and sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	3[1]
Incremental Cost	Varies by measure, see Appendix D

Measure Description

RW CFL lamps save energy by reducing the total input wattage of the luminaire as compared to the same luminaire operating with standard wattage lamps. This measure can be applied to common area spaces where there is more than sufficient light available for the tasks in that space using standard wattage CFL lamps, as these are areas where RW CFL lamps can be considered.

Description of Baseline Condition

The baseline equipment is standard wattage, pin-based CFL lamps.

Description of Efficient Condition

The efficient equipment is a RW CFL lamp being used to replace a standard wattage CFL lamp.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1,000 * HOU$

Where:

$Watts_{BASE}$ = Power consumption of baseline measure (= see table below)

$Watts_{EE}$ = Power consumption of efficient measure (= see table below)

Baseline and Efficient Wattage by Type of Measures

	Type 1	Type 2	Type 3	Type 4
Baseline Measure	18-Watt Pin-Based CFL Lamp	26-Watt Pin-Based CFL Lamp	32-Watt Pin-Based CFL Lamp	42-Watt Pin-Based CFL Lamp
Efficient Measure	14-Watt, 15-Watt, or 16-Watt Pin-Based CFL Lamp	21-Watt or 23-Watt Pin-Based CFL Lamp	27-Watt or 28-Watt Pin-Based CFL Lamp	33-Watt or 38-Watt Pin-Based CFL Lamp
$Watts_{BASE}$	18	26	32	42
$Watts_{EE}$	14, 15, 16	21, 23	27, 28	33, 38

1,000 = Kilowatt conversion factor

HOU = Annual operating hours (= see table below)

- **Annual Operating Hours by Sector** [2]

Sector	HOU
Multifamily	5,950
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239

2

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1,000 * CF$

Where:

CF = Coincidence factor (= 0.77)[3]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 3 years)[1]

Deemed Savings

Average Annual Deemed Savings for Pin-Based, Reduced-Wattage CFL Lamps

Measure	MMID	Existing Building
CFL, Reduced Wattage, Pin Based, 18 Watt, Replacing CFL	3031	18 kWh / 0.002 kW
CFL, Reduced Wattage, Pin Based, 26 Watt, Replacing CFL	3032	24 kWh / 0.003 kW
CFL, Reduced Wattage, Pin Based, 32 Watt, Replacing CFL	3033	27 kWh / 0.003 kW
CFL, Reduced Wattage, Pin Based, 42 Watt, Replacing CFL	3034	39 kWh / 0.005 kW

Average Lifecycle Deemed Savings for Pin-Based, Reduced-Wattage CFL Lamps

Measure	MMID	Existing Building
CFL, Reduced Wattage, Pin Based, 18 Watt, Replacing CFL	3031	54 kWh
CFL, Reduced Wattage, Pin Based, 26 Watt, Replacing CFL	3032	72 kWh
CFL, Reduced Wattage, Pin Based, 32 Watt, Replacing CFL	3033	81 kWh
CFL, Reduced Wattage, Pin Based, 42 Watt, Replacing CFL	3034	117 kWh

Assumptions

An average of 33% each of 14-watt, 15-watt, and 16-watt pin-based CFL lamps were used to generate the new measure average energy use for 18-watt lamp replacements.

An average of 50% each of 21-watt and 23-watt pin-based CFL lamps were used to generate the new measure average energy use for 26-watt lamp replacements.

An average of 50% each of 27-watt and 28-watt pin-based CFL lamps were used to generate the new measure average energy use for 32-watt lamp replacements.

An average of 50% each of 33-watt and 38-watt pin-based CFL lamps were used to generate the new measure average energy use for 42-watt lamp replacements.

Sources

1. Manufacturer rated life.
2. PA Consulting Group Inc. and Public Service Commission of Wisconsin. Focus on Energy. Evaluation, Business Programs: Deemed Savings Manual V1.0. March 22, 2010. Hours of Use can be found in Table 3.2. Average connected wattages can be found on Final Report, Page 4-194 and Table 4-163

3. State of Wisconsin Public Service Commission. *Business Programs Deemed Savings Manual V1.0*. Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

CFL, Direct Install, 9, 14, 19, or 23 Watts

	Measure Details
Measure Master ID	CFL, Direct Install: 9 Watts, 2116 and 2132 14 Watts, 2117 and 2133 19 Watts, 2118 and 2134 23 Watts, 2119 and 2135
Measure Unit	Per bulb
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Compact (CFL)
Sector(s)	Residential- multifamily, Residential-single family
Annual Energy Savings (kWh)	Varies by wattage and sector
Peak Demand Reduction (kW)	Varies by wattage and sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by wattage and sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	6[1]
Incremental Cost	Varies by measure, see Appendix D

Measure Description

This measure is the Program Implementer or a subcontractor of the Program Implementer installing a 9-watt, 14-watt, 19-watt, or 23-watt ENERGY STAR-qualified screw-in CFL in place of an incandescent screw-in bulb. Assumptions are based on a direct installation, not a time-of sale purchase.

Description of Baseline Condition

The baseline equipment is an incandescent or halogen light bulb.

Description of Efficient Condition

The efficient equipment is a standard screw-based CFL lamp installed by the Program Implementer or a subcontractor.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1,000 * HOU$

Where:

$Watts_{BASE}$ = Baseline wattage (= see table below)

$Watts_{EE}$ = Efficient wattage (= see table below)

Baseline and Efficient Wattages by Measure

$Watts_{BASE}$	MMIDs	$Watts_{EFFICIENT}$
72	2119 and 2135	23
53	2118 and 2134	19
43	2117 and 2133	14
29	2116 and 2132	9

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 829 for single family;[2] = 734 for multifamily)[3]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1,000 * CF$

Where:

CF = Coincident factor (= 0.075 for single family;[2] = 0.055 for multifamily)[3]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 6 years)[1]

Deemed Savings

Single Family Savings

$Watts_{EE}$	MMID	Annual kWh_{SAVED}	kW_{SAVED}	Lifecycle kWh_{SAVED}
23	2119 and 2135	41	0.0037	244
19	2118 and 2134	28	0.0026	169
14	2117 and 2133	24	0.0022	144
9	2116 and 2132	17	0.0015	99

Multifamily Savings

Watts$_{EE}$	MMID	Annual kWh$_{SAVED}$	kW$_{SAVED}$	Lifecycle kWh$_{SAVED}$
23	2119 and 2135	36	0.0030	216
19	2118 and 2134	26	0.0020	156
14	2117 and 2133	21	0.0020	128
9	2116 and 2132	15	0.0010	88

Sources

1. Average of 2013 Cadmus database, CALMAC 2001, 2007 GDS, DEER 2008.
2. Cadmus. *Focus on Energy Evaluated Deemed Savings Changes: 2013 Final Report.* November 26, 2013. Available online: https://focusonenergy.com/sites/default/files/FOC_XC_Deemed_WriteUp_12122013%20%282%29.pdf.
3. Cadmus. *Focus on Energy Evaluated Deemed Savings Changes: 2014 Final Report.* November 14, 2014. Available online: https://focusonenergy.com/sites/default/files/FoE_Deemed_WriteUp%20CY14%20Final.pdf.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

CFL, Direct Install, 20 Watt

	Measure Details
Measure Master ID	CFL, Direct Install, 20 Watt, 3487
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Compact (CFL)
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	27
Peak Demand Reduction (kW)	0.0025
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	164
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	6[1]
Incremental ($/unit)	$5.00

Measure Description

This measure is the Program Implementer or a subcontractor of the Program Implementer installing a 20-watt ENERGY STAR-qualified screw-in CFL in place of an incandescent screw-in bulb. The incremental cost of the CFL compared to the incandescent light bulb is the full installed cost. Savings are based on a direct installation, not a time-of-sale purchase.

Description of Baseline Condition

The baseline equipment is an incandescent 53-watt or 75-watt equivalent light bulb. Savings are evaluated using a baseline wattage of 53 watts for both scenarios.

Description of Efficient Condition

This measure applies to standard screw-based 20-watt CFL lamps.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1,000 * HOU$

Where:

$Watts_{BASE}$ = Baseline wattage (= 53)

$Watts_{EE}$ = Efficient wattage (= 20)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use per year (= 829)[2]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1{,}000 * CF$

Where:

CF = Coincidence factor (= 0.075)[2]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 6 years)[1]

Sources

1. Average of 2013 Cadmus database, CALMAC 2001, 2007 GDS, DEER 2008.
2. Cadmus. *Focus on Energy Evaluated Deemed Savings Changes.* November 26, 2013.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

CFL, Direct Install, 13 Watt, 18 Watt

	Measure Details
Measure Master ID	CFL, Direct Install, 13 Watt 3413
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Compact (CFL)
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	25 or 35
Peak Demand Reduction (kW)	0.0023
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	149
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	6[1]
Incremental Cost	$0.37

Measure Description

This measure is the Program Implementer or a subcontractor of the Program Implementer installing a 13-watt or 18-watt ENERGY STAR-qualified screw-in CFL in place of an incandescent screw-in bulb. The incremental cost of the CFL compared to the incandescent light bulb is the full installed cost. Savings are based on a direct installation, not a time-of-sale purchase.

Description of Baseline Condition

The baseline equipment is an incandescent 43-watt or 60-watt light bulb.

Description of Efficient Condition

This measure applies to standard screw-based 13-watt CFL lamps.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1,000 * HOU$

Where:

$Watts_{BASE}$ = Baseline wattage (= 43 or 60-watt)

$Watts_{EE}$ = Efficient wattage (= 13 watt)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 829)[2]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1{,}000 * CF$

Where:

CF = Coincidence factor (= 0.075)[2]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 6 years)[1]

Sources

1. Average of 2013 Cadmus database, CALMAC 2001, 2007 GDS, DEER 2008.
2. Cadmus. *Focus on Energy Evaluated Deemed Savings Changes*. November 26, 2013.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

CFL Fixture, Interior or Exterior, 24 Hours, CALP

	Measure Details
Measure Master ID	CFL Fixture, Interior or Exterior,- 24 Hour, CALP, 3197
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Linear
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	555
Peak Demand Reduction (kW)	0.0634
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by installation year
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	13[1]
Incremental Cost ($/unit)	$79.00[2]

Measure Description

Hardwired CFL incentives apply only to complete new fixtures or modular (pin or GU-24 based) retrofits with hardwired electronic ballasts. Incentives are for the replacement of incandescent fixtures only and must result in a net decrease in energy use. CFLs provide the same or better light output than incandescent lamps while using 75% less energy.[2]

Description of Baseline Condition

The baseline equipment is a 1-lamp or 2-lamp 60-watt incandescent fixture that is “on” 24 hours per day in an existing multifamily building.

Description of Efficient Condition

Hardwired CFL incentives apply only to complete new fixtures or modular (pin or GU-24 based) retrofits with hardwired electronic ballasts. Incentives are for the replacement of incandescent fixtures only.

Annual Energy-Savings Algorithm

$$kWh_{SAVED} = kWh_{INCANDESCENT} - kWh_{NEW\ MEASURE\ CFL}$$

Where:

$kWh_{INCANDESCENT}$ = Baseline unit annual energy use

$kWh_{NEW\ MEASURE\ CFL}$ = Efficient unit annual energy use

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = Wattage / 1,000

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 13 years)[1]

Deemed Savings

EISA Compliant Lifetime Savings*

Measure	Installation Year			
	2013	2014	2015	2016 and Beyond
Multifamily CALP CFL Fixture, 24 Hour	4,822.4 kWh 0.0634 kW	4,613.9 kWh 0.0634 kW	4,509.6 kWh 0.0396 kW	4,509.6 kWh 0.0396 kW

* Pre-EISA savings ended on July 1, 2014, 6 months after EISA phased out the standard 60-watt A-19 incandescent lamp.

Assumptions

A weighted average between 1-lamp and 2-lamp fixtures with 60-watt incandescent lamps being replaced with a fixture containing one or two– 13-watt CFLs (based on historical project data and estimates).

Sources

1. PA Consulting Group Inc. *Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs: Measure Life Study, Final Report*. August 25, 2009.
2. Michigan DEER Measure Master database. 2013.

Revision History

Version Number	Date	Description of Change
01	06/20/2013	Initial draft

CFL Reflector Lamps

	Measure Details
Measure Master ID	CFL, Reflector Flood Lamps, ≤ 32 Watts, 2246
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Compact (CFL)
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	45
Peak Demand Reduction (kW)	0.004
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	225
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	5[1]
Incremental Cost	$3.00

Measure Description

CFLs are designed to replace an incandescent lamp and fit into most existing in-unit light fixtures used for incandescent lamps (E26 base). This measure includes flood-type screw-based CFL lamps. CFLs use less power and have a longer rated life than their incandescent equivalents.

Description of Baseline Condition

The baseline equipment is an incandescent light bulb.

Description of Efficient Condition

The efficient condition is CFL lamps replacing incandescent lamps. The replacement lamp must be screw based, up to 30 watts, and with an integrated reflector.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1{,}000 * HOU$

Where:

$Watts_{BASE}$ = Wattage of baseline incandescent lamp
$Watts_{EE}$ = Wattage of efficient CFL lamp
1,000 = Kilowatt conversion factor
HOU = Annual operating hours (= see table below)

- **Annual Operating Hours by Sector [1]**

Sector	HOU
Multifamily	5,950
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239
Single family	734[2]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{EE})/1{,}000 * CF$

Where:

CF = Coincidence factor (= 0.075)[2]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (Single family=5 Nonresidential= 12)[1]

Assumptions

The savings for this measure were evaluated using a combination of the ENERGY STAR QPL for CFL bulbs and information from the U.S. DOE EERE data book.[3] Baseline and efficient wattage values were determined for a set of lumens bins prescribed by the U.S. DOE in the EERE data book. The overall energy-savings value and an overall demand reduction value are weighted values determined based on the relative number of qualified products from the ENERGY STAR QPL. A summary of the analysis is shown in the table below.

Baseline and Efficient Wattages, and Savings, by Lumen Range

Lumens Range [L]	$Watts_{BASE}$	$Watts_{EE}$	Energy Savings (kWh)	Demand Reduction (kW)	Weight
420-560	45	12	27	0.002	5%
561-837	65	15	42	0.004	59%
838-1,203	75	21	45	0.004	8%
1,204-1,681	90	23	55	0.005	28%

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf
2. Cadmus. Field Study Research of Residential Lighting. October 18, 2013. Results published in the 2014 Focus on Energy Deemed Savings Report: https://focusonenergy.com/sites/default/files/FoE_Deemed_WriteUp%20CY14%20Final.pdf
3. ENERGY STAR. *Qualified Product List*. October 25, 2013. Available online: https://data.energystar.gov/Government/ENERGY-STAR-Certified-Light-Bulbs/8qjd-zcsy.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

CFL, Reflector, 15 Watt, Retail Store Markdown

	Measure Details
Measure Master ID	CFL, Reflector, 15 Watt, Retail Store Markdown, 3552
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Compact (CFL)
Sector(s)	Residential – single family, Residential – multi family
Annual Energy Savings (kWh)	51
Peak Demand Reduction (kW)	0.0059
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	404
Lifecycle Therm Savings (Therms)	0
Effective Useful Life (years)	8[1]
Incremental Cost	$4.00[2]

Measure Description

This measure is installing an ENERGY STAR-certified CFL reflector that is purchased through a retail outlet to replace an incandescent bulb. Savings are based on a time-of-sale purchase for installation in a residential location.

Description of Baseline Condition

The baseline is an incandescent 65-watt reflector. Reflectors are exempt from EISA legislation.[4]

Description of Efficient Condition

The efficient equipment is a standard screw-based 15-watt ENERGY STAR-certified CFL reflector.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1{,}000 * HOU$

Where:

$Watts_{BASE}$ = Power consumption of baseline measure (= 65 watts)

$Watts_{EE}$ = Power consumption of efficient measure (= 15 watts)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 1,011)[3]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1,000 * CF$

Where:

CF = Coincidence factor (= 0.1189)[3]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 8 years)[1]

Assumptions

A 65-watt baseline is used based on 2014 Focus on Energy Residential Lighting CFL study revealing that 65-watt replacements represented 96% of reflector sales. The table below shows total 2014 reflector sales by baseline wattage.

2014 Reflector Sales by Baseline Wattage

Baseline Wattage	Total Reflector Units Sold in 2014	Percentage of Total Reflector Sales
50	6,433	1%
65	71,5395	96%
75	2,137	0%
100	19,503	3%
Total	**743,468**	**N/A**

Hours-of-use is a weighted average of single-family residential, multifamily, and commercial use. The weighting for these variables are given in the table below.[3]

Variable Weightings by Home Type

Housing Type	Weighting	HOU per Day	Coincidence Factor
Single Family	74.7%	2.27	7.5%
Multifamily	25.3%	2.01	5.5%
Residential	**93%**	**2.20**	**6.99%**
Commercial	7%	10.2	77%

Sources

1. EUL based on similar measure; CFL, reflector replacing incandescent.
2. *Focus on Energy Incremental Cost Database*. 2014. Cost assumed the same as measure 2246, CFL, Reflector Lamp.
3. Cadmus. Focus on Energy Evaluated Deemed Savings Changes. November 14, 2014.
4. EISA 2007 legislation. https://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/eisa_2007.pdf

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

CFL, Standard Bulb, Retail Store Markdown

	Measure Details
Measure Master ID	CFL, Standard Bulb, Retail Store Markdown: 310-749 Lumens, 3548 750-1,049 Lumens, 3549 1,050-1,489 Lumens, 3550 1,490-2,600 Lumens, 3551
Measure Unit	Per bulb
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Compact (CFL)
Sector(s)	Residential – single family, Residential – multi family
Annual Energy Savings (kWh)	Varies by light output
Peak Demand Reduction (kW)	Varies by light output
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by light output
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	8[1]
Incremental Cost	Varies by measure, see Appendix D

Measure Description

This measure is installing an ENERGY STAR-certified standard screw-in CFL purchased through a retail outlet in place of an incandescent or halogen screw-in bulb. Assumptions are based on a time-of-sale purchase for installation in a residential location.

Description of Baseline Condition

The baseline equipment is an incandescent light bulb (standard or EISA compliant halogen). The baseline wattage is determined using the lumens equivalence method in conjunction with the lumen output of the efficient bulb.

Description of Efficient Condition

The efficient measure is a standard ENERGY STAR-certified CFL.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1{,}000 * HOU$

Where:

$Watts_{BASE}$ = Baseline wattage (= see table below)

$Watts_{EE}$ = Efficient wattage (= see table below)

Baseline and Efficient Wattages

$Watts_{BASE}$	$Watts_{EE}$
29	9
43	13
53	18
72	23

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 1,011)[2]

Summer Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1{,}000 * CF$

Where:

CF = Coincidence factor (= 0.1189)[2]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 8 years)[1]

Deemed Savings

Deemed Savings by Measure

MMID	Annual kWh_{SAVED}	kW_{SAVED}	Lifecycle kWh_{SAVED}
3548	20	0.0024	162
3549	30	0.0036	243
3550	35	0.0042	283
3551	50	0.0058	396

Assumptions

Incremental costs by lumen bin for CFL standard bulb:

- 310-749 lumens = $2.12 (cost assumed the same as measure 2116, CFL 9 Watt)
- 750-1,049 lumens = $1.28 (cost assumed the same as measure 2117, CFL 14 Watt)
- 1,050-1,489 lumens = $1.28 (cost assumed the same as measure 2117, CFL 19 Watt)
- 1,490-2,600 lumens = $1.94 (cost assumed the same as measure 2118, CFL 23 Watt)

Sources

1. Similar measure ID 2959, CFL Retail Store Markdown.
2. Cadmus. *Focus on Energy Evaluated Deemed Savings Changes*. November 14, 2014.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

2-Lamp F28T5, HPT8, RWT8 2x4 High- Efficiency Recessed Fixtures

	Measure Details
Measure Master ID	2 Lamp F28T5, HPT8, RWT8 2x4 High-Efficiency Recessed Fixtures, 2703
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Linear
Sector(s)	Commercial, Industrial, Agriculture, Schools & Government, Residential-multifamily
Annual Energy Savings (kWh)	Varies by type of fixture
Peak Demand Reduction (kW)	Varies by type of fixture
Annual Therm Savings (Therms)	None
Lifecycle Energy Savings (kWh)	Varies by type of fixture
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[3]
Incremental Cost ($/unit)	$50.00 Existing Buildings; $8.19 New Construction[4]

Measure Description

This measure is replacing 3-lamp or 4-lamp 4-footstandard T8 and T12 fixtures with 2-lamp F28T5, HPT8, RWT8 2x4 high-efficiency recessed fixtures.

Description of Baseline Condition

The baseline equipment is 3-lamp or 4-lamp 4-foot standard T8 and T12 fixtures.

Description of Efficient Condition

The efficient equipment is 2-lamp F28T5, HPT8, RWT8 2x4 high-efficiency recessed fixtures.

Annual Energy-Savings Algorithm

$$kWh_{SAVED} = kWh_{DEEMED} * (HOURS_{MULTIFAMILY} / HOURS_{COMMERCIAL})$$

Where:

kWh_{DEEMED} = Annual commercial deemed electricity savings

$HOURS_{MULTIFAMILY}$ = Annual multifamily deemed lighting hours

$HOURS_{COMMERCIAL}$ = Annual commercial deemed lighting hours

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = Wattage / 1,000 * CF

Where: CF=0.77 [1]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE}$ = kWh_{SAVED} * EUL

Where:

EUL = Effective useful life (= 15 years)[3]

Deemed Savings

Annual Deemed Savings[2]

Measure	Annual Energy Savings (kWh)	Coincident Peak Demand Reduction (kW)
4-Foot 2-Lamp T5 Fixtures	179.0	0.0231
4-Foot 2-Lamp T8 Fixtures	276.0	0.0355

Lifecycle Deemed Savings[2]

Measure	Energy Savings (kWh)
4-Foot 2-Lamp T5 Fixtures	2,685.0
4-Foot 2-Lamp T8 Fixtures	4,140.0

Assumptions

3,730 annual operating hours used. [1]

Sources

1. ACES. *Deemed Savings Desk Review*. Multifamily applications for common areas. November 3, 2010.
2. *Focus on Energy Business Programs Deemed Savings Manual V1.0*. Tables 4-190 and 4-208 Commercial Applications. March 22, 2010.
3. CA DEER EUL ID "ILtg-Lfluor-CommArea" "Linear Fluorescents - MF Common Area."
4. 2005 DEER D03-852 Database.
5. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 4-185 Commercial Applications. March 22, 2010.

Revision History

Version Number	Date	Description of Change
01	01/02/2013	New measure

8-Foot Linear Fluorescent T8 Replacement System Parking Garage

	Measure Details
Measure Master ID	T8 2-Lamp, 4-Foot, HPT8 or RWT8: Replacing T12 1-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage, 3144 Replacing T12 1-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage, 3145 Replacing T12HO 1-Lamp, 8-Foot, BF > 1.00, Parking Garage, 3148 Replacing T12HO 1-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage, 3149 Replacing T12HO 1-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage, 3150 T8 4-Lamp, 4-Foot, HPT8 or RWT8: Replacing T12 2-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage, 3146 Replacing T12 2-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage, 3147 Replacing T12HO 2-Lamp, 8-Foot, BF > 1.00, Parking Garage, 3151 Replacing T12HO 2-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage, 3152 Replacing T12HO 2-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage, 3153 Replacing T12VHO 2-Lamp, 8-Foot, BF > 1.00, Parking Garage, 3154 Replacing T12VHO 2-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage, 3155 Replacing T12VHO 2-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage, 3156
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Linear
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	Varies by measure
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	Varies by measure

Measure Description

High performance (HP) and reduced wattage (RW) 4-foot linear fluorescent lighting fixtures that use low ballast factors, high wattage lamps, or reduced wattage lamps are an energy-efficient alternative to 8-foot standard wattage T12, T12HO, and T12VHO linear fluorescent fixtures commonly found in parking garages within multifamily buildings. These products can be installed on a two-to-one basis to replace 1-lamp or 2-lamp T12 luminaires without sacrificing lighting quality.

Description of Baseline Condition

For existing building parking garages, the baseline measure is 8-foot, 1-lamp or 2-lamp, standard T12, T12HO, and T12VHO linear fluorescent fixtures.

Description of Efficient Condition

The efficient measure is 2-lamp or 4-lamp, 4-foot, high performance T8 fixtures with normal and low ballast factor, and reduced wattage, 25-watt and 28-watt T8s with high, normal, and low ballast factors.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{8' T12} - kWh_{HP/RW}$

Where:

$kWh_{8' T12}$ = Annual electricity consumption of an 8-foot, T12, T12HO, or T12VHO lamp linear fluorescent fixture

$kWh_{HP/RW}$ = Annual electricity consumption of a 4-foot linear fluorescent high performance or reduced wattage fixture

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = Wattage / 1,000 * CF

Where:

Wattage = Wattage used

1,000 = Kilowatt conversion factor

CF = Demand coincidence factor (= 1.0) [3]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED}$ * EUL

Where:

EUL = Effective useful life (= 15 years)[1]

Deemed Savings

Annual Deemed Savings for 8-Foot Linear Fluorescent T8 Replacement System Parking Garage

Measure	MMID	Existing Building	
		kWh	kW
T8 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12 1-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	3144	263	0.0301
T8 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12 1-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	3145	322	0.0368
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12 2-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	3146	303	0.0346
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12 2-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	3147	412	0.047
T8 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 1-Lamp, 8-Foot, BF > 1.00, Parking Garage	3148	473	0.0541
T8 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 1-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	3149	631	0.0721
T8 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 1-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	3150	690	0.0788
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 2-Lamp, 8-Foot, BF > 1.00, Parking Garage	3151	756	0.0863
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 2-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	3152	1,083	0.1236
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 2-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	3153	1,191	0.136
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO 2-Lamp, 8-Foot, BF > 1.00, Parking Garage	3154	2,271	0.2593
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO 2-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	3155	2,598	0.2966
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO 2-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	3156	2,707	0.309

Lifecycle Deemed Savings for 8-Foot Linear Fluorescent T8 Replacement System Parking Garage

Measure	MMID	Existing Building (kWh)
T8 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12 1-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	3144	3,945
T8 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12 1-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	3145	4,830
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12 2-Lamp, 8-	3146	4,545

Measure	MMID	Existing Building (kWh)
Foot, 0.78 < BF < 1.00, Parking Garage		
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12 2-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	3147	6,180
T8 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 1-Lamp, 8-Foot, BF > 1.00, Parking Garage	3148	7,095
T8 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 1-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	3149	9,465
T8 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 1-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	3150	10,350
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 2-Lamp, 8-Foot, BF > 1.00, Parking Garage	3151	11,340
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 2-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	3152	16,245
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 2-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	3153	17,865
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO 2-Lamp, 8-Foot, BF > 1.00, Parking Garage	3154	34,065
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO 2-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	3155	38,970
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO 2-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	3156	40,605

Measure Costs for 8-Foot Linear Fluorescent T8 Replacement System Parking Garage[2]

Measure	MMID	Existing Building Cost
T8 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12 1-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	3144	$41.00
T8 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12 1-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	3145	$41.00
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12 2-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	3146	$66.00
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12 2-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	3147	$66.00
T8 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 1-Lamp, 8-Foot, BF > 1.00, Parking Garage	3148	$41.00
T8 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 1-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	3149	$41.00
T8 2-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 1-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	3150	$41.00

Measure	MMID	Existing Building Cost
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 2-Lamp, 8-Foot, BF > 1.00, Parking Garage	3151	$66.00
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 2-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	3152	$66.00
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12HO 2-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	3153	$66.00
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO 2-Lamp, 8-Foot, BF > 1.00, Parking Garage	3154	$66.00
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO 2-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	3155	$66.00
T8 4-Lamp, 4-Foot, HPT8 or RWT8 Replacing T12VHO 2-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	3156	$66.00

Sources

1. California Energy Commission and California Public Utilities Commission. Database for Energy Efficient Resources (DEER) 2008. http://www.energy.ca.gov/deer/ .
2. Michigan Master Measure Database. 2011 baselines. Updated May 26, 2011.
3. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Commercial Applications. March 22, 2010.
4. ACES. *Deemed Savings Desk Review*. November 3, 2010.

Revision History

Version Number	Date	Description of Change
01	12/31/2012	New measure

Linear Fluorescent, 2-Lamp, 4-Foot, RWT8 Replacements, 24 Hours, CALP

	Measure Details
Measure Master ID	Linear Fluorescent, 2-Lamp, 4-Foot, RWT8 Replacements, 24 Hours, CALP, 3195
Measure Unit	Per fixture (lamps and ballast)
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Linear
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	307.00
Peak Demand Reduction (kW)	0.035
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by installation year
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	$110.90[2]

Measure Description

Reduced wattage (RW) 4-foot linear fluorescent lighting fixtures that use low ballast factors are an energy-efficient alternative to standard 40-watt or 34-watt linear T12 fluorescent products commonly found in multifamily buildings. These products can be installed on a one-for-one basis to replace 2-lamp T12 luminaires that are “on” 24 hours per day without sacrificing lighting quality.

Description of Baseline Condition

The baseline equipment for existing buildings is a standard 2-lamp T12 fixture.

Description of Efficient Condition

The efficient equipment is a reduced wattage, 2-lamp, 28-watt T8 with a low ballast factor.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{2L\ 4'\ T12} - kWh_{HP/RW}$

Where:

$kWh_{2L\ 4'\ T12}$ = Annual electricity consumption of 2-lamp T12 luminaire

$kWh_{HP/RW}$ = Annual electricity consumption of a 4-foot, linear fluorescent, high performance or low wattage fixture

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = Wattage / 1,000 * CF

Where:

Wattage = Wattage per fixtures

1,000 = Conversion

CF = Demand coincidence factor (= 1.0)[3]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[1]

Deemed Savings

Annual Deemed Savings for 4-Foot RWT8 Linear Fluorescents

Measure	Existing Building
Low Watt T8 System: 28-Watt, 2-Lamp, 4-Foot Ballast & Lamps ≤ 0.78	307 kWh 0.035 kW

Lifecycle Deemed Savings for 4-Foot RWT8 Linear Fluorescents*

Measure	Installation Year			
	2013	2014	2015	2016 and Beyond
Multifamily Common Area 4-Foot 2-Lamp T12 to T8	2,706.8 kWh 0.0350 kW	2,549.2 kWh 0.0350 kW	2,391.5 kWh 0.0350 kW	2,233.8 kWh 0.0170 kW

* kWh savings for products replacing T12 lamps calculated using the following methodology:

- Installed in 2013: receive three years T12 savings and 12 years EISA compliant T8 baseline savings.
- Installed in 2014: receive two years T12 savings and 13 years EISA compliant T8 baseline savings.
- Installed in 2015: receive one year T12 savings and 14 years EISA compliant T8 baseline savings.
- Installed in 2016: receive no T12 savings and 15 years of EISA compliant T8 baseline savings.

Measure Costs for 4-Foot RWT8 Linear Fluorescents

Measure	Existing Building Cost
Low Watt T8 System: 28-Watt, 2-Lamp, 4-Foot Ballast & Lamps ≤ 0.78	$110.90

Assumptions

Annual operating hours: 8,760. 2-lamp T12 fixtures used to generate baseline usage. For 2-lamp reduced wattage with low ballast factor, 28-watt, T8 lamps were used to calculate the new measure average annual energy savings.

Sources

1. *PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf*
2. RS Means Costworks 2007.
3. *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Commercial Applications. March 22, 2010.

Revision History

Version Number	Date	Description of Change
01	06/20/2013	New measure

Linear Fluorescent, 2-Lamp, 4-Foot, RWT8 Replacements, 12 Hours, CALP

	Measure Details
Measure Master ID	Linear Fluorescent, 2-Lamp, 4-Foot, RWT8 Replacements, 12 Hours, CALP, 3196
Measure Unit	Per fixture (lamps and ballast)
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Fluorescent, Linear
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	153.00
Peak Demand Reduction (kW)	0.0270
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by installation year
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost ($/unit)	$110.90[2]

Measure Description

Reduced wattage 4-foot linear fluorescent lighting fixtures that use low ballast factors are an energy-efficient alternative to standard 40-watt or 34-watt linear T12 fluorescent products commonly found in multifamily buildings. These products can be installed on a one-for-one basis to replace 2-lamp T12 luminaires without sacrificing lighting quality.

Description of Baseline Condition

The baseline equipment for existing buildings is a standard 2-lamp T12 fixture.

Description of Efficient Condition

The efficient equipment is a reduced wattage, 2-lamp, 28-watt T8 with a low ballast factor.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{2L\ 4'\ T12} - kWh_{HP/RW}$

Where:

$kWh_{2L\ 4'\ T12}$ = Annual electricity consumption of 2-lamp T12 luminaire

$kWh_{HP/RW}$ = Annual electricity consumption of a 4-foot, linear fluorescent, high performance or low wattage fixture

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = Wattage / 1,000 * CF

Where:

Wattage = Wattage per fixtures

1,000 = Conversion

CF = Demand coincidence factor (= 0.77)[3]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE}$ = kWh_{SAVED} * EUL

Where:

EUL = Effective useful life (= 15 years)[1]

Deemed Savings

Annual Deemed Savings for 4-Foot RWT8 Linear Fluorescents

Measure	Existing Building
Low Watt T8 System: 28-Watt, 2-Lamp, 4-Foot Ballast & Lamps ≤ 0.78	153 kWh 0.0270 kW

Lifecycle Deemed Savings for 4-Foot RWT8 Linear Fluorescents*

Measure	Installation Year			
	2013	2014	2015	2016 and Beyond
Multifamily Common Area 4-Foot 2-Lamp T12 to T8	1,353.4 kWh 0.0270 kW	1,274.6 kWh 0.0270 kW	1,195.7 kWh 0.0270 kW	1,116.9 kWh 0.0131 kW

* kWh savings for products replacing T12 lamps calculated using the following methodology:

- Installed in 2013: receive three years T12 savings and 12 years EISA compliant T8 baseline savings.
- Installed in 2014: receive two years T12 savings and 13 years EISA compliant T8 baseline savings.
- Installed in 2015: receive one year T12 savings and 14 years EISA compliant T8 baseline savings.
- Installed in 2016: receive no T12 savings and 15 years of EISA compliant T8 baseline savings.

Measure Costs for 4-Foot RWT8 Linear Fluorescents

Measure	Existing Building Cost
Low Watt T8 System: 28-Watt, 2-Lamp, 4-Foot Ballast & Lamps ≤ 0.78	$110.90

Assumptions

Annual operating hours: 4,380

2-lamp T12 fixtures used to generate baseline usage.

For 2-lamp reduced wattage with low ballast factor, 28-watt, T8 lamps were used to calculate the new measure average annual energy savings.

Sources

1. *PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf*
2. *RS Means Costworks 2007.*
3. *Focus on Energy Business Programs Deemed Savings Manual V1.0*. Commercial Applications. March 22, 2010.

Revision History

Version Number	Date	Description of Change
01	06/20/2013	New measure

LED, Direct Install, 9.5 Watt

	Measure Details
Measure Master ID	LED, Direct Install, 9.5 Watt, 3279
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	42
Peak Demand Reduction (kW)	0.0031
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	840
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1] (in unit only)
Incremental Cost	$7.07

Measure Description

ENERGY STAR-rated LED replacement lamps save energy by reducing the total input wattage of the luminaire as compared to the same luminaire operating with standard wattage incandescent lamps. This measure provides an energy-efficient alternative to using incandescent lamps in several applications.

Description of Baseline Condition

An average of 16.67% each of EISA compliant standard 53-watt incandescent, 60-watt incandescent and halogen, 65-watt incandescent, 70-watt halogen, 72-watt halogen, and 80-watt halogen lamps were used to generate the baseline usage. Existing lamps above 80 watts will be replaced by CFL lamps and are not part of this measure.

Description of Efficient Condition

The efficient condition is an ENERGY STAR-rated, 9.5-watt LED lamp.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = [(Watts_{INCAN} - Watts_{LED}) / 1{,}000] * HOU$

Where:

$Watts_{INCAN}$ = Electricity consumption of standard incandescent lamp (= 53 watts, 60 watts, 65 watts, 70 watts, 72 watts, or 80 watts)

$Watts_{LED}$ = Electricity consumption of ENERGY STAR-rated LED lamp with a lumen output rating (= 9.5 watts)

1,000 = Kilowatt conversion

HOU = Hours-of-use (= 734)[2]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = [(Watts_{INCAN} - Watts_{LED}) / 1{,}000] * CF$

Where:

CF = Coincidence factor (= 0.055)[3]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 15 years)[1]

Sources

1. Cadmus review of manufacturers measure life; capped at 20 years.
2. Cadmus. *Focus on Energy Evaluated Deemed Savings Changes: 2014 Final Report*. November 6, 2014. Available online: https://focusonenergy.com/sites/default/files/FoE_Deemed_WriteUp%20CY14%20Final.pdf.
3. ACES. *Default Deemed Savings Review Final Report.* Table 4-1 MF housing (in unit). June 24, 2008. Available online: http://www.coned.com/documents/Con%20Edison%20Callable%20Load%20Study_Final%20Report_5-15-08.pdf. CF of 65% to 83% is within range of similar programs.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

LED, Omnidirectional, Retail Store Markdown

	Measure Details
Measure Master ID	LED, Omnidirectional, Retail Store Markdown: 310-749 Lumens, 3553 750-1,049 Lumens, 3554 1,050-1,489 Lumens, 3555 1,490-2,600 Lumens, 3556
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Residential – Single family; Residential Multi family
Annual Energy Savings (kWh)	Varies by light output
Peak Demand Reduction (kW)	Varies by light output
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by light output
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	15[1]
Incremental Cost	$12.50[3]

Measure Description

This measure is installing an ENERGY STAR-certified omnidirectional LED bulb that is purchased through a retail outlet to replace an incandescent or halogen bulb. The assumptions were based on a time-of-sale purchase for installation in a residential location.

Description of Baseline Condition

The baseline equipment is a general service incandescent light bulb (standard or EISA compliant halogen). The wattage of the baseline bulb is determined by the lumens equivalence method.

Description of Efficient Condition

The efficient equipment is an ENERGY STAR-certified omnidirectional LED bulb. The actual wattage of the installed bulb will be used to evaluate savings.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1{,}000 * HOU$

Where:

$Watts_{BASE}$ = Power consumption of baseline measure (= see table below)

$Watts_{EE}$ = Power consumption of efficient measure (= see table below)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 1,011)[1]

Power Consumption of Baseline and Efficient Measures by Lumen Bin

Lumen Bin	Mean Wattage of Omnidirectional LED Bulbs[2]	EISA Compliant Baseline Wattages[4]
310-749	6.94	29
750-1,049	10.57	43
1,050-1,489	12.93	53
1,490-2,600	17.27	72

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{EE})/1{,}000 * CF$

Where:

CF = Coincidence factor (= 0.1189)[2]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 20 years)[1]

Deemed Savings

The deemed savings were calculated using the mean wattage of the omnidirectional bulbs in the approved ENERGY STAR Qualified Product List, available December 5, 2014. The mean wattage values are shown in the table below.

Mean Savings Values by Lumen Bin

Lumens Bin	MMID	Annual Energy Savings (kWh)	Lifecycle Energy Savings (kWh)	Coincident Peak Demand Reduction (kW)
310-749	3553	22	335	0.0026
750-1,049	3554	33	492	0.0039
1,050-1,489	3555	41	608	0.0048
1,490-2,600	3556	55	830	0.0065

Sources

1. Cadmus review of manufacturers measure life.
2. ENERGY STAR. *Qualified Products List*. December 5, 2014. Mean wattage of omnidirectional LEDs falling within the specified lumens bin.
3. Focus on Energy. *Incremental Cost Database*. 2014. Cost assumed the same as measure 3385, LED, Non PI Direct Install, 13.5 Watt.
4. Cadmus. Research based on EISA 2007 backstop legislation. https://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/eisa_2007.pdf

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

LED, Direct Install, 10 Watt

	Measure Details
Measure Master ID	LED, Direct Install, 10 Watt, 3488, 3567
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Residential– single family
Annual Energy Savings (kWh)	27
Peak Demand Reduction (kW)	0.0025
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	540
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Incremental Cost	$12.50

Measure Description

This measure is the Program Implementer or a subcontractor of the Program Implementer installing a 10-watt ENERGY STAR-qualified screw-in LED in place of an incandescent screw-in bulb. The incremental cost of the LED compared to the incandescent light bulb is the full installed cost. Assumptions are based on a direct installation, not a time-of-sale purchase. Replacement involves a functioning bulb.

Description of Baseline Condition

The baseline equipment is a 43-watt or 60-watt incandescent light bulb. The baseline of 43 watts was used to calculate savings for both cases.

Description of Efficient Condition

This measure applies to standard screw-based 10-watt LED lamps.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} - Watts_{EE})/1{,}000 * HOU$

Where:

$Watts_{BASE}$ = Baseline wattage (= 43)

$Watts_{EE}$ = Efficient wattage (= 10)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 829)

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1,000 * CF$

Where:

CF = Coincidence factor (= 0.075)[1]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 20 years)[1]

Sources

1. Cadmus review of manufacturers measure life; capped at 20 years.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

LED, Direct Install, 13.5 Watt

	Measure Details
Measure Master ID	LED, Direct Install, 13.5 Watt, 3385, 3439
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	39
Peak Demand Reduction (kW)	0.0035
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	780
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Incremental Cost	$12.50

Measure Description

This measure is the Program Implementer or a subcontractor of the Program Implementer installing a 13.5-watt ENERGY STAR-qualified screw-in LED in place of an incandescent screw-in bulb. The incremental cost of the LED compared to the incandescent light bulb is the full installed cost. Savings are based on a direct installation, not a time-of-sale purchase.

Description of Baseline Condition

The baseline equipment is a 43-watt or 60-watt incandescent light bulb. Energy savings are evaluated using a baseline of 43 watts.

Description of Efficient Condition

This measure applies to standard screw-based 13.5-watt LED lamps.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1{,}000 * HOU$

Where:

$Watts_{BASE}$ = Baseline wattage (= 60)

$Watts_{EE}$ = Efficient wattage (= 13.5)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 829)[2]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{BASE} - Watts_{EE}) / 1{,}000 * CF$

Where:

CF = Coincidence factor (= 0.075)[2]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 20 years)[1]

Sources

1. Cadmus review of manufacturers' measure life.
2. Cadmus. *Focus on Energy Evaluated Deemed Savings Changes*. November 6, 2013.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

LED, Reflector, 12 Watt, Retail Store Markdown

	Measure Details
Measure Master ID	LED, Reflector, 12 Watt, Retail Store Markdown, 3557
Measure Unit	Per reflector
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Upstream
Annual Energy Savings (kWh)	54
Peak Demand Reduction (kW)	0.0063
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	1,080
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Incremental Cost	$8.08

Measure Description

This measure is installing an ENERGY STAR-certified LED reflector or LED recessed downlight that is purchased through a retail outlet to replace an incandescent bulb. The savings are based on a time-of-sale purchase for installation in a residential location.

Description of Baseline Condition

The baseline is an incandescent 65-watt reflector or downlight. Reflectors are exempt from EISA legislation.[3]

Description of Efficient Condition

The efficient equipment is a standard screw-based 12-watt ENERGY STAR-certified LED reflector or downlight.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (Watts_{BASE} – Watts_{EE}) / 1,000 * HOU$

Where:

$Watts_{BASE}$ = Power consumption of baseline measure (= 65 watts)

$Watts_{EE}$ = Power consumption of efficient measure (= 12 watts)

1,000 = Kilowatt conversion factor

HOU = Hours-of-use (= 1,011)[2]

Summer Coincident Peak Savings Algorithm

kW_{SAVED}= ($Watts_{BASE}$ - $Watts_{EE}$) / 1,000 * CF

Where:

CF = Coincidence factor (= 0.1189)[2]

Lifecycle Energy-Savings Algorithm

KWhLIFECYCLE = kWh_{SAVED} * EUL

Where:

EUL = Effective useful life (= 20 years) [1]

Assumptions

A 65-watt baseline is used based on 2014 Focus on Energy Residential Lighting CFL data revealing that 65-watt replacements represented 96% of reflector sales. The table below shows total 2014 reflector sales by baseline wattage.

Total 2014 Reflector Sales by Baseline Wattage

Baseline Wattage	Total Reflector Units Sold in 2014	Percentage of Total Reflector Sales
50	6,433	1%
65	71,5395	96%
75	2,137	0%
100	19,503	3%
Total	**743,468**	**100%**

Sources

1. Cadmus review of manufacturers measure life; capped at 20 years.
2. Cadmus. *Focus on Energy Evaluated Deemed Savings Changes.* November 14, 2014.
3. EISA 2007 legislation. https://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/eisa_2007.pdf

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

LED Fixture, Interior, Above 12 Hours to 24 Hours- CALP

	Measure Details
Measure Master ID	LED Fixture, Interior, 12 Hours, CALP, 3603 LED Fixture, Interior, 24 Hours, CALP, 3604
Measure Unit	Per fixture
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by measure
Peak Demand Reduction (kW)	Varies by measure
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by measure
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	12 hour: 6 and 24 hour:13 [1]
Incremental Cost ($/unit)	$80.13[2]

Measure Description

This measures is installing hardwired LEDs to complete new fixtures. Incentives are only provided for replacing incandescent fixtures. LEDs provide the same or better light output than incandescent lamps while using significantly less energy.

Description of Baseline Condition

The baseline condition is a 1-lamp 72-watt, 65-watt, 43-watt, or 29-watt; a 2-lamp 43-watt or 29-watt; or a 3-lamp 29-watt incandescent fixture on a switch, photocell, or timer that is used for 12 or more hours per day up to 24 hours a day.

Description of Efficient Condition

LED incentives apply only to complete, new, hardwired fixtures that are ENERGY STAR or DLC qualified and meet the EISA lumen equivalency of their incandescent baselines. Incentives are only for replacing incandescent fixtures.

The contractor and/or Program Implementer verifies the hours-of-use during assessments and/or pre-installs. Typically, lights in the common areas are on for 24 hours, especially those in interior spaces and corridors, and are on for 12 to 16 hours on timers or photocells in the entries and/or lobbies with windows.

The effective useful life of this measure is based on the average rated hours for qualifying products, divided by 12 hours and 24 hours, then rounded.

Annual Energy-Savings Algorithm

KWhSAVED = (Watts$_{INCANDESCENT}$ - Watts$_{LED}$) / 1,000 * HOU

Where:

Watts$_{INCANDESCENT}$ = Power consumption of baseline measure (= 63.7 watts;[3] see table below)

Baseline Wattage

Baseline Bulb	Wattage	Weighting	Contribution to Baseline (watts)
1L EISA 100w incand	72	5%	3.60
1L 65w BR30 incand	65	25%	16.25
2L EISA 60w incand	86	25%	21.50
1L EISA 60w incand	43	25%	10.75
3L EISA 40w incand	87	5%	4.35
2L EISA 40w incand	58	10%	5.80
1L EISA 40w incand	29	5%	1.45
Total		**100%**	**63.70**

Watts$_{LED}$ = Power consumption of efficient measure (= 20.93 watts;[4] see table below)

Efficient Wattage

Bulb	Wattage	Weighting	Contribution to Efficient (watts)
LED (1,490-2,600 lumens) replacing 1L EISA 100w incand	32.14	5%	1.6000
LED (600-750 lumens) replacing 1L 65w BR30 incand	13.03	25%	3.2575
LED (750-1,049 lumens) replacing 2L EISA 60w incand	31.18	25%	7.7950
LED (750-1,049 lumens) replacing 1L EISA 60w incand	15.59	25%	3.8975
LED (310-749 lumens) replacing 3L EISA 40w incand	32.81	5%	1.6405
LED (310-749 lumens) replacing 2L EISA 40w incand	21.88	10%	2.1880
LED (310-749 lumens) replacing 1L EISA 40w incand	10.94	5%	0.5470
Total		**100%**	**20.9325**

1,000 = Kilowatt conversion factor

HOU = Average annual hours-of-use (= 4,380 for 12-hour use; = 8,760 for 24-hour use)

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (Watts_{INCANDESCENT} - Watts_{LED}) / 1{,}000 * CF$

Where:

CF = Coincidence factor (= 0.0 to 1.0 for 24-hour use)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = = 12 hour: 6 and 24 hour: 13 [1]

Deemed Savings

Annual Savings

Measure	MMID	Multifamily	
		kWh	kW
LED Fixture, Interior, 12 Hours, CALP	3603	187	0.0000
LED Fixture, Interior, 24 Hours, CALP	3604	375	0.0428

Lifecycle Savings

Measure	MMID	Multifamily (kWh)
LED Fixture, Interior, 12 Hours, CALP	3603	2,431
LED Fixture, Interior, 24 Hours, CALP	3604	2,250

Assumptions

Lamp weightings were developed through previous CALP workpapers and based on typical lamp wattages in common area light fixtures such as downlights, wall sconces, and flush/ceiling mounts, using typical lamping configuration data from manufacturers. This information was gathered from previous 12-hour and 24-hour use CFL fixture installations, field assessments in 2014, and data on currently available qualifying fixtures.

Sources

1. ENERGY STAR. "ENERGY STAR Certified Light Bulbs." Accessed January 30, 2015. https://www.energystar.gov/productfinder/product/certified-light-bulbs/results. Filtered EUL per respective incandescent lumen equivalency and indoor application type, rounded to whole number. EULs based on average rated hours for qualifying products, divided by 12-hours and 24-hours usage.
2. "LED Fixture, Downlights, Accent Lights and Monopoint, 18 Watts, Common Area." Incremental cost from similar SPECTRUM MMID 2984; and: Incremental Cost Workbook Final Reconciliation. January 2015.
3. EISA equivalent wattages for common incandescent lamps.
4. Average wattage of equivalent qualifying ENERGY STAR and DLC-listed LED fixtures as of January 30, 2015.

Revision History

Version Number	Date	Description of Change
01	01/30/2015	New measure
02	03/30/2015	Revised and combined 12 hour and 24 hour workpapers

LED, ENERGY STAR, Replacing Incandescent ≤ 40 Watts

	Measure Details
Measure Master ID	LED, ENERGY STAR, Replacing Incandescent ≤ 40 Watts: In Unit, 3161 Common Area, 3162
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	In Unit= 20; Common Area = 7[1]
Incremental Cost ($/unit)	$15.00[2]

Measure Description

ENERGY STAR-rated LED replacement lamps save energy by reducing the total input wattage of the luminaire compared to using standard wattage incandescent lamps. This measure is an energy-efficient alternative to incandescent lamps in several applications.

Description of Baseline Condition

The baseline measure is standard 25-watt and 40-watt incandescent lamps.

Description of Efficient Condition

The efficient equipment is an ENERGY STAR-rated LED that appears on the "ENERGY STAR® SSL Qualified Light Bulbs" list and is 5 watts to 9 watts.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{INCANDESCENT} - kWh_{LED}$

Where:

$KWh_{INCANDESCENT}$ = Annual electricity consumption of standard 25-watt or 40-watt incandescent lamp

KWh_{LED} = Annual electricity consumption of reduced wattage ENERGY STAR-rated lamp of equivalent lumen output to ≤ 40 watt incandescent

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = Wattage / 1,000 * CF$

Where:

Wattage = Wattage of fixture

1,000 = Conversion factor

CF = Demand coincidence factor (= 0.082 for in-unit; = 0.775 for common area)[4]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 20 years in unit; = 7 years common area)[1]

Deemed Savings

Average Annual Deemed Savings for LED Replacing Incandescent Lamp ≤ 40 Watts

Measure	MMID	Existing Building	New Construction
LED Replacing Incandescent Lamp ≤ 40 Watts, In Unit	3161	23.0 kWh 0.0022 kW	23.0 kWh 0.0022 kW
LED Replacing Incandescent Lamp ≤ 40 Watts, Common Area	3162	160.0 kWh 0.0207 kW	160.0 kWh 0.0207 kW

Average Lifecycle Deemed Savings for LED Replacing Incandescent Lamp ≤ 40 Watts

Measure	MMID	Existing Building	New Construction
LED Replacing Incandescent Lamp ≤ 40 Watts, In Unit	3161	667 kWh	667 kWh
LED Replacing Incandescent Lamp ≤ 40 Watts, Common Area	3162	640 kWh	640 kWh

Assumptions

Common Area (MMID 3162):

- Annual operating hours: 5,949.5
- Assumes 40-watt and 25-watt incandescent lamps in calculation of baseline usage
- Assumes average ENERGY STAR-rated LED (5.64 watts) for ≤ 40 watt replacement products

In Unit (MMID 3161):

- Annual operating hours: 839.5
- Assumes 40-watt and 25-watt incandescent lamps in calculation of baseline usage
- Assumes average ENERGY STAR-rated LED (5.64 watts) for ≤ 40 watt replacement products

Sources

1. Cadmus review of manufacturers' measure life; in unit capped at 20 years.
2. Based on market knowledge. Data gathered December 15, 2012.
3. ACES. Deemed Savings Desk Review. November 3, 2010.
4. ACES. Default Deemed Savings Review Final Report. June 24, 2008.
5. Focus on Energy Business Programs Deemed Savings Manual V1.0. Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.

Revision History

Version Number	Date	Description of Change
01	12/27/2012	New measure

LED, ENERGY STAR, Replacing Incandescent > 40 Watts

	Measure Details
Measure Master ID	LED, ENERGY STAR, Replacing Incandescent > 40 Watts: In Unit, 3159 Common Area, 3160
Measure Unit	Per lamp
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	In Unit = 20; Common Area = 7[1]
Incremental Cost ($/unit)	$25.00[2]

Measure Description

ENERGY STAR-rated LED replacement lamps save energy by reducing the total input wattage of the luminaire as compared to the same luminaire operating with standard wattage incandescent lamps. This measure provides an energy-efficient alternative to incandescent lamps in several applications.

Description of Baseline Condition

The baseline measure is standard 60-watt, 65-watt, 75-watt, 90-watt, 100-watt, and 120-watt incandescent lamps.

Description of Efficient Condition

The efficient measure is an ENERGY STAR-rated LED.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{LED} - kWh_{INCANDESCENT}$

Where:

KWh_{LED} = Annual electricity consumption of ENERGY STAR-rated LED with a lumen output rating equivalent to a > 40-watt incandescent

$KWh_{INCANDESCENT}$ = Annual electricity consumption of standard 60-watt, 65-watt, 75-watt, 90-watt, 100-watt, or 120-watt incandescent lamp

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = Wattage / 1{,}000 * CF$

Where:

Wattage = Unit wattage

1,000 = Conversion factor

CF = Demand coincidence factor (= 0.77 common area; = 0.0825 in-unit)[4]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 7 years in unit; = 20 years common area)[1]

Deemed Savings

Average Annual Deemed Savings for LED Lamp Replacing Incandescent Lamp > 40 Watts

Measure	MMID	Existing Building	New Construction
LED Replacing Incandescent Lamp > 40 Watts, In Unit	3159	58.0 kWh 0.0057 kW	43.0 kWh 0.0042 kW
LED Replacing Incandescent Lamp > 40 Watts, Common Area	3160	414.0 kWh 0.0536 kW	305.0 kWh 0.0395 kW

Average Lifecycle Deemed Savings for LED Lamp Replacing Incandescent Lamp > 40 Watts

Measure	MMID	Existing Building	New Construction
LED Replacing Incandescent Lamp > 40 Watts, In Unit	3159	2,378 kWh	1,763 kWh
LED Replacing Incandescent Lamp > 40 Watts, Common Area	3160	2,070 kWh	1,525 kWh

Assumptions

Existing Building/Common Area: Assumes 5,949.5 annual operating hours

- An average of 16.67% each of 60-watt, 65-watt, 75-watt, 90-watt, 100-watt, and 120-watt incandescent lamps was used to generate baseline usage
- An average of 33% each of 11.68-watt, 16.70-watt, and 17.81-watt ENERGY STAR-rated LEDs was used to generate new measure usage

Existing Building/In Unit: Assumes 839.5 annual operating hours

- An average of 16.67% each of 60-watt, 65-watt, 75-watt, 90-watt, 100-watt, and 120-watt incandescent lamps was used to generate baseline usage
- An average of 33% each of 11.68-watt, 16.70-watt, and 17.81-watt ENERGY STAR-rated LEDs was used to generate new measure usage

New Construction/Common Area: Assumes 5,939.5 annual operating hours

- An average of 16.67% each of 53-watt incandescent, 60-watt incandescent and halogen, 65-watt incandescent, 70-watt halogen, 72-watt halogen, and 80-watt halogen lamps was used to generate the baseline usage
- An average of 33% each of 11.68-watt, 16.70-watt, and 17.81-watt ENERGY STAR-rated LEDs was used to generate new measure usage

New Construction / In Unit: Assumes 839.5 annual operating hours

- An average of 16.67% each of 53-watt incandescent, 60-watt incandescent and halogen, 65-watt incandescent, 70-watt halogen, 72-watt halogen, and 80-watt halogen lamps was used to generate the baseline usage
- An average of 33% each 11.68-watt, 16.70-watt, and 17.81-watt ENERGY STAR-rated LEDs was used to generate new measure usage

Sources

1. Cadmus review of manufacturers measure life; capped at 20 years.
2. Based on market knowledge.
3. ACES. *Deemed Savings Desk Review.* November 3, 2010.
4. *Focus on Energy Business Programs Deemed Savings Manual V1.0*. Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.
5. ACES. *Default Deemed Savings Review Final Report*. June 24, 2008.

Revision History

Version Number	Date	Description of Change
01	12/26/2012	New measure

ENERGY STAR LED Porch Fixtures

	Measure Details
Measure Master ID	ENERGY STAR LED Porch Fixtures, 3157
Measure Unit	LED Porch Luminaire
Measure Type	Prescriptive
Measure Group	Lighting
Measure Category	Light Emitting Diode (LED)
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	77.0 Existing Building; 58.0 New Construction
Peak Demand Reduction (kW)	0
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	1,155 Existing Building; 870 New Construction
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Incremental Cost ($/unit)	$40.00 Existing Building; $40.00 New Construction[2]

Measure Description

ENERGY STAR-qualified LED porch lights are verified to meet both performance and efficiency thresholds, which ensures that an LED product's performance is similar to other time-tested technologies used for the same applications and meets ENERGY STAR efficiency criteria.

Description of Baseline Condition

The baseline condition is standard, screw-based incandescent lamps/luminaires.

Description of Efficient Condition

The efficient equipment is an ENERGY STAR-rated LED porch light.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = kWh_{STANDARD} - kWh_{ES}$

Where:

$kWh_{STANDARD}$ = Annual electricity consumption of standard incandescent porch luminaire

kWh_{ES} = Annual electricity consumption of ENERGY STAR-rated LED porch luminaire

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = kWh_{SAVED} / HOURS * CF$

Where:

HOURS = Average annual run hours (= 1,131.5)[3]

CF = Demand coincidence factor (= 0.082)[3]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 20 years)[1]

Deemed Savings

Average Annual Deemed Savings for ENERGY STAR-Rated LED Porch Fixtures

Measure	Existing Building	New Construction
ENERGY STAR-Rated LED Porch Fixtures	77 kWh	58 kWh

Average Lifecycle Deemed Savings for ENERGY STAR-Rated LED Porch Fixtures

Measure	Existing Building	New Construction
ENERGY STAR-Rated LED Porch Fixtures	1,155 kWh	870 kWh

Assumptions

It was assumed the annual operating hours are 1,131.5.[3]

For existing buildings, an average of 33% 60 watt, 33% 75 watt, and 33% 100-watt A-19 halogen and incandescent lamps that meet EISA 2007 as of January 1, 2013 were used to generate the baseline usage.

For new construction, an average of 33% 53 watt, 33% 60 watt, and 33% 72-watt lamps were used to generate the baseline usage.

Sources

1. Cadmus review of manufacturers measure life; capped at 20 years.
2. 2008 DEER EUL Summary. ID "Oltg-LED" "LED Lighting"
3. ACES. *Default Deemed Savings Review Final Report*. June 24, 2008.

Revision History

Version Number	Date	Description of Change
01	12/26/2012	New measure

Motors and Drives

ECM, Furnace or Air Handler

	Measure Details
Measure Master ID	ECM, Furnace, New or Replacement, 2989
Measure Unit	Per motor
Measure Type	Prescriptive
Measure Group	Motors and Drives
Measure Category	Motor
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	415
Peak Demand Reduction (kW)	0.0792
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	7,470
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	18[1]
Incremental Cost	$172.00

Measure Description

Conventional natural gas furnaces and air handlers contain a PSC blower motor to deliver the treated air to the home. This motor can be replaced with a brushless DC motor, commonly called an ECM, for electrical savings.

Description of Baseline Condition

The baseline is a furnace or air handler with a PSC motor.

Description of Efficient Condition

The efficient condition is an ECM motor replacing a PSC motor in a furnace or air handler.

Annual Energy-Savings Algorithm

$$\text{kWh}_{\text{SAVED}} = \Delta\text{kWh}_{\text{COOL}} + \Delta\text{kWh}_{\text{HEAT}} + \Delta\text{kWh}_{\text{CIRC}}$$

$$\text{kWh}_{\text{COOL}} = \text{Tons} * \text{EFLH}_{\text{COOL}} * 12\ \text{kBTU/ton} * (1/\text{SEER}_{\text{BASE}} - 1/\text{SEER}_{\text{ECM}}) * \%\ \text{AC}$$

$$\text{kWh}_{\text{HEAT}} = \text{HOURS}_{\text{HEAT}} * \Delta\text{kW}_{\text{HEAT}}$$

$kWh_{CIRC} = HOURS_{CIRC} * \Delta kW_{CIRC}$

Where:

$Tons$ = Air conditioner capacity in tons (= 2.425)[2]

$EFLH_{COOL}$ = Equivalent full-load cooling hours (= see table below)[2]

Equivalent Full Load Cooling Hours by Location

Location	$EFLH_{COOL}$	Weighting by Participant
Green Bay	344	22%
Lacrosse	323	3%
Madison	395	18%
Milwaukee	457	48%
Wisconsin Average	380	9%
Overall	**410**	

$SEER_{BASE}$ = Baseline SEER (= 12)[2]

$SEER_{ECM}$ = Efficient condition SEER (= 13)[2]

% AC = Amount of furnaces with AC (= 92.5%)[2]

$HOURS_{HEAT}$ = Hours of heating operation (= 1,158)[2]

ΔkW_{HEAT} = Energy savings in heating (= 0.116 kW)[2]

$HOURS_{CIRC}$ = Hours of fan-only operation (= 1,020)[2]

ΔkW_{CIRC} = Energy savings in fan-only (= 0.207 kW)[2]

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = Tons * 12kBtu/ton * (1/EER_{BASE} – 1/EER_{ECM}) * CF * \%AC$

Where:

EER_{BASE} = Baseline EER (= 10.5)[2]

EER_{ECM} = Efficient condition EER (= 11)[2]

CF = Coincidence factor (= 68%)[2]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 18 years)[1]

Sources

1. PA Consulting Group Inc. State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study. Final Report. August 25, 2009. Available online: https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf

2. *Focus on Energy, Deemed Savings Report*. November 14, 2014.

Revision History

Version Number	Date	Description of Change
01	01/2015	Initial TRM entry

Air Source Heat Pump, ≥ 16 SEER

	Measure Details
Measure Master ID	Air Source Heat Pump, ≥ 16 SEER, 2992
Measure Unit	Per heat pump
Measure Type	Prescriptive
Measure Group	HVAC
Measure Category	Other
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	933
Peak Demand Reduction (kW)	0.2823
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	16,794
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	18[1]
Incremental Cost	$1,274.10[2]

Measure Description

A residential-sized air-source heat pump has an input capacity of ≤ 65,000 Btu/hour. The deemed measure algorithms and associated savings for the air-source heat pump were derived from the use of the Illinois Statewide Technical Reference Manual – Section 5.3.1 Air Source Heat Pumps.[2]

Description of Baseline Condition

The baseline measure is a federal standard baseline air-source heat pump of SEER 13 and HSPF 7.7.[2]

Description of Efficient Condition

The efficient measure is a residential-sized air-source heat pump of SEER 16 and HSPF 8.4.[2]

Annual Energy-Savings Algorithm

$$kWh_{SAVED} = ((EFLH_{COOL} * CAP * (1/SEER_{BASE} - 1/SEER_{EE}))/ 1{,}000) + ((EFLH_{HEAT} * CAP * (1 / HPSF_{BASE} - 1 / HSPF_{EE})) / 1{,}000)$$

Where:

$EFLH_{COOL}$ = Equivalent full-load cooling hours (= 321)

CAP = Capacity (= 37,000 Btu/hour)

$SEER_{BASE}$ = Baseline seasonal energy efficiency ratio (= 13)

$SEER_{EE}$ = Efficient measure seasonal energy efficiency ratio (= 16)

1,000 = Kilowatt conversion factor

$EFLH_{HEAT}$ = Equivalent full-load heating hours (= 1,909)[3]

$HSPF_{BASE}$ = Baseline heating seasonal performance factor (= 7.7)

$HSPF_{EE}$ = Efficient measure heating seasonal performance factor (= 8.4)

Summer Coincident Peak Savings Algorithm

$kW_{SAVED} = (CAP * (1/ EER_{BASE} – 1 / EER_{EE})) / 1{,}000 * CF$

Where:

EER_{BASE} = Baseline energy efficiency ratio (= 11.2)[2]

EER_{EE} = Efficient energy efficiency ratio (= 12.8)[2]

CF = Coincidence factor (= 0.68)[4]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (=18 years)[1]

Assumptions

Measure characteristics assume an all-electric heated and cooled home.

The capacity of residential heat pumps is assumed to be 3.1 tons for equipment installed in the Wisconsin market, based on analysis of 75 air-source heat pumps installed between 2013 and 2015 through the Focus on Energy Residential Prescriptive Program. At 12,000 Btu/hour per ton, the assumed average capacity is 37,200 Btu/hr.

Supporting inputs for heating load hours in several Wisconsin cities are shown in the table below.

Equivalent Full Load Heating Hours by Location

Location	$EFLH_{HEAT}$ [3]
Green Bay	1,852
La Crosse	1,966
Madison	1,934
Milwaukee	1,883
Wisconsin Average	**1,909**

Incremental cost is based on the Illinois TRM reported IMC of $411/ton, multiplied by an installed capacity of 3.1 tons.

Cooling hours are based on the cooling hours for an air conditioner in the Deemed Savings Report[4] adjusted for the larger capacity system (410 hours at 2.425 tons is equivalent to 284 hours at 3.5 tons).

Sources

1. 2007 GDS study for New England working group: http://www.iar.unicamp.br/lab/luz/ld/Arquitetural/interiores/ilumina%E7%E3o%20industrial/measure_life_GDS.pdf.
2. Illinois Energy Efficiency Statewide Advisory Group. *Illinois Statewide Technical Reference Manual.* February 2014. Available online: http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_3/Final_Draft/Illinois_Statewide_TRM_Effective_060114_Version_3%200_021414_Final_Clean.pdf
3. Several Cadmus metering studies reveal that the ENERGY STAR calculator EFLH are over-estimated by 25%. The heating EFLH were adjusted by population-weighted HDD and TMY-3 values.
4. Focus on Energy, Deemed Savings Report. November 14, 2014.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry
02	01/2015	Updated EFLH

Other

Multifamily Benchmarking Incentive

	Measure Details
Measure Master ID	Multifamily Benchmarking Incentive, 2746
Measure Unit	Per application
Measure Type	Custom
Measure Group	Other
Measure Category	Other
Sector(s)	Residential- multifamily
Annual Energy Savings (kWh)	Varies by project
Peak Demand Reduction (kW)	Varies by project
Annual Therm Savings (Therms)	Varies by project
Lifecycle Energy Savings (kWh)	Varies by project
Lifecycle Therm Savings (Therms)	Varies by project
Water Savings (gal/yr)	0
Effective Useful Life (years)	Varies by project
Incremental Cost ($/unit)	$0.00 (no cost in addition to initial project cost)

Measure Description

This measure is benchmark tracking incentives, which are progressive, require 12 months of pre-project utility usage, 12 months of post-project completion usage for tracking participation, and are awarded for projects that exceed projected energy savings. The incentive amount is based on the levels of energy savings and peak demand reduction. Owners may sign up for benchmarking at Tier 1 and Tier 2 incentive levels when submitting a custom application, but Tier 3 benchmarking is mandatory to validate these savings because the most savings and financial risk is associated with Tier 3:

- Tier 1 Benchmarking (initial project savings < 15%): $0.40/therm, $0.03/kWh, and $50/peak kW
- Tier 2 Benchmarking (initial project savings > 15%): $0.63/therm, $0.04/kWh, and $75/peak kW
- Tier 3 Benchmarking (initial project savings > 20%): $0.75/therm, $0.05/kWh, and $100/peak kW

This incentive is provided one time and is not available for multiple years of benchmarking. Original project savings estimates tend to be conservative for calculations and assumptions. To verify that the savings are accurate and conservative, benchmarking can include accounting for any shortfalls in the estimates and tracking the accuracy of the calculations.

By offering benchmarking for all tier levels, customers are validated and rewarded for any savings difference between expected and actual. This accounts for any conservative calculation tendencies and rewards savings from measures that could not be offered as prescriptive or custom.

Description of Baseline Condition

The baseline condition varies based on the building use of electricity and/or natural gas as calculated in the original analysis for the measures installed. This baseline is the actual utility usage, minus the calculated savings for the original efficiency project. A dual baseline may be used to calculate lifecycle savings for equipment that is nearing the end of its useful life or is impacted by EISA lighting phase-outs.

Description of Efficient Condition

The efficient condition varies based on equipment installed and equipment performance once installed in reducing electric and/ or natural gas use beyond the original analysis for the measures indicated. All active kWh- and therm-saving program measures are eligible for benchmarking.

Annual Energy-Savings Algorithm

$\text{Therm}_{\text{SAVED}}$ = Benchmark Therm Savings - Initial Project Savings Estimates

$\text{kWh}_{\text{SAVED}}$ = Benchmark kWh Savings - Initial Project Savings Estimates

kW_{SAVED} = Benchmark kW Savings - Initial Project Savings Estimates

Therms

$\text{Therm}_{\text{SAVED}}$ = Annual $\text{Therm}_{\text{PRE}}$ - Annual $\text{Therm}_{\text{POST}}$

Annual $\text{Therm}_{\text{PRE}}$ = Sum $\text{Therms}_{\text{PRE}}$ calculation for all 12 months (Jan + Feb + Mar +…+ Dec)

$\text{Therm}_{\text{PRE}}$ = (Total Building Monthly Consumption - Building Baseline Monthly Consumption) / (Actual Monthly HDDs) * (Average Historical Monthly HDDs + Building Baseline Monthly Consumption)

Annual $\text{Therm}_{\text{POST}}$ = Sum $\text{Therms}_{\text{POST}}$ calculation for all 12 months (Jan + Feb + Mar +…+ Dec)

Therm$_{POST}$ = (Total Building Monthly Consumption - Building Baseline Monthly Consumption) / Actual Monthly HDDs * Average Historical Monthly HDDs + Building Baseline Monthly Consumption

Where:

Annual Therm$_{PRE}$ = Total yearly weather-normalized therm consumption before efficiency upgrades

Annual Therm$_{POST}$ = Total yearly weather-normalized therm consumption after efficiency upgrades

Therm$_{PRE}$ = Total monthly weather-normalized therm consumption before efficiency upgrades

Total Building Monthly Consumption = Therm consumption from utility history

Building Baseline Monthly Consumption = Minimum therm consumption of June, July, or August

Actual Monthly HDDs = Heating degree days from nearest weather station for actual utility month[1]

Average Historical Monthly HDDs = From NOAA 30 year average data[2]

Therm$_{POST}$ = Total monthly weather-normalized therm consumption after efficiency upgrades

kWh

kWh$_{SAVED}$ = Annual kWh$_{PRE}$ - Annual kWh$_{POST}$

Annual kWh$_{PRE}$ = Sum kWh$_{PRE}$ calculation for all 12 months (Jan + Feb + Mar +…+ Dec)

kWh$_{PRE}$ = (Total Building Monthly Consumption - Building Baseline Monthly Consumption) / Actual Monthly CDDs * Average Historical Monthly CDDs + Building Baseline Monthly Consumption

Annual kWh$_{POST}$ = Sum kWh$_{POST}$ calculation for all 12 months (Jan + Feb + Mar +…+ Dec)

kWh_{POST} = (Total Building Monthly Consumption - Building Baseline Monthly Consumption) / Actual Monthly CDDs * Average Historical Monthly CDDs + Building Baseline Monthly Consumption

Where:

Annual kWh_{PRE} = Total yearly weather-normalized kWh consumption before efficiency upgrades

Annual kWh_{POST} = Total yearly weather-normalized kWh consumption after efficiency upgrades

kWh_{PRE} = Total monthly weather-normalized kWh consumption before efficiency upgrades

Total Building Monthly Consumption = kWh consumption from utility history

Building Baseline Monthly Consumption = Minimum kWh consumption of all 12 months

Actual Monthly CDDs = Cooling degree days from nearest weather station for actual utility month[1]

Average Historical Monthly CDDs = From NOAA 30 year average data[2]

kWh_{POST} = Total monthly weather-normalized kWh consumption after efficiency upgrades

kW

kW_{SAVED} = Annual kW_{PRE} - Annual kW_{POST}

Where:

Annual kW_{PRE} = Highest kW usage from 12 month utility history before efficiency upgrades

Annual kW_{POST} = Highest kW usage from 12 month utility history after efficiency upgrades

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = Annual kW_{PRE} - Annual kW_{POST}

Where:

Annual kW_{PRE} = Highest kW usage from 12 month utility history before efficiency upgrades

Annual kW_{POST} = Highest kW usage from 12 month utility history after efficiency upgrades

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE}$ or $Therm_{LIFECYCLE}$ = Weighted EUL of the original measures * Verified Annual kWh or Therm Savings

Lifecycle savings account for the impacts of EISA for affected lighting technologies. A dual baseline lifecycle savings will be used for equipment that is nearing the end of its useful life.

Dual Baseline EUL Example: Boiler EUL deemed at 20 years

- Existing boiler being replaced is 13 years and has an efficiency of 70%.
- New boiler has an efficiency of 92.5%.
- A code baseline boiler has an efficiency of 80%.
- $Therm_{SAVED}$ = Existing (70%) vs. New (92.5%) = 10,000 therms
- $Therm_{SAVED}$ = Code (80%) vs. New (92.5%) = 4,500 therms
- $Therm_{LIFECYCLE}$ = (4,500 * 13) + (10,000 * 7) = 128,500 therms

Deemed Savings

The annual and lifecycle savings are calculated on a per-project basis from weather-normalized data.

Lifecycle savings are based on the original measure life or the weighted average of multiple measures.

Assumptions

Projects are only rewarded benchmarking incentives if they exceed initial savings estimates.

If additional efficiency measures or building alterations occur during any part of the benchmarking and data collection time period, that additional energy use or savings will be added or subtracted from the total consumption before weather normalization.

Benchmarking utility data will be collected for the 12 months closest to the project start and 12 months closest to project completion, but will not include the implementation and construction months.

If a customer enrolls in the benchmarking and provide the utility data needed to quantify project savings as well as additional savings after one year, the program claims the additional electricity or natural gas and rewards the customer at a discounted incentive rate of 50%. The building was benchmarked prior to work beginning, an application was submitted for the initial project, and it is possible to know when to start the utility tracking for post install benchmarking.

The minimum energy consumptions for calculating baseline monthly consumption is the lowest consumption value for the time period. This lowest value will not consist of any weather-dependent consumption for natural gas during peak summer months, or weather-dependent electric usage during the winter heating season.

Since this is a custom measure, engineers can and will account for other conditions at their discretion; however, most of the measures are weather dependent or run hour dependent and were included in this workpaper. Other adjustments include, but are not limited to, change of occupancy, equipment failures, and implementing other energy efficiency measures beyond the original scope.

Sources

1. State of Wisconsin Department of Administration. “Heating, Cooling and Growing Degree Days.” http://www.doa.state.wi.us/degreedays/
2. National Oceanographic and Atmospheric Administration, National Climatic Data Center. “Heating and Cooling Degree Day Data.” Wisconsin state-level data. http://www.ncdc.noaa.gov/oa/documentlibrary/hcs/hcs.html

Revision History

Version Number	Date	Description of Change
01	11/01/2013	New measure

Refrigeration

Refrigerator and Freezer Recycling

	Measure Details
Measure Master ID	Refrigerator, Recycling and Replacement, 2955 Freezer, Recycling and Replacement, 2956
Measure Unit	Per unit recycled
Measure Type	Prescriptive
Measure Group	Refrigeration
Measure Category	Other
Sector(s)	Residential –multifamily, Residential- single family
Annual Energy Savings (kWh)	Varies by appliance
Peak Demand Reduction (kW)	Varies by appliance
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	Varies by appliance
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	8[1]
Incremental Cost	$85.00

Measure Description

This measure involves removing an operable refrigerator or freezer from service prior to its natural end of life. The average age of a harvested unit is anticipated to be 20+ years. Savings are based on the estimated energy consumption during the remaining life of the unit, per unit characteristics at the time of removal.

Description of Baseline Condition

The baseline is an existing, inefficient unit in working order not being removed from service.

Description of Efficient Condition

The efficient condition is to remove an existing inefficient unit from circulation and send it for recycling.

Annual Energy-Savings Algorithm

kWhSAVED= Unadjusted gross annual kWh savings/unit * Part_Use

Focus on Energy's evaluation work in CYs 2013 and 2014 provides data to update both factors. First, modeling present in the CY 2013 report provides an updated estimate of gross annual savings specific to

Wisconsin's jurisdiction, which results in a slight reduction in assumed savings for both refrigerators and freezers. Second, the determined part-use factors for both refrigerators and freezers are lower than the assumed factor of 0.90. Applying the updated part-use factors to the updated gross savings assumptions yields an evaluated-adjusted per-unit gross savings less than the CY 2014 deemed savings.

The annual energy savings is a deemed value based on EM&V analyses conducted by Cadmus,[2] with adjustments for envisioned Wisconsin conditions as noted below.

Refrigerator and Freezer Variables

Metric	Refrigerators	Freezers
Unadjusted gross annual kWh savings/unit[2]	1,081	1,215
Part-use factor	0.82	0.79
Adjusted gross annual kWh savings/unit	886	962

Summer Coincident Peak Savings Algorithm

kWSAVED = [(kWh savings/unit) / HOURS] * P *Part_Use

Where:

HOURS = Annual operating hours (= 8,760)

P = Peak intensity factor, captures the increase in compressor cycling time in summer peak conditions relative to average annual conditions (= 1.01 for refrigerators; = 1.08 for freezers)[4]

Part_Use = Part-use factor determined by Evaluation Team (= 0.82 for refrigerators; = 0.79 for freezers)

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life of replaced refrigerator (= 8 years)[1]

For this technology, eight years is technically the remaining useful life of the equipment; however, for consistency it is represented as the EUL.

Deemed Savings

Deemed Savings by Measure

	Refrigerator (MMID 2955)	Freezer (MMID 2956)
Annual Energy Savings (kWh)	886	962
Peak Demand Reduction (kW)	0.102	0.119
Lifecycle Energy Savings (kWh)	7,088	7,696

Assumptions

The per-unit deemed energy saving and demand reduction values quantify the early retirement of inefficient refrigerators and freezers. These values should be reviewed and updated every two or three years to quantify expected gradual improvements in the average unit efficiency (i.e., as reflected in lower kWh/unit).

Sources

1. 2004 KEMA Study- Southern California Edison. https://www.sce.com/wps/wcm/connect/d6b04314-457c-4338-8b0c-213d9a1ed779/A0807021EE_PP_PPP_Workpapers.pdf?MOD=AJPERES&ContentCache=NONE .
2. Cadmus. *Focus on Energy Calendar Year 2013 Evaluation Report, Volume II*. Table 24. May 15, 2014.
3. Cadmus. *Appliance Recycling Measure Savings Study*. Memo prepared for Michigan Evaluation Working Group. August 20, 2012.
4. Cadmus. Appliance Recycling Measure Savings Study. Memo prepared for Michigan Evaluation Working Group. August 20, 2012.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Renewable Energy

Ground Source Heat Pump, Residential, Natural Gas and Electric Backup

	Measure Details
Measure Master ID	Ground Source Heat Pump, 2820 (Electric Back-Up) and2821 (NG Back-Up)
Measure Unit	Per heat pump
Measure Type	Prescriptive
Measure Group	Renewable Energy
Measure Category	Geothermal
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	3,999
Peak Demand Reduction (kW)	0.9286
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	71,982
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	18[1]
Incremental Cost	Varies by project

Measure Description

This measure is installing residential-sized geothermal (ground source) heat pump systems in residential applications. Geothermal heat pump systems use the earth as a source of heating and cooling by installing an exterior underground loop that works in combination with an interior heat pump unit. The measure provides sites with a centralized heating and cooling system, similar to that of a standard air-source heat pump.

Description of Baseline Condition

The baseline is a 13 SEER air-source heat pump. For estimating therm savings, the calculated results are converted to Btus.

Description of Efficient Condition

A qualifying product must meet a minimum of 15 EER in a closed-loop application, but Focus on Energy will accept program applications for open or closed loop systems. Additionally, the procedures followed to install the equipment must conform to the ACCA Standard 5 Quality Installation requirements.

Annual Energy-Savings Algorithm

$kWh_{SAVED} = (FLH_{COOL} * Btu/h_{COOL} * (1/SEER_{BASE} – 1/(EER_{EE} * 1.02)))/1{,}000 + (FLH_{HEAT} * Btu/h_{HEAT} * (1/HSPF_{BASE} – 1/(COP_{EE} * 3.412))) / 1{,}000$

Where:

FLH_{COOL} = Full-load cooling hours (= 410)[2]

Btu/h_{COOL} = Cooling capacity of equipment (= 40,089 Btu/hour)[3]

$SEER_{BASE}$ = Seasonal energy efficiency ratio of baseline equipment (= 13)[4]

EER_{EE} = Energy efficiency ratio of efficient equipment (= 22.43 kBtu/kWh)[3]

1.02 = Factor to determine SEER based on its EER

1,000 = Conversion

FLH_{HEAT} = Full-load heating hours (= 1,890)[2]

Btu/h_{HEAT} = Heating capacity of the equipment (= 30,579 Btu/hour)[3]

$HSPF_{BASE}$ = Heating seasonal performance factor of baseline equipment (= 7.7 kBtu/kWh)[4]

COP_{EE} = Coefficient of performance (= 4.18)[3]

3.412 = Conversion from Watt to Btu

Summer Coincident Peak Savings Algorithm

The summer coincident peak is defined as the period from 1:00 p.m. to 4:00 p.m. during weekdays from June through August. Using the supplied Wisconsin calculator, the demand reduction was calculated with the following algorithms and methodology:

$kW_{SAVED} = (Btu/h_{COOL} * (1/EER_{BASE} – 1/EER_{EE})) / 1{,}000 * CF$

Where:

EER_{BASE} = Energy efficiency ratio of baseline equipment (= 11)[4]

CF = Coincidence factor (= 0.5)[6]

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 18 years)[1]

Assumptions

This system life expectancy is generally constrained by the heat pump exchanger and compressor equipment. The actual ground loop installation itself often has a much longer life expectancy.

Supporting inputs for load hours in several Wisconsin cities are shown in the table below.[2]

Supporting Load Hours Inputs by City[7]

Location	FLH_{COOL}	FLH_{HEAT}
Green Bay	344	1,852
La Crosse	323	1,966
Madison	395	1,934
Milwaukee	457	1,883
Wisconsin Average	380	1,909
Weighted Average	**410**	**1,890**

Sources

1. 2012 Illinois TRM. http://www.ilsag.info/technical-reference-manual.html .
2. Several Cadmus metering studies reveal that the ENERGY STAR calculator EFLHs are over-estimated by 30% for cooling, and by 25% for heat pump heating hours. The heating and cooling EFLH values used are adjusted by population-weighted CDD and HDD TMY-3 values.
3. Tracking data model look-ups of AHRI certifications.
4. Federal standard.
5. Proposed update to 2011 Pennsylvania TRM.
6. Energy Center of Wisconsin. *Update of Geothermal Analysis*. Pgs. 19-21. August 31, 2009. Available online: http://www.ecw.org/sites/default/files/249-1.pdf.
7. Several Cadmus metering studies reveal that the ENERGY STAR calculator EFLH are over-estimated by 25%. The heating EFLH were adjusted by population-weighted HDD and TMY-3 values.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry
02	01/2015	Updated EFLH

Solar Photovoltaic

	Measure Details
Measure Master ID	Solar PV, 2819
Measure Unit	Per kWDC installed
Measure Type	Hybrid
Measure Group	Renewable Energy
Measure Category	Photovoltaics
Sector(s)	Residential- single family
Annual Energy Savings (kWh)	1,121
Peak Demand Reduction (kW)	0.450
Annual Therm Savings (Therms)	0
Lifecycle Energy Savings (kWh)	28,025
Lifecycle Therm Savings (Therms)	0
Water Savings (gal/yr)	0
Effective Useful Life (years)	25[1]
Incremental Cost	Varies by project

Measure Description

PV systems generate DC electric current through the photovoltaic effect when exposed to light. The DC power in one or more series of PV modules, called strings, is converted to AC power by an inverter. Inverters can either be classified as string inverters, which are centrally located and combine the output of multiple modules or strings of modules, or can be classified as microinverters, which are installed at the module and convert each module's DC output to AC individually.

AC modules are growing in popularity. They provide AC output without the need for external inverters. Once the output of the PV system is converted into AC current compatible with the local utility grid, the system is interconnected to the residence wiring system.

The total system output is affected by the tilt and azimuth of the modules, module temperature, inverter efficiency, and shading factors. Ideal systems are designed to face south, have minimal shading, have a tilt close to the local latitude, and are installed in a safe area. The most common application is fixed-mounted panels on a south-facing rooftop, but other configurations can include ground mounted or pole mounted arrays, and can be in fixed, manual, or automatic sun tracking configurations.

The average installed capacity of residential PV systems in Wisconsin is 4.4 kWDC.[2]

Description of Baseline Condition

The baseline for this measure is having no PV system installed at the home.

Description of Efficient Condition

PV arrays are designed to be installed within 45 degrees of due south in a safe area, and where there is 10% or less shading they can have a tilt between 10-50 degrees of the local latitude. A central inverter is typically installed in a basement or garage. In some cases, microinverters are used for one or two PV modules, which convert DC to AC power.

Annual Energy-Savings Algorithm

The energy savings for residential PV systems can be calculated using PVWatts, a free online tool developed by NREL. This tool uses TMY2 solar radiation data, combined with user-entered capacity, array type, tilt, azimuth, and derate factor, to calculate hourly AC energy output and annual energy output. The table below summarizes the expected savings per kWDC installed by location. Note that these general calculations do not reflect the actual conditions at any site, but are a general representation of typical PV systems installed in Wisconsin.

System Derate Factor = DerateFactor * (1 - ShadeFactor) * (1 - SnowFactor)

Where:

DerateFactor = Amount of power lost in DC to AC conversion (= 0.80)[3]

ShadeFactor = Percentage of time system is shaded (= 10 per program rules)

SnowFactor = Percentage of time system in covered in snow (= 2 for 34° tilt)[3]

Installed Capacity by City

Reference City	Reference ZIP Code	AC kWh/kWDC Installed Capacity
Milwaukee	53220	1,128
Madison	53706	1,130
Green Bay	54302	1,106
Average		**1,121**

Summer Coincident Peak Savings Algorithm

kW_{SAVED} = Peak Period kWh Product / Peak Period Hours

Peak Hours by City

Reference City	Reference ZIP Code	Peak Hours AC kWh (June, July, August)	kW
Milwaukee	53220	87	0.447
Madison	53706	92	0.469
Green Bay	54302	85	0.434
Average		**88**	**0.450**

Lifecycle Energy-Savings Algorithm

$kWh_{LIFECYCLE} = kWh_{SAVED} * EUL$

Where:

EUL = Effective useful life (= 25 years)[1]

Assumptions

Throughout this document, kWDC is used to refer to the nameplate installed capacity of solar at STCs of 25C and 1,000 W/m2 irradiance.

Generation estimates were made in accordance with PV system guidelines[3] or, when available, are Residential Rewards Program-specific data:

- Array azimuth of 183°
- Derate factor of 0.80
- Fixed array (i.e., non-tracking)
- Array tilt of 34°

All results are normalized to installed kWDC capacity and can be scaled to actual installed capacity on a one-to-one basis (e.g., a 2 kW system will produce twice the output and peak demand reduction of a 1 kW system).

Sources

1. NREL - System Useful Life http://www.nrel.gov/analysis/tech_footprint.html.
2. *Focus on Energy 2012 Evaluation Report: Volume II*. August 28, 2013. Analysis of 2012 Residential Rewards Program data for 79 funded PV systems. https://focusonenergy.com/sites/default/files/FOC_XC_CY%2012%20Report%20Volume%20II%20Final_08-28-2013.pdf

3. Tetra Tech. *State of Wisconsin Public Service Commission Focus on Energy Evaluation: Standard Calculation Recommendations for Renewable Energy Systems.* January 18, 2011. Available online: https://focusonenergy.com/sites/default/files/standardcalculationrecommendationsCY10_evaluationreport.pdf.

Revision History

Version Number	Date	Description of Change
01	08/2014	Initial TRM entry

Solar Thermal

	Measure Details
Measure Master ID	Solar Thermal, 2905 (Electric) and 2906 (NG)
Measure Unit	Per system
Measure Type	Hybrid
Measure Group	Renewable Energy
Measure Category	Solar Thermal
Sector(s)	Residential- multifamily, Residential- single family
Annual Energy Savings (kWh)	Varies by sector
Peak Demand Reduction (kW)	Varies by sector
Annual Therm Savings (Therms)	Varies by sector
Lifecycle Energy Savings (kWh)	Varies by sector
Lifecycle Therm Savings (Therms)	Varies by sector
Water Savings (gal/yr)	0
Effective Useful Life (years)	20[1]
Incremental Cost	Varies by project

Measure Description

This measure is installing single family and multifamily residential SWH systems. SWH systems typically use one or more rooftop thermal collector to capture solar energy and transfer that energy to heat a working fluid, such as water or antifreeze solutions. The systems are typically integrated with a backup water heating system fueled by natural gas or electricity to provide residential DHW. Thermal collectors can also be used to heat swimming pools or be used to provide space heating.[2]

Typical single family residential SWH systems consist of one or two collectors, a 40- to 80-gallon storage tank, and associated pumps and controllers. Collectors are most commonly flat-plate, though evacuated tube collectors are also available. There are a variety of system types. One type is a closed loop glycol system, which uses an antifreeze solution as a heat transfer medium. Another type is a drainback system, which uses water as a heat transfer medium but (as the name implies) drains the fluid from the collectors when there is no heat being drawn.

In multifamily applications, systems are similar to those for single family use but on a larger scale. System size can vary widely, depending on the number of housing units served. There is little data available at this time on regional or national applications that are typical for multifamily SWH, but most systems consist of at least six solar collectors and storage tanks of 200 gallons or more.

Solar collectors and packaged systems are tested and rated by the Solar Rating and Certification Corporation. These ratings can provide a useful and consistent benchmark for comparing the performance of different SWH systems.[3]

Description of Baseline Condition

A baseline condition is a residential single-family house or multifamily facility that uses an electric resistive or natural gas fired water heater.

Description of Efficient Condition

The efficient condition is a SWH system that is installed to supplant the use of electricity or natural gas for hot water heating.

Annual Energy-Savings Algorithm

Deemed savings for SWH systems are calculated separately for single family and multifamily applications using the System Advisor Model (SAM) developed by NREL.[5]

Single-Family Applications

Substantial data are available on the performance of single-family SWH systems. An NREL report provides energy savings for a typical SWH system in every state, including Wisconsin.[4] This archetypal system has the following characteristics, which are consistent with residential SWH systems installed through the programs:

- Azimuth of 180° (true south)
- Collector tilt of 26.5°
- 40-square-foot gross collector area (equivalent to two typical collectors)
- 60-gallon storage tank
- 90% energy factor (electric)
- 60% energy factor (natural gas)/80% efficiency
- 60 GPD hot water consumption

Using these parameters from NREL's SAM, annual energy savings for both electric and natural gas hot water heating fuel scenarios were predicted for locations nationwide.[5] For Madison, Wisconsin, the study reports typical annual energy savings of:

- 1,919 kWh for systems with electric back-up hot water heating (solar fraction of 0.53)
- 73 therms for systems with natural gas back-up hot water heating (solar fraction of 0.55)

Note that approximately 68.2% of single-family residences in the East-North Central Census region heat hot water with natural gas and 29.5% heat hot water with electricity.[4]

Multifamily Applications

A typical SWH system was modeled using SAM, using with the following key assumptions and variables:

- 20 residents at 15.6 gallons per person per day for a total daily use of 312 gallons of hot water
- 6 collectors with a total 180-square-foot gross area
- Collectors oriented at 180° (true south) and titled at 43° (latitude)
- 264-gallon storage tank
- 90% EF (electric)
- 60% EF (natural gas)

The results of the simulation indicate annual savings of:

- 13,060 kWh for systems with electric back-up hot water heating
- 669 therms for systems with natural gas back-up hot water heating

The savings estimated in both the single family and multifamily cases should be viewed as general estimates only. Neither estimate includes losses due to shading or sub-optimal system orientation.

Summer Coincident Peak Savings Algorithm

Accurately calculating the peak demand reduction from SWH requires accurate knowledge of hourly hot water heating load profiles for residential customers. At this time, data is not available at that level of granularity, so peak demand reduction for SWH systems should be estimated using the method provided in the Standard Calculations document.[6] These calculations assume there is a constant daily hot water heating load for the year and that the SWH system fully offsets use of the baseline hot water heater during summer peaks. This is reasonable because most SWH systems are designed to provide a very high proportion of hot water demand in the summer months. The peak demand reduction for electrically backed up SWH systems are:

- 0.4 kW for single-family applications
- 2.1 kW for multifamily applications

Though SWH systems require the use of pumps and/or electronic controls, these loads are generally very small compared to the energy savings and will have a minimal impact on peak demand. These loads are included, however, in annual energy-savings projections.

There is no electrical demand reduction associated with SWH systems using natural gas as the backup hot water heating fuel.

As discussed above, a deemed savings approach can be used to perform a preliminary energy-savings calculation for SWH systems, using the approach described above. Where possible, this deemed savings value should be replaced with site-specific system characteristics and modeling using SAM. Deemed energy savings are shown in the following table.

Deemed Energy Savings

Hot Water Heating Fuel (Baseline)	MMID	Single-Family Annual Energy Savings	Multifamily Annual Energy Savings
Electric	2905	1,919 kWh	13,060 kWh
Natural Gas	2906	73 therms	669 therms

The demand reduction for SWH systems with electric backup hot water heating can be estimated using the deemed savings values shown in the following table.

Fuel (Baseline)	MMID	Single-Family Demand Savings	Multifamily Demand Savings
Electric	2905	0.4 kW	2.1 kW
Gas	2906	0	0

Lifecycle Energy-Savings Algorithm

$\text{kWh}_{\text{LIFECYCLE}} = \text{kWh}_{\text{SAVED}} * \text{EUL}$

$\text{Therm}_{\text{LIFECYCLE}} = \text{Therm}_{\text{SAVED}} * \text{EUL}$

Where:

EUL = Effective useful life (= 20 years)[1]

Sources

1. 2013 Connecticut TRM. http://www.energizect.com/sites/default/files/2013%20PSD_ProgramSavingsDocumentation-Final110112.pdf .
2. National Institute of Building Science (Andy Walker). *Solar Water Heating*. August 24, 2012. Available online: http://www.wbdg.org/resources/swheating.php.
3. Solar Rating & Certification Corporation. Solar Facts – System Ratings. OG-300 Certification of Solar Water Heating Systems. http://www.solar-rating.org/facts/system_ratings.html.
4. National Renewable Energy Laboratory (Cassard, Hannah, P. Denholm, and S. Ong). *Break-Even Cost for Residential Solar Water Heating in the United States: Key Drivers and Sensitivities*.. February 2011. Available online: http://www.nrel.gov/docs/fy11osti/48986.pdf.

5. National Renewable Energy Laboratory. *System Advisor Model*. April 5, 2010. Available for download: https://sam.nrel.gov/.
6. Tetra Tech. *State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation: Standard Calculation Recommendations for Renewable Energy Systems.* Revised January 18, 2011. http://www.focusonenergy.com/sites/default/files/standardcalculationrecommendationsCY10_evaluationreport.pdf.

Revision History

Version Number	Date	Description of Change
01	09/2014	Initial TRM entry

Appendix A: List of Acronyms

AC	Alternating current
	Air conditioning
AFUE	Annual Fuel Utilization Efficiency
ACH	Air changes per hour
Btu	British thermal units
CDD	Cooling degree day
CEE	Consortium for Energy Efficiency
CFL	Compact fluorescent light bulb
CMH	Ceramic metal halide
COP	Coefficient of performance
DC	Direct current
DDC	Direct digital control
DHW	Domestic hot water
DLC	Design Lights Consortium
DOE	U.S. Department of Energy
EBTU	Express Building Tune Up
ECM	Electronically commutated motor
EER	Energy efficiency ratio
EF	Energy factor
EFLH	Equivalent full-load hours
EISA	Energy Independence and Security Act
EM&V	Evaluation, measurement, and verification
ERV	Energy recovery ventilator
ETL	Intertek's ETL Mark
EUL	Effective useful life
FSTC	Food Service Technology Center
HDD	Heating degree day
HESCC	High-efficiency sealed combustion condensing
HESCCM	High-efficiency sealed combustion condensing modulating
HID	High-intensity discharge
HO	High output
HOU	Hours-of-use
HP	High performance
HSPF	Heating Season Performance Factor
IECC	International Energy Conservation Code
IPLV	Integrated part load volume
ISR	In-service rate

kWDC	Direct current kilowatts
LED	Light-emitting diode
NAIMA	North American Insulation Manufacturers Association
NPS	Nominal Pipe Size
NREL	National Renewable Energy Laboratory
NRTL	Nationally Recognized Testing Laboratory
OAT	Outside Air Temperature
PIR	Passive infrared
PSC	Public Service Commission of Wisconsin
	Permanent split capacitor
PSMH	Pulse-start metal halide
PTAC	Packaged terminal air conditioner
PTHP	Packaged terminal heat pump
PV	Photovoltaic
QPL	Qualified Product List
RCA	Refrigerant charge and airflow
RFP	Request for proposals
RH	Relative humidity
RTU	Rooftop unit
RW	Reduced wattage
SAM	System Advisor Model
SEER	Seasonal energy efficiency ratio
SP	Shaded pole
STC	Standard test conditions
SWH	Solar water heating
TE	Thermal efficiency
TMY	Typical meteorological year
TRC	Total Resource Cost
TRM	Technical Reference Manual
UL	Underwriters Laboratories
VAV	Variable air volume
VFD	Variable frequency drive
VHO	Very high output
VSD	Variable speed drive

Appendix B: Common Variables

Hours-of-Use

Compressed Air

HOU = Average annual run hours (= 5,083)[4]

Commercial/Industrial Lighting

Commercial/Industrial Lighting HOU by Sector

Sector	HOU
Commercial	3,730
Industrial	4,745
Agriculture	4,698
Schools & Government	3,239

Source: State of Wisconsin Public Service Commission. *Business Programs Deemed Savings Manual V1.0*. Table 3.2 Lighting Hours of Use in Commercial Applications. March 22, 2010.

Multifamily Lighting (Daily HOU for In-Unit Room estimates)

HOU = Average annual run hours (= 5,950 for multifamily common areas)[5]

Multifamily Lighting HOU by Sector

Room Type	Hours of Use
Bathroom	2.26
Bedroom	1.32
Dining	2.34
Kitchen	2.92
Living Room	2.67
Other (Hall and Office)	0.51

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[4] United States Department of Energy Office of Energy Efficiency & Renewable Energy. *United States Industrial Electric Motor Systems Market Opportunities Assessment*. Pg 42. December 2002.

[5] ACES. *Focus on Energy Deemed Savings Desk Review: Multifamily Applications for Common Areas.* November 3, 2010.

Single Family Residential Lighting (Daily HOU)

Single Family Lighting HOU by Sector

Room Type	Hours of Use
Bathroom	1.00
Bedroom	1.62
Dining	3.18
Kitchen	0.65
Living Room	2.17
Other	0.66
Average Daily Use	2.77

Source: Cadmus. *Focus on Energy Residential Single Family Lighting Hours of Use and Peak Coincidence Factor Findings Memo*. July 2, 2014.

Retail Lighting

Because retail lighting incentives are covered through retail price markdowns at the store level, the program does not collect participant-specific data for where purchased bulbs will be installed. General figures are calculated using the following weighting assumptions:

- Single Family Weighting, 74.7%[6]
- Multifamily Weighting, 25.3%[7]
- Single Family HOU, 2.27 hours per day[8]
- Multifamily HOU, 2.01 hours per day[9]
- Residential Weighting 93%[10]
- Commercial Weighting 7%[11]
    - Residential HOU Average, 2.20
    - Commercial HOU Average, 10.2[12]

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[6] U.S. Census Bureau. Percentage of Wisconsin housing stock that is single family. 2013 Estimates.

[7] U.S. Census Bureau. Percentage of Wisconsin housing stock that is multifamily. 2013 Estimates.

[8] Cadmus. Single family light logger study, 2013.

[9] Cadmus. Multifamily light logger study. 2013.

[10] Cadmus. In-store intercept surveys. 2012.

[11] Ibid.

- Single Family Coincidence Factor 7.5%[13]
- Multifamily Coincidence Factor 5.5%[14]
- Residential, Averaged, Coincidence Factor 6.99%
- Commercial Coincidence Factor 77%[15]

Average Annual HOU based on weighting metrics outlined above = 1,011

Coincidence Factor based on weighting metrics outline above = 0.1189

Coincidence Factors

Commercial/Industrial/Multifamily Lighting Coincidence Factors

Sector	CF
Commercial*	0.77
Industrial	0.77
Schools & Government	0.64
Agriculture	0.67
Multifamily Common Area	0.77
In-Residence**	0.055

* *Focus on Energy Business Programs Deemed Savings Manual V1.0.* Table 3.2 Coincidence Factor for Lighting in Commercial Applications. March 22, 2010.

** Cadmus. Field Study: Residential Lighting. October 18, 2013. (Report based on using CFL bulbs to replace incandescent bulbs. Since LEDs will initially be treated the same as CFLs, those values were used.)

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[12] *Wisconsin Business Deemed Savings*. 2010.

[13] U.S. Census Bureau. Percentage of Wisconsin housing stock that is single family. 2013 Estimates.

[14] U.S. Census Bureau. Percentage of Wisconsin housing stock that is multifamily. 2013 Estimates.

[15] Focus on Energy Business Programs Deemed Savings Manual V1.0. Lighting in Commercial Applications. March 22, 2010.

Multifamily Residential Lighting Coincidence Factors*

Exposure Type	Percentage of Lamps	Coincidence Factor	Lower 90% CI	Upper 90% CI
Exposed	41%	2.08%	1.26%	2.90%
Non-Exposed	59%	7.82%	7.58%	8.07%
Overall	**100%**	**5.47%**	**5.11%**	**5.84%**

* Cadmus. *Focus on Energy Residential Multifamily Lighting Hours of Use and Peak Coincidence Factor Findings Memo*. June 30, 2014.

Single Family Residential Lighting*

Room Type	Wisconsin CFL Distribution	Mean Peak CF	Average Time On During Peak (minutes)
Bathroom	15.4%	10.8%	19.5
Bedroom	17.8%	6.8%	12.2
Kitchen	10.0%	8.8%	15.9
Living Room/Family Room	19.9%	10.0%	18.0
Other	36.9%	4.7%	8.5
Weighted Mean CF		**7.5%**	**13.5**

* Cadmus. *Focus on Energy Residential Single Family Lighting Hours of Use and Peak Coincidence Factor Findings Memo*. July 2, 2014.

Phased-In EISA 2007 Standards

Phase-in of these standards occurred in savings calculations as new requirements became effective. From 2015 forward, all baselines have been adjusted to meet these standards.

EISA Requirements and Effective Dates by Lumen Output

Lumen Output	Typical Wattage: Current Incandescent Technology	EISA Requirements		
		Maximum Wattage	Minimum Lifecycle (hours)	Effective Date
1,490-2,600	100	72	1,000	1/1/2012
1,050-1,489	75	53	1,000	1/1/2013
750-1,049	60	43	1,000	1/1/2014
310-749	40	29	1,000	1/1/2014

Equivalent Full-Load Hours

Residential Natural Gas Measures

EFLH = 1,759 hours[16]

Residential Heat Pumps and Split HVAC

Equivalent Full-Load Hours for Air Sealing, Air-Source Heat Pumps, Ground-Source Heat Pumps, and Split A/C System.[17]

Location	$EFLH_{COOL}$	$EFLH_{HEAT}$
Green Bay	344	1,852
La Crosse	323	1,966
Madison	395	1,934
Milwaukee	457	1,883
Wisconsin Average	**380**	**1,909**

* Full load hours calculated using an average from Illinois Statewide Technical Reference Manual, applied to Wisconsin CDDs.

Flow Rates

Faucet Aerators

$GPM_{EXISTING}$ = Baseline flow rate (= 2.2 GPM)[18]

Low-Flow Showerheads

$GPM_{EXISTING}$ = Baseline flow rate (= 2.5 GPM)[19]

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[16] 800 therms consumed by 90% AFUE furnaces (i.e., 720 therms output) for all residential natural gas measures estimate from: Pigg and Nevius. *Electricity Use by New Furnaces.* 2000. Available online: http://www.ecw.org/sites/d3efault/files/230-1.pdf. Using average furnace size of 72,000 Btu (from 2012 SPECTRUM database of 13,000 furnaces), 1,000 full-load heating hours are estimated.

[17]

[18] Federal minimum at 80 psi.

[19] Federal minimum at 80 psi.

Temperature (Water)

Water Heaters, Faucet Aerators, and Low-Flow Showerheads

T_{WH} = Water heater temperature setpoint (= 125°F)[20]

$T_{ENTERING}$ = Temperature of water entering water heater (= 52.3°F)[21]

Faucet Aerators (Kitchen)

$T_{POINT\ OF\ USE}$ = Temperature of water at point of use (= 91°F)[22]

Faucet Aerators (Bathroom)

$T_{POINT\ OF\ USE}$ = Temperature of water at point of use (= 86°F)[18]

Low-Flow Showerheads

$T_{POINT\ OF\ USE}$ = Temperature of water at point of use (= 101°F)[18]

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[20] The water heater set point is assumed to be 125°F, as Wisconsin building code 704.06 requires landlords to set water heaters to 125°F: https://docs.legis.wisconsin.gov/statutes/statutes/704/06. Water heater setpoints typically range between 120°F and 140°F because temperatures below 120°F are susceptible to Legionella bacteria (which lead to Legionnaires Disease) and heaters set to temperatures above 140°F can quickly scald users: http://www.nrel.gov/docs/fy12osti/55074.pdf. Most TRMs assume water heater set points of 120°F, 125°F, or 130°F, though most of these are unsourced engineering assumptions. (Residential water heater setpoints include: Connecticut 2012 TRM PSD: 130°F for natural gas DWH and 125°F for tank wrap, HPWH, and temperature reduction; Mid- Atlantic TRM v3.0: 130°F for tank wrap and pipe insulation; Illinois TRM v2.0: 125°F for pipe insulation, natural gas water heater, HPWH, and tank wrap and 120°F for temperature reduction; and Indiana TRM v1.0: 130°F for pipe insulation.)

[21] U.S. Department of Energy. *Domestic Hot Water Scheduler.* Average water main temperature of all locations measured in Wisconsin by scheduler, weighted by city populations.

[22] Calculated from TMY3 weather files of the seven Wisconsin locations using *ASHRAE Estimation of Degree-Days: Fundamentals*, Chapter 14. Statewide weighted values calculated using 2010 US Census data for Wisconsin.

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Outside Air Temperature Bin Analysis

Bin Analysis

Bin	Max of Bin	Midpoint	GREEN BAY	LA CROSSE	MADISON	MILWAUKEE	MINOCQUA	RICE LAKE	WAUSAU	Average Hours for WI	Note
95 to 100	100	97.5	0	2	0	3	0	0	0	1	
90 to 95	95	92.5	22	51	25	18	22	4	29	24	
85 to 90	90	87.5	62	121	86	59	36	22	91	68	
80 to 85	85	82.5	275	355	339	225	222	213	335	281	
75 to 80	80	77.5	398	445	486	400	397	398	532	437	
70 to 75	75	72.5	445	489	447	497	413	508	420	460	
65 to 70	70	67.5	675	762	723	692	555	693	666	681	
60 to 65	65	62.5	871	746	770	936	852	810	699	812	
55 to 60	60	57.5	647	583	605	545	680	673	502	605	
50 to 55	55	52.5	420	510	470	547	557	541	423	495	Boiler enabled
45 to 50	50	47.5	527	549	618	603	515	557	586	565	Boiler enabled
40 to 45	45	42.5	579	597	510	723	554	477	718	594	Boiler enabled
35 to 40	40	37.5	777	826	905	883	589	632	619	747	Boiler enabled
30 to 35	35	32.5	820	719	741	720	669	675	792	734	Boiler enabled
25 to 29	30	27.5	507	425	396	423	424	366	539	440	Boiler enabled
20 to 25	25	22.5	579	457	439	531	506	365	551	490	Boiler enabled
15 to 20	20	17.5	443	319	353	390	478	420	406	401	Boiler enabled
10 to 15	15	12.5	265	227	212	228	475	367	252	289	Boiler enabled
5 to 10	10	7.5	157	174	117	97	315	296	247	200	Boiler enabled
0 to 5	5	2.5	111	144	152	116	203	286	138	164	Boiler enabled
-5 to 0	0	-2.5	81	106	157	61	136	182	115	120	Boiler enabled
-10 to -5	-5	-7.5	83	109	105	57	90	177	84	101	Boiler enabled
-15 to -10	-10	-12.5	9	23	70	6	40	69	16	33	Boiler enabled
-20 to -15	-15	-17.5	7	9	21	0	24	24	0	12	Boiler enabled
-25 to -20	-20	-22.5	0	6	9	0	8	5	0	4	Boiler enabled
-30 to -25	-25	-27.5	0	6	4	0	0	0	0	1	Boiler enabled
-35 to -30	-30	-32.5	0	0	0	0	0	0	0	0	Boiler enabled
			5365	5206	5279	5385	5583	5439	5486	5392	Boiler enabled total

Heating and Cooling Degree Days

Heating and Cooling Degree Days for Residential Applications*

Location	HDD	CDD
Milwaukee	7,276	548
Green Bay	7,725	516
Wausau	7,805	654
Madison	7,599	630
La Crosse	7,397	729
Minocqua	8,616	423
Rice Lake	8,552	438
Statewide Weighted	**7,616**	**565**

* Cadmus. *Michigan Water Meter Study.* 2012.

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Appendix C: Effective Useful Life Table

The EUL figures listed in the table below were reviewed and updated in CY 2015 and will continue to be updated every odd-numbered year.

Prescriptive Measures by Measure Master ID

MMID	Measure Name	EUL (years)
566	PC Network Energy Management System	2
1981	NG Furnace with ECM, 95%+ AFUE (Existing)	23 (Residential- single family) 18 (Nonresidential)
1983	Hot Water Boiler, 95%+ AFUE	20
1986	Condensing Water Heater, NG, 90%+	15 (Residential- single family) 18 (Nonresidential) 12 (Residential-multifamily)
1988	Water Heater, Indirect	15
1989	Water Heater, Electric, EF of 0.93 or greater	15 (Residential and Nonresidential)
2116	CFL, Non PI Direct Install, 9 Watt	6
2117	CFL, Non PI Direct Install, 14 Watt	6
2118	CFL, Non PI Direct Install, 19 Watt	6
2119	CFL, Non PI Direct Install, 23 Watt	6
2120	Faucet Aerator, Non PI Direct Install, 1.5 gpm, Kitchen, NG	20
2121	Faucet Aerator, Non PI Direct Install, 1.0 gpm, Bathroom, NG	20
2122	Insulation, Non PI Direct Install, 6' pipe, NG	10
2123	Showerhead, Non PI Direct Install, 1.5 gpm, NG	10
2125	DHW Temperature Turn Down, Non PI Direct Install, NG	15
2126	Faucet Aerator, Non PI Direct Install, 1.5 gpm, Kitchen, Electric	10
2127	Faucet Aerator, Non PI Direct Install, 1.0 gpm, Bathroom, Electric	10
2128	Insulation, Non PI Direct Install, 6' pipe, Electric	15
2129	Showerhead, Non PI Direct Install, 1.5 gpm, Electric	10
2131	DHW Temperature Turn Down, Non PI Direct Install, Electric	15
2132	CFL, Direct Install, 9 Watt	6 (Residential)
2133	CFL, Direct Install, 14 Watt	6 (Residential) 5 (Nonresidential)
2134	CFL, Direct Install, 19 Watt	7 (Residential) 5 (Nonresidential)
2135	CFL, Direct Install, 23 Watt	6

MMID	Measure Name	EUL (years)
2136	Faucet Aerators, Direct Install, 1.5 gpm, Kitchen, NG	10
2137	Faucet Aerator, Direct Install, 1.0 gpm, Bathroom, NG	10
2138	Insulation, Direct Install, 6' pipe, NG	12 (Residential- single family) 14 (Nonresidential)
2139	Showerhead, Direct Install, 1.5 gpm, NG	10
2140	Showerhead, Direct Install, 1.75 gpm, NG	10
2141	DHW Temperature Turn Down, Direct Install, NG	15
2145	Showerhead, Direct Install, 1.5 gpm, Electric	10
2146	Showerhead, Direct Install, 1.75 gpm, Electric	10
2147	DHW Temperature Turn Down, Direct Install, Electric	15
2150	Cooler Miser, Direct Install	9
2151	Faucet Aerator, Direct Install, .5 gpm, Bathroom, Electric	10
2155	Faucet Aerator, Direct Install, 1.5 gpm, Kitchen, Electric	10
2156	Faucet Aerator, Direct Install, 1.5 gpm, Kitchen, NG	10
2158	Pre-Rinse Sprayer, Direct Install, 1.28 gpm, Electric	5
2159	Pre-Rinse Sprayer, Direct Install, 1.28 gpm, NG	5
2192	A/C Split System ≤ 65 MBh, SEER 15	15
2193	A/C Split System ≤ 65 MBh, SEER 16 or greater	15
2194	A/C Split System, ≤ 65 MBh, SEER 14	15
2197	Anti-sweat Heater Controls, Freezer Case, Low-heat Door	12
2198	Anti-sweat Heater Controls, Freezer Case, No-heat Door	12
2199	Anti-sweat Heater Controls, Freezer Case, Standard Door	12
2200	Anti-sweat Heater Controls, Refrigerated Case, Low-heat or No-heat Door	12
2201	Anti-sweat Heater Controls, Refrigerated Case, Standard Door	12
2202	Beverage Cooler Controls, Occupancy Based	5
2203	Boiler Burner, 10:1 High Turn Down	20
2205	Boiler Control, Linkageless	20
2206	Boiler Oxygen Trim Combustion Controls	5
2209	Boiler Plant Retrofit, Mid Efficiency Plant, 1- 5 MMBh	20
2211	Boiler Tune Up	1
2218	Boiler, Hot Water, Modulating, ≥ 90% AFUE, < 300 mbh	20
2221	Boiler, Outside Temperature Reset/Cutout Control	5
2234	Case Door, Freezer, Low Heat	11
2235	Case Door, Freezer, No Heat	11
2236	Case Door, Cooler, No Heat	11
2237	Ceramic Metal Halide (CMH) Fixture, 20-70 Watts	11
2238	Ceramic Metal Halide (CMH) Lamp, ≤ 25 Watts	11

MMID	Measure Name	EUL (years)
2239	CFL Fixture, ≤100 Watts	13
2243	CFL, 31-115 Watts	5
2245	CFL, Cold Cathode, ≤ 32 Watt	4
2246	CFL, Reflector Flood Lamps, ≤ 32 Watts	5 (Residential-multifamily) 12 (Nonresidential)
2254	Compressed Air Condensate Drains, No Loss Drain	20
2259	Compressed Air Nozzles, Air Entraining	15
2264	Compressed Air, Cycling Thermal Mass Air Dryers	15
2269	Cooler Evaporator Fan Control	16
2271	Cooler Night Curtains, Open Coolers	5
2276	Delamping, T12 to T8, 4'	10
2277	Delamping, T8 to T8	TBA
2280	Dishwasher, Low Temp, Door Type, ENERGY STAR, ENERGY STAR, Electric	10
2281	Dishwasher, High Temp, Electric Booster, Door Type, ENERGY STAR, Electric	10
2282	Dishwasher, High Temp, Electric Booster, Door Type, ENERGY STAR, NG	10
2283	Dishwasher, High Temp, Electric Booster, Multi Tank Conveyor, ENERGY STAR, Electric	10
2284	Dishwasher, High Temp, Electric Booster, Multi Tank Conveyor, ENERGY STAR, NG	10
2285	Dishwasher, High Temp, Electric Booster, Single Tank Conveyor, ENERGY STAR, Electric	10
2286	Dishwasher, High Temp, Electric Booster, Single Tank Conveyor, ENERGY STAR, NG	10
2287	Dishwasher, High Temp, Electric Booster, Under Counter, ENERGY STAR, Electric	10
2288	Dishwasher, High Temp, Electric Booster, Under Counter, ENERGY STAR, NG	10
2289	Dishwasher, High Temp, Gas Booster, Door Type, ENERGY STAR, NG	10
2290	Dishwasher, High Temp, Gas Booster, Multi Tank Conveyor, ENERGY STAR, NG	10
2291	Dishwasher, High Temp, Gas Booster, Single Tank Conveyor, ENERGY STAR, NG	10
2292	Dishwasher, High Temp, Gas Heat, Gas Booster, Under Counter, ENERGY STAR, NG	10
2293	Dishwasher, Low Temp, Door Type, ENERGY STAR, NG	10
2294	Dishwasher, Low Temp, Multi Tank Conveyor, ENERGY STAR, Electric	10
2295	Dishwasher, Low Temp, Multi Tank Conveyor, ENERGY STAR, NG	10
2296	Dishwasher, Low Temp, Single Tank Conveyor, ENERGY STAR, Electric	10
2297	Dishwasher, Low Temp, Single Tank Conveyor, ENERGY STAR, NG	10
2298	Dishwasher, Low Temp, Under Counter, ENERGY STAR, Electric	10
2299	Dishwasher, Low Temp, Under Counter, ENERGY STAR, NG	10

MMID	Measure Name	EUL (years)
2300	Dock Door Infiltration Reduction, New Install	10
2301	Dock Door Infiltration Reduction, Replace Existing	10
2302	Dock Pit/Ramp External Seal, Added to Existing "Brush" Barrier	10
2303	Dock Pit/Ramp External Seal, No Brush Barrier Present	10
2306	ECM Compressor Fan Motor	15
2307	ECM Condenser/Condensing Unit Fan Motor	16
2308	ECM Evaporator Fan Motor, Walk-in Cooler, < 1/20hp	16
2309	ECM Evaporator Fan Motor, Walk-in Cooler, 1/20hp - 1 hp	16
2310	ECM Evaporator Fan Motor, Walk-in Freezer, < 1/20hp	16
2311	ECM Evaporator Fan Motor, Walk-in Freezer, 1/20hp - 1 hp	16
2312	ECM Motor, Cooler/Freezer Case	16
2316	Fans, High Volume Low Speed (HVLS), 20 ft. dia.	15
2317	Fans, High Volume Low Speed (HVLS), 22 ft. dia.	15
2318	Fans, High Volume Low Speed (HVLS), 24 ft. dia.	13
2321	Freezer, Chest, Glass Door, < 15 cu ft, ENERGY STAR	12
2322	Freezer, Chest, Glass Door, 15-29 cu ft, ENERGY STAR	12
2323	Freezer, Chest, Glass Door, 30-49 cu ft, ENERGY STAR	12
2324	Freezer, Chest, Glass Door, 50+ cu ft, ENERGY STAR	12
2325	Freezer, Chest, Solid Door, < 15 cu ft, ENERGY STAR	12
2326	Freezer, Chest, Solid Door, 15-29 cu ft, ENERGY STAR	12
2327	Freezer, Chest, Solid Door, 30-49 cu ft, ENERGY STAR	12
2328	Freezer, Chest, Solid Door, 50+ cu ft, ENERGY STAR	12
2329	Freezer, Vertical, Glass Door, < 15 cu ft, ENERGY STAR	12
2330	Freezer, Vertical, Glass Door, 15-29 cu ft, ENERGY STAR	12
2331	Freezer, Vertical, Glass Door, 30-49 cu ft, ENERGY STAR	12
2332	Freezer, Vertical, Glass Door, 50+ cu ft,ENERGY STAR	12
2333	Freezer, Vertical, Solid Door, < 15 cu ft, ENERGY STAR	12
2334	Freezer, Vertical, Solid Door, 15-29 cu ft, ENERGY STAR	12
2335	Freezer, Vertical, Solid Door, 30-49 cu ft, ENERGY STAR	12
2336	Freezer, Vertical, Solid Door, 50+ cu ft, ENERGY STAR	12
2337	Fryer, ENERGY STAR, Electric	12
2338	Fryer, ENERGY STAR, NG	12
2350	Furnace, ECM, 95%+ AFUE, NG 109.9 - 120.7 MBh	18
2352	Furnace, ECM, 95%+ AFUE, NG 133.0 - 146.1 MBh	18
2354	Furnace, ECM, 95%+ AFUE, NG 54.675 - 60.749 MBh	18
2355	Furnace, ECM, 95%+ AFUE, NG 60.750 - 67.499 MBh	18
2356	Furnace, ECM, 95%+ AFUE, NG 67.5 - 74.9 MBh	18
2357	Furnace, ECM, 95%+ AFUE, NG 75.0 - 82.49 MBh	18

MMID	Measure Name	EUL (years)
2358	Furnace, ECM, 95%+ AFUE, NG 82.5 - 90.75 MBh	18
2359	Furnace, ECM, 95%+ AFUE, NG 90.76 - 99.82 MBh	18
2360	Furnace, ECM, 95%+ AFUE, NG 99.83 - 109.8 MBh	18
2362	Glazing, Triple Poly Carbonate, Roof and Walls, Double Pane Replacement	10
2363	Glazing, Triple Poly Carbonate, Roof and Walls, Single Pane Replacement	10
2364	Glazing, Triple Poly Carbonate, Roof, Double Pane Replacement	10
2365	Glazing, Triple Poly Carbonate, Roof, Single Pane Replacement	10
2366	Glazing, Triple Poly Carbonate, Walls, Double Pane Replacement	10
2367	Glazing, Triple Poly Carbonate, Walls, Single Pane Replacement	10
2371	Griddle, ENERGY STAR, Electric	11
2372	Griddle, ENERGY STAR, NG	11
2373	Guest Room Energy Management Controls, Electric Heat PTAC Systems	10
2422	Infrared Heating Units, High or Low Intensity	15
2429	Insulation, Steam Fitting, Removable, NG	10
2430	Insulation, Steam Piping, NG	10
2456	LED, Reach-In Refrigerated Case, Replaces T12 or T8	20
2457	LED, Reach-In Refrigerated Case, Replaces T12 or T8 w/ Occupancy Control	20
2458	LED, Recessed Downlight, ENERGY STAR	15
2471	Occupancy Sensor, Ceiling Mount, ≤500 Watts	8
2472	Occupancy Sensor, Ceiling Mount, ≥1001 Watts	8
2473	Occupancy Sensor, Ceiling Mount, 501-1000 Watts	8
2474	Occupancy Sensor, Fixture Mount, ≤200 Watts	8
2475	Occupancy Sensor, Fixture Mount, >200 Watts	8
2482	Occupancy Sensor, LED Refrigerated Case Lights	10
2483	Occupancy Sensor, Wall Mount, ≤200 Watts	8
2484	Occupancy Sensor, Wall Mount, >200 Watts	8
2485	Oven, Convection, ENERGY STAR, Electric	12
2486	Oven, Convection, ENERGY STAR, NG	12
2487	Oven, Rack Type, Double Compartment, Focus QPL, NG	12
2488	Oven, Rack Type, Single Compartment, Focus QPL, NG	12
2494	Pre-Rinse Sprayer, ≤.65 gpm, Electric	5
2495	Pre-Rinse Sprayer, ≤.65 gpm, NG	5
2509	Reach In Refrigerated Case w/ Doors replacing Open Multi Deck Case	15
2510	Refrigeration Controls, Floating Head Pressure, ≤ 150 tons	10
2513	Refrigeration Tune-up, Non Self-Contained Cooler	3
2514	Refrigeration Tune-up, Non Self-Contained Freezer	3
2515	Refrigeration Tune-up, Self-contained Cooler	3
2516	Refrigeration Tune-up, Self-contained Freezer	3

MMID	Measure Name	EUL (years)
2521	Refrigerator, Chest, Glass Door, < 15 cu ft, ENERGY STAR	12
2522	Refrigerator, Chest, Glass Door, 15-29 cu ft, ENERGY STAR	12
2523	Refrigerator, Chest, Glass Door, 30-49 cu ft, ENERGY STAR	12
2524	Refrigerator, Chest, Glass Door, 50+ cu ft, ENERGY STAR	12
2525	Refrigerator, Chest, Solid Door, < 15 cu ft, ENERGY STAR	12
2526	Refrigerator, Chest, Solid Door, 15-29 cu ft, ENERGY STAR	12
2527	Refrigerator, Chest, Solid Door, 30-49 cu ft, ENERGY STAR	12
2528	Refrigerator, Chest, Solid Door, 50+ cu ft, ENERGY STAR	12
2529	Refrigerator, Vertical, Glass Door, < 15 cu ft, ENERGY STAR	12
2530	Refrigerator, Vertical, Glass Door, 15-29 cu ft, ENERGY STAR	12
2531	Refrigerator, Vertical, Glass Door, 30-49 cu ft, ENERGY STAR	12
2532	Refrigerator, Vertical, Glass Door, 50+ cu ft, ENERGY STAR	12
2533	Refrigerator, Vertical, Solid Door, < 15 cu ft, ENERGY STAR	12
2534	Refrigerator, Vertical, Solid Door, 15-29 cu ft, ENERGY STAR	12
2535	Refrigerator, Vertical, Solid Door, 30-49 cu ft, ENERGY STAR	12
2536	Refrigerator, Vertical, Solid Door, 50+ cu ft, ENERGY STAR	12
2542	Steam Trap Repair, < 50 psig, Industrial	6
2544	Steam Trap Repair, > 225 psig, Industrial	6
2546	Steam Trap Repair, 126-225 psig, Industrial	6
2548	Steam Trap Repair, 50-125 psig, Industrial	6
2549	Steamer, 3 Pan, ENERGY STAR, Electric	11
2550	Steamer, 4 Pan, ENERGY STAR, Electric	11
2551	Steamer, 5 Pan, ENERGY STAR, Electric	11
2552	Steamer, 5 Pan, ENERGY STAR, NG	11
2553	Steamer, 6 Pan, ENERGY STAR, Electric	11
2554	Steamer, 6 Pan, ENERGY STAR, NG	11
2556	T8 1L 4', 25W, CEE, BF ≤ 0.78	15
2557	T8 1L 4', 28W, CEE, BF ≤ 0.78	15
2558	T8 1L 4', 28W, CEE, BF > 0.78	15
2559	T8 1L 4', HPT8, CEE, BF > 0.78	15
2560	T8 1L, 4', 25W, CEE, BF > 0.78	15
2561	T8 1L, 4', HPT8, CEE, BF ≤ 0.78	15
2562	T8 2L 4', 25W, CEE, BF ≤ 0.78	15
2563	T8 2L 4', 25W, CEE, BF > 0.78	15
2564	T8 2L 4', 28W, CEE, BF ≤ 0.78	15
2565	T8 2L 4', 28W, CEE, BF > 0.78	15
2566	T8 2L 4', HPT8, CEE, BF ≤ 0.78	15
2567	T8 2L 4', HPT8, CEE, BF > 0.78	15

MMID	Measure Name	EUL (years)
2568	T8 2L 4', HPT8, CEE, replacing 8' 1L T12HO	15
2569	T8 2L 4', HPT8, CEE, replacing 8' 2L T12	15
2571	T8 3L 4', 25W, CEE, BF ≤ 0.78	15
2572	T8 3L 4', 25W, CEE, BF > 0.78	15
2573	T8 3L 4', 28W, CEE, BF ≤ 0.78	15
2574	T8 3L 4', 28W, CEE, BF > 0.78	15
2575	T8 3L 4', HPT8, CEE, BF ≤ 0.78	15
2576	T8 3L 4', HPT8, CEE, BF > 0.78	15
2577	T8 4L 4', 25W, CEE, BF ≤ 0.78	15
2578	T8 4L 4', 25W, CEE, BF > 0.78	15
2579	T8 4L 4', 28W, CEE, BF ≤ 0.78	15
2580	T8 4L 4', 28W, CEE, BF > 0.78	15
2581	T8 4L 4', HPT8, CEE, BF ≤ 0.78	15
2582	T8 4L 4', HPT8, CEE, BF > 0.78	15
2590	T8, Low Watt Relamp, 25 Watts, 4'	15
2591	T8, Low Watt Relamp, 28 Watts, 4'	15
2596	Thermal Curtain, Double Pane Glass Walls and Ceiling, Overhead Heating	5
2597	Thermal Curtain, Double Pane Glass Walls and Ceiling, Under Bench Heating	5
2598	Thermal Curtain, Double Pane Glass Walls and Poly Film Ceiling, Overhead Heating	5
2599	Thermal Curtain, Double Pane Glass Walls and Poly Film Ceiling, Under Bench Heating	5
2601	Thermal Curtain, Poly Film Walls and Ceiling, Overhead Heating	5
2602	Thermal Curtain, Poly Film Walls and Ceiling, Under Bench Heating	5
2603	Thermal Curtain, Single Pane Glass Walls and Ceiling, Overhead Heating	5
2604	Thermal Curtain, Single Pane Glass Walls and Ceiling, Under Bench Heating	5
2605	Thermal Curtain, Single Pane Glass Walls and Poly Film Ceiling, Overhead Heating	5
2606	Thermal curtain, Single Pane Glass Walls and Poly Film Ceiling, Under Bench Heating	5
2608	Unit Heater, ≥90% Thermal Efficiency	15
2611	Vending Machine Controls, Occupancy Based, Cold Beverage Machine	5
2612	Vending Machine Controls, Occupancy Based, Snack Machine	5
2613	Vending Machine Controls, Sales Based, Cold Beverage Machine	5
2614	Vending Machine Controls, Sales Based, Snack Machine	5
2615	Vending Machine, Cold Beverage, Not Software Activated, ENERGY STAR	10
2616	Vending Machine, Cold Beverage, Software Activated, ENERGY STAR	10
2620	Ventilation Controls, Kitchen Hood, Temp only, Adder for MUA, New	10
2621	Ventilation Controls, Kitchen Hood, Temp only, Adder for MUA, Retrofit	10

MMID	Measure Name	EUL (years)
2622	Ventilation Controls, Kitchen Hood, Temp only, Exhaust Only, New	10
2623	Ventilation Controls, Kitchen Hood, Temp only, Exhaust Only, Retrofit	10
2624	Ventilation Controls, Kitchen Hood, with Optical, Adder for MUA, New	10
2625	Ventilation Controls, Kitchen Hood, with Optical, Adder for MUA, Retrofit	10
2626	Ventilation Controls, Kitchen Hood, with Optical, Exhaust Only, New	10
2627	Ventilation Controls, Kitchen Hood, with Optical, Exhaust Only, Retrofit	10
2628	Ventilation Fan, 36" Dia., Ag	16
2629	Ventilation Fan, 42" Dia., Ag	16
2630	Ventilation Fan, 48" Dia., Ag	16
2631	Ventilation Fan, 50" Dia., Ag	16
2632	Ventilation Fan, 51" Dia., Ag	16
2633	Ventilation Fan, 52" Dia., Ag	16
2634	Ventilation Fan, 54" Dia., Ag	16
2635	Ventilation Fan, 55" Dia., Ag	16
2636	Ventilation Fan, 57" Dia., Ag	16
2637	Ventilation Fan, 60" Dia., Ag	16
2638	Ventilation Fan, 72" Dia., Ag	16
2651	Water Heater, ≥ 0.67 EF, Storage, NG	10
2652	Water Heater, ≥ 0.82 EF, Tankless, Residential, NG	13
2658	Water Heater, Indirect, 90% AFUE Boiler, NG	15
2660	Waterer, Livestock, < 250 Watts	10
2665	T8, Reduced Wattage, Relamp 8'	15
2666	Chiller System Tune Up, Air Cooled, ≤ 500 Tons	5
2667	Chiller System Tune Up, Air Cooled, > 500 Tons	5
2668	Chiller System Tune Up, Water Cooled, ≤ 500 Tons	5
2669	Chiller System Tune Up, Water Cooled, > 500 Tons	5
2670	CFL, ≤32 Watt	5
2671	Coil Cleaning, Direct Install, Self Contained Unit	4
2677	Hot Food Holding Cabinet, V = 13-28 cu. ft., ENERGY STAR	12
2678	Hot Food Holding Cabinet, V < 13 cu. ft., ENERGY STAR	12
2679	Hot Food Holding Cabinet, V ≥ 28 cu. ft., ENERGY STAR	12
2686	Faucet Aerator, Direct Install, .5 gpm, Public Restroom, Electric	10
2687	Faucet Aerator, Direct Install, .5 gpm, Public Restroom, NG	10
2688	Faucet Aerator, Direct Install, .5 gpm, Employee Restroom, Electric	10
2689	Faucet Aerator, Direct Install, .5 gpm, Employee Restroom, NG	10
2699	PTHP, <8000 Btuh	15
2700	PTHP, ≥13000 Btuh	15
2701	PTHP, 10000-12999 Btuh	15

MMID	Measure Name	EUL (years)
2702	PTHP, 8000 - 9999 Btuh	15
2703	T5 2L Recessed Indirect Fixture, F28, replacing 3 or 4L - T8 or T12	15
2704	T8 2L 4', Recessed Indirect Fixture, HPT8, replacing 3 or 4L - T8 or T12	15
2707	T8, Low-Watt Relamp, 54 Watts, 8-Foot	5
2711	Insulation, Project Based, Attic,	35
2712	Insulation, Project Based, Wall,	25
2713	Insulation, Project Based, Foundation,	20
2714	Insulation, Project Based, Sillbox	20
2732	CFL, Direct Install, 13 Watt	6 (Residential-multifamily) 5 (Nonresidential)
2734	Faucet Aerator, Direct Install, 1.5 gpm, Bathroom, Electric	10
2735	Faucet Aerator, Direct Install, 1.5 gpm, Bathroom, NG	10
2736	LED, Direct Install, Exit Sign, Retrofit	8
2740	CFL, Direct Install, 18 Watt	6
2741	Insulation, Direct Install, 3' Pipe, Electric	10
2742	Insulation, Direct Install, 3' Pipe, NG	15
2743	Boiler, Hot Water, Modulating, ≥90% AFUE,≤300 MBH	20
2744	Boiler Tune Up	2
2753	CFL, ≤ 32 Watts, Common Area	2
2754	CFL, ≤32 Watt, In Unit	10
2756	Clothes Washer, Common Area, Electric, ENERGY STAR	11
2757	Clothes Washer, Common Area, NG, ENERGY STAR	11
2764	Furnace, ECM, ≥95%+ AfUE, NG	18
2768	LED, Exit Sign, Retrofit	8 (Residential-multifamily) 16 (Nonresidential)
2772	Steam Trap Repair, < 10 psig, Radiator	6
2792	Insulation, Direct Install, Pipe, Per Foot, 2" Thickness, Electric	14
2793	Insulation, Direct Install, Pipe, Per Foot, 2" Thickness, NG	14
2794	Insulation, Direct Install, Pipe, Per Foot, 1" Thickness, Electric	16 (Commercial) 14 (Other Business)
2795	Insulation, Direct Install, Pipe, Per Foot, 1" Thickness, NG	16 (Commercial) 14 (Other Business)
2797	Occupancy Sensor, With Co-Pay, Wall Mount, ≤ 200 Watts	9
2798	Occupancy Sensor, With Co-Pay, Wall Mount, >200 Watts	9
2810	Timer, Engine Block Heater	15
2820	Ground Source Heat Pump, Electric Back-up	18
2821	Ground Source Heat Pump, NG Back-up	18

MMID	Measure Name	EUL (years)
2825	Water Heater Fuel Switching, Electric to NG	15
2884	T8 4L Replacing 250-399 W HID	14
2885	T8 6L Replacing 400-999 W HID	14
2886	T8 8L Replacing 400-999 W HID	14
2887	T8 8L ≤ 500W, Replacing ≥1000 W HID	14
2888	T8 10L ≤ 500W, Replacing ≥1000 W HID	14
2889	T8 (2) 6L≤ 500W, Replacing ≥1000 W HID	14
2890	T5HO 2L Replacing 250-399 W HID	14
2891	T5HO 3L Replacing 250-399 W HID	14
2892	T5HO 4L Replacing 400-999 W HID	14
2893	T5HO 6L Replacing 400-999 W HID	14
2894	T5HO 6L ≤ 500W, Replacing ≥1000 W HID	14
2895	T5HO 8L ≤ 500W, Replacing ≥1000 W HID	14
2896	T5HO (2) 4L ≤ 500W, Replacing ≥1000 W HID	14
2897	T5HO (2) 6L ≤ 800W, Replacing ≥1000 W HID	14
2899	Insulation, Above Grade, R-5 or greater	20
2902	Water Heater, Power Vented, EF = .67-.82, Storage, NG	15
2955	Refrigerator, Recycling and Replacement	8
2956	Freezer, Recycling and Replacement	8
2957	Refrigerator, MESP Referral, Recycling and Replacement	8
2958	Refrigerator, Recycling and Replacement Referral	8
2971	LED Lamp, Direct Install, Walk-in Cooler or Freezer	6
2979	LED, Exit Sign, Retrofit, Over Program Limit	16
2984	LED Fixture, Downlights, Accent Lights and Monopoint, ≤18 Watts, Common Area	11
2989	ECM, Furnace, New or Replacement	18
2990	Furnace And A/C, ECM, 95% + AFUE, ≥ 16 SEER	23
2992	Air Source Heat Pump, ≥ 16 SEER	18
3001	Delamping, 200-399 Watt Fixture	TBA
3002	Delamping, ≥400 Watt Fixture	TBA
3003	LED, Replacing Neon Sign	15
3017	Showerheads, Retail Store Markdown	10
3018	Waterer, Livestock, Energy Free	10
3019	Lighting Fixture, Agricultural Daylighting ≤ 155 Watts	15
3020	Lighting Fixture, Agricultural Daylighting 156 - 250 Watts	15
3021	Lighting Fixture, Agricultural Daylighting 251 - 365 Watts	15
3023	T5, Reduced Wattage, Replacing T5 Or T5HO	6
3024	T5HO, Reduced Wattage, Replacing Standard T5 Or T5HO	8

MMID	Measure Name	EUL (years)
3025	Faucet Aerator, 1.5 gpm, Kitchen, NG	10
3026	Faucet Aerator, 1.5 gpm, Kitchen, Electric	10
3027	Faucet Aerator, 1.5 gpm, Bathroom, NG	10
3028	Faucet Aerator, 1.5 gpm, Bathroom, Electric	10
3029	Faucet Aerator, 1.5 gpm, Shower, NG	10
3030	Faucet Aerator, 1.5 gpm, Shower, Electric	10
3031	CFL, Reduced Wattage, Pin Based, 18 Watt, Replacing CFL	3
3032	CFL, Reduced Wattage, Pin Based, 26 Watt, Replacing CFL	3
3033	CFL, Reduced Wattage, Pin Based, 32 Watt, Replacing CFL	3
3034	CFL, Reduced Wattage, Pin Based, 42 Watt, Replacing CFL	3
3036	HID, Reduced Wattage, Replacing 1000 Watt HID, Exterior	4
3037	HID, Reduced Wattage, Replacing 400 Watt HID, Exterior	4
3038	HID, Reduced Wattage, Replacing 320 Watt HID, Exterior	4
3039	HID, Reduced Wattage, Replacing 250 Watt HID, Exterior	4
3040	HID, Reduced Wattage, Replacing 175 Watt HID, Exterior	4
3041	T5HO, Exterior Reduced Wattage, Replacing 250-399 Watt HID	15
3042	T5HO, Exterior Reduced Wattage, Replacing 400-999 Watt HID	15
3043	T5HO, Exterior < 500 Watts, Replacing ≥ 1000 Watt HID	15
3056	LED Fixture, Replacing 320 Watt HID, Parking Garage, 24 Hour	8
3065	Ceramic Metal Halide, 575 Watt, Replacing 1000 Watt HID, High Bay	15
3067	HID, Reduced Wattage, Replacing 1000 Watt HID, Interior	4
3068	HID, Reduced Wattage, Replacing 175 Watt HID, Interior	4
3069	HID, Reduced Wattage, Replacing 175 Watt HID, Parking Garage	4
3070	HID, Reduced Wattage, Replacing 250 Watt HID, Interior	4
3071	HID, Reduced Wattage, Replacing 250 Watt HID, Parking Garage	4
3072	HID, Reduced Wattage, Replacing 320 Watt HID, Interior	4
3073	HID, Reduced Wattage, Replacing 400 Watt HID, Interior	4
3074	Induction, 750 Watt, Replacing 1000 Watt HID, High Bay	27
3075	Induction, PSMH/CMH, ≤250 Watt, Replacing 320-400 Watt HID, High Bay	15
3076	Induction, PSMH/CMH, ≤250 Watt, Replacing 400 Watt HID, High Bay	15
3077	Induction, PSMH/CMH, ≤365 Watt, Replacing 400 Watt HID, High Bay	15
3078	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 150-175 Watt HID, Exterior	15
3079	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 150-175 Watt HID, Parking Garage, 24 Hour	15
3080	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 150-175 Watt HID, Parking Garage, Dusk to Dawn	15
3081	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 250 Watt HID, Exterior	15

MMID	Measure Name	EUL (years)
3082	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 250 Watt HID, Parking Garage, 24 Hour	15
3083	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 250 Watt HID, Parking Garage, Dusk to Dawn	15
3084	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 320 Watt HID, Exterior	15
3085	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 320-400 Watt HID, Exterior	15
3086	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 400 Watt HID, Exterior	15
3087	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 70-100 Watt HID, Exterior	15
3088	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 70-100 Watt HID, Parking Garage, 24 Hour	15
3089	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 70-100 Watt HID, Parking Garage, Dusk to Dawn	15
3090	Induction, PSMH/CMH, Replacing 250 Watt HID, High Bay	15
3091	LED Fixture, <155 Watts, Replacing 250 Watt HID, High Bay	20
3092	LED Fixture, <250 Watts, Replacing 320-400 Watt HID, High Bay	20
3093	LED Fixture, <250 Watts, Replacing 400 Watt HID, High Bay	20
3094	LED Fixture, <365 Watts, Replacing 400 Watt HID, High Bay	20
3095	LED Fixture, <500 Watts, Replacing 1000 Watt HID, High Bay	20
3096	LED Fixture, <800 Watts, Replacing 1000 Watt HID, High Bay	20
3097	LED Fixture, Bilevel, Stairwell and Passageway	9
3098	LED Fixture, Downlights, Accent Lights and Monopoint, > 18 Watts, Common Area	11
3099	LED Fixture, Replacing 150-175 Watt HID, Exterior	20
3100	LED Fixture, Replacing 150-175 Watt HID, Parking Garage, 24 Hour	8
3101	LED Fixture, Replacing 150-175 Watt HID, Parking Garage, Dusk to Dawn	16
3102	LED Fixture, Replacing 250 Watt HID, Exterior	20
3103	LED Fixture, Replacing 250 Watt HID, Parking Garage, 24 Hour	8
3104	LED Fixture, Replacing 250 Watt HID, Parking Garage, Dusk to Dawn	16
3105	LED Fixture, Replacing 320 Watt HID, Exterior	20
3106	LED Fixture, Replacing 320-400 Watt HID, Exterior	20
3107	LED Fixture, Replacing 400 Watt HID, Exterior	20
3108	LED Fixture, Replacing 70-100 Watt HID, Exterior	20
3109	LED Fixture, Replacing 70-100 Watt HID, Parking Garage, 24 Hour	8
3110	LED Fixture, Replacing 70-100 Watt HID, Parking Garage, Dusk to Dawn	16
3111	LED Troffer, 2x4, Replacing 4' 3-4 Lamp T8 Troffer	16

MMID	Measure Name	EUL (years)
3112	LED, ≤ 40 Watt, ENERGY STAR, Replacing Incandescent	7
3113	LED, > 40 Watt, ENERGY STAR, Replacing Incandescent	7
3114	LED, Horizontal Case Lighting	20
3117	Linear Fluorescent, Bilevel, Stairwell and Passageway	18 (Residential-multifamily) 8 (Nonresidential)
3118	Oven, Combination, ENERGY STAR, Electric	12
3119	Oven, Combination, ENERGY STAR, NG	12
3122	T8 2L 4', HPT8 or RWT8, Replacing T12 1L 8', 0.78 < BF < 1.00	15
3123	T8 2L 4', HPT8 or RWT8, Replacing T12 1L 8', BF ≤ 0.78	15
3124	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', 0.78 < BF < 1.00	15
3125	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', BF ≤ 0.78	15
3126	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', BF > 1.00	15
3127	T8 4L 4', HPT8 or RWT8, Replacing T12 2L 8', 0.78 < BF < 1.00	15
3128	T8 4L 4', HPT8 or RWT8, Replacing T12 2L 8', BF ≤ 0.78	15
3129	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', 0.78 < BF < 1.00	15
3130	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', BF ≤ 0.78	15
3131	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', BF > 1.00	15
3132	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', 0.78 < BF < 1.00	15
3133	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', BF ≤ 0.78	15
3134	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', BF > 1.00	15
3135	T8, Low Wattage Relamp, 8'	15
3136	Dishwasher, High Temp, Electric Booster, Pots/Pans Type, ENERGY STAR, Electric	10
3137	Dishwasher, High Temp, Electric Booster, Pots/Pans Type, ENERGY STAR, NG	10
3138	Dishwasher, High Temp, Gas Booster, Pots/Pans Type, ENERGY STAR, NG	10
3139	Dishwasher, Low Temp, Pots/Pans Type, ENERGY STAR, Electric	10
3140	Dishwasher, Low Temp, Pots/Pans Type, ENERGY STAR, NG	10
3141	LED, ≤ 8W	7
3142	LED, > 12W (Max 20W) Flood Lamp	11
3143	LED, MR16, 8-12W	7
3144	T8 2L 4', HPT8 or RWT8, Replacing T12 1L 8', 0.78 < BF < 1.00, Parking Garage	15
3145	T8 2L 4', HPT8 or RWT8, Replacing T12 1L 8', BF ≤ 0.78, Parking Garage	15
3146	T8 4L 4', HPT8 or RWT8, Replacing T12 2L 8', 0.78 < BF < 1.00, Parking Garage	15
3147	T8 4L 4', HPT8 or RWT8, Replacing T12 2L 8', BF ≤ 0.78, Parking Garage	15
3148	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', BF > 1.00, Parking Garage	15
3149	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', 0.78 < BF < 1.00, Parking Garage	15
3150	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', BF ≤ 0.78, Parking Garage	15

MMID	Measure Name	EUL (years)
3151	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', BF > 1.00, Parking Garage	15
3152	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', 0.78 < BF < 1.00, Parking Garage	15
3153	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', BF ≤ 0.78, Parking Garage	15
3154	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', BF > 1.00, Parking Garage	15
3155	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', 0.78 < BF < 1.00, Parking Garage	15
3156	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', BF ≤ 0.78, Parking Garage	15
3157	LED, Porch Fixture, ENERGY STAR	20
3158	LED Fixture, Downlights, Accent Lights and Monopoint, ≤ 18 Watts, In Unit	20
3159	LED, ENERGY STAR, Replacing Incandescent > 40W, In Unit	20
3160	LED, ENERGY STAR, Replacing Incandescent > 40W, Common Area	7
3161	LED, ENERGY STAR, Replacing Incandescent ≤ 40W, In Unit	20
3162	LED, ENERGY STAR, Replacing Incandescent ≤ 40W, Common Area	7
3163	T8 1L 4', HPT8, CEE, BF ≤ 0.78, Parking Garage	15
3164	T8 1L 4', 28W, CEE, BF > 0.78, Parking Garage	15
3165	T8 1L 4', 28W, CEE, BF ≤ 0.78, Parking Garage	15
3166	T8 1L 4', 25W, CEE, BF > 0.78, Parking Garage	15
3167	T8 1L 4', 25W, CEE, BF ≤ 0.78, Parking Garage	15
3168	T8 2L 4', HPT8, CEE, BF ≤ 0.78, Parking Garage	15
3169	T8 2L 4', 28W, CEE, BF > 0.78, Parking Garage	15
3170	T8 2L 4', 28W, CEE, BF ≤ 0.78, Parking Garage	15
3171	T8 2L 4', 25W, CEE, BF > 0.78, Parking Garage	15
3172	T8 2L 4', 25W, CEE, BF ≤ 0.78, Parking Garage	15
3173	T8 3L 4', HPT8, CEE, BF ≤ 0.78, Parking Garage	15
3174	T8 3L 4', 28W, CEE, BF > 0.78, Parking Garage	15
3175	T8 3L 4', 28W, CEE, BF ≤ 0.78, Parking Garage	15
3176	T8 3L 4', 25W, CEE, BF > 0.78, Parking Garage	15
3177	T8 3L 4', 25W, CEE, BF ≤ 0.78, Parking Garage	15
3178	T8 4L 4', HPT8, CEE, BF ≤ 0.78, Parking Garage	15
3179	T8 4L 4', 28W, CEE, BF > 0.78, Parking Garage	15
3180	T8 4L 4', 28W, CEE, BF ≤ 0.78, Parking Garage	15
3181	T8 4L 4', 25W, CEE, BF > 0.78, Parking Garage	15
3182	T8 4L 4', 25W, CEE, BF ≤ 0.78, Parking Garage	15
3183	Strip Curtain, Walk-In Freezers and Coolers	4
3184	Delamping, T12 to T8, 8'	10
3186	Water Heater, Geothermal Heat Pump	15
3195	Linear Fluorescent, 2L 4’RWT8 Replacements, 24 Hours, CALP	15

MMID	Measure Name	EUL (years)
3196	Linear Fluorescent, 2L 4’RWT8 Replacements, 12 Hours, CALP	15
3197	CFL Fixture, Interior or Exterior, 24 Hours, CALP	13
3198	CFL Fixture, Interior, 12 Hours, CALP	13
3199	CFL Fixture, Exterior, 12 Hours, CALP	13
3200	LED, Exit Sign, Retrofit, CALP	8
3201	Occupancy Sensor, Wall or Ceiling Mount ≤200 Watts, CALP	8
3202	Occupancy Sensor, Wall or Ceiling Mount >200 Watts, CALP	8
3206	ELO, CMH Lamp, 330 Watts, Replacing 400 Watt HID	4
3207	ELO, CMH Lamp With Controls, 330 Watts, Replacing 400 Watt HID	4
3208	ELO, CMH Lamp, 205 Watts, Replacing 250 Watt HID	4
3209	ELO, CMH Lamp With Controls, 205 Watts, Replacing 250 Watt HID	4
3210	ELO, CMH System, 210-220 Watts, Replacing 400 Watt HID	13
3211	ELO, CMH System With Controls, 210-220 Watts, Replacing 400 Watt HID	13
3212	ELO, CMH System, 140-150 Watts, Replacing 250 Watt HID	13
3213	ELO, CMH System With Controls, 140-150 Watts, Replacing 250 Watt HID	13
3214	ELO, CMH System, 90 Watts, Replacing 150-175 Watt HID	13
3215	ELO, CMH System With Controls, 90 Watts, Replacing 150-175 Watt HID	11
3216	ELO, LED ≤ 200 Watts, Replacing 400 Watt HID	20
3217	ELO, LED ≤ 200 Watts With Controls, Replacing 400 Watt HID	20
3218	ELO, LED ≤ 125 Watts, Replacing 250 Watt HID	20
3219	ELO, LED ≤ 125 Watts With Controls, Replacing 250 Watt HID	20
3220	ELO, LED ≤ 60 Watts, Replacing 150-175 Watt HID	20
3221	ELO, LED ≤ 60 Watts With Controls, Replacing 150-175 Watt HID	20
3224	Retrocommissioning, Express Building Tune-Up	5
3232	LED, 2x4, Replacing T12 2L	16
3233	LED, 2x4, Replacing T12 3L	16
3234	LED, 2x4, Replacing T12 4L	16
3235	LED, 2x4, Replacing T8 2L	16
3236	LED, 2x4, Replacing T8 3L	16
3237	LED, 2x4, Replacing T8 4L	16
3238	LED, 2x2, Replacing T12 2L U-Tube	16
3239	LED, 2x2, Replacing T8 2L U-Tube	16
3240	T8, 2’ Lamps, Replacing T12 Single U-Tube	6
3241	T8, 2’ Lamps, Replacing T12 Dual U-Tube	6
3242	T8, 2’ Lamps, Replacing T8 Single U-Tube	6
3243	T8, 2’ Lamps, Replacing T8 Dual U-Tube	6
3251	Lighting Controls, Bilevel, Exterior and Parking Garage Fixtures, Dusk to Dawn	8
3252	Lighting Controls, Bilevel, Parking Garage Fixtures, 24 Hour	8

MMID	Measure Name	EUL (years)
3253	Lighting Controls, Photocell with Internal Timer or Wireless Schedule, Exterior	8
3254	Occupancy Sensor, High Bay Fixtures, Gymnasium	8
3255	Occupancy Sensor, High Bay Fixtures, Industrial	8
3256	Occupancy Sensor, High Bay Fixtures, Retail	8
3257	Occupancy Sensor, High Bay Fixtures, Warehouse	8
3258	Occupancy Sensor, High Bay Fixtures, Public Assembly	8
3259	Occupancy Sensor, High Bay Fixtures, Other	8
3260	Bi Level Controls, High Bay Fixtures, Gymnasium	8
3261	Bi Level Controls, High Bay Fixtures, Industrial	8
3262	Bi Level Controls, High Bay Fixtures, Retail	8
3263	Bi Level Controls, High Bay Fixtures, Warehouse	8
3264	Bi Level Controls, High Bay Fixtures, Public Assembly	8
3265	Bi Level Controls, High Bay Fixtures, Other	8
3273	LED, 8 watts	7
3274	LED, 12 watts	7
3275	Boiler Plant Retrofit, Hybrid Plant, ≥1 MMBh	20
3276	Boiler, Hot Water, Condensing, ≥90% AFUE, ≥300 mbh	20
3277	Boiler, Hot Water, Near Condensing, ≥85% AFUE, ≥300 mbh	20
3279	LED, Direct Install, 9.5 Watt	20
3284	Strip Curtain, Walk-In Freezers and Coolers, SBP A La Carte	4
3285	LED Fixture, <155 Watts, Replacing 250 Watt HID, High Bay, SBP A La Carte	20
3287	LED Fixture, <250 Watts, Replacing 400 Watt HID, High Bay, SBP A La Carte	20
3288	LED Fixture, <365 Watts, Replacing 400 Watt HID, High Bay, SBP A La Carte	20
3289	LED Fixture, Replacing 150-175 Watt HID, Exterior, SBP A La Carte	20
3290	LED Fixture, Replacing 320-400 Watt HID, Exterior, SBP A La Carte	20
3291	LED Troffer, 2x4, Replacing 4' 3-4 Lamp T8 Troffer, SBP A La Carte	13
3292	Occupancy Sensor, High Bay Fluorescent Fixtures, Retail, SBP A La Carte	8
3293	Occupancy Sensor, High Bay Fluorescent Fixtures, Warehouse, SBP A La Carte	8
3294	Occupancy Sensor, High Bay Fluorescent Fixtures, Public Assembly, SBP A La Carte	8
3295	Occupancy Sensor, High Bay Fluorescent Fixtures, Gymnasium, SBP A La Carte	8
3296	Occupancy Sensor, High Bay Fluorescent Fixtures, Other, SBP A La Carte	8
3297	Occupancy Sensor, High Bay Fluorescent Fixtures, Industrial, SBP A La Carte	8
3298	LED, Reach-In Refrigerated Case, Replaces T12 or T8, SBP A La Carte	16
3299	LED, Reach-In Refrigerated Case, Replaces T12 or T8 w/ Occupancy Control, SBP A La Carte	16
3300	T8 2L 4', HPT8, CEE, replacing 8' 1L T12HO, SBP A La Carte	15
3301	LED Fixture, Replacing 250 Watt HID, Exterior, SBP A La Carte	20

MMID	Measure Name	EUL (years)
3303	LED Fixture, Replacing 400 Watt HID, Exterior, SBP A La Carte	20
3304	LED Fixture, Replacing 70-100 Watt HID, Exterior, SBP A La Carte	20
3305	T8 6L or T5HO 4L Replacing 400-999 W HID, SBP A La Carte	14
3306	T8 or T5HO, Replacing ≥1000 Watt HID, SBP A La Carte	15
3307	T8 2L 4', HPT8 or RWT8, Replacing T12 1L 8', 0.78 < BF < 1.00, SBP A La Carte	15
3308	T8 2L 4', HPT8 or RWT8, Replacing T12 1L 8', BF ≤ 0.78, SBP A La Carte	15
3309	T8 4L 4', HPT8 or RWT8, Replacing T12 2L 8', 0.78 < BF < 1.00, SBP A La Carte	15
3310	T8 4L 4', HPT8 or RWT8, Replacing T12 2L 8', BF ≤ 0.78, SBP A La Carte	15
3311	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', BF > 1.00, SBP A La Carte	15
3312	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', 0.78 < BF < 1.00, SBP A La Carte	15
3313	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', BF ≤ 0.78, SBP A La Carte	15
3314	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', 0.78 < BF < 1.00, SBP A La Carte	15
3315	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', BF ≤ 0.78, SBP A La Carte	15
3316	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', BF > 1.00, SBP A La Carte	15
3317	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', 0.78 < BF < 1.00, SBP A La Carte	15
3318	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', BF ≤ 0.78, SBP A La Carte	15
3319	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', BF > 1.00, SBP A La Carte	15
3320	Delamping, T12 to T8, 8', SBP A La Carte	TBA
3321	Delamping, 200-399 Watt Fixture, SBP A La Carte	TBA
3322	Delamping, ≥400 Watt Fixture, SBP A La Carte	TBA
3323	LED, 2x2, Replacing T12 2L U-Tube, SBP A La Carte	16
3324	LED, 2x2, Replacing T8 2L U-Tube, SBP A La Carte	16
3325	T8, 2' Lamps, Replacing T12 Single U-Tube, SBP A La Carte	15
3326	T8, 2' Lamps, Replacing T12 Dual U-Tube, SBP A La Carte	15
3327	T8, 2' Lamps, Replacing T8 Single U-Tube, SBP A La Carte	15
3328	T8, 2' Lamps, Replacing T8 Dual U-Tube, SBP A La Carte	15
3329	T8 4L Replacing 250-399 W HID, SBP A La Carte	15
3330	T5HO 2L Replacing 250-399 W HID, SBP A La Carte	15
3331	T8 6L Replacing 400-999 W HID, SBP A La Carte	15
3332	T5HO 4L Replacing 400-999 W HID, SBP A La Carte	15
3333	T8 8L ≤ 500W, Replacing ≥1000 W HID, SBP A La Carte	15
3334	T5HO 6L ≤ 500W, Replacing ≥1000 W HID, SBP A La Carte	15
3335	LED, Horizontal Case Lighting, SBP A La Carte	16
3336	T8 2L 4', recessed Indirect Fixture, HPT8 replacing 3 or 4L - T8 or T12, SBP A La Carte	15
3337	Bi Level Controls, High Bay Fixtures, Gymnasium, SBP A La Carte	8

MMID	Measure Name	EUL (years)
3338	Bi Level Controls, High Bay Fixtures, Industrial, SBP A La Carte	8
3339	Bi Level Controls, High Bay Fixtures, Other, SBP A La Carte	8
3340	Bi Level Controls, High Bay Fixtures, Public Assembly, SBP A La Carte	8
3341	Bi Level Controls, High Bay Fixtures, Retail, SBP A La Carte	8
3342	Bi Level Controls, High Bay Fixtures, Warehouse, SBP A La Carte	8
3343	Lighting Controls, Bilevel, Exterior and Parking Garage Fixtures, Dusk to Dawn, SBP A La Carte	8
3344	Lighting Controls, Bilevel, Parking Garage Fixtures, 24 Hour, SBP A La Carte	8
3345	Lighting Controls, Photocell with Internal Timer or Wireless Schedule, Exterior, SBP A La Carte	8
3347	LED, 12 Watts, SBP Package	7
3348	LED Troffer, 2x4, Replacing 4' 3-4 Lamp T8 Troffer, SBP Package	16
3349	CFL, 31-115 Watts, SBP Package	5
3350	Insulation, Direct Install, Pipe, Per Foot, 1" Thickness, Electric, SBP Package	10
3351	Insulation, Direct Install, Pipe, Per Foot, 1" Thickness, NG, SBP Package	10
3352	LED, 8-12 Watts, SBP Package	7
3353	LED, Replacing Neon Sign, SBP Package	15
3354	CFL, ≤32 Watt, SBP Package	5
3355	Faucet Aerator, Direct Install, 1.5 gpm, Bathroom, Electric, SBP Package	10
3356	Faucet Aerator, Direct Install, 1.5 gpm, Bathroom, NG, SBP Package	10
3357	Occupancy Sensor, Wall Mount, >200 Watts, SBP Package	8
3358	Showerhead, Direct Install, 1.75 gpm, Electric, SBP Package	9
3359	Showerhead, Direct Install, 1.75 gpm, NG, SBP Package	9
3360	LED, Exit Sign, Retrofit, SBP Package	10
3361	Occupancy Sensor, Wall Mount, ≤200 Watts, SBP Package	8
3362	Vending Machine Controls, Occupancy Based, Cold Beverage Machine, SBP Package	10
3363	LED, ≤ 8W, SBP Package	7
3364	LED, > 12W (Max 20W) Flood Lamp, SBP Package	11
3365	LED, MR16, 8-12W, SBP Package	7
3366	LED, 2x2, Replacing T12 2L U-Tube, SBP Package	16
3367	LED, 2x2, Replacing T8 2L U-Tube, SBP Package	16
3368	Faucet Aerator, Direct Install, .5 gpm Public Restroom, Elec, SBP Package	16
3369	Faucet Aerator, Direct Install, .5 gpm Public Restroom, NG, SBP Package	7
3370	Faucet Aerator, Direct Install, .5 gpm Employee Restroom, Elec, SBP Package	16
3371	Faucet Aerator, Direct Install, .5 gpm employee Restroom, NG, SBP Package	16
3372	T8 2L 4', recessed Indirect Fixture, HPT8 replacing 3 or 4L - T8 or T12, SBP Package	16
3385	LED, Non PI Direct Install, 13.5 Watt	20

MMID	Measure Name	EUL (years)
3387	LED, 1x4, replacing T8 or T12, 2L	16
3388	LED, 1x4 replacing T8 or T12, 2L, SBP A La Carte	16
3389	LED, 1x4 replacing T8 or T12, 2L, SBP Package	16
3390	HPT8, 1x4, replacing T12 or T8, 2L	13
3391	HPT8, 1x4, replacing T12 or T8, 2L, SBP A La Carte	13
3392	HPT8, 1x4, replacing T12 or T8, 2L, SBP Package	13
3393	LED Fixture,≤180 Watts, Replacing 4 lamp T5 or 6 lamp T8, High Bay, DLC Listed	20
3394	LED Fixture, Downlights, ≤18 Watts, Replacing 1 lamp pin based CFL Downlight	11
3395	LED Fixture, Downlights, >18 Watts, Replacing 2 lamp pin based CFL Downlight	11
3396	LED Fixture, Downlights, ≤100 Watts, > =4000 Lumens, Interior	11
3397	LED Fixture, Downlights, ≤100 Watts, ≥4000 Lumens, Exterior	11
3398	LED Fixture, Downlights, ≥6000 Lumens, Interior	11
3399	LED Fixture, Downlights, ≥6000 Lumens, Exterior	11
3400	LED Fixture, 2x2, Low Output, DLC Listed	16
3401	LED Fixture, 2x2, High Output, DLC Listed	16
3402	LED Lamp, ENERGY STAR, Replacing Incandescent Lamp ≤40 Watts, Exterior	7
3403	LED Lamp, ENERGY STAR, Replacing Incandescent Lamp >40 Watts, Exterior	7
3404	LED Fixture, Downlights, >18 Watts, Replacing Incandescent Downlight, Exterior	11
3405	LED Fixture, Downlights, ≤18 Watts, Replacing Incandescent Downlight, Exterior	11
3406	Daylighting Controls	8
3407	LED Fixture, Replacing 1000 Watt HID, Exterior	20
3408	PSMH/CMH, Replacing 1000 Watt HID, Exterior	15
3409	Retrofit Open Refrigerated Cases with Doors	12
3413	CFL, Non PI Direct Install, 13 Watt	8
3414	Ice Machine, CEE Tier 2, Air Cooled, Self Contained, 0-499 lbs/day	10
3415	Ice Machine, CEE Tier 2, Water Cooled, Self Contained, 0-499 lbs/day	10
3416	Ice Machine, CEE Tier 2, Air Cooled, Ice Making Head, 0-499 lbs/day	10
3417	Ice Machine, CEE Tier 2, Air Cooled, Ice Making Head, 500-999 lbs/day	10
3418	Ice Machine, CEE Tier 2, Air Cooled, Ice Making Head, ≥1,000 lbs/day	10
3419	Ice Machine, CEE Tier 2, Water Cooled, Ice Making Head, <500 lbs/day	10
3420	Ice Machine, CEE Tier 2, Water Cooled, Ice Making Head, 500-999 lbs/day	10
3421	Ice Machine, CEE Tier 2, Water Cooled, Ice Making Head, ≥1,000 lbs/day	10
3422	Ice Machine, CEE Tier 2, Air Cooled, Remote Condensing, 0-499 lbs/day	10
3423	Ice Machine, CEE Tier 2, Air Cooled, Remote Condensing, 500-999 lbs/day	10
3424	Ice Machine, CEE Tier 2, Air Cooled, Remote Condensing, ≥1,000 lbs/day	10

MMID	Measure Name	EUL (years)
3425	LED, 8ft, Replacing T12 or T8, 1L	16
3426	LED, 8ft, Replacing T12 or T8, 1L, SBP A La Carte	16
3427	LED, 8ft, Replacing T12 or T8, 1L, SBP Package	16
3428	LED, 8ft, Replacing T12 or T8, 2L	16
3429	LED, 8ft, Replacing T12 or T8, 2L, SBP A La Carte	16
3430	LED, 8ft, Replacing T12 or T8, 2L, SBP Package	16
3431	LED, 8ft, Replacing T12HO or T8HO, 1L	16
3432	LED, 8ft, Replacing T12HO or T8HO, 1L, SBP A La Carte	16
3433	LED, 8ft, Replacing T12HO or T8HO, 1L, SBP Package	16
3434	LED, 8ft, Replacing T12HO or T8HO, 2L	16
3435	LED, 8ft, Replacing T12HO or T8HO, 2L, SBP A La Carte	16
3436	LED, 8ft, Replacing T12HO or T8HO, 2L, SBP Package	16
3439	LED, Non-PI Direct Install, 13.5 Watt, With Co-Pay	20
3440	NG Furnace with ECM, 97%+ AFUE	23
3441	NG Furnace, 95% AFUE	23
3442	NG Furnace with ECM, 97+ AFUE, Enhanced Rewards	23
3443	NG Furnace with ECM, 95+ AFUE (Existing), Enhanced Rewards	23
3444	LED, Recessed Downlight, ENERGY STAR, SBP Package	11
3445	LED Fixture, Downlights, Accent Lights, and Monopoint Fixtures ≤ 18 Watts, replacing 750-1,049 lumen incandescent, in unit	11
3446	LED Fixture, Downlights, Accent Lights, and Monopoint Fixtures ≤ 18 Watts, replacing 750-1,049 lumen incandescent, common area	11
3447	LED Fixture, Downlights, Accent Lights, and Monopoint Fixtures ≤ 18 Watts, replacing 1,050-1,489 lumen incandescent, in unit	11
3448	LED Fixture, Downlights, Accent Lights, and Monopoint Fixtures ≤ 18 Watts, replacing 1,050-1,489 lumen incandescent, common area	11
3449	Refrigerator, Manual or Partial Automatic Defrost, ENERGY STAR	11
3450	Refrigerator, Top-Mounted Freezer, ENERGY STAR	11
3451	Refrigerator, Side-by-Side, ENERGY STAR	11
3452	Refrigerator, Side-by-Side, Through-the-Door Ice, ENERGY STAR	11
3453	Refrigerator, Bottom-Mounted Freezer, ENERGY STAR	11
3454	Refrigerator, Bottom-Mounted Freezer, Through-the-Door Ice, ENERGY STAR	11
3455	Freezer, Chest, ENERGY STAR	12
3456	Freezer, Chest, Compact, ENERGY STAR	12
3457	Freezer, Upright, Compact, Manual Defrost, ENERGY STAR,	12
3458	Freezer, Upright, Compact, Automatic Defrost, ENERGY STAR,	12
3459	Freezer, Upright, Manual Defrost, ENERGY STAR,	12
3460	Freezer, Upright, Automatic Defrost, ENERGY STAR,	12
3461	LED, Recessed Downlight, Replacing Incandescent, ENERGY STAR, In Unit	11

MMID	Measure Name	EUL (years)
3462	LED, Recessed Downlight, Replacing Incandescent, ENERGY STAR, Common Area	11
3463	LED, Recessed Downlight, Replacing CFL, ENERGY STAR, In Unit	11
3464	LED, Recessed Downlight, Replacing CFL, ENERGY STAR, Common Area	11
3465	Boiler, 90%+ AFUE, With DHW, NG	15
3487	CFL, Direct Install, 20 Watt	6
3488	LED, Direct Install, 10 Watt	20
3489	DHW Temperature Turn Down, Serving Multiple Dwelling Units, Direct Install, Electric	15
3490	DHW Temperature Turn Down, Serving Multiple Dwelling Units, Direct Install, NG	15
3491	Furnace with ECM, ≥95%+ AFUE, NG	18
3492	Furnace with ECM, ≥90%+ AFUE, NG	18
3494	Variable Speed ECM Pump, < 100 Watts Max Input, Domestic Hot Water Recirculation	15
3495	Variable Speed ECM Pump, 100 - 500 Watts Max Input, Domestic Hot Water Recirculation	15
3496	Variable Speed ECM Pump, > 500 Watts Max Input, Domestic Hot Water Recirculation	15
3497	Variable Speed ECM Pump, < 100 Watts Max Input, Heating Water Circulation	15
3498	Variable Speed ECM Pump, 100 - 500 Watts Max Input, Heating Water Circulation	15
3499	Variable Speed ECM Pump, > 500 Watts Max Input, Heating Water Circulation	15
3500	Variable Speed ECM Pump, < 100 Watts Max Input, Cooling Water Circulation	15
3501	Variable Speed ECM Pump, 100 - 500 Watts Max Input, Cooling Water Circulation	15
3502	Variable Speed ECM Pump, > 500 Watts Max Input, Cooling Water Circulation	15
3503	Variable Speed ECM Pump, < 100 Watts Max Input, Water Loop Heat Pump Circulation	15
3504	Variable Speed ECM Pump, 100 - 500 Watts Max Input, Water Loop Heat Pump Circulation	15
3505	Variable Speed ECM Pump, > 500 Watts Max Input, Water Loop Heat Pump Circulation	15
3506	Faucet Aerator, 1.0 gpm, Kitchen, Electric	10
3507	Faucet Aerator, 1.0 gpm, Kitchen, NG	10
3508	Faucet Aerator, 0.5 gpm, Bathroom, NG	10
3509	Faucet Aerator, 0.5 gpm, Kitchen, Electric	10
3510	Faucet Aerator, 0.5 gpm, Kitchen, NG	10
3511	LED Replacement of 4' T8 Lamps w/Integral or External Driver	16

MMID	Measure Name	EUL (years)
3512	LED Replacement of 4’ T8 Lamps utilizing existing ballast	16
3514	Steam Trap Repair, 50-125 psig, General Heating, 3/8" or Larger	6
3515	Steam Trap Repair, 50-125 psig, General Heating, 5/16"	6
3516	Steam Trap Repair, 50-125 psig, General Heating, 7/32" or Smaller	6
3517	Steam Trap Repair, 126-225 psig, General Heating, 1/4"	6
3518	Steam Trap Repair, 126-225 psig, General Heating, 3/8" or Larger	6
3519	Steam Trap Repair, 126-225 psig, General Heating, 5/16"	6
3520	Steam Trap Repair, 126-225 psig, General Heating, 7/32" or Smaller	6
3521	Steam Trap Repair, >225 psig, General Heating, 1/4"	6
3522	Steam Trap Repair, >225 psig, General Heating, 3/8" or Larger	6
3523	Steam Trap Repair, >225 psig, General Heating, 5/16"	6
3524	Steam Trap Repair, >225 psig, General Heating, 7/32" or Smaller	6
3526	HPT8, 1x4, replacing T12 or T8, 2L, WPS Gold Plus Package	13
3527	T8 2L 4', recessed Indirect Fixture, HPT8 replacing 3 or 4L - T8 or T12, WPS Gold Plus Package	13
3528	T8 2L 4', HPT8 or RWT8, Replacing T12 1L 8', 0.78 < BF < 1.00, WPS Gold Plus Package	15
3529	T8 2L 4', HPT8 or RWT8, Replacing T12 1L 8', BF ≤ 0.78, WPS Gold Plus Package	15
3530	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', 0.78 < BF < 1.00, WPS Gold Plus Package	15
3531	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', BF ≤ 0.78, WPS Gold Plus Package	15
3532	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', BF > 1.00, WPS Gold Plus Package	15
3533	T8 2L 4', HPT8, CEE, replacing 8' 1L T12HO, WPS Gold Plus Package	15
3534	T8 4L 4', HPT8 or RWT8, Replacing T12 2L 8', 0.78 < BF < 1.00, WPS Gold Plus Package	15
3535	T8 4L 4', HPT8 or RWT8, Replacing T12 2L 8', BF ≤ 0.78, WPS Gold Plus Package	15
3536	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', 0.78 < BF < 1.00, WPS Gold Plus Package	15
3537	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', BF ≤ 0.78, WPS Gold Plus Package	15
3538	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', BF > 1.00, WPS Gold Plus Package	15
3539	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', 0.78 < BF < 1.00, WPS Gold Plus Package	15
3540	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', BF ≤ 0.78, WPS Gold Plus Package	15
3541	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', BF > 1.00, WPS Gold Plus	15

MMID	Measure Name	EUL (years)
	Package	
3542	T8, 2’ Lamps, Replacing T12 Dual U-Tube, WPS Gold Plus Package	6
3543	T8, 2’ Lamps, Replacing T12 Single U-Tube, WPS Gold Plus Package	6
3544	T8, 2’ Lamps, Replacing T8 Dual U-Tube, WPS Gold Plus Package	15
3545	T8, 2’ Lamps, Replacing T8 Single U-Tube, WPS Gold Plus Package	15
3548	CFL, Standard Bulb, 310-749 Lumens, Retail Store Markdown	8
3549	CFL, Standard Bulb, 750-1049 Lumens, Retail Store Markdown	8
3550	CFL, Standard Bulb, 1050-1489 Lumens, Retail Store Markdown	8
3551	CFL, Standard Bulb, 1490-2600 Lumens, Retail Store Markdown	8
3552	CFL, Reflector, 15 watt, Retail Store Markdown	8
3553	LED, Omnidirectional, 310-749 Lumens, Retail Store Markdown	20
3554	LED, Omnidirectional, 750-1049 Lumens, Retail Store Markdown	20
3555	LED, Omnidirectional, 1050-1489 Lumens, Retail Store Markdown	20
3556	LED, Omnidirectional, 1490-2600 Lumens, Retail Store Markdown	20
3557	LED, Reflector, 12 watt, Retail Store Markdown	20
3558	Insulation, Attic, R-19 to R-38	20
3559	Boiler, 95%+ AFUE, With DHW, NG	20
3560	Occupancy Sensor, Fixture Mount, > 60 Watts	8
3561	Occupancy Sensor, Fixture Mount, ≤ 60 Watts	8
3567	LED, Direct Install, 10 Watt, with Co-pay	20
3569	Furnace And A/C, ECM, 95% + AFUE, ≥ 16 SEER, Enhanced Rewards	23
3570	Insulation and Air Sealing, Attic, R-11 to R-38	20
3571	Showerhead, Handheld, Direct Install, 1.5 gpm, Electric	10
3572	Showerhead, Handheld, Direct Install, 1.5 gpm, NG	10
3573	Faucet Aerator, Direct Install, 1.5 gpm, Kitchen, Swivel, Electric	10
3574	Faucet Aerator, Direct Install, 1.5 gpm, Kitchen, Swivel, NG	10
3575	CFL, Direct Install, 9 Watt, Torpedo, Candelabra Base	6
3576	CFL, Direct Install, 14 Watt, Torpedo, Medium Base	6
3577	LED, > 12W	7
3578	LED, > 12W, SBP Package	7
3579	LED, > 16W	7
3580	LED, > 16W, SBP Package	7
3581	T8 LED < 20 Watts, 3L, Replacing 3L or 4L T12/T8	16
3582	T8 LED < 20 Watts, 2L, Replacing 3L or 4L T12/T8	16
3583	Steam Trap Repair, 50-125 psig, General Heating, 1/4"	6
3584	Condensing Water Heater, NG, 90%+, Claim Only	15
3585	Water Heater, Indirect, Claim Only	15
3586	Water Heater, Electric, EF of 0.93 or greater, Claim Only	15

MMID	Measure Name	EUL (years)
3587	Water Heater, ≥ 0.67 EF, Storage, NG, Claim Only	10
3588	Water Heater, ≥ 0.82 EF, Tankless, Residential, NG, Claim Only	13
3596	LED Fixture, Bilevel, Stairwell and Passageway, SBP A La Carte	9
3597	LED Fixture, Bilevel, Stairwell and Passageway, SBP After A La Carte	9
3603	LED Fixture, Interior, 12 Hours, CALP	13
3604	LED Fixture, Interior, 24 Hours, CALP	6
3605	Occupancy Sensor, Fixture Mount, ≤200 Watts, CALP	8
3606	Occupancy Sensor, Fixture Mount, >200 Watts, CALP	8
3607	LED, 4L 4’, <20W, Replacing 8’ 2L T12 or T8	16
3608	LED, 2L 4', <20W, Replacing 8’ 1L T12 or T8	16
3609	Smart Thermostat, Existing NG Boiler	10
3610	Smart Thermostat, Existing NG Furnace	10
3611	Smart Thermostat, Existing Air Source Heat Pump	10
3612	Smart Thermostat, Installed with 95% AFUE NG Furnace	10
3613	Smart Thermostat, Installed with 95% AFUE NG Boiler	10
3614	Smart Thermostat, Installed with Furnace and A/C	10
3615	Smart Thermostat, Installed with Air Source Heat Pump	10
3616	LED, 2L 4', <20W, Replacing 8’ 1L T12 or T8, SBP A La Carte	16
3617	LED, 4L 4’, <20W, Replacing 8’ 2L T12 or T8, SBP A La Carte	16
3679	LP Furnace with ECM, 90%+ AFUE (Existing)	23

Hybrid and Custom Measures by Measure Master ID

MMID	Measure Name	EUL (years)
212	Coarse Bubble Aeration	20
223	Blower Purge Dryer	15
224	Cycling Air Dryer	15
232	Laundry Heat Recovery	15
246	Overhead Door Seals	20
279	Air-Conditioning Economizer, Automatic	10
281	Air Rotation or Air Turnover Units to Minimize Stratification	15
284	Exhaust Air Heat Recovery System	15
285	Ventilation Filtration vs Make Up Air System	15
287	Mechanical Vent Dampers	15
289	Desiccant Dehumidifier	15
296	Chiller Optimization Controls	10
299	Replace Constant Volume HVAC with VAV	15
309	Air Filtration for Exhaust Air System	15
312	Refrigeration Waste Heat Recovery	15

MMID	Measure Name	EUL (years)
315	Cooler Economizer	16
371	Combustion Management System on Boiler	15
525	Variable Displacement Compressor	15
548	Compressed Air Nozzles	15
2191	A/C Coil Cleaning, Ultraviolet	20
2196	Air Compressor, Variable Speed Drive, Constant Speed Replacement	15
2204	Boiler Burner, Not Otherwise Specified	20
2207	Boiler Oxygen Trim Controls	10
2210	Boiler System, Automatic Chemical Feed Component	15
2213	Boiler, Combustion Management System	15
2215	Boiler, Flue Gas Heat Recovery	15
2220	Boiler, Not Otherwise Specified	20
2228	Building Envelope, Glazing Retrofit	20
2229	Building Envelope, Not Otherwise Specified	25
2230	Building Envelope, Reduce Air Infiltration	20
2232	Building Envelope, Window Replacement	20
2233	Burners, Recuperative	10
2247	Chiller System, Not Otherwise Specified	20
2248	Chiller System, Water Free Cooling Controls and Equipment	10
2249	Chiller, High Efficiency, Air Cooled, Replacement	20
2250	Chiller, High Efficiency, Water Cooled < 150 Tons, Replacement	20
2251	Chiller, High Efficiency, Water Cooled ≥ 300 Tons, Replacement	20
2252	Chiller, High Efficiency, Water Cooled 150-299 Tons, Replacement	20
2255	Compressed Air Controller, Pressure/Flow Controller	15
2256	Compressed Air Heat Recovery, Non-space Heating	15
2257	Compressed Air Heat Recovery, Space Heating	15
2258	Compressed Air Mist Eliminators	5 (New construction) 3 (Retrofit)
2260	Compressed Air System Isolation	15
2261	Compressed Air System Leak Survey and Repair, Year 1	2
2262	Compressed Air System Leak Survey and Repair, Year 2	2
2263	Compressed Air System Leak Survey and Repair, Year 3	2
2265	Compressed Air, Not Otherwise Specified	15
2266	Compressed Air, Process Load Reduction	15
2267	Compressor, Duct in Outside Air	10
2268	Cooler Curtain	5
2270	Cooler Night Covers	5
2274	Daylighting Controls, Automatic	8

MMID	Measure Name	EUL (years)
2275	Delamping, Not Otherwise Specified	TBA
2278	Demand Limiting Controls	15
2279	Destratification	15
2304	Domestic Hot Water, Not Otherwise Specified	13
2305	Drycooler, Computer Room Air Conditioner Economizer	10
2313	ECM Motor, Not Otherwise Specified	15
2314	Energy Recovery Ventilator	15
2319	Fans, High Volume Low Speed (HVLS), Not Otherwise Specified	15
2320	Food Service, Not Otherwise Specified	15
2361	Furnace, Stack, Melting	15
2368	Grain Dryer, Energy Efficient	20
2600	Thermal Curtain, Not Otherwise Specified	5
2374	Guest Room Energy Management Controls, Not Otherwise Specified	8
2377	Heat Recovery, Compressor Heat Used For Space Heating	15
2378	Heat Recovery, Compressor Heat Used To Pre-heat DHW	15
2379	Heat Recovery, Not Otherwise Specified	15
2381	HVAC Controls, Air Side Economizer, Free Cooling	10
2382	HVAC Controls, Scheduling/Setpoint Optimization	5
2383	HVAC Energy Management System	15
2385	HVAC, Low Temp System w/ Condensing Boilers	20
2386	HVAC, Not Otherwise Specified	15
2387	HVAC, Variable Refrigerant Flow/Volume Systems	15
2420	Induction Lighting, Not Otherwise Specified	15
2421	Industrial Oven or Furnace, Not Otherwise Specified	15
2423	Insulation, Attic, Not Otherwise Specified	25
2425	Insulation, Boiler Plumbing	15
2426	Insulation, Ceiling	25
2428	Insulation, Roof	25
2431	Insulation, Wall, Not Otherwise Specified	25
2432	Insulation, Water Heater, Not Otherwise Specified	6
2435	IT Systems, Cold Aisle Containment	5
2436	IT Systems, Not Otherwise Specified	5
2438	IT Systems, Server Consolidation	5
2440	IT Systems, Server Virtualization, Not Otherwise Specified	5
2441	IT Systems, Uninterruptible Power Supply	20
2443	Laundry Equipment - Not Otherwise Specified	15
2444	Laundry, Not Otherwise Specified	15
2454	LED, Loading Dock Fixture	12

MMID	Measure Name	EUL (years)
2455	LED, Not Otherwise Specified	18
2459	LED, Traffic Lights	6
2461	Lighting Controls, Not Otherwise Specified	8
2462	Lighting Layout Reconfiguration	10
2463	Lighting, Not Otherwise Specified	12
2464	Mechanical Sub-Cooling	10
2470	Motor, Not Otherwise Specified	15
2489	Overhead Door Retrofit	20
2490	Plastics Equipment, Radiant Heater Band Retrofit	15
2725	Refrigeration System Tune-up, Agriculture	10
3386	Grain Dryer, Energy Efficient, Hybrid	20
2493	Pool, Not Otherwise Specified	15
2496	Pressure Screen Rotor	15
2497	Process Heat Recovery, Condensing Heat Exchanger	15
2498	Process Heat Recovery, Not Otherwise Specified	15
2499	Process, Not Otherwise Specified	15
2504	Pumping and Piping System Efficiency Improvement	15
2505	Pumping, Shift To Off-peak	15
2507	Kiln Lumber Drying	5
2508	Radiant Tube Inserts, Not Otherwise Specified	5
2511	Refrigeration Economizer, Ambient Subcooling	15
2517	Refrigeration, Central Parallel Rack System Replacing Individual Units	10
2518	Refrigeration, Defrost Controls	10
2519	Refrigeration, Liquid Pressure Amplifiers	5
2520	Refrigeration, Not Otherwise Specified	16
2537	Regenerative Thermal Oxidizer (RTO)	12
2538	Repulper Rotor	15
2539	Rooftop Unit	15
2543	Steam Trap Repair, > 225 psig, General Heating	6
2545	Steam Trap Repair, 126-225 psig, General Heating	6
2547	Steam Trap Repair, 50-125 psig, General Heating	6
2589	T8, CEE, Not Otherwise Specified	15
409	Greenhouse Perimeter Insulation	15
598	Greenhouse Climate Controls	10
2253	Circulation Fan, High Efficiency, Ag	15
2272	Dairy Refrigeration, Scroll Compressors, Ag	15
2369	Greenhouse Roof Vents	10
2370	Greenhouse Thermal blanket	10

MMID	Measure Name	EUL (years)
2376	Heat Recovery Tank, No Heating Element, Ag, Electric or NG	15
2433	Irrigation Measure, Not Otherwise Specified	15
2434	Irrigation Pressure Reduction, Nozzle Installation & Motor Downsizing	15
2468	Milk Pasteurization System, Ag, Electric	15
2469	Milk Pasteurization System, Ag, NG	15
2607	Ultraviolet, Not Otherwise Specified	20
2609	Unit Heater, Not Otherwise Specified	15
2610	Variable Speed Drive, Chilled Water Pump or Cooling Tower Condensing Pump	15
2619	Ventilation Controls, Kitchen Exhaust Hood	10
2491	Plate Heat Exchanger and Well Water Pre-Cooler	15
2640	VFD, Boiler Draft Fan	15
2641	VFD, Cooling Tower Fan	15
2492	Plate Heat Exchanger, Milk Pipeline, VFD On Milk Vacuum Pump, Ag	15
2643	VFD, HVAC Fan	15
2644	VFD, HVAC Heating Pump	15
2639	VFD, Ag Second Use Water System	15
2646	VFD, Pool Pump Motor	15
2647	VFD, Process Fan	15
2648	VFD, Process Pump	15
2650	Waste Water Treatment, Not Otherwise Specified	20
2654	Water Heater, >90% TE, Condensing, Residential	15
2655	Water Heater, Dual Thermostat, Ag, NG	15
2656	Water Heater, Fuel Switching, Electric to NG	15
2657	Water Heater, Fuel Switching, Electric to NG, Ag	15
2659	Water Heater, Not Otherwise Specified	13
2642	VFD, Dairy Vacuum Pump, Ag	15
2645	VFD, Not Otherwise Specified	15
2662	Weather Stripping Around Doors, Replacement	20
2663	Welder, Replace w/ High Efficiency Unit	13
2664	Well and Pump Installation	15
2676	High Intensity Discharge Lighting, Not Otherwise Specified	12
2680	HVAC Controls, Not Otherwise Specified	15
2690	Insulation, Attic	25
2710	Air Sealing, Project Based	20
2722	Ventilation Controls, Demand Controlled Ventilation	10
2723	Evaporative Condensers Replace Air-Cooled Condensers	10
2724	Ventilation Controls, Exhaust/Supply For Paint/Spray Booth	10
2726	VFD, Chilled Water Distribution Pump	15

MMID	Measure Name	EUL (years)
2727	Aeration, Not Otherwise Specified	20
2745	Air Sealing	20
2747	Boiler, ≥ 90% AFUE, NG	20
2748	Boiler, 85-90% AFUE, NG	20
2755	Chiller, High Efficiency, Water Cooled, Replacement	20
2760	DHW Plant Replacement	15
2765	HID, Not Otherwise Specified	15
2773	Windows, ENERGY STAR	20
2774	Insulation, DHW Plumbing	15
2775	Ventilation Controls	5
2808	T8 6L or T5HO 4L Replacing 400-999 W HID	15
2809	T8 or T5HO, Replacing ≥1000 Watt HID	15
2819	Solar PV	25
2661	Waterer, Livestock, Not Otherwise Specified, Ag	10
2848	Compressed Air Process Load Shifting	20
2853	Ventilation Controls, Demand Control Ventilation For Air Handling Units	10
2900	Ground Source Heat Pump, Electric Back-up	15
2901	Ground Source Heat Pump, NG Back-up	15
2903	Ground Source Heat Pump, LP Back-up	15
2904	Ground Source Heat Pump, No Back-up	15
2905	Solar Thermal, Electric	20
2906	Solar Thermal, NG	20
2908	Wind	20
2909	Biogas	20
2910	Biomass	20
2911	Solar Thermal, Not Otherwise Specified	20
2912	Ground Source Heat Pump, Not Otherwise Specified	15
2916	Boiler, Not Otherwise Specified	20
2917	Chiller System, Not Otherwise Specified	20
2918	Compressed Air System, Not Otherwise Specified	15
2919	Domestic Hot Water, Not Otherwise Specified	13
2920	Heat Recovery, Not Otherwise Specified	15
2921	HVAC Controls, Not Otherwise Specified	15
2922	HVAC, Not Otherwise Specified	15
2923	IT Systems, Not Otherwise Specified	5
2924	Lighting Controls, Not Otherwise Specified	8
2925	Motors, Not Otherwise Specified	15
2926	Pool, Not Otherwise Specified	5

MMID	Measure Name	EUL (years)
2927	Process, Not Otherwise Specified	15
2928	Refrigeration, Not Otherwise Specified	15
2933	Roof Top Upgrade, DCV & Economizer, ≤7.5 Tons	10
2934	Roof Top Upgrade, DCV, ≤7.5 Tons	10
2935	Roof Top Upgrade, DCV, >7.5 Tons	10
2936	Roof Top Upgrade, Economizer, ≤7.5 Tons	10
2937	Roof Top Upgrade, Thermostat & DCV, ≤7.5 Tons	10
2938	Roof Top Upgrade, Thermostat & Economizer, ≤7.5 Tons	10
2939	Roof Top Upgrade, Thermostat and DCV, >7.5 Tons	10
2940	Roof Top Upgrade, Thermostat, ≤7.5 Tons	15
2941	Roof Top Upgrade, Thermostat, >7.5 Tons	15
2942	Roof Top Upgrade, Thermostat, DCV, & Economizer, ≤7.5 Tons	10
2824	VFD, Ag Primary Use Water System	15
2960	T8 or T5HO ≤155W, Replacing 250-399W HID, Not Otherwise Specified	15
2961	T8 or T5HO ≤250W, Replacing 400-999W HID, Not Otherwise Specified	15
2962	T8 or T5HO 251-365W, Replacing 400-999W HID, Not Otherwise Specified	15
2963	T8 or T5HO ≤500W, Replacing ≥1000W HID, Not Otherwise Specified	15
2964	T8 or T5HO ≤800W, Replacing 1000W HID, Not Otherwise Specified	15
3016	Ventilation Controls, Parking Lot	5
2954	VFD, Dairy Milk Pump	15
3022	A/C Split or Packaged System, High Efficiency	15
3045	Water Heater, High Usage, ≥90% TE, NG	10
3046	Water Heater, High Usage, ≥ 0.82 EF, Tankless, NG	15
3047	Water Heater, High Usage, ≥ 2 EF, Heat Pump Storage, Electric	15
3059	A/C Coil Cleaning, < 10 tons	3
3060	A/C Coil Cleaning, > 20 tons	3
3061	A/C Coil Cleaning, 10-20 tons	3
3062	A/C Refrigerant Charge Correction, < 10 tons	10
3063	A/C Refrigerant Charge Correction, > 20 tons	10
3064	A/C Refrigerant Charge Correction, 10-20 tons	10
3066	Economizer, RTU Optimization	10
3120	Programmable Thermostat, RTU Optimization Advanced	5
3121	Programmable Thermostat, RTU Optimization Standard	5
3244	Process Exhaust Filtration	15
3266	Demand Control Ventilation, RTU Optimization	15
3280	VFD, Constant Torque	15
3493	Parking Garage Ventilation Controls with Heating	5
3598	Compressed Air System Leak Survey and Repair, Year 4 and Beyond	2

Appendix D: Incremental Costs

MMID	Measure Name	Source	Incremental Cost
566	PC Network Energy Management System	Historical Project Data	$36.97
598	Greenhouse Climate Controls, Hybrid	Historical Project Data	$790.00
1981	Gas Furnace with ECM, 95+ AFUE (Existing)	CLEAResult surveyed 40 Trade Allies at length concerning cost points at various AFUE increments, both with and without staging and with or without ECMs. CLEAResult took the average reported cost for a 92% furnace with no staging and no ECM and subtracted that amount from the average reported cost for a 95% multi-stage with ECM.	$345.93
1983	Hot Water Boiler, 95%+ AFUE	Trade Ally Survey	$3,105.00
1985	Water Heater, Power Vented, EF ≥0.67	Existing Cost Figure	$14.32
1986	Water Heater, Condensing	2010. This value comes from the middle of the range ($1985) of installed costs from the above source minus the $865 installed cost of the baseline. These units are only recently on the market and a review of available pricing support this number.	$1,120.00
1987	Tankless Water Heater, EF 0.82+	DEER/RSMeans	$454.09
1988	Water Heater, Indirect	Existing Cost Data/Workpaper	$204.88
1989	Water Heater, Electric, EF 0.93 or greater	DEER/RSMeans	$25.16
1993	Level 1: 10-19.9%	Cadmus has no additional data to change original assumptions.	$1,200.00
1994	Level 2: 20-29.9%	Cadmus has no additional data to change original assumptions.	$1,450.00
1995	Level 3: 30-39.9%	Cadmus has no additional data to change original assumptions.	$3,600.00
1996	Level 4: 40 or greater%	Cadmus has no additional data to change original assumptions.	$11,100.00
1997	Level 1: 10-19.9%	Cadmus has no additional data to change original assumptions.	$1,200.00
1998	Level 2: 20-29.9%	Cadmus has no additional data to change	$1,450.00

MMID	Measure Name	Source	Incremental Cost
		original assumptions.	
1999	Level 3: 30-39.9%	Cadmus has no additional data to change original assumptions.	$3,600.00
2000	Level 4: 40 or greater%	Cadmus has no additional data to change original assumptions.	$11,100.00
3679	LP Gas Furnace with ECM, 90%+ AFUE	Existing Cost Figure	$432.00
2116	CFL, 9 Watt	Light bulb sales data obtained by Cadmus for California- 2010 through 2012. Note that the CFL average lamp costs include incented lamps.	$1.21
2117	CFL, 14 Watt	Light bulb sales data obtained by Cadmus for California- 2010 through 2012. Note that the CFL average lamp costs include incented lamps.	$0.37
2118	CFL, 19 Watt	Light bulb sales data obtained by Cadmus for California- 2010 through 2012. Note that the CFL average lamp costs include incented lamps.	$0.38
2119	CFL, 23 Watt	Light bulb sales data obtained by Cadmus for California- 2010 through 2012. Note that the CFL average lamp costs include incented lamps.	$1.03
2120	Faucet Aerator, Non PI Direct Install, 1.5 gpm, Kitchen, NG	Cadmus agrees that program data is the best source for future measure cost, and including installation is ideal for direct install measures. Please provide a more robust source citation that includes program name, date range, etc.	$5.00
2121	Faucet Aerator, Non PI Direct Install, 1.0 gpm, Bathroom, NG	Cadmus agrees that program data is the best source for future measure cost, and including installation is ideal for direct install measures. Please provide a more robust source citation that includes program name, date range, etc.	$3.00
2122	Insulation, Non PI Direct Install, 6' pipe, NG	RSMeans	$23.76
2123	Low-flow Showerhead, 1.5 gpm, Gas MF	Cadmus agrees that program data is the best source for future measure cost, and including installation is ideal for direct install measures.	$5.00

MMID	Measure Name	Source	Incremental Cost
2124	Low-flow Showerhead, 1.75 gpm, Gas	Cadmus agrees that program data is the best source for future measure cost, and including installation is ideal for direct install measures.	$5.00
2125	DHW Temperature Turn Down, Non PI Direct Install, NG	Existing Cost Figure	$-
2126	Faucet Aerator, Non PI Direct Install, 1.5 gpm, Kitchen, Electric	Cadmus agrees that program data is the best source for future measure cost, and including installation is ideal for direct install measures.	$5.00
2127	Faucet Aerator, Non PI Direct Install, 1.0 gpm, Bathroom, Electric	Cadmus agrees that program data is the best source for future measure cost, and including installation is ideal for direct install measures.	$3.00
2128	Insulation, Non PI Direct Install, 6' pipe, Electric	RSMeans	$23.76
2129	Low-flow Showerhead, 1.5 gpm, Electric	Cadmus agrees that program data is the best source for future measure cost, and including installation is ideal for direct install measures.	$5.00
2131	DHW Temperature Turn Down, Non PI Direct Install, Electric	Existing Cost Figure	$-
2132	CFL, Direct Install, 9 Watt	MMID 2116	$1.21
2133	CFL, Direct Install, 14 Watt	MMID 2117	$0.37
2134	CFL, Direct Install, 19 Watt	MMID 2118	$0.38
2135	CFL, Direct Install 23W	MMID 2119	$1.03
2136	Faucet Aerators, Direct Install, 1.5 gpm, Kitchen, NG	MMID 2126	$5.00
2137	Faucet Aerator, Direct Install, 1.0 gpm, Bathroom, NG	MMID 2127	$3.00
2138	Pipe Insulation 6', Gas	MMID 2128	$23.76
2139	Low-flow Showerhead, 1.5 gpm, Gas	Cadmus agrees that program data is the best source for future measure cost, and including installation is ideal for direct install measures.	$5.00
2140	Water Saving Showerheads, Direct Install, NG	Cadmus agrees that program data is the best source for future measure cost, and including installation is ideal for direct install measures.	$5.00
2141	DHW Temperature Turn Down, Direct Install, NG	MMID 2131	$-
2145	Low-Flow Showerhead, 1.5 gpm, Electric MF	Cadmus agrees that program data is the best source for future measure cost, and including installation is ideal for direct install measures.	$5.00

MMID	Measure Name	Source	Incremental Cost
2146	Water Saving Showerheads, Direct Install, Electric	Cadmus agrees that program data is the best source for future measure cost, and including installation is ideal for direct install measures.	$5.00
2147	DHW Temperature Turn Down, Electric & Gas	MMID 2131	$-
2150	Cooler Miser-Direct Install	Implementer Data	$205.33
2155	Low Flow Faucet Aerators, Direct Install, Electric, Kitchen	Cadmus agrees that program data is the best source for future measure cost, and including installation is ideal for direct install measures.	$8.00
2156	Low Flow Faucet Aerators, Direct Install, Natural Gas, Kitchen	Cadmus agrees that program data is the best source for future measure cost, and including installation is ideal for direct install measures.	$8.00
2158	Pre-rinse Spray Valve, Electric MF	Niagara m/n N2180 per www.conservationmart.com/p-301-niagara-128-gpm-prerinse-kitchen-spray-n2180.aspx	$37.50
2159	Pre-rinse Spray Valve, Gas MF	Niagara m/n N2180 per www.conservationmart.com/p-301-niagara-128-gpm-prerinse-kitchen-spray-n2180.aspx	$37.50
2192	A/C Split System < 65 MBh SEER 15	Online Retailers/RSMeans	$663.59
2193	A/C Split System < 65 MBh SEER 16 or greater	Online Retailers/RSMeans	$712.61
2194	A/C Split System < 65 MBh SEER 14	Online Retailers/RSMeans	$390.46
2196	VSD Air Compressor, Hybrid	Illinois TRM	$1446+$127/hp
2197	Anti-sweat heater controls, on freezer case with low-heat door	RTF, SDG&E Working Paper (cost per door assuming 2.5 ft door)	$95.00
2198	Anti-sweat heater controls, on freezer case with no-heat door	RTF, SDG&E Working Paper (cost per door assuming 2.5 ft door)	$95.00
2199	Anti-sweat heater controls, on freezer case with standard door	RTF, SDG&E Working Paper (cost per door assuming 2.5 ft door)	$95.00
2200	Anti-sweat heater controls, on refrigerated case with low-heat or no-heat doors	RTF, SDG&E Working Paper (cost per door assuming 2.5 ft door)	$95.00
2201	Anti-sweat heater controls, on refrigerated case with standard door	RTF, SDG&E Working Paper (cost per door assuming 2.5 ft door)	$95.00
2203	High Turn Down Burner - NEW	Historical Project Data	$26,034.00

MMID	Measure Name	Source	Incremental Cost
2205	Linkageless Boiler Control, per hp	2010. Available and Emerging Technologies for Reducing Greenhouse Gas Emissions from Industrial, Commercial, and Institutional Boilers, Prepared by the Sector Policies and Programs Division Office of Air Quality Planning and Standards U.S. Environmental Protection Agency Research Triangle Park, North Carolina 27711, October 2010, Table 1. ICI Boilers – Summary of Greenhouse Gas Emission Reduction Measures, pg. 8	$26,000.00
2206	Boiler oxygen trim controls, per hp	2011. CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE) PROCESS BOILERS, 2013 California Building Energy Efficiency Standards, California Utilities Statewide Codes and Standards Team, October 2011, pg. 22	$29,416.00
2209	Boiler Plant 1M - 5M, Mid Efficiency - NEW	Historical Project Data	$16.43/MBh
2211	Boiler Tune-up - service buy down	Online Research	$119.95
2217	Boiler, hot water, high efficiency modulating, for space heating (AFUE ≥90%)	Existing Cost Figure	$2,857.55
2218	Boiler, Hot Water Modulating, ≥90% AFUE, >300 MBH	Historical Project Data	$50.25/MBh
2221	Boiler Control - Outside Air Reset/Cutout	2006. Nexant. Questar DSM Market Characterization Report. August 9, 2006	$612.00
2234	Case door, freezer, low heat	2013. Based on manufacturers cost data and EVT experience.	$145.00
2235	Case door, freezer, no heat	2013. Based on manufacturers cost data and EVT experience.	$290.00
2236	Case door, refrigerated, no heat	2013. Based on manufacturers cost data and EVT experience.	$72.50
2237	HO T-5, 10 Lamp Fixture: Interior, Metal Halide, > 600 ≤1080 Watt, Direct Install	Implementer's cost (other rows), Cadmus estimate for labor duration and RSMeans for labor cost.	$-
2237	HO T-5, 2 Lamp/T-8, 4 Lamp Fixture: Interior Replacing Metal	Implementer's cost (other rows), Cadmus estimate for labor duration and RSMeans for	$156.14

MMID	Measure Name	Source	Incremental Cost
	Halide, > 200 < 400 W, Direct Install	labor cost.	
2237	HO T-5, 4 Lamp/T-8, 6 Lamp Fixture: Interior Metal Halide, >400 ≤600 W, Direct Install	Implementer's cost (other rows) and Cadmus estimate for labor duration and RSMeans for labor cost.	$163.56
2237	Metal Halide Ceramic 20-70 Watts - Replaces Incandescent	2012-2013 application data.	$147.37
2238	Ceramic Metal Halide Lamp, ≤25 Watts	MMID 3208	$43.54
2239	CFL Fixture, ≤100 Watts	From MMID 3203/3204	$7.29
2243	CFL High Wattage 31-115 Watts, replacing incandescent	Online research on 1000bulbs.com comparing 250 watt PAR38 Halogen ($15 average) with 50-65 watt CFL ($18 average).	$3.00
2245	CFL Cold Cathode Screw-In, replacing incandescent	Online Research	$7.16
2246	CFL reflector flood lamps replacing incandescent reflector flood lamps	Online research on 1000bulbs.com comparing 250 watt PAR38 Halogen ($15 average) with 50-65 watt CFL ($18 average).	$3.00
2249	High Efficiency Chillers - Retrofit, air cooled all sizes	2008. Calculated as the simple average of screw and reciprocating air-cooled chiller incremental costs from DEER2008. This assumes that baseline shift from IECC 2009 to IECC 2012 carries the same incremental costs. Values should be verified during evaluation	$127/ton
2250	High Efficiency Chillers - Retrofit, water cooled < 150 tons	2008. Calculated as the simple average of screw and reciprocating air-cooled chiller incremental costs from DEER2008. This assumes that baseline shift from IECC 2009 to IECC 2012 carries the same incremental costs. Values should be verified during evaluation	$128/ton
2251	High Efficiency Chillers - Retrofit, water cooled ≥300 tons	2008. Calculated as the simple average of screw and reciprocating air-cooled chiller incremental costs from DEER2008. This assumes that baseline shift from IECC 2009 to IECC 2012 carries the same incremental costs. Values should be verified during evaluation	$48/ton
2252	High Efficiency Chillers - Retrofit, water cooled ≥150 tons and < 300	2008. Calculated as the simple average of screw and reciprocating air-cooled chiller	$70/ton

MMID	Measure Name	Source	Incremental Cost
	tons	incremental costs from DEER2008. This assumes that baseline shift from IECC 2009 to IECC 2012 carries the same incremental costs.	
2253	Agricultural Circulation Fan, High Efficiency, Per Inch od Fan Diameter -	'Per Illinois TRM v3.0 (pg. 68): ag circulation or exhaust fan incremental cost (all sizes) is $150 each.	$150.00
2254	No Loss Air Condensate Drains New	Online Pricing Research	$624.10
2255	Pressure/Flow Controllers, New	RSMeans and Online Research	$151.13
2258	Compressed Air Mist Eliminators, New	Historical Project Data	$21.55/hp
2259	Compressed Air Nozzles, Air Entraining	Historical Project Data	$36.42/nozzle
2261	Compressed Air System Leak Survey and Repair	Historical Project Data	$9.81/hp
2262	Compressed Air System Leak Survey and Repair, Year 2	Historical Project Data	$6.41/hp
2263	Compressed Air System Leak Survey and Repair, Year 3	Historical Project Data	$5.71/hp
2264	Cycled Refrigeration Thermal Mass Air Dryers New	Product Research	$10.20
2269	Cooler Evaporator Fan Control	RSMeans	$275.00
2271	Night Curtains for Open Coolers, per linear foot	Historical Project Data	$38.21
2272	Scroll Compressors for Dairy Refrigeration, Hybrid	Historical Project Data	$6,201.00
2276	Delamping, Direct Install, 4-Foot Lamp	Cadmus estimate for labor duration and RSMeans for labor cost.	$3.92
2277	Delamping, T8 to T8	Cadmus estimate for labor duration and RSMeans for labor cost.	$3.92
2280	Dishwasher, Low Temp, Door Type, ENERGY STAR, Electric	Illinois TRM	$530.00
2281	Dishwasher, High Temp, Electric Booster, Door Type, ENERGY STAR, Electric	ENERGY STAR Calculator	$770.00
2282	Dishwasher, High Temp, Electric Booster, Door Type, ENERGY STAR, NG	ENERGY STAR Calculator	$770.00

MMID	Measure Name	Source	Incremental Cost
2283	Dishwasher, High Temp, Electric Booster, Multi Tank Conveyor, ENERGY STAR, Electric	ENERGY STAR Calculator	$970.00
2284	Dishwasher, High Temp, Electric Booster, Multi Tank Conveyor, ENERGY STAR, NG	ENERGY STAR Calculator	$970.00
2285	Dishwasher, High Temp, Electric Booster, Single Tank Conveyor, ENERGY STAR, Electric	ENERGY STAR Calculator	$2,050.00
2286	Dishwasher, High Temp, Electric Booster, Single Tank Conveyor, ENERGY STAR, NG	ENERGY STAR Calculator	$2,050.00
2287	Dishwasher, High Temp, Electric Booster, Under Counter, ENERGY STAR, Electric	Illinois TRM	$1,000.00
2288	Dishwasher, High Temp, Electric Booster, Under Counter, ENERGY STAR, NG	Illinois TRM	$1,000.00
2289	Dishwasher, High Temp, Gas Booster, Door Type, ENERGY STAR, NG	ENERGY STAR Calculator	$770.00
2290	Dishwasher, High Temp, Gas Booster, Multi Tank Conveyor, ENERGY STAR, NG	ENERGY STAR Calculator	$970.00
2291	Dishwasher, High Temp, Gas Booster, Single Tank Conveyor, ENERGY STAR, NG	ENERGY STAR Calculator	$2,050.00
2292	Dishwasher, High Temp, Gas Heat, Gas Booster, Under Counter, ENERGY STAR, NG	Illinois TRM	$1,000.00
2293	Dishwasher, Low Temp, Door Type, ENERGY STAR, NG	Illinois TRM	$530.00
2294	Dishwasher, Low Temp, Multi Tank Conveyor, ENERGY STAR, Electric	ENERGY STAR Calculator	$970.00
2295	Dishwasher, Low Temp, Multi Tank Conveyor, ENERGY STAR, NG	ENERGY STAR Calculator	$970.00
2296	Dishwasher, Low Temp, Single	Illinois TRM	$170.00

MMID	Measure Name	Source	Incremental Cost
	Tank Conveyor, ENERGY STAR, Electric		
2297	Dishwasher, Low Temp, Single Tank Conveyor, ENERGY STAR, NG	Illinois TRM	$170.00
2298	Dishwasher, Low Temp, Under Counter, ENERGY STAR, Electric	Illinois TRM	$530.00
2299	Dishwasher, Low Temp, Under Counter, ENERGY STAR, NG	Illinois TRM	$530.00
2301	Dock Ramp/Pit Seal, Replacement	Online/Book Research	$1,250.00
2301	Dock Seals, Replacement	Online/Book Research	$1,370.41
2302	Dock Seal, Added to Existing Barrier	Online/Book Research	$1,370.41
2303	Dock Ramp/Pit Seal, From SPECTRUM	Online/Book Research	$1,250.00
2303	Dock Seals, New	Online/Book Research	$1,370.41
2305	Drycooler, Computer Room Air Conditioner Economizer	Existing Cost Figure	$340.17
2306	Compressor Cooler Motor, ECM - New	Online Research	$80.00
2307	ECM Condenser/Condensing Unit Fan Motor	Online Research	$80.00
2308	ECM Evaporator fan motor replacing shaded-pole motor, <1/20 hp, in walk-in cooler	Online/Book Research	$61.61
2309	ECM Evaporator fan motor replacing shaded-pole motor, ≥1/20 hp, <1hp, in walk-in cooler	Online/Book Research	$61.59
2310	ECM Evaporator fan motor replacing shaded-pole motor, <1/20 hp, in walk-in freezer	Online/Book Research	$61.61
2311	ECM Evaporator fan motor replacing shaded-pole motor, ≥1/20 hp, <1hp, in walk-in freezer	Online/Book Research	$61.59
2312	ECM replacing shaded-pole motor in refrig/freezer case	Illinois TRM	$50.00
2314	Energy Recovery Ventilator	Online Research	$1,500.00
2314	Energy recovery ventilator, Hybrid	Historical Project Data	$6.14/CFM

MMID	Measure Name	Source	Incremental Cost
2316	High Volume Low Speed fans replace Box Fans, 20 ft	RSMeans	$4,235.25
2317	High Volume Low Speed fans replace Box Fans, 22 ft	RSMeans	$4,689.88
2318	High Volume Low Speed fans replace Box Fans, 24 ft	RSMeans	$4,689.88
2321	Freezer, Chest, Glass Door, < 15 cu ft, ENERGY STAR	Illinois TRM	$142.00
2322	Freezer, Chest, Glass Door, 15-29 cu ft, ENERGY STAR	Illinois TRM	$166.00
2323	Freezer, Chest, Glass Door, 30-49 cu ft, ENERGY STAR	Illinois TRM	$166.00
2324	Freezer, Chest, Glass Door, 50+ cu ft, ENERGY STAR	Illinois TRM	$407.00
2325	Freezer, Chest, Solid Door, < 15 cu ft, ENERGY STAR	Illinois TRM	$142.00
2326	Freezer, Chest, Solid Door, 15-29 cu ft, ENERGY STAR	Illinois TRM	$166.00
2327	Freezer, Chest, Solid Door, 30-49 cu ft, ENERGY STAR	Illinois TRM	$166.00
2328	Freezer, Chest, Solid Door, 50+ cu ft, ENERGY STAR	Illinois TRM	$407.00
2329	Freezer, Vertical, Glass Door, < 15 cu ft, ENERGY STAR	Illinois TRM	$142.00
2330	Freezer, Vertical, Glass Door, 15-29 cu ft, ENERGY STAR	Illinois TRM	$166.00
2331	Freezer, Vertical, Glass Door, 30-49 cu ft, ENERGY STAR	Illinois TRM	$166.00
2332	Freezer, Vertical, Glass Door, 50+ cu ft, ENERGY STAR	Illinois TRM	$407.00
2333	Freezer, Vertical, Solid Door, < 15 cu ft, ENERGY STAR	Illinois TRM	$142.00
2334	Freezer, Vertical, Solid Door, 15-29 cu ft, ENERGY STAR	Illinois TRM	$166.00
2335	Freezer, Vertical, Solid Door, 30-49 cu ft, ENERGY STAR	Illinois TRM	$166.00
2336	Freezer, Vertical, Solid Door, 50+ cu ft, ENERGY STAR	Illinois TRM	$407.00

MMID	Measure Name	Source	Incremental Cost
2337	Fryer, Electric, ENERGY STAR	ENERGY STAR Calculator	$210.00
2338	Fryer, Gas, ENERGY STAR	Illinois TRM	$1,200.00
2350	Furnace, with ECM fan motor, for space heating (AFUE ≥95%), 109.9 - 120.7 MBh	Navigant Incremental Cost Study	$1,688.71
2352	Furnace, with ECM fan motor, for space heating (AFUE ≥95%), 133.0 - 146.1 MBh	Navigant Incremental Cost Study	$1,708.52
2354	Furnace, with ECM fan motor, for space heating (AFUE ≥95%), 54.675 - 60.749 MBh	Navigant Incremental Cost Study	$1,629.71
2355	Furnace, with ECM fan motor, for space heating (AFUE ≥95%), 60.750 - 67.499 MBh	Navigant Incremental Cost Study	$1,629.71
2356	Furnace, with ECM fan motor, for space heating (AFUE ≥95%), 67.5 - 74.9 MBh	Navigant Incremental Cost Study	$1,640.50
2357	Furnace, with ECM fan motor, for space heating (AFUE ≥95%), 75.0 - 82.5 MBh	Navigant Incremental Cost Study	$1,650.50
2358	Furnace, with ECM fan motor, for space heating (AFUE ≥95%), 82.5 - 90.75 MBh	Navigant Incremental Cost Study	$1,650.50
2359	Furnace, with ECM fan motor, for space heating (AFUE ≥95%), 90.76 - 99.82 MBh	Navigant Incremental Cost Study	$1,660.50
2360	Furnace, with ECM fan motor, for space heating (AFUE ≥95%), 99.83 - 109.8 MBh	Navigant Incremental Cost Study	$1,670.50
2362	Glazing, Triple Poly Carbonate, Roof and Walls, Double Pane Replacement	Implementer research	$0.30/ft
2363	Glazing, Triple Poly Carbonate, Roof and Walls, Single Pane Replacement	Implementer research	$0.30/ft
2364	Glazing, Triple Poly Carbonate, Roof, Double Pane Replacement	Implementer research	$0.30/ft
2365	Glazing, Triple Poly Carbonate,	Implementer research	$0.30/ft

MMID	Measure Name	Source	Incremental Cost
	Roof, Single Pane Replacement		
2366	Glazing, Triple Poly Carbonate, Walls, Double Pane Replacement	Implementer research	$0.30/ft
2367	Glazing, Triple Poly Carbonate, Walls, Single Pane Replacement	Implementer research	$0.30/ft
2371	Griddle, Electric, ENERGY STAR	ENERGY STAR Calculator	$-
2372	Griddle, Gas, ENERGY STAR	ENERGY STAR Calculator	$360.00
2373	Guest Room Energy Management Controls, Electric Heat PTAC Systems	Illinois TRM	$260.00
2374	Guest Room Energy Management Controls, Not Otherwise Specified	MMID 2373	$260.00
2376	Heat Recovery Tank, No Heating Element, Ag, Electric or NG	Historical Project Data	$3,674.00
2419	Induction Lighting, 300 Watt	Implementer's cost and Cadmus estimate for labor duration and RSMeans for labor cost.	$774.39
2422	Infrared Heating Units, High or Low Intensity - Existing Building,	Online/Book Research	$4.35
2429	Steam Fittings Insulation - New	Online/Book Research	$45.44
2430	Steam Piping Insulation - New	Online/Book Research	$22.76
2434	Irrigation Pressure Reduction, Nozzle Installation	Project quote; assumes labor cost and proportionately minimal cost for fixing nozzles	$2,000.00
2454	LED loading dock light fixture, Hybrid	Cadmus estimate for labor duration and RSMeans for labor cost. and http://loadingdocksupply.com/led_dock_lights	$409.40
2456	LED Reach-In Refrigerated Case Lighting replaces T12 or T8	Existing cost figure. Used S&G figure as median, assuming it reflects that BIP will account for a lot of the projects	$145.44
2457	LED Reach-In Refrigerated Case Lighting replaces T12 or T8- with Occupancy Control	MMID 2456. Likely understates because doesn't account for occupancy sensor cost.	$145.44
2458	LED Down Lights	Existing Cost Figure	$46.01
2471	Occupancy Sensors - Ceiling Mount ≤500 Watts	MMID 2473	$120.00
2472	Occupancy Sensors - Ceiling Mount ≥1001 Watts	WESCO Distribution pricing+labor	$120.00
2473	Occupancy Sensors - Ceiling Mount 501-1000 Watts	WESCO Distribution pricing+labor	$120.00

MMID	Measure Name	Source	Incremental Cost
2474	Occupancy Sensors - Fixture Mount ≤200 Watts	Navigant Incremental Cost Study	$115.00
2475	Occupancy Sensors - Fixture Mount > 200 Watts	Navigant Incremental Cost Study	$115.00
2482	LED Case Lights with Occupancy Control - NEW	Existing cost figure	$220.50
2482	Occupancy Sensors - for LED Refrigerated Case Lights, per door controlled	Existing Cost Figure	$22.00
2483	Occupancy Sensors - Wall Mount ≤200 Watts	WESCO Distribution pricing+labor	$35.00
2484	Occupancy Sensors - Wall Mount ≥201 Watts	WESCO Distribution pricing+labor	$35.00
2485	Oven, Convection, Electric, ENERGY STAR - per cavity	ENERGY STAR Calculator	$50.00
2486	Oven, Convection, Gas, ENERGY STAR - per cavity	ENERGY STAR Calculator	$50.00
2487	Oven, Rack Type, Gas, Double Compartment, High Efficiency	Existing Cost Figure	$5,558.13
2488	Oven, Rack Type, Gas, Single Compartment, High Efficiency	Existing Cost Figure	$2,719.88
2490	Plastics equipment, efficient radiant heater band retrofit	Existing Cost Figure	$12,757.21
2491	Plate Heat Exchanger and Well Water Pre-Cooler	Vermont TRM	$4,595.00
2494	PreRinse Sprayers, 0.65 GPM Ultra Low Flow- Electric NEW	Online Research	$51.54
2495	PreRinse Sprayers, 0.65 GPM Ultra Low Flow- Gas NEW	Online Research	$51.54
2496	Pressure Screen Rotor	Workpaper	variable
2507	Radiant tube inserts installed in exhaust of radiant tube burners, Hybrid	Existing Cost Figure	$34,021.91
2509	Open Multideck Cases Replaced by Reach-in Cases with Doors-New	Online/Book Research	$700.00
2510	Floating Head Pressure Control-New	Online/Book Research	$235.38

MMID	Measure Name	Source	Incremental Cost
2513	Refrigeration Tune-up, Non Self-Contained Cooler	Historical Project Data	$30/ton
2514	Refrigeration Tune-up, Non Self-Contained Freezer	Historical Project Data	$36/ton
2515	Refrigeration Tune-up, Self-contained Cooler	Historical Project Data	$230/ton
2516	Refrigeration Tune-up, Self-contained Freezer	Historical Project Data	$245/ton
2521	Refrigerator, Chest, Glass Door, < 15 cu ft, ENERGY STAR	Illinois TRM	$143.00
2522	Refrigerator, Chest, Glass Door, 15-29 cu ft, ENERGY STAR	Illinois TRM	$164.00
2523	Refrigerator, Chest, Glass Door, 30-49 cu ft, ENERGY STAR	Illinois TRM	$164.00
2524	Refrigerator, Chest, Glass Door, 50+ cu ft, ENERGY STAR	Illinois TRM	$249.00
2525	Refrigerator, Chest, Solid Door, < 15 cu ft, ENERGY STAR	Illinois TRM	$143.00
2526	Refrigerator, Chest, Solid Door, 15-29 cu ft, ENERGY STAR	Illinois TRM	$164.00
2527	Refrigerator, Chest, Solid Door, 30-49 cu ft, ENERGY STAR	Illinois TRM	$164.00
2528	Refrigerator, Chest, Solid Door, 50+ cu ft, ENERGY STAR	Illinois TRM	$249.00
2529	Refrigerator, Vertical, Glass Door, < 15 cu ft, ENERGY STAR	Illinois TRM	$143.00
2530	Refrigerator, Vertical, Glass Door, 15-29 cu ft, ENERGY STAR	Illinois TRM	$164.00
2531	Refrigerator, Vertical, Glass Door, 30-49 cu ft, ENERGY STAR	Illinois TRM	$164.00
2532	Refrigerator, Vertical, Glass Door, 50+ cu ft, ENERGY STAR	Illinois TRM	$249.00
2533	Refrigerator, Vertical, Solid Door, < 15 cu ft, ENERGY STAR	Illinois TRM	$143.00
2534	Refrigerator, Vertical, Solid Door, 15-29 cu ft, ENERGY STAR	Illinois TRM	$164.00
2535	Refrigerator, Vertical, Solid Door, 30-49 cu ft, ENERGY STAR	Illinois TRM	$164.00

MMID	Measure Name	Source	Incremental Cost
2536	Refrigerator, Vertical, Solid Door, 50+ cu ft, ENERGY STAR	Illinois TRM	$249.00
2538	Repulper Rotor	Workpaper	variable
2542	Repair leaking steam trap, <50 psig steam (Industrial Only)	Online/Book Research	$453.79
2543	Repair leaking steam trap, >225 psig, General Heating	Online/Book Research	$1,005.89
2544	Repair leaking steam trap, >225 psig steam (Industrial Only)	Online/Book Research	$1,602.50
2545	Repair leaking steam trap, 126-225 psig, General Heating	Multiple studies	$350.00
2546	Repair leaking steam trap, 126-225 psig steam (Industrial Only)	Online/Book Research	$1,007.71
2547	Repair leaking steam trap, 50-125 psig, General Heating	Online/Book Research	$888.52
2548	Repair leaking steam trap, 50-125 psig steam (Industrial Only)	Online/Book Research	$916.44
2549	Steamer, Electric, 3 pan - ENERGY STAR	California Workpapers	$2,490.00
2550	Steamer, Electric, 4 pan - ENERGY STAR	California Workpapers	$2,490.00
2551	Steamer, Electric, 5 pan - ENERGY STAR	California Workpapers	$2,490.00
2552	Steamer, Gas, 5 pan - ENERGY STAR	California Workpapers	$998.00
2553	Steamer, Electric, 6 pan - ENERGY STAR	California Workpapers	$2,490.00
2554	Steamer, Gas, 6 pan - ENERGY STAR	California Workpapers	$998.00
2556	T8 1L-4 ft Reduced Wattage with CEE Ballast - 25 Watts (Low BF)	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$2.45
2557	T8 1L-4 ft Reduced Wattage with CEE Ballast - 28 Watts (Low BF)	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$2.07
2558	T8 1L 4', 28W, CEE, BF > 0.78	2014 application data; verified against 1000	$2.07

MMID	Measure Name	Source	Incremental Cost
		bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	
2559	T8 1L-4 ft Hi Lumen Lamp with CEE Ballast	Implementer’s assessment plus Cadmus estimate for labor duration and RSMeans for labor cost. Assumed CEE ballast as baseline.	$3.85
2560	T8 1L-4 ft Reduced Wattage with CEE Ballast - 25 Watts	Implementer’s assessment plus Cadmus estimate for labor duration and RSMeans for labor cost. Assumed CEE ballast as baseline.	$2.45
2560	T8 2L-4 ft Reduced Wattage with CEE Ballast - 25 Watts	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$4.90
2561	T8 1L-4 ft Hi Lumen Lamp with CEE Ballast (Low BF)	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$7.70
2562	T8 2L-4 ft Reduced Wattage with CEE Ballast - 25 Watts (Low BF)	Implementer’s assessment plus Cadmus estimate for labor duration and RSMeans for labor cost. Assumed CEE ballast as baseline.	$4.90
2563	T8 2L 4', 25W, CEE, BF > 0.78	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$4.90
2564	T8 2L-4 ft Reduced Wattage with CEE Ballast - 28 Watts (Low BF)	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$4.13
2565	T8 2L-4 ft Reduced Wattage with CEE Ballast - 28 Watts	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$4.13
2566	T8 2L-4 ft Hi Lumen Lamp with CEE Ballast (Low BF)	Implementer’s assessment plus Cadmus estimate for labor duration and RSMeans for labor cost. No add'l cost for ballast.	$15.40
2567	T8 2L-4 ft Hi Lumen Lamp with CEE Ballast	Implementer’s assessment plus Cadmus estimate for labor duration and RSMeans for labor cost. No add'l cost for ballast.	$15.40

MMID	Measure Name	Source	Incremental Cost
2568	T8 2L-4ft High Performance Tandem Replacing T12HO/VHO 2L-8 ft - From Spectrum	Implementer's cost, plus Cadmus estimate for labor duration and RSMeans for labor cost.	$130.98
2569	T8 2L 4', HPT8, CEE, replacing 8' 2L T12	Implementer's cost, plus Cadmus estimate for labor duration and RSMeans for labor cost.	$130.98
2571	T8 3L-4 ft Low Watt with CEE Ballast - 25 Watts (Low BF)	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$7.35
2572	T8 3L-4 ft Reduced Wattage with CEE Ballast - 25 Watts	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$7.35
2573	T8 3L-4 ft Reduced Wattage with CEE Ballast - 28 Watts (Low BF)	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$6.20
2574	T8 3L 4', 28W, CEE, BF > 0.78	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$6.20
2575	T8 3L-4 ft Hi Lumen Lamp with CEE Ballast (Low BF)	Implementer’s assessment plus Cadmus estimate for labor duration and RSMeans for labor cost. Assumes CEE ballast as baseline.	$11.55
2576	T8 3L-4 ft Hi Lumen Lamp with CEE Ballast	Implementer’s assessment plus Cadmus estimate for labor duration and RSMeans for labor cost. Assumes CEE ballast as baseline.	$11.55
2577	T8 4L-4 ft Low Watt with CEE Ballast - 25 Watts (Low BF)	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$9.80
2578	T8 4L-4 ft Reduced Wattage with CEE Ballast - 25 Watts	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$9.80
2579	T8 4L-4 ft Reduced Wattage with CEE Ballast - 28 Watts (Low BF)	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes	$8.27

MMID	Measure Name	Source	Incremental Cost
		T8 and CEE ballast as baseline.	
2580	T8 4L 4', 28W, CEE, BF > 0.78	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$8.27
2581	T8 4L-4 ft Hi Lumen Lamp with CEE Ballast (Low BF)	Implementer's assessment plus Cadmus estimate for labor duration and RSMeans for labor cost. Assumes CEE ballast as baseline.	$15.40
2582	T8 4L-4 ft Hi Lumen Lamp with CEE Ballast	Implementer's assessment plus Cadmus estimate for labor duration and RSMeans for labor cost. Assumes CEE ballast as baseline.	$15.40
2590	T8 Low Watt Relamp - 25 Watts	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$2.45
2591	T8 Low Watt Relamp - 28 Watts	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$2.07
2592	Thermal Curtain, 8mm Double Polycarbonate Walls and Ceiling, Overhead Heating	Implementer Assessment	$2.15
2593	Thermal Curtain, 8mm Double Polycarbonate Walls and Ceiling, Under Bench Heating	Implementer Assessment	$2.15
2594	Thermal Curtain, 8mm Double Polycarbonate Walls and Poly Film Ceiling, Overhead Heating	Implementer Assessment	$2.15
2595	Thermal Curtain, 8mm Double Polycarbonate Walls and Poly Film Ceiling, Under Bench Heating	Implementer Assessment	$2.15
2596	Thermal Curtain, Double Pane Glass Walls and Ceiling, Overhead Heating	Implementer Assessment	$2.15
2597	Thermal Curtain, Double Pane Glass Walls and Ceiling, Under Bench Heating	Implementer Assessment	$2.15
2598	Thermal Curtain, Double Pane	Implementer Assessment	$2.15

MMID	Measure Name	Source	Incremental Cost
	Glass Walls and Poly Film Ceiling, Overhead Heating		
2599	Thermal Curtain, Double Pane Glass Walls and Poly Film Ceiling, Under Bench Heating	Implementer Assessment	$2.15
2601	Thermal Curtain, Poly Film Walls and Ceiling, Overhead Heating	Implementer Assessment	$2.15
2602	Thermal Curtain, Poly Film Walls and Ceiling, Under Bench Heating	Implementer Assessment	$2.15
2603	Thermal Curtain, Single Pane Glass Walls and Ceiling, Overhead Heating	Implementer Assessment	$2.15
2604	Thermal Curtain, Single Pane Glass Walls and Ceiling, Under Bench Heating	Implementer Assessment	$2.15
2605	Thermal Curtain, Single Pane Glass Walls and Poly Film Ceiling, Overhead Heating	Implementer Assessment	$2.15
2606	Thermal curtain, Single Pane Glass Walls and Poly Film Ceiling, Under Bench Heating	Implementer Assessment	$2.15
2608	Unit Heater, ≥90% thermal efficiency, per input MBh, for retrofit	Focus on Energy Study	$14.01
2611	Vending Machine Controls, occupancy based, on cold beverage machine	Online Research	$160.00
2612	Snack Machine - Install Vending Miser Controller	Online Research	$156.00
2613	Beverage Cooler Controls	Online Research	$170.00
2613	Vending Machine Controls, sales based, on cold beverage machine	Online Research	$372.00
2614	Vending Machine Controls, Sales Based, Snack Machine	Online Research	$5,840.17
2615	Vending Machine, ENERGY STAR, Cold Beverage, Not Software Activated	Existing Cost Figure	$206.59
2616	Vending Machine Controller,	MMID 2611	$160.00

MMID	Measure Name	Source	Incremental Cost
	Direct Install, Cooled Machine		
2620	Kitchen Hood Ventilation Controls, Temperature Only, New System, Bonus for controlling MUA fan	Existing Cost Figure	$500.00
2621	Kitchen Hood Ventilation Controls, Temperature Only, Retrofit, Bonus for controlling MUA fan	Existing Cost Figure	$1,000.00
2622	Kitchen Hood Ventilation Controls, Temperature Only, New System, Exhaust Fan Controlled	Existing Cost Figure	$994.00
2623	Kitchen Hood Ventilation Controls, Temperature Only, Retrofit, Exhaust Fan Controlled	Existing Cost Figure	$1,988.00
2624	Kitchen Hood Ventilation Controls, Temp and Optical, New System, Bonus for controlling MUA fan	Existing Cost Figure	$500.00
2625	Kitchen Hood Ventilation Controls, Temp and Optical, Retrofit, Bonus for controlling MUA fan	California studies	$1,566.91
2626	Ventilation Controls, Kitchen Hood, with Optical, Exhaust Only, New	Existing Cost Figure	$994.00
2627	Kitchen Hood Ventilation Controls, Temp and Optical, Retrofit, Exhaust Fan Controlled	Existing Cost Figure	$1,988.00
2628	Agricultural Exhaust Fan, High Efficiency - 36"	Implementer Assessment	$150.00
2629	Agricultural Exhaust Fan, High Efficiency - 42"	MMIDs 2628 and 2630	$150.00
2630	Agricultural Exhaust Fan, High Efficiency - 48"	Implementer Assessment	$150.00
2631	Agricultural Exhaust Fan, High Efficiency - 50"	MMID 2630	$150.00
2632	Agricultural Exhaust Fan, High	MMID 2630	$150.00

MMID	Measure Name	Source	Incremental Cost
	Efficiency - 51"		
2633	Agricultural Exhaust Fan, High Efficiency - 52"	MMID 2630	$150.00
2634	Agricultural Exhaust Fan, High Efficiency - 54"	Historical Project Data	$1,139.00
2635	Agricultural Exhaust Fan, High Efficiency - 55"	MMID 2635	$1,139.00
2636	Agricultural Exhaust Fan, High Efficiency - 57"	Historical Project Data	$1,695.00
2637	Agricultural Exhaust Fan, High Efficiency - 60"	Historical Project Data	$2,010.00
2638	Agricultural Exhaust Fan, High Efficiency - 72"	Historical Project Data	$2,287.00
2639	VFD, Ag Second Use Water System	NEEP Incremental Cost Study	$130/hp
2640	VFD, Boiler Draft Fan	NEEP Incremental Cost Study	$130/hp
2641	VFD, Cooling Tower Fan	NEEP Incremental Cost Study	$130/hp
2642	VFD, Dairy Vacuum Pump, Ag	Vermont Program Data	$4,000.00
2643	VFD Fan, Hybrid	NEEP Incremental Cost Study	$130/hp
2644	VFD, HVAC Heating Pump	NEEP Incremental Cost Study	$130/hp
2646	VFD, Pool Pump Motor	NEEP Incremental Cost Study	$130/hp
2647	VFD, Process Fan	NEEP Incremental Cost Study	$130/hp
2648	VFD Pump, Hybrid	NEEP Incremental Cost Study	$130/hp
2651	Storage Water Heater EF >0.67	Ohio TRM	$400.00
2652	Water Heater, ≥0.82 EF, Tankless, Residential, NG	Ohio TRM	$605.00
2653	DHW - Ag, Hybrid	Implementer Assessment	$1,200.00
2655	Water Heater, Dual Thermostat, Ag, NG	Historical Project Data	$5,908.00
2657	Water Heater, Fuel Switching, Electric to NG, Ag	MMID 2825	$500.00
2658	Water Heater, Residential Type - Indirect, with 90% AFUE+ Modulating Hot Water Boiler	Online Research and Navigant Incremental Cost Study	$3,356.49
2660	Waterer, Livestock, <250 Watts	Illinois TRM	$710.33
2665	T8 Reduced Wattage Relamp 8 ft - 54 Watts	Existing Cost Figure	$4.33

MMID	Measure Name	Source	Incremental Cost
2666	Air Cooled Chiller System Tune Up, Service Buy Down ≤500 Tons	Act On Energy TRM	$35/ton
2667	Air Cooled Chiller System Tune Up, Service Buy Down>500 Tones	Act On Energy TRM	$35/ton
2668	Chiller Tune-Up	Act On Energy TRM	$35/ton
2668	Water Cooled Chiller System Tune Up, Service Buy Down ≤500 Tons	Act On Energy TRM	$35/ton
2669	Water Cooled Chiller System Tune Up, Service Buy Down >500 Tons	Act On Energy TRM	$35/ton
2670	CFL ≤30 Watts, replacing incandescent	MMID 2243	$3.00
2671	Coil cleaning, self-contained unit - New	Existing Cost Figure	$13.72
2673	Fryer, Large Vat, Electric, High Efficiency	ENERGY STAR Calculator	$-
2674	Fryer, Large Vat, Gas, High Efficiency	ENERGY STAR Calculator	$1,120.00
2677	Hot Food Holding Cabinet - ENERGY STAR, 13 ≤ V < 28 cu ft	Illinois TRM	$1,800.00
2678	Hot Food Holding Cabinet - ENERGY STAR, V < 13 cu ft	Illinois TRM	$1,500.00
2679	Hot Food Holding Cabinet - ENERGY STAR, V ≥ 28 cu ft	Illinois TRM	$1,200.00
2686	Low Flow Faucet Aerators (Public Restroom), Direct Install, Electric	Historical Project Data	$2.00
2687	Low Flow Faucet Aerators (Public Restroom), Direct Install, Natural Gas	Historical Project Data	$2.00
2688	Faucet Aerators, Direct Install, Electric	Historical Project Data	$8.00
2689	Faucet Aerators, Direct Install, NG	Historical Project Data	$8.00
2691	LED Canopy Fixture - New	Cadmus estimate for labor duration and RSMeans for labor cost. and GreenElectricalSupply.com	$332.94
2692	LED Canopy Fixture, Dusk to Dawn	Cadmus estimate for labor duration and RSMeans for labor cost. and	$332.94

MMID	Measure Name	Source	Incremental Cost
		GreenElectricalSupply.com	
2693	LED Pole Mounted - New	Cadmus estimate for labor duration and RSMeans for labor cost. and GreenElectricalSupply.com	$1,062.40
2694	LED Wall Pack - New	Cadmus estimate for labor duration and RSMeans for labor cost. and GreenElectricalSupply.com	$196.40
2695	LED Wall Pack, Dusk to Dawn	Cadmus estimate for labor duration and RSMeans for labor cost. and GreenElectricalSupply.com	$196.40
2699	PTHP, <8000 Btuh, ≥12.3 EER, ≥3.2 COP, Retrofit Application	Illinois TRM	$49/PTHP
2700	PTHP, ≥13000 Btuh, ≥12.3 EER, ≥3.2 COP, Retrofit Application	Illinois TRM	$105/PTHP
2701	PTHP, 10000-12999 Btuh, ≥12.3 EER, ≥3.2 COP, Retrofit Application	Illinois TRM	$84/PTHP
2702	PTHP, 8000 - 9999 Btuh, ≥12.3 EER, ≥3.2 COP, Retrofit Application	Illinois TRM	$63/PTHP
2703	T5 2L - F28T5 Fixture, Recessed Indirect 2x4, replacing 3LT8 or 4LT12	1000bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost.	$185.50
2704	T8 2L - HPT8 Fixture or Retrofit Module, Recessed Direct or Indirect 2x4, replacing 3L or 4L T8 or T12	1000bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost.	$167.17
2705	Ice Machine, CEE Tier 2, Remote Condensing Without Remote Compressor, Air Cooled, Flake, <500 lbs/day	Illinois TRM	$981.00
2709	Metal Halide, Electronic Ballast, Pulse Start, 320 Watt	Implementer's cost + labor	$105.60
2711	Insulation, Project Based, Attic	Navigant Incremental Cost Study	$2.69
2712	Insulation, Sidewall, Foam	Average of four existing figures provided for different sizes.	$380.00
2713	Insulation, Foundation - Interior	Navigant Incremental Cost Study	$2.93
2714	Insulation, Sill Box	Navigant Incremental Cost Study	$5.97

MMID	Measure Name	Source	Incremental Cost
2721	Ground Source Heat Pump	Cost data compiled at the end of each CY	Actual Cost
2725	Dairy Tune Up, Hybrid	Historical Project Data	$212.00
2726	VFD, Chilled Water Distribution Pump	NEEP Incremental Cost Study	$130/HP
2732	CFL, Direct Install 13W	MMID 2117	$0.37
2734	Faucet Aerator, Direct Install, 1.5 gpm, Bathroom, Electric	Historical Project Data	$2.00
2735	Faucet Aerator, Direct Install, 1.5 gpm, Bathroom, NG	Historical Project Data	$2.00
2736	LED Exit Sign, Direct Install	WESCO Distribution pricing+labor	$105.60
2740	CFL, Direct Install, 18 Watt	Online Research	$2.86
2741	Insulation, Direct Install, 3' Pipe, Electric	RSMeans	$11.88
2742	Insulation, Direct Install, 3' Pipe, NG	RSMeans	$11.88
2743	Boiler, hot water, high efficiency modulating, for space heating (AFUE ≥90%)(175 - 300 MBh)	Historical Project Data	$50.82/MBH
2744	Boiler Tune Up	Online Research	$119.95
2753	CFL - Common Area	Online Research	$2.71
2754	CFL - In Unit	Online Research	$2.71
2756	Clothes Washer, ENERGY STAR Tier 3, Electric	Online Research	$325.40
2757	Clothes Washer, ENERGY STAR Tier 3, Gas	Online Research	$325.40
2760	Domestic Hot Water Plant Replacement	Historical Project Data	$27.07/MBH
2764	Furnace, with ECM fan motor, for space heating (AFUE ≥95%)	Navigant Incremental Cost Study	$1,667.84
2767	LED Lamps - Common Area	Implementer Assessment	$15.00
2768	LED Exit Fixture or Retrofit Kits	RSMeans	$91.61
2769	LED Lamps - In Unit	Implementer Assessment	$15.00
2772	Steam Trap Radiator Repair or Replace	Online/Book Research	$219.40
2778	Water Heater, Dual Thermostat, Ag, Electric	Historical Project Data	$1,468.00
2784	CFL, Direct Install, 15 Watt	MMID 2117	$0.37

MMID	Measure Name	Source	Incremental Cost
2785	CFL, Direct Install, 42 Watt ≥2,600 Lumens	Online Research	$4.00
2786	CFL, Direct Install, 7 Watt	MMID 2116	$1.21
2787	CFL, Direct Install, 9 Watt	MMID 2813	$0.37
2792	Insulation, Direct Install, Pipe, Per Foot, 2" Thickness, Electric	RSMeans	$7.30
2793	Pipe Insulation for Hot Water, Direct Install, 2-inch, NG	RSMeans	$7.92
2794	Pipe Insulation for Hot Water, Direct Install, 1-inch, NG	RSMeans	$3.96
2795	Insulation, Direct Install, Pipe, Per Foot, 1" Thickness, NG	RSMeans	$3.64
2797	Occupancy Sensor, With Co-Pay, Wall Mount, ≤200 Watts	WESCO Distribution pricing+labor	$35.00
2798	Occupancy Sensor, With Co-Pay, Wall Mount, >200 Watts	WESCO Distribution pricing+labor	$35.00
2799	T8 1L-4 ft Reduced Wattage with CEE Ballast - 28 Watts	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$2.07
2800	T8 1L 4', With Co-Pay, 28W, CEE, BF > 0.78	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$2.07
2801	T8 2L 4', 28W, CEE, BF > 0.78	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$4.13
2802	T8 2L 4', With Co-Pay, 28W, CEE, BF > 0.78	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$4.13
2803	T8 3L-4 ft Reduced Wattage with CEE Ballast - 28 Watts	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$6.20
2804	T8 3L 4', With Co-Pay, 28W, CEE, BF > 0.78	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor	$6.20

MMID	Measure Name	Source	Incremental Cost
		duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	
2805	T8 4L-4 ft Reduced Wattage with CEE Ballast - 28 Watts	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$8.27
2806	T8 4L 4', With Co-Pay, 28W, CEE, BF > 0.78	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$8.27
2807	T8 4L or T5HO 2L Replacing 250-399 W HID	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$156.14
2808	T8 6L or T5HO 4L Replacing 400-999 W HID	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$163.56
2809	T8 10 lamp replacing 1000W HID	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$215.29
2809	T8 8 lamp replacing 1000W HID	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$273.80
2810	Engine Block Heater Timer	Existing Cost Figure	$25.00
2811	CFL, Direct Install, 9 Watt	MMID 2116	$1.21
2812	CFL, Direct Install, 13 Watt ≥800 Lumens	MMID 2813	$0.37
2813	CFL Reflector, Direct Install, 14 Watt	Light bulb sales data obtained by Cadmus for California- 2010 through 2012. Note that the CFL average lamp costs include incented lamps.	$0.37
2813	CFL Reflector, Direct Install, 23 Watt	Light bulb sales data obtained by Cadmus for California- 2010 through 2012. Note that the CFL average lamp costs include incented lamps.	$1.03
2815	CFL, Direct Install, 23 Watt 1,400 to 1,599 Lumens	Light bulb sales data obtained by Cadmus for California- 2010 through 2012. Note that the CFL average lamp costs include incented lamps.	$1.03
2816	CFL, Direct Install, 18 Watt	MMID 2118	$0.38
2819	Solar PV	Cost data compiled at the end of each CY	Actual Cost
2820	Ground Source Heat Pump, Electric Back-up	Cost data compiled at the end of each CY	Actual Cost

MMID	Measure Name	Source	Incremental Cost
2821	Ground Source Heat Pump, NG Back-up	Cost data compiled at the end of each CY	Actual Cost
2824	VFD, Ag Primary Use Water System	NEEP Incremental Cost Study	$130/HP
2825	Water Heater, Electric to Gas Conversion	Existing Cost Figure	$500.00
2826	Rooftop Tune Up - < 7.5 Ton w/ All Options Office, Hybrid	Existing Cost Figure	$1,250.00
2827	Rooftop Tune Up - < 7.5 Ton w/ DCV Only Office, Hybrid	Existing Cost Figure	$850.00
2828	Rooftop Tune Up - < 7.5 Ton w/ Eco & DCV Office, Hybrid	Existing Cost Figure	$1,250.00
2829	Rooftop Tune Up - < 7.5 Ton w/ Eco Only Office, Hybrid	Existing Cost Figure	$1,050.00
2830	Rooftop Tune Up - < 7.5 Ton w/ Programmable Thermostat Only Office, Hybrid	Existing Cost Figure	$250.00
2831	Rooftop Tune Up - < 7.5 Ton w/ Programmable Thermostat & DCV Office, Hybrid	Existing Cost Figure	$850.00
2832	Rooftop Tune Up - < 7.5 Ton w/ Programmable Thermostat & Eco Office, Hybrid	Existing Cost Figure	$1,050.00
2833	Roof Top Upgrade, Thermostat, DCV, & Economizer, ≤7.5 Tons	Existing Cost Figure	$1,250.00
2834	Rooftop Tune Up > 7.5 Ton w/ All Options Office, Hybrid	Existing Cost Figure	$1,250.00
2835	Rooftop Tune Up > 7.5 Ton w/ Programmable Thermostat Office, Hybrid	Existing Cost Figure	$250.00
2836	Rooftop Tune Up > 7.5 Ton w/ DCV Office, Hybrid	Existing Cost Figure	$850.00
2837	Roof Top Upgrade, Thermostat and DCV, >7.5 Tons	Existing Cost Figure	$1,250.00
2853	Demand Control Ventilation for AHU or Rooftop - New	Historical Project Data	$1.32/CFM
2862	CFL, Direct Install 18W	Light bulb sales data obtained by Cadmus for California- 2010 through 2012. Note that the	$0.37

MMID	Measure Name	Source	Incremental Cost
		CFL average lamp costs include incented lamps.	
2884	T8 4 lamp replacing 250-399W HID	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$156.14
2885	T8 (2) 6 lamp replacing 1000W HID	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$327.12
2885	T8 6 lamp replacing 400-999W HID	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$163.56
2886	T8 8 lamp replacing 400-999W HID	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$215.29
2887	T8 8L ≤500W, Replacing ≥1000 W HID	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$215.29
2888	T8 10L ≤500W, Replacing ≥1000 W HID	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$273.80
2889	T8 (2) 6L ≤500W, Replacing ≥1000 W HID	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$327.12
2890	T5HO 2 lamp replacing 250-399W HID	Implementer's cost (other rows), Cadmus estimate for labor duration and RSMeans for labor cost.	$156.14
2891	T5HO 3L Replacing 250-399 W HID	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$195.49
2892	T5HO 4 lamp replacing 400-900W HID	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$163.56
2893	T5HO 6 lamp replacing 400-999W HID	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$210.22
2894	T5HO 6 lamp <500W replacing 1000W HID	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$210.22
2895	T5HO 8 lamp or (2) T5HO 4 Lamp <500W replacing 1000W HID	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$262.28
2896	T5HO (2) 4L ≤500W, Replacing ≥1000 W HID	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$327.12
2897	T5HO (2) 6L ≤800W, Replacing ≥1000 W HID	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$420.44
2900	Ground Source Heat Pump, Electric Back-up	Cost data compiled at the end of each CY	Actual Cost
2901	Ground Source Heat Pump, NG Back-up	Cost data compiled at the end of each CY	Actual Cost
2902	Water Heater, Power Vented, EF	0	$-

MMID	Measure Name	Source	Incremental Cost
	0.67-0.82, Storage, NG		
2903	Ground Source Heat Pump, LP Back-up	Cost data compiled at the end of each CY	Actual Cost
2904	Ground Source Heat Pump, No Back-up	Cost data compiled at the end of each CY	Actual Cost
2905	Solar Thermal, Electric	Cost data compiled at the end of each CY	Actual Cost
2906	Solar Thermal, NG	Cost data compiled at the end of each CY	Actual Cost
2908	Wind	Cost data compiled at the end of each CY	Actual Cost
2909	Biogas	Cost data compiled at the end of each CY	Actual Cost
2910	Biomass	Cost data compiled at the end of each CY	Actual Cost
2931	LED Fixture, Canopy	Cadmus estimate for labor duration and RSMeans for labor cost. and GreenElectricalSupply.com	$332.94
2932	LED Fixture, Exterior Pole Mounted	Cadmus estimate for labor duration and RSMeans for labor cost. and GreenElectricalSupply.com	$1,062.40
2933	Roof Top Upgrade, DCV & Economizer, ≤7.5 Tons	MMID 2828	$1,250.00
2934	Roof Top Upgrade, DCV, ≤7.5 Tons	MMID 2827	$850.00
2935	Roof Top Upgrade, DCV, >7.5 Tons	MMID 2827	$850.00
2936	Roof Top Upgrade, Economizer, ≤7.5 Tons	MMID 2829	$1,050.00
2937	Roof Top Upgrade, Thermostat & DCV, ≤7.5 Tons	MMID 2831	$850.00
2938	Roof Top Upgrade, Thermostat & Economizer, ≤7.5 Tons	MMID 2832	$1,050.00
2939	Roof Top Upgrade, Thermostat and DCV, >7.5 Tons	MMID 2831	$850.00
2940	Roof Top Upgrade, Thermostat, ≤7.5 Tons	MMID 2830	$250.00
2941	Roof Top Upgrade, Thermostat, >7.5 Tons	MMID 2830	$250.00
2942	Roof Top Upgrade, Thermostat, DCV, & Economizer, ≤7.5 Tons	MMID 2826	$1,250.00
2954	VFD Dairy, Hybrid	Vermont Program Data	$3,004.00

MMID	Measure Name	Source	Incremental Cost
2955	Refrigerator Recycling	Program Data	$85.00
2956	Freezer Recycling	Program Data	$85.00
2959	CFL, Markdown 17 watts or less	Light bulb sales data obtained by Cadmus for California- 2010 through 2012. Note that the CFL average lamp costs include incented lamps.	$0.37
2959	CFL, Markdown 18 to 24 watts	Light bulb sales data obtained by Cadmus for California- 2010 through 2012. Note that the CFL average lamp costs include incented lamps.	$0.38
2960	T8 or T5HO ≤155W, Replacing 250-399W HID, Not Otherwise Specified	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$156.14
2961	T8 or T5HO ≤250W, Replacing 400-999W HID, Not Otherwise Specified	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$163.56
2962	T8 or T5HO 251-365W, Replacing 400-999W HID, Not Otherwise Specified	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$215.29
2963	T8 or T5HO ≤500W, Replacing ≥1000W HID, Not Otherwise Specified	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$273.80
2964	T8 or T5HO ≤800W, Replacing 1000W HID, Not Otherwise Specified	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$342.04
2971	LED Lamp, Direct Install, Walk-in Cooler or Freezer	WESCO Distribution pricing+labor	$15.00
2979	LED, Exit Sign, Retrofit, Over Program Limit	WESCO Distribution pricing+labor	$35.00
2984	LED Fixture, Downlights, Accent Lights and Monopoint, ≤18 Watts, Common Area	Historical Project Data + Labor Cost	$80.13
2986	Insulation, Attic, R-11 to R-38	RSMeans	$0.99
2987	Water Heater, Heat Pump, EF ≥2.0, Electric	MMID 3047	$2,893.00
2989	ECM, Furnace, New or Replacement	Implementer Assessment	$172.00
2990	Furnace And A/C, ECM, 95% +	Implementer Assessment	$1,451.66

MMID	Measure Name	Source	Incremental Cost
	AFUE, ≥16 SEER		
2992	Air Source Heat Pump, ≥16 SEER	Illinois TRM	$1,274.10
3001	Delamping, 200-399 Watt Fixture	Implementer's cost of labor	$15.00
3002	Delamping, ≥400 Watt Fixture	Implementer's cost of labor	$15.00
3003	LED, Replacing Neon Sign	Implementer's cost of labor	$55.00
3016	Ventilation Controls, Parking Lot	Historical Project Data	$607.00
3017	Showerheads, Retail Store Markdown	Historical Project Data	$5.00
3018	Waterer, Livestock, Energy Free	Historical Project Data	$741.00
3019	Lighting Fixture, Agricultural Daylighting ≤155 Watts	Implementer's cost of labor	$325.87
3020	Lighting Fixture, Agricultural Daylighting 156 - 250 Watts	Implementer's cost of labor	$325.87
3021	Lighting Fixture, Agricultural Daylighting 251 - 365 Watts	Implementer's cost of labor	$535.04
3022	Room A/C	2014. Based on a review of TRM incremental cost assumptions from Vermont, Wisconsin, and California. This assumes that baseline shift from IECC 2009 to IECC 2012 carries the same incremental costs. Values should be verified during evaluation	$100/ton
3022	Split System A/C	2014. Based on a review of TRM incremental cost assumptions from Vermont, Wisconsin, and California. This assumes that baseline shift from IECC 2009 to IECC 2012 carries the same incremental costs. Values should be verified during evaluation	$100/ton
3023	T5, Reduced Wattage, Replacing T5 Or T5HO	Online Research	$15.04
3024	T5HO, Reduced Wattage, Replacing Standard T5 Or T5HO	Online Research	$12.63
3025	Faucet Aerator, Kitchen, Gas	Historical Project Data	$8.00
3026	Faucet Aerator, Kitchen, Electric	Historical Project Data	$8.00
3027	Faucet Aerator, Bath, Gas	Historical Project Data	$8.00
3028	Faucet Aerator, Bath, Electric	Historical Project Data	$8.00
3029	Faucet Aerator, 1.5 gpm, Shower, NG	Historical Project Data	$12.00

MMID	Measure Name	Source	Incremental Cost
3030	Faucet Aerator, 1.5 gpm, Shower, Electric	Historical Project Data	$12.00
3031	CFL, Reduced Wattage, Pin Based, 18 Watt, Replacing CFL	Online research on GU24 18 watt CFL on 1000bulbs.com; prices range from $4 -$7.30, compared to $3.75 (from light bulb sales data obtained by Cadmus). Plus $1 labor cost for replacement.	$3.00
3032	CFL, Reduced Wattage, Pin Based, 26 Watt, Replacing CFL	Online research on GU24 26 watt CFL on 1000bulbs.com; prices range from $3.40 - $6.50, compared to $3.18 (from light bulb sales data obtained by Cadmus). Plus $1 labor cost for replacement.	$2.77
3033	CFL, Reduced Wattage, Pin Based, 32 Watt, Replacing CFL	Assumed same as 42 watt.	$-
3034	CFL, Reduced Wattage, Pin Based, 42 Watt, Replacing CFL	Online research on GU24 26 watt CFL on 1000bulbs.com; prices range from $7 -$11.33, compared to $7 - $13.25 (also on 1000bulbs.com).	$-
3036	HID, Reduced Wattage, Replacing 1000 Watt HID, Exterior	MMIDs 3206-3215	$43.54
3037	HID, Reduced Wattage, Replacing 400 Watt HID, Exterior	MMIDs 3206-3215	$43.54
3038	HID, Reduced Wattage, Replacing 320 Watt HID, Exterior	MMIDs 3206-3215	$43.54
3039	HID, Reduced Wattage, Replacing 250 Watt HID, Exterior	MMIDs 3206-3215	$43.54
3040	HID, Reduced Wattage, Replacing 175 Watt HID, Exterior	MMIDs 3206-3215	$43.54
3041	T5HO, Exterior Reduced Wattage, Replacing 250-399 Watt HID	Implementer's Cost	$150.00
3042	T5HO, Exterior Reduced Wattage, Replacing 400-999 Watt HID	Implementer's Cost	$150.00
3043	T5HO, Exterior < 500 Watts, Replacing ≥1000 Watt HID	Implementer's Cost	$200.00
3045	Water Heater, High Usage, ≥90% TE, NG	Historical Project Data	$7,303.00
3046	Water Heater, High Usage, ≥0.82 EF, Tankless, NG	Historical Project Data	$1,120.00

MMID	Measure Name	Source	Incremental Cost
3047	Water Heater, High Usage, ≥2 EF, Heat Pump Storage, Electric	Historical Project Data	$2,893.00
3056	LED Fixture, Replacing 320 Watt HID, Parking Garage, 24 Hour	MMID 3103	$150.00
3059	A/C Coil Cleaning, < 10 tons	Act On Energy TRM	$35/ton
3060	A/C Coil Cleaning, > 20 tons	Act On Energy TRM	$35/ton
3061	A/C Coil Cleaning, 10-20 tons	Act On Energy TRM	$35/ton
3062	A/C Refrigerant Charge Correction, < 10 tons	Act On Energy TRM	$35/ton
3063	A/C Refrigerant Charge Correction, > 20 tons	Act On Energy TRM	$35/ton
3064	A/C Refrigerant Charge Correction, 10-20 tons	Act On Energy TRM	$35/ton
3065	Ceramic Metal Halide, 575 Watt, Replacing 1000 Watt HID, High Bay	Workpaper	$100.00
3066	Economizer, RTU Optimization	Workpaper	$155.00
3067	HID, Reduced Wattage, Replacing 1000 Watt HID, Interior	Workpaper	$35.00
3068	HID, Reduced Wattage, Replacing 175 Watt HID, Interior	Workpaper	$35.00
3069	HID, Reduced Wattage, Replacing 175 Watt HID, Parking Garage	Workpaper	$35.00
3070	HID, Reduced Wattage, Replacing 250 Watt HID, Interior	Workpaper	$35.00
3071	HID, Reduced Wattage, Replacing 250 Watt HID, Parking Garage	Workpaper	$35.00
3072	HID, Reduced Wattage, Replacing 320 Watt HID, Interior	Workpaper	$35.00
3073	HID, Reduced Wattage, Replacing 400 Watt HID, Interior	Workpaper	$35.00
3074	Induction, 750 Watt, Replacing 1000 Watt HID, High Bay	Workpaper	$750.00
3075	Induction, PSMH/CMH, ≤250 Watt, Replacing 320-400 Watt HID, High Bay	Workpaper	$290.00
3076	Metal Halide, Electronic Ballast Pulse Start - 250W replacing	Implementer's cost	$159.05

MMID	Measure Name	Source	Incremental Cost
	400W HID		
3077	Metal Halide, Electronic Ballast Pulse Start - 320W replacing 400W HID	Implementer's cost + labor	$100.26
3078	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 150-175 Watt HID, Exterior	Workpaper	$15.00
3079	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 150-175 Watt HID, Parking Garage, 24 Hour	Workpaper	$15.00
3080	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 150-175 Watt HID, Parking Garage, Dusk to Dawn	Workpaper	$15.00
3081	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 250 Watt HID, Exterior	Workpaper	$100.00
3082	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 250 Watt HID, Parking Garage, 24 Hour	Workpaper	$100.00
3083	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 250 Watt HID, Parking Garage, Dusk to Dawn	Workpaper	$100.00
3084	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 320 Watt HID, Exterior	Workpaper	$340.00
3085	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 320-400 Watt HID, Exterior	Workpaper	$290.00
3086	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 400 Watt HID, Exterior	Workpaper	$240.00
3087	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 70-100 Watt HID, Exterior	Workpaper	$50.00
3088	Induction, PSMH/CMH, or Linear	Workpaper	$50.00

MMID	Measure Name	Source	Incremental Cost
	Fluorescent, Replacing 70-100 Watt HID, Parking Garage, 24 Hour		
3089	Induction, PSMH/CMH, or Linear Fluorescent, Replacing 70-100 Watt HID, Parking Garage, Dusk to Dawn	Workpaper	$50.00
3090	Induction, PSMH/CMH, Replacing 250 Watt HID, High Bay	Workpaper	$100.00
3091	LED Fixture, <155 Watts, Replacing 250 Watt HID, High Bay	GreenElectricalSupply.com and Cadmus estimate for labor duration and RSMeans for labor cost.	$401.32
3092	LED Fixture, <250 Watts, Replacing 320-400 Watt HID, High Bay	GreenElectricalSupply.com and Cadmus estimate for labor duration and RSMeans for labor cost.	$588.40
3093	LED Fixture, <250 Watts, Replacing 400 Watt HID, High Bay	GreenElectricalSupply.com and Cadmus estimate for labor duration and RSMeans for labor cost.	$588.40
3094	LED Fixture, <365 Watts, Replacing 400 Watt HID, High Bay	GreenElectricalSupply.com and Cadmus estimate for labor duration and RSMeans for labor cost.	$688.40
3095	LED Fixture, <500 Watts, Replacing 1000 Watt HID, High Bay	GreenElectricalSupply.com and Cadmus estimate for labor duration and RSMeans for labor cost.	$1,563.40
3096	LED Fixture, <800 Watts, Replacing 1000 Watt HID, High Bay	GreenElectricalSupply.com and Cadmus estimate for labor duration and RSMeans for labor cost.	$1,563.40
3097	LED Fixture, Bilevel, Stairwell and Passageway	Workpaper	$120.00
3098	LED Fixture, Downlights, Accent Lights and Monopoint, > 18 Watts, Common Area	Workpaper	$60.00
3099	LED Fixture, Replacing 150-175 Watt HID, Exterior	Workpaper	$100.00
3100	LED Fixture, Replacing 150-175 Watt HID, Parking Garage, 24 Hour	Workpaper	$100.00
3101	LED Fixture, Replacing 150-175	Workpaper	$100.00

MMID	Measure Name	Source	Incremental Cost
	Watt HID, Parking Garage, Dusk to Dawn		
3102	LED Fixture, Replacing 250 Watt HID, Exterior	Workpaper	$150.00
3103	LED Fixture, Replacing 250 Watt HID, Parking Garage, 24 Hour	Workpaper	$150.00
3104	LED Fixture, Replacing 250 Watt HID, Parking Garage, Dusk to Dawn	Workpaper	$150.00
3105	LED Fixture, Replacing 320 Watt HID, Exterior	Workpaper	$250.00
3106	LED Fixture, Replacing 320-400 Watt HID, Exterior	Workpaper	$300.00
3107	LED Fixture, Replacing 400 Watt HID, Exterior	Workpaper	$350.00
3108	LED Fixture, Replacing 70-100 Watt HID, Exterior	Workpaper	$100.00
3109	LED Fixture, Replacing 70-100 Watt HID, Parking Garage, 24 Hour	Workpaper	$100.00
3110	LED Fixture, Replacing 70-100 Watt HID, Parking Garage, Dusk to Dawn	Workpaper	$100.00
3111	LED Troffer, 2x4, Replacing 4' 3-4 Lamp T8 Troffer	Online research on LED troffer data	$214.00
3112	LED, ≤40 Watt, ENERGY STAR, Replacing Incandescent	Lighting sales data obtained by Cadmus	$12.75
3113	LED, > 40 Watt, ENERGY STAR, Replacing Incandescent	2014 application data.	$20.00
3114	LED, Horizontal Case Lighting	WESCO distribution pricing + labor	$86.00
3117	Linear Fluorescent, Bilevel, Stairwell and Passageway	Workpaper	$120.00
3118	Oven, Combination, ENERGY STAR, Electric	Nicor Gas Deemed Values	$4,300.00
3119	Oven, Combination, ENERGY STAR, NG	Illinois TRM	$4,300.00
3120	Programmable Thermostat, RTU Optimization Advanced	Historical Project Data	$638.42

MMID	Measure Name	Source	Incremental Cost
3121	Programmable Thermostat, RTU Optimization Standard	Historical Project Data	$473.28
3122	T8 2L 4', HPT8 or RWT8, Replacing T12 1L 8', 0.78 < BF < 1.00	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$4.90
3123	T8 2L 4', HPT8 or RWT8, Replacing T12 1L 8', BF ≤0.78	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$4.90
3124	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', 0.78 < BF < 1.00	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$4.90
3125	T8 2L-4ft High Performance High Ballast Factor Replacing T12HO 1L-8 ft	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$4.90
3126	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', BF > 1.00	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$4.90
3127	T8 4L-4-4ft High Performance Replacing T12 2L-8 ft	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$9.80
3128	T8 4L 4', HPT8 or RWT8, Replacing T12 2L 8', BF ≤0.78	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$9.80
3129	T8 4L-4ft High Performance Replacing T12HO 2L-8 ft -	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$9.80
3130	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', BF ≤0.78	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$9.80
3131	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', BF > 1.00	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$9.80
3132	T8 4L-4ft High Performance Replacing T12HO/VHO 2L-8 ft	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$9.80
3133	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', BF ≤0.78	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$9.80
3134	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', BF > 1.00	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$9.80
3135	Low Watt T8 Lamps	Average of MMID 2590 and MMID 2591	$2.26
3136	Dishwasher, High Temp, Electric Booster, Pots/Pans Type, ENERGY STAR, Electric	Implementer's Assessment	$500.00
3137	Dishwasher, High Temp, Electric Booster, Pots/Pans Type, ENERGY STAR, NG	Implementer's Assessment	$500.00

MMID	Measure Name	Source	Incremental Cost
3138	Dishwasher, High Temp, Gas Booster, Pots/Pans Type, ENERGY STAR, NG	Implementer's Assessment	$500.00
3139	Dishwasher, Low Temp, Pots/Pans Type, ENERGY STAR, Electric	Implementer's Assessment	$500.00
3140	Dishwasher, Low Temp, Pots/Pans Type, ENERGY STAR, NG	Implementer's Assessment	$500.00
3141	LED, ≤8W	Implementer's Assessment	$7.50
3142	LED, > 12W (Max 20W) Flood Lamp	Implementer's Assessment	$16.70
3143	LED, MR16, 8-12W	Implementer's Assessment	$9.90
3144	T8 2L 4', HPT8 or RWT8, Replacing T12 1L 8', 0.78 < BF < 1.00, Parking Garage	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$4.90
3145	T8 2L 4', HPT8 or RWT8, Replacing T12 1L 8', BF ≤0.78, Parking Garage	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$4.90
3146	T8 4L 4', HPT8 or RWT8, Replacing T12 2L 8', 0.78 < BF < 1.00, Parking Garage	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$9.80
3147	T8 4L 4', HPT8 or RWT8, Replacing T12 2L 8', BF ≤0.78, Parking Garage	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$9.80
3148	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', BF > 1.00, Parking Garage	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$9.80
3149	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', 0.78 < BF < 1.00, Parking Garage	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$4.90
3150	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', BF ≤0.78, Parking Garage	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$4.90
3151	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', BF > 1.00, Parking Garage	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$9.80
3152	T8 4L 4', HPT8 or RWT8,	Implementer's cost plus Cadmus estimate for	$9.80

MMID	Measure Name	Source	Incremental Cost
	Replacing T12HO 2L 8', 0.78 < BF < 1.00, Parking Garage	labor duration and RSMeans for labor cost.	
3153	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', BF ≤0.78, Parking Garage	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$9.80
3154	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', BF > 1.00, Parking Garage	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$9.80
3155	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', 0.78 < BF < 1.00, Parking Garage	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$9.80
3156	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', BF ≤0.78, Parking Garage	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$9.80
3157	LED, Porch Fixture, ENERGY STAR	Workpaper	$40.00
3158	LED Fixture, Downlights, Accent Lights and Monopoint, ≤18 Watts, In Unit	Historical Project Data	$88.38
3159	LED, ENERGY STAR, Replacing Incandescent > 40W, In Unit	Implementer's Assessment	$16.70
3160	LED, ENERGY STAR, Replacing Incandescent > 40W, Common Area	Implementer's Assessment	$16.70
3161	LED, ENERGY STAR, Replacing Incandescent ≤40W, In Unit	Implementer's Assessment	$7.50
3162	LED, ENERGY STAR, Replacing Incandescent ≤40W, Common Area	Implementer's Assessment	$7.50
3163	T8 1L 4', HPT8, CEE, BF ≤0.78, Parking Garage	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$2.07
3164	T8 1L 4', 28W, CEE, BF > 0.78, Parking Garage	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$2.07
3165	T8 1L 4', 28W, CEE, BF ≤0.78, Parking Garage	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor	$2.07

MMID	Measure Name	Source	Incremental Cost
		duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	
3166	T8 1L 4', 25W, CEE, BF > 0.78, Parking Garage	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$2.45
3167	T8 1L 4', 25W, CEE, BF ≤0.78, Parking Garage	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$2.45
3168	T8 2L 4', HPT8, CEE, BF ≤0.78, Parking Garage	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$4.06
3169	T8 2L 4', 28W, CEE, BF > 0.78, Parking Garage	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$4.13
3170	T8 2L 4', 28W, CEE, BF ≤0.78, Parking Garage	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$4.13
3171	T8 2L 4', 25W, CEE, BF > 0.78, Parking Garage	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$4.90
3172	T8 2L 4', 25W, CEE, BF ≤0.78, Parking Garage	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$4.90
3173	T8 3L 4', HPT8, CEE, BF ≤0.78, Parking Garage	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$6.09
3174	T8 3L 4', 28W, CEE, BF > 0.78, Parking Garage	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$6.20

MMID	Measure Name	Source	Incremental Cost
3175	T8 3L 4', 28W, CEE, BF ≤0.78, Parking Garage	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$6.20
3176	T8 3L 4', 25W, CEE, BF > 0.78, Parking Garage	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$7.35
3177	T8 3L 4', 25W, CEE, BF ≤0.78, Parking Garage	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$7.35
3178	T8 4L 4', HPT8, CEE, BF ≤0.78, Parking Garage	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$8.12
3179	T8 4L 4', 28W, CEE, BF > 0.78, Parking Garage	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$8.27
3180	T8 4L 4', 28W, CEE, BF ≤0.78, Parking Garage	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$8.27
3181	T8 4L 4', 25W, CEE, BF > 0.78, Parking Garage	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$9.80
3182	T8 4L 4', 25W, CEE, BF ≤0.78, Parking Garage	2014 application data; verified against 1000 bulbs.com and Cadmus estimate for labor duration and RSMeans for labor cost. Assumes T8 and CEE ballast as baseline.	$9.80
3183	Strip Curtain, Walk-In Freezers and Coolers	WESCO Distribution Pricing + Labor	$45.00
3184	Delamping, Direct Install, 8-Foot Lamp	Implementer's Labor Cost	$2.00
3186	Water Heater, Geothermal Heat Pump	Cost data compiled at the end of each CY	Actual Cost

MMID	Measure Name	Source	Incremental Cost
3188	Hot Water Boiler, 95%+ AFUE	MMID 1983	$3,105.00
3195	Linear Fluorescent, 2L 4’RWT8 Replacements, 24 Hours, CALP	Workpaper	$110.90
3196	T8 2L-4ft High Performance Tandem Replacing T12 2L-8ft	RSMeans	$9.80
3197	CFL Fixture, Interior or Exterior, 24 Hours, CALP	RSMeans	$2.33
3198	CFL Hardwired Interior Fixture, Direct Install - 28 Watt	Existing Cost Figure	$68.00
3199	CFL Hardwired Exterior Fixture, Direct Install - 18 Watt > 1,100 Lumens	Existing Cost Figure	$68.00
3200	LED, Exit Sign, Retrofit, CALP	Workpaper	$52.67
3201	Occupancy Sensor, Wall or Ceiling Mount ≤200 Watts, CALP	Workpaper	$87.54
3202	Occupancy Sensor, Wall or Ceiling Mount >200 Watts, CALP	Workpaper	$87.54
3203	CFL Fixture, replacing incandescent fixture	Online Research	$7.29
3204	CFL Fixtures	Online Research	$7.29
3205	CFL Fixture, ≤100 Watts, with Copay	MMIDSs 3203-3204	$7.29
3206	ELO, CMH Lamp, 330 Watts, Replacing 400 Watt HID	Workpaper	$43.54
3207	ELO, CMH Lamp With Controls, 330 Watts, Replacing 400 Watt HID	Workpaper	$43.54
3208	ELO, CMH Lamp, 205 Watts, Replacing 250 Watt HID	Workpaper	$43.54
3209	ELO, CMH Lamp With Controls, 205 Watts, Replacing 250 Watt HID	Workpaper	$43.54
3210	ELO, CMH System, 210-220 Watts, Replacing 400 Watt HID	Workpaper	$43.54
3211	ELO, CMH System With Controls, 210-220 Watts, Replacing 400 Watt HID	Workpaper	$43.54
3212	ELO, CMH System, 140-150	Workpaper	$43.54

MMID	Measure Name	Source	Incremental Cost
	Watts, Replacing 250 Watt HID		
3213	ELO, CMH System With Controls, 140-150 Watts, Replacing 250 Watt HID	Workpaper	$43.54
3214	ELO, CMH System, 90 Watts, Replacing 150-175 Watt HID	Workpaper	$43.54
3215	ELO, CMH System With Controls, 90 Watts, Replacing 150-175 Watt HID	Workpaper	$43.54
3216	ELO, LED ≤ 200 Watts, Replacing 400 Watt HID	Workpaper	$1,295.21
3217	ELO, LED ≤ 200 Watts With Controls, Replacing 400 Watt HID	Workpaper	$1,295.21
3218	ELO, LED ≤ 125 Watts, Replacing 250 Watt HID	Workpaper	$1,295.21
3219	ELO, LED ≤ 125 Watts With Controls, Replacing 250 Watt HID	Workpaper	$1,295.21
3220	ELO, LED ≤ 60 Watts, Replacing 150-175 Watt HID	Workpaper	$1,295.21
3221	ELO, LED ≤ 60 Watts With Controls, Replacing 150-175 Watt HID	Workpaper	$1,295.21
3223	Coil Brush, Direct Install	Workpaper	$-
3232	LED, 2x4, Replacing T12 2L	Workpaper	$110.00
3233	LED, 2x4, Replacing T12 3L	Workpaper	$110.00
3234	LED, 2x4, Replacing T12 4L	Workpaper	$110.00
3235	LED, 2x4, Replacing T8 2L	Workpaper	$110.00
3236	LED, 2x4, Replacing T8 3L	Workpaper	$110.00
3237	LED, 2x4, Replacing T8 4L	Workpaper	$110.00
3238	LED, 2x2, Replacing T12 2L U-Tube	RSMeans	$16.69
3239	LED, 2x2, Replacing T8 2L U-Tube	RSMeans	$16.69
3240	T8, 2’ Lamps, Replacing T12 Single U-Tube	Workpaper	$40.00
3241	T8, 2’ Lamps, Replacing T12 Dual U-Tube	RSMeans	$1.22
3242	T8, 2’ Lamps, Replacing T8 Single	RSMeans	$1.22

MMID	Measure Name	Source	Incremental Cost
	U-Tube		
3243	T8, 2’ Lamps, Replacing T8 Dual U-Tube	RSMeans	$1.22
3244	Process Exhaust Filtration	Historical Project Data	$2.89/CFM
3251	Lighting Controls, Bilevel, Exterior and Parking Garage Fixtures, Dusk to Dawn	Implementer's cost.	$111.00
3252	Lighting Controls, Bilevel, Parking Garage Fixtures, 24 Hour	Implementer's cost.	$111.00
3253	Lighting Controls, Photocell with Internal Timer or Wireless Schedule, Exterior	Implementer's cost.	$108.57
3254	Occupancy Sensor, High Bay Fixtures, Gymnasium	RSMeans	$95.00
3255	Occupancy Sensor, High Bay Fixtures, Industrial	RSMeans	$95.00
3256	Occupancy Sensor, High Bay Fixtures, Retail	RSMeans	$95.00
3257	Occupancy Sensor, High Bay Fixtures, Warehouse	RSMeans	$95.00
3258	Occupancy Sensor, High Bay Fixtures, Public Assembly	RSMeans	$95.00
3259	Occupancy Sensor, High Bay Fixtures, Other	RSMeans	$95.00
3260	Bi Level Controls, High Bay Fixtures, Gymnasium	RSMeans	$95.00
3261	Bi Level Controls, High Bay Fixtures, Industrial	RSMeans	$95.00
3262	Bi Level Controls, High Bay Fixtures, Retail	RSMeans	$95.00
3263	Bi Level Controls, High Bay Fixtures, Warehouse	RSMeans	$95.00
3264	Bi Level Controls, High Bay Fixtures, Public Assembly	RSMeans	$95.00
3265	Bi Level Controls, High Bay Fixtures, Other	RSMeans	$95.00
3266	Demand Control Ventilation, RTU Optimization	RSMeans	$95.00

MMID	Measure Name	Source	Incremental Cost
3268	Duct Sealing	Workpaper	$450.00
3269	Steam Trap Repair, < 50 psig, General Heating, 7/32"	Consistent with Other Measures	$385.72
3270	Steam Trap Repair, < 50 psig, General Heating, 1/4"	Consistent with Other Measures	$408.41
3271	Steam Trap Repair, < 50 psig, General Heating, 5/16"	Consistent with Other Measures	$431.10
3272	Steam Trap Repair, < 50 psig, General Heating, 3/8"	Consistent with Other Measures	$453.79
3273	LED, 8 watts	RSMeans	$15.00
3274	LED, 12 watts	RSMeans	$7.50
3275	Boiler Plant Retrofit, Hybrid Plant, ≥1 MMBh	Historical Project Data	$25.65
3276	Boiler, Hot Water, Condensing, ≥90% AFUE, ≥300 mbh	Historical Project Data	$25.26
3277	Boiler, Hot Water, Near Condensing, ≥85% AFUE, ≥300 mbh	Historical Project Data	$14.72
3279	LED, Direct Install, 9.5 Watt	Implementer's Assessment	$7.07
3280	VFD, Constant Torque	Historical Project Data	$149.50
3284	Strip Curtain, Walk-In Freezers and Coolers, SBP A La Carte	WESCO Distribution Pricing + Labor	$45.00
3285	LED Fixture, <155 Watts, Replacing 250 Watt HID, High Bay, SBP A La Carte	RSMeans	$401.32
3287	LED Fixture, <250 Watts, Replacing 400 Watt HID, High Bay, SBP A La Carte	RSMeans	$588.40
3288	LED Fixture, <365 Watts, Replacing 400 Watt HID, High Bay, SBP A La Carte	RSMeans	$688.40
3289	LED Fixture, Replacing 150-175 Watt HID, Exterior, SBP A La Carte	Workpaper	$100.00
3290	LED Fixture, Replacing 320-400 Watt HID, Exterior, SBP A La Carte	Workpaper	$350.00
3291	LED Troffer, 2x4, Replacing 4' 3-4 Lamp T8 Troffer, SBP A La Carte	Workpaper	$110.00
3292	Occupancy Sensor, High Bay	Workpaper	$70.00

MMID	Measure Name	Source	Incremental Cost
	Fluorescent Fixtures, Retail, SBP A La Carte		
3293	Occupancy Sensor, High Bay Fluorescent Fixtures, Warehouse, SBP A La Carte	Workpaper	$70.00
3294	Occupancy Sensor, High Bay Fluorescent Fixtures, Public Assembly, SBP A La Carte	Workpaper	$70.00
3295	Occupancy Sensor, High Bay Fluorescent Fixtures, Gymnasium, SBP A La Carte	Workpaper	$70.00
3296	Occupancy Sensor, High Bay Fluorescent Fixtures, Other, SBP A La Carte	Workpaper	$70.00
3297	Occupancy Sensor, High Bay Fluorescent Fixtures, Industrial, SBP A La Carte	Workpaper	$70.00
3298	LED, Reach-In Refrigerated Case, Replaces T12 or T8, SBP A La Carte	WESCO distribution pricing + labor	$86.00
3299	LED, Reach-In Refrigerated Case, Replaces T12 or T8 w/ Occupancy Control, SBP A La Carte	WESCO distribution pricing + labor	$86.00
3300	T8 2L 4', HPT8, CEE, replacing 8' 1L T12HO, SBP A La Carte	Workpaper	$41.00
3301	LED Fixture, Replacing 250 Watt HID, Exterior, SBP A La Carte	Workpaper	$150.00
3303	LED Fixture, Replacing 400 Watt HID, Exterior, SBP A La Carte	Workpaper	$350.00
3304	LED Fixture, Replacing 70-100 Watt HID, Exterior, SBP A La Carte	Workpaper	$100.00
3305	T8 6L or T5HO 4L Replacing 400-999 W HID, SBP A La Carte	Itron Database+RSMeans	$163.56
3306	T8 or T5HO, Replacing ≥1000 Watt HID, SBP A La Carte	Itron Database+RSMeans	$342.04
3307	T8 2L 4', HPT8 or RWT8, Replacing T12 1L 8', 0.78 < BF < 1.00, SBP A La Carte	Workpaper	$41.00

MMID	Measure Name	Source	Incremental Cost
3308	T8 2L 4', HPT8 or RWT8, Replacing T12 1L 8', BF ≤0.78, SBP A La Carte	Workpaper	$41.00
3309	T8 4L 4', HPT8 or RWT8, Replacing T12 2L 8', 0.78 < BF < 1.00, SBP A La Carte	Itron Database+RSMeans	$9.80
3310	T8 4L 4', HPT8 or RWT8, Replacing T12 2L 8', BF ≤0.78, SBP A La Carte	Itron Database+RSMeans	$9.80
3311	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', BF > 1.00, SBP A La Carte	Workpaper	$41.00
3312	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', 0.78 < BF < 1.00, SBP A La Carte	Workpaper	$41.00
3313	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', BF ≤0.78, SBP A La Carte	Workpaper	$41.00
3314	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', 0.78 < BF < 1.00, SBP A La Carte	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$9.80
3315	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', BF ≤0.78, SBP A La Carte	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$9.80
3316	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', BF > 1.00, SBP A La Carte	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$9.80
3317	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', 0.78 < BF < 1.00, SBP A La Carte	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$9.80
3318	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', BF ≤0.78, SBP A La Carte	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$9.80
3319	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', BF > 1.00, SBP A La Carte	Implementer's cost plus Cadmus estimate for labor duration and RSMeans for labor cost.	$9.80
3320	Delamping, T12 to T8, 8', SBP A La Carte	Implementer's cost for labor.	$2.00

MMID	Measure Name	Source	Incremental Cost
3321	Delamping, 200-399 Watt Fixture, SBP A La Carte	Implementer's cost.	$15.00
3322	Delamping, ≥400 Watt Fixture, SBP A La Carte	Implementer's cost.	$15.00
3323	LED, 2x2, Replacing T12 2L U-Tube, SBP A La Carte	RSMeans	$16.69
3324	LED, 2x2, Replacing T8 2L U-Tube, SBP A La Carte	RSMeans	$16.69
3325	T8, 2’ Lamps, Replacing T12 Single U-Tube, SBP A La Carte	Workpaper	$40.00
3326	T8, 2’ Lamps, Replacing T12 Dual U-Tube, SBP A La Carte	RSMeans	$1.22
3327	T8, 2’ Lamps, Replacing T8 Single U-Tube, SBP A La Carte	Workpaper	$40.00
3328	T8, 2’ Lamps, Replacing T8 Dual U-Tube, SBP A La Carte	RSMeans	$1.22
3329	T8 4L Replacing 250-399 W HID, SBP A La Carte	RSMeans	$156.14
3330	T5HO 2L Replacing 250-399 W HID, SBP A La Carte	Workpaper	$132.61
3331	T8 6L Replacing 400-999 W HID, SBP A La Carte	RSMeans	$163.56
3332	T5HO 4L Replacing 400-999 W HID, SBP A La Carte	RSMeans	$163.56
3333	T8 8L ≤500W, Replacing ≥1000 W HID, SBP A La Carte	RSMeans	$215.29
3334	T5HO 6L ≤500W, Replacing ≥1000 W HID, SBP A La Carte	RSMeans	$210.22
3335	LED, Horizontal Case Lighting, SBP A La Carte	WESCO distribution pricing + labor	$86.00
3336	T8 2L 4', recessed Indirect Fixture, HPT8 replacing 3 or 4L - T8 or T12, SBP A La Carte	RSMeans	$14.06
3337	Bi Level Controls, High Bay Fixtures, Gymnasium, SBP A La Carte	RSMeans	$95.00
3338	Bi Level Controls, High Bay Fixtures, Industrial, SBP A La	RSMeans	$95.00

MMID	Measure Name	Source	Incremental Cost
	Carte		
3339	Bi Level Controls, High Bay Fixtures, Other, SBP A La Carte	RSMeans	$95.00
3340	Bi Level Controls, High Bay Fixtures, Public Assembly, SBP A La Carte	RSMeans	$95.00
3341	Bi Level Controls, High Bay Fixtures, Retail, SBP A La Carte	RSMeans	$95.00
3342	Bi Level Controls, High Bay Fixtures, Warehouse, SBP A La Carte	RSMeans	$95.00
3343	Lighting Controls, Bilevel, Exterior and Parking Garage Fixtures, Dusk to Dawn, SBP A La Carte	Workpaper	$150.00
3344	Lighting Controls, Bilevel, Parking Garage Fixtures, 24 Hour, SBP A La Carte	Workpaper	$150.00
3345	Lighting Controls, Photocell with Internal Timer or Wireless Schedule, Exterior, SBP A La Carte	Workpaper	$30.00
3347	LED, 12 Watts, SBP Package	RSMeans	$7.50
3348	LED Troffer, 2x4, Replacing 4' 3-4 Lamp T8 Troffer, SBP Package	Workpaper	$110.00
3349	CFL, 31-115 Watts, SBP Package	Historical Program Data	$3.00
3350	Insulation, Direct Install, Pipe, Per Foot, 1" Thickness, Electric, SBP Package	http://bc3.pnnl.gov/sites/default/files/Cost-Estimation-for-Materials-and-Installation-of-Hot-Water-Piping-Insulation.pdf	$2/ft
3351	Insulation, Direct Install, Pipe, Per Foot, 1" Thickness, NG, SBP Package	http://bc3.pnnl.gov/sites/default/files/Cost-Estimation-for-Materials-and-Installation-of-Hot-Water-Piping-Insulation.pdf	$2/ft
3352	LED, 8-12 Watts, SBP Package	Refer to MMID 3347	$11.25
3353	LED, Replacing Neon Sign, SBP Package	Workpaper	$55.00
3354	CFL, ≤32 Watt, SBP Package	Average of Data from other recommendations	$3.19
3355	Faucet Aerator, Direct Install, 1.5 gpm, Bathroom, Electric, SBP Package	historical project data	$2.00
3356	Faucet Aerator, Direct Install, 1.5	Historical Program Data	$2.00

MMID	Measure Name	Source	Incremental Cost
	gpm, Bathroom, NG, SBP Package		
3357	Occupancy Sensor, Wall Mount, >200 Watts, SBP Package	RSMeans	$35.00
3358	Showerhead, Direct Install, 1.75 gpm, Electric, SBP Package	Historical Program Data	$5.00
3359	Showerhead, Direct Install, 1.75 gpm, NG, SBP Package	Historical Program Data	$5.00
3360	LED, Exit Sign, Retrofit, SBP Package	WESCO distribution pricing + labor	$35.00
3361	Occupancy Sensor, Wall Mount, ≤200 Watts, SBP Package	RSMeans	$35.00
3362	Vending Machine Controls, Occupancy Based, Cold Beverage Machine, SBP Package	MMID 2611	$160.00
3363	LED, ≤8W, SBP Package	Workpaper	$15.00
3364	LED, > 12W (Max 20W) Flood Lamp, SBP Package	MMID 3142	$16.70
3365	LED, MR16, 8-12W, SBP Package	RSMeans	$9.90
3366	LED, 2x2, Replacing T12 2L U-Tube, SBP Package	RSMeans	$16.69
3367	LED, 2x2, Replacing T8 2L U-Tube, SBP Package	RSMeans	$16.69
3368	Faucet Aerator, Direct Install, .5 gpm Public Restroom, Elec, SBP Package	Historical Program Data	$2.00
3369	Faucet Aerator, Direct Install, .5 gpm Public Restroom, NG, SBP Package	Historical Program Data	$2.00
3370	Faucet Aerator, Direct Install, .5 gpm Employee Restroom, Elec, SBP Package	Historical Program Data	$2.00
3371	Faucet Aerator, Direct Install, .5 gpm employee Restroom, NG, SBP Package	Historical Program Data	$2.00
3372	T8 2L 4', recessed Indirect Fixture, HPT8 replacing 3 or 4L - T8 or T12, SBP Package	RSMeans	$14.06
3385	LED, Non PI Direct Install, 13.5	Workpaper	$12.50

MMID	Measure Name	Source	Incremental Cost
	Watt		
3387	LED, 1x4, replacing T8 or T12, 2L	Workpaper	$110.00
3388	LED, 1x4 replacing T8 or T12, 2L, SBP A La Carte	Workpaper	$110.00
3389	LED, 1x4 replacing T8 or T12, 2L, SBP Package	Workpaper	$110.00
3390	HPT8, 1x4, replacing T12 or T8, 2L	Workpaper	$45.00
3391	HPT8, 1x4, replacing T12 or T8, 2L, SBP A La Carte	Workpaper	$45.00
3392	HPT8, 1x4, replacing T12 or T8, 2L, SBP Package	Workpaper	$45.00
3393	LED Fixture, ≤180 Watts, Replacing 4 lamp T5 or 6 lamp T8, High Bay, DLC Listed	Workpaper	$300.00
3394	LED Fixture, Downlights, ≤18 Watts, Replacing 1 lamp pin based CFL Downlight	Workpaper	$51.16
3395	LED Fixture, Downlights, >18 Watts, Replacing 2 lamp pin based CFL Downlight	Workpaper	$215.35
3396	LED Fixture, Downlights, ≤100 Watts, ≥4000 Lumens, Interior	Workpaper	$60.00
3397	LED Fixture, Downlights, ≤100 Watts, ≥4000 Lumens, Exterior	Workpaper	$60.00
3398	LED Fixture, Downlights, ≥6000 Lumens, Interior	Workpaper	$60.00
3399	LED Fixture, Downlights, ≥6000 Lumens, Exterior	Workpaper	$60.00
3400	LED Fixture, 2x2, Low Output, DLC Listed	RSMeans	$23.16
3401	LED Fixture, 2x2, High Output, DLC Listed	RSMeans	$23.16
3402	LED Lamp, ENERGY STAR, Replacing Incandescent Lamp ≤40 Watts, Exterior	Workpaper	$15.00
3403	LED Lamp, ENERGY STAR, Replacing Incandescent Lamp >40 Watts, Exterior	Workpaper	$15.00

MMID	Measure Name	Source	Incremental Cost
3404	LED Fixture, Downlights, >18 Watts, Replacing Incandescent Downlight, Exterior	Workpaper	$84.98
3405	LED Fixture, Downlights, ≤18 Watts, Replacing Incandescent Downlight, Exterior	Workpaper	$66.29
3407	LED Fixture, Replacing 1000 Watt HID, Exterior	Workpaper	$1,214.33
3408	PSMH/CMH, Replacing 1000 Watt HID, Exterior	Workpaper	$50.83
3409	Retrofit Open Refrigerated Cases with Doors	Historical Project Data	$126.53/foot
3413	CFL, Non PI Direct Install, 13 Watt	MMID 2117	$0.37
3414	Ice Machine, CEE Tier 2, Air Cooled, Self Contained, 0-499 lbs/day	Illinois TRM/California Workpapers	$981.00
3415	Ice Machine, CEE Tier 2, Water Cooled, Self Contained, 0-499 lbs/day	Illinois TRM/California Workpapers	$981.00
3416	Ice Machine, CEE Tier 2, Air Cooled, Ice Making Head, 0-499 lbs/day	Illinois TRM/California Workpapers	$981.00
3417	Ice Machine, CEE Tier 2, Air Cooled, Ice Making Head, 500-999 lbs/day	Illinois TRM/California Workpapers	$1,485.00
3418	Ice Machine, CEE Tier 2, Air Cooled, Ice Making Head, ≥1,000 lbs/day	Illinois TRM/California Workpapers	$1,812.00
3419	Ice Machine, CEE Tier 2, Water Cooled, Ice Making Head, <500 lbs/day	Illinois TRM/California Workpapers	$981.00
3420	Ice Machine, CEE Tier 2, Water Cooled, Ice Making Head, 500-999 lbs/day	Illinois TRM/California Workpapers	$981.00
3421	Ice Machine, CEE Tier 2, Water Cooled, Ice Making Head, ≥1,000 lbs/day	Illinois TRM/California Workpapers	$1,812.00
3422	Ice Machine, CEE Tier 2, Air	Illinois TRM/California Workpapers	$981.00

MMID	Measure Name	Source	Incremental Cost
	Cooled, Remote Condensing, 0-499 lbs/day		
3423	Ice Machine, CEE Tier 2, Air Cooled, Remote Condensing, 500-999 lbs/day	Illinois TRM/California Workpapers	$1,485.00
3424	Ice Machine, CEE Tier 2, Air Cooled, Remote Condensing, ≥1,000 lbs/day	Illinois TRM/California Workpapers	$1,812.00
3425	LED, 8ft, Replacing T12 or T8, 1L	Labor cost: p. 453, Hours p.259, Interior LED Fixtures 3010 (2 crew, 1.311 hr), Crew no. R-31, Electrician rate. RSMeans Green Building Cost Data, 2014. Material cost, market review, see costs tab.	$52.92
3426	LED, 8ft, Replacing T12 or T8, 1L, SBP A La Carte	Labor cost: p. 453, Hours p.259, Interior LED Fixtures 3010 (2 crew, 1.311 hr), Crew no. R-31, Electrician rate. RSMeans Green Building Cost Data, 2014. Material cost, market review, see costs tab.	$52.92
3427	LED, 8ft, Replacing T12 or T8, 1L, SBP Package	Labor cost: p. 453, Hours p.259, Interior LED Fixtures 3010 (2 crew, 1.311 hr), Crew no. R-31, Electrician rate. RSMeans Green Building Cost Data, 2014. Material cost, market review, see costs tab.	$52.92
3428	LED, 8ft, Replacing T12 or T8, 2L	Workpaper	$370.00
3429	LED, 8ft, Replacing T12 or T8, 2L, SBP A La Carte	Workpaper	$370.00
3430	LED, 8ft, Replacing T12 or T8, 2L, SBP Package	Workpaper	$370.00
3431	LED, 8ft, Replacing T12HO or T8HO, 1L	Workpaper	$370.00
3432	LED, 8ft, Replacing T12HO or T8HO, 1L, SBP A La Carte	Workpaper	$370.00
3433	LED, 8ft, Replacing T12HO or T8HO, 1L, SBP Package	Workpaper	$370.00
3434	LED, 8ft, Replacing T12HO or T8HO, 2L	Workpaper	$370.00
3435	LED, 8ft, Replacing T12HO or T8HO, 2L, SBP A La Carte	Workpaper	$370.00

MMID	Measure Name	Source	Incremental Cost
3436	LED, 8ft, Replacing T12HO or T8HO, 2L, SBP Package	Workpaper	$370.00
3439	LED, Non-PI Direct Install, 13.5 Watt, With Co-Pay	Workpaper	$12.50
3440	NG Furnace with ECM, 97%+ AFUE	$1,797 based on average contractor response between 92% no staging no ECM and 97% multi-stage with ECM.	$1,797.00
3441	NG Furnace, 95% AFUE	Based on 15 contractors' response on 78% furnace baseline subtracted from responses to cost for 95% without staging or ECM.	$1,194.00
3442	NG Furnace with ECM, 97+ AFUE, Enhanced Rewards	$2,450 based on average contractor response between 92% no staging no ECM and 97% multi-stage with ECM.	$2,450.00
3443	NG Furnace with ECM, 95+ AFUE (Existing), Enhanced Rewards	CLEAResult surveyed 15 Trade Allies to gauge IMC from 80% to 92% then used survey data from 40 Trade Allies to gauge 92% to 95% IMC. Added, this is $1,565.	$1,565.00
3444	LED, Recessed Downlight, ENERGY STAR, SBP Package	Labor cost: p. 453, Hours p.259, Interior LED Fixtures 3010 (2 crew, 1.311 hr), Crew no. R-31, Electrician rate. RSMeans Green Building Cost Data, 2014. Material cost, market review, see costs tab.	$36.08
3487	CFL, Direct Install, 20 Watt	Workpaper	$5.00
3488	LED, Direct Install, 10 Watt	Workpaper	$12.50
3489	DHW Temperature Turn Down, Serving Multiple Dwelling Units, Direct Install, Electric	MMID 2125	$-
3490	DHW Temperature Turn Down, Serving Multiple Dwelling Units, Direct Install, NG	MMID 2125	$-
3525	LED, Direct Install, 10 Watt, HES	Workpaper	$12.50
3526	HPT8, 1x4, replacing T12 or T8, 2L, WPS Gold Plus Package	MMID 3390	$45.00
3527	T8 2L 4', recessed Indirect Fixture, HPT8 replacing 3 or 4L - T8 or T12, WPS Gold Plus Package	MMID 3336	$14.06
3528	T8 2L 4', HPT8 or RWT8, Replacing T12 1L 8', 0.78 < BF <	MMID 3122	$4.90

MMID	Measure Name	Source	Incremental Cost
	1.00, WPS Gold Plus Package		
3529	T8 2L 4', HPT8 or RWT8, Replacing T12 1L 8', BF ≤0.78, WPS Gold Plus Package	MMID 3123	$4.90
3530	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', 0.78 < BF < 1.00, WPS Gold Plus Package	MMID 3124	$4.90
3531	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', BF ≤0.78, WPS Gold Plus Package	MMIDs 3122-3126	$4.90
3532	T8 2L 4', HPT8 or RWT8, Replacing T12HO 1L 8', BF > 1.00, WPS Gold Plus Package	MMID 3126	$4.90
3533	T8 2L 4', HPT8, CEE, replacing 8' 1L T12HO, WPS Gold Plus Package	MMID 3125	$4.90
3534	T8 4L 4', HPT8 or RWT8, Replacing T12 2L 8', 0.78 < BF < 1.00, WPS Gold Plus Package	MMIDs 3127-3134	$9.80
3535	T8 4L 4', HPT8 or RWT8, Replacing T12 2L 8', BF ≤0.78, WPS Gold Plus Package	MMIDs 3127-3134	$9.80
3536	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', 0.78 < BF < 1.00, WPS Gold Plus Package	MMIDs 3127-3134	$9.80
3537	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', BF ≤0.78, WPS Gold Plus Package	MMIDs 3127-3134	$9.80
3538	T8 4L 4', HPT8 or RWT8, Replacing T12HO 2L 8', BF > 1.00, WPS Gold Plus Package	MMIDs 3127-3134	$9.80
3539	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', 0.78 < BF < 1.00, WPS Gold Plus Package	MMIDs 3127-3134	$9.80
3540	T8 4L 4', HPT8 or RWT8, Replacing T12VHO 2L 8', BF ≤0.78, WPS Gold Plus Package	MMIDs 3127-3134	$9.80
3541	T8 4L 4', HPT8 or RWT8,	MMIDs 3127-3134	$9.80

MMID	Measure Name	Source	Incremental Cost
	Replacing T12VHO 2L 8', BF > 1.00, WPS Gold Plus Package		
3542	T8, 2’ Lamps, Replacing T12 Dual U-Tube, WPS Gold Plus Package	MMID 3241	$1.22
3543	T8, 2’ Lamps, Replacing T12 Single U-Tube, WPS Gold Plus Package	MMIDs 3241-3243	$1.22
3544	T8, 2’ Lamps, Replacing T8 Dual U-Tube, WPS Gold Plus Package	MMID 3243	$1.22
3545	T8, 2’ Lamps, Replacing T8 Single U-Tube, WPS Gold Plus Package	MMID 3242	$1.22
3548	CFL, Standard Bulb, 310-749 Lumens, Retail Store Markdown	MMID 2116	$1.21
3549	CFL, Standard Bulb, 750-1049 Lumens, Retail Store Markdown	MMID 2117	$0.37
3550	CFL, Standard Bulb, 1050-1489 Lumens, Retail Store Markdown	MMID 2118	$0.38
3551	CFL, Standard Bulb, 1490-2600 Lumens, Retail Store Markdown	MMID 2119	$1.03
3552	CFL, Reflector, 15 watt, Retail Store Markdown	Workpaper	$4.00
3553	LED, Omnidirectional, 310-749 Lumens, Retail Store Markdown	Workpaper	$12.50
3554	LED, Omnidirectional, 750-1049 Lumens, Retail Store Markdown	Workpaper	$12.50
3555	LED, Omnidirectional, 1050-1489 Lumens, Retail Store Markdown	Workpaper	$12.50
3556	LED, Omnidirectional, 1490-2600 Lumens, Retail Store Markdown	Workpaper	$12.50
3557	LED, Reflector, 12 watt, Retail Store Markdown	Workpaper	$8.08
3567	LED, Direct Install, 10 Watt, with Co-pay	MMID 3488	$12.50
3569	Furnace And A/C, ECM, 95% + AFUE, ≥16 SEER, Enhanced Rewards	Trade Ally Survey	$2,238.73

Appendix E: Measure Lookup by MMID

MMID	Measure Name	Page #
1981	Natural Gas Furnace with ECM, 95%+ AFUE (Existing)	112
1983	Hot Water Boiler, 95%+ AFUE	456
1986	Condensing Water Heater, NG, 90%+	508
1988	Water Heater, Indirect, 95% or greater	516
1989	Water Heater, Electric, EF ≥ 0.93	516
2116	CFL, Direct Install, 9 Watts	549
2117	CFL, Direct Install, 14 Watts	549
2118	CFL, Direct Install, 19 Watts	549
2119	CFL, Direct Install, 23 Watts	549
2120	Faucet Aerator, 1.5 GPM, Kitchen, NG	480
2121	Faucet Aerator, 1.0 GPM, Bathroom, Residential, NG	480
2122	Insulation Direct Install, 6-Foot Pipe, NG	497
2123	Showerhead, Direct Install, 1.5 GPM, NG	481
2125	DHW Temperature Turn Down, Direct Install, NG	489
2126	Faucet Aerator, 1.5 GPM, Kitchen, Electric	480
2127	Faucet Aerator, 1.0 GPM, Bathroom, Residential, Electric	480
2128	Insulation, Direct Install, 6-Foot Pipe, Electric	494
2129	Showerhead, Direct Install, 1.5 GPM, Electric	480
2131	DHW Temperature Turn Down, Direct Install, Electric	489
2132	CFL, Direct Install, 9 Watts	549
2133	CFL, Direct Install, 14 Watts	549
2134	CFL, Direct Install, 19 Watts	549
2135	CFL, Direct Install, 23 Watts	549
2136	Faucet Aerator, 1.5 GPM, Kitchen, NG	480
2137	Faucet Aerator, 1.0 GPM, Bathroom, Residential, NG	480
2138	Insulation Direct Install, 6-Foot Pipe, NG	497
2141	DHW Temperature Turn Down, Direct Install, NG	489
2143	Faucet Aerator, 1.0 GPM, Bathroom, Electric	485
2147	DHW Temperature Turn Down, Direct Install, Electric	489
2192	A/C Split System, ≤ 65 MBh, SEER 15	134
2193	A/C Split System, ≤ 65 MBh, SEER 16+	134
2194	A/C Split System, ≤ 65 MBh, SEER 14	134
2209	Boiler Plant Retrofit, Mid-Efficiency Plant, 1-5 MMBh	134
2221	Boiler Control, Outside Air Temperature Reset/Cutout Control	461
2238	Ceramic Metal Halide Lamp, ≤ 25 Watts	259
2246	CFL Reflector Lamps	558

MMID	Measure Name	Page #
2253	Circulation Fan, High Efficiency, Ag	12
2254	Compressed Air Condensate Drains, No Loss Drain	46
2255	Compressed Air Controller, Pressure/Flow Controller	29
2257	Compressed Air Heat Recovery, Space Heating	35
2258	Compressed Air Mist Eliminators	37
2259	Compressed Air Nozzles, Air Entraining	40
2261	Compressed Air System Leak Survey and Repair, Year 1	42
2262	Compressed Air System Leak Survey and Repair, Year 2	42
2263	Compressed Air System Leak Survey and Repair, Year 3	42
2264	Compressed Air, Cycling Thermal Mass Air Dryers	32
2269	Cooler Evaporator Fan Control	430
2276	Delamping, T12 to T8, 4-Foot	281
2277	Delamping, T8 to T8	281
2280	Dishwasher, Low Temp, Door Type, ENERGY STAR, Electric	56
2281	Dishwasher, High Temp, Electric Booster, Door Type, ENERGY STAR, Electric	56
2282	Dishwasher, High Temp, Electric Booster, Door Type, ENERGY STAR, NG	56
2283	Dishwasher, High Temp, Electric Booster, Multi Tank Conveyor, ENERGY STAR, Electric	56
2284	Dishwasher, High Temp, Electric Booster, Multi Tank Conveyor, ENERGY STAR, NG	56
2285	Dishwasher, High Temp, Electric Booster, Single Tank Conveyor, ENERGY STAR, Electric	56
2286	Dishwasher, High Temp, Electric Booster, Single Tank Conveyor, ENERGY STAR, NG	56
2287	Dishwasher, High Temp, Electric Booster, Under Counter, ENERGY STAR, Electric	56
2288	Dishwasher, High Temp, Electric Booster, Under Counter, ENERGY STAR, NG	56
2289	Dishwasher, High Temp, Natural Gas Booster, Door Type, ENERGY STAR, NG	56
2290	Dishwasher, High Temp, Natural Gas Booster, Multi Tank Conveyor, ENERGY STAR, NG	56
2291	Dishwasher, High Temp, Natural Gas Booster, Single Tank Conveyor, ENERGY STAR, NG	56
2292	Dishwasher, High Temp, Natural Gas Heat, Natural Gas Booster, Under Counter, ENERGY STAR, NG	56
2293	Dishwasher, Low Temp, Door Type, ENERGY STAR, NG	56
2294	Dishwasher, Low Temp, Multi Tank Conveyor, ENERGY STAR, Electric	56
2295	Dishwasher, Low Temp, Multi Tank Conveyor, ENERGY STAR, NG	56
2296	Dishwasher, Low Temp, Single Tank Conveyor, ENERGY STAR, Electric	56
2297	Dishwasher, Low Temp, Single Tank Conveyor, ENERGY STAR, NG	56
2298	Dishwasher, Low Temp, Under Counter, ENERGY STAR, Electric	56
2299	Dishwasher, Low Temp, Under Counter, ENERGY STAR, NG	56
2306	ECM Compressor Fan Motor	434
2314	Energy Recovery Ventilator	107
2321	Freezer, Chest, Glass Door, < 15 cu ft, ENERGY STAR	85
2322	Freezer, Chest, Glass Door, 15-29 cu ft, ENERGY STAR	85

MMID	Measure Name	Page #
2323	Freezer, Chest, Glass Door, 30-49 cu ft, ENERGY STAR	85
2324	Freezer, Chest, Glass Door, 50+ cu ft, ENERGY STAR	85
2325	Freezer, Chest, Solid Door, < 15 cu ft, ENERGY STAR	85
2326	Freezer, Chest, Solid Door, 15-29 cu ft, ENERGY STAR	85
2327	Freezer, Chest, Solid Door, 30-49 cu ft, ENERGY STAR	85
2328	Freezer, Chest, Solid Door, 50+ cu ft, ENERGY STAR	85
2329	Freezer, Vertical, Glass Door, < 15 cu ft, ENERGY STAR	85
2330	Freezer, Vertical, Glass Door, 15-29 cu ft, ENERGY STAR	85
2331	Freezer, Vertical, Glass Door, 30-49 cu ft, ENERGY STAR	85
2332	Freezer, Vertical, Glass Door, 50+ cu ft, ENERGY STAR	85
2333	Freezer, Vertical, Solid Door, < 15 cu ft, ENERGY STAR	85
2334	Freezer, Vertical, Solid Door, 15-29 cu ft, ENERGY STAR	85
2335	Freezer, Vertical, Solid Door, 30-49 cu ft, ENERGY STAR	85
2336	Freezer, Vertical, Solid Door, 50+ cu ft, ENERGY STAR	85
2429	Insulation, Steam Fitting, Removable, NG	26
2430	Insulation, Steam Piping, NG	26
2471	Occupancy Sensor, Ceiling Mount, ≤ 500 Watts	228
2472	Occupancy Sensor, Ceiling Mount, ≥ 1,001 Watts	228
2473	Occupancy Sensor, Ceiling Mount, 501-Watts to 1,000 Watts	228
2474	Occupancy Sensor, ≤ 200 Watts, Fixture Mount	228
2475	Occupancy Sensor > 200 Watts, Fixture Mount	228
2483	Occupancy Sensor, ≤ 200 Watts, Wall Mount	228
2484	Occupancy Sensor > 200 Watts, Wall Mount	228
2485	Oven, Convection, ENERGY STAR, Electric	73
2486	Oven, Convection, ENERGY STAR, Natural Gas	77
2496	Pressure Screen Rotor	419
2509	Reach In Refrigerated Case w/ Doors Replacing Open Multi Deck Case	436
2521	Refrigerator, Chest, Glass Door, < 15 cu ft, ENERGY STAR	80
2522	Refrigerator, Chest, Glass Door, 15-29 cu ft, ENERGY STAR	80
2523	Refrigerator, Chest, Glass Door, 30-49 cu ft, ENERGY STAR	80
2524	Refrigerator, Chest, Glass Door, 50+ cu ft, ENERGY STAR	80
2525	Refrigerator, Chest, Solid Door, < 15 cu ft, ENERGY STAR	80
2526	Refrigerator, Chest, Solid Door, 15-29 cu ft, ENERGY STAR	80
2527	Refrigerator, Chest, Solid Door, 30-49 cu ft, ENERGY STAR	80
2528	Refrigerator, Chest, Solid Door, 50+ cu ft, ENERGY STAR	80
2529	Refrigerator, Vertical, Glass Door, < 15 cu ft, ENERGY STAR	80
2530	Refrigerator, Vertical, Glass Door, 15-29 cu ft, ENERGY STAR	80
2531	Refrigerator, Vertical, Glass Door, 30-49 cu ft, ENERGY STAR	80

MMID	Measure Name	Page #
2532	Refrigerator, Vertical, Glass Door, 50+ cu ft, ENERGY STAR	80
2533	Refrigerator, Vertical, Solid Door, < 15 cu ft, ENERGY STAR	80
2534	Refrigerator, Vertical, Solid Door, 15-29 cu ft, ENERGY STAR	80
2535	Refrigerator, Vertical, Solid Door, 30-49 cu ft, ENERGY STAR	80
2536	Refrigerator, Vertical, Solid Door, 50+ cu ft, ENERGY STAR	80
2538	Repulper Rotor	422
2643	Variable Frequency Drive, HVAC Fan	114
2644	Variable Frequency Drive, HVAC Heating Pump	114
2647	Variable Frequency Drive, Process Fan	425
2648	Variable Frequency Drive, Process Pump	425
2652	Water Heater, ≥ 0.82 EF, Tankless, Residential, NG	513
2660	Waterer, Livestock, < 250 Watts	9
2665	Reduced Wattage 8-Foot T8 Lamps Replacing 8-Foot Standard T8 Lamps	252
2666	Chiller System Tune Up, Air Cooled, ≤ 500 Tons	153
2667	Chiller System Tune Up, Air Cooled, > 500 Tons	153
2668	Chiller System Tune Up, Water Cooled, ≤ 500 Tons	153
2669	Chiller System Tune Up, Water Cooled, > 500 Tons	153
2703	2-Lamp F28T5, HPT8, RWT8 2x4 High- Efficiency Recessed Fixtures	567
2704	T8, 2 Lamp, 4-Foot, Recessed Indirect Fixture, HPT8, Replacing 3 Lamp or 4 Lamp T8 or T12	257
2707	T8, Low-Watt Relamp, 54 Watts, 8-Foot	255
2743	Natural Gas Boilers (≤ 300 MBh) 90%+ AFUE	23
2744	Boiler Tune-Up	464
2745	Air Sealing	470
2746	Multifamily Benchmarking Incentive	615
2756	Clothes Washer, Common Area, ENERGY STAR, Electric	542
2757	Clothes Washer, Common Area, ENERGY STAR, NG	542
2760	Domestic Hot Water Plant Replacement	479
2768	LED Exit Sign, Retrofit	342
2772	Steam Trap Repair, < 10 psig, Radiator	138
2819	Solar Photovoltaic	628
2820	Ground Source Heat Pump, Electric Back-up nonresidential	450
2820	Ground Source Heat Pump, Electric Back-Up residential	624
2821	Ground Source Heat Pump, Natural Gas Back-up nonresidential	450
2821	Ground Source Heat Pump, NG Back-Up nonresidential	624
2853	Demand Control Ventilation for Air Handling Units	89
2884	High Bay Fluorescent Lighting, T8 4L Replacing 250-399 W HID	392
2885	High Bay Fluorescent Lighting, T8 6L Replacing 400-999 W HID	392

MMID	Measure Name	Page #
2886	High Bay Fluorescent Lighting, T8 8L Replacing 400-999 W HID	392
2887	High Bay Fluorescent Lighting, T8 8L ≤ 500 W, Replacing ≥ 1,000 W HID	392
2888	High Bay Fluorescent Lighting, T8 10L ≤ 500 W, Replacing ≥ 1,000 W HID	392
2889	High Bay Fluorescent Lighting, T8 (2) 6L ≤ 500 W, Replacing ≥ 1,000 W HID	392
2890	High Bay Fluorescent Lighting, T5HO 2L Replacing 250-399 W HID	392
2891	High Bay Fluorescent Lighting, T5HO 3L Replacing 250-399 W HID	392
2892	High Bay Fluorescent Lighting, T5HO 4L Replacing 400-999 W HID	392
2893	High Bay Fluorescent Lighting, T5HO 6L Replacing 400-999 W HID	392
2894	High Bay Fluorescent Lighting, T5HO 6L ≤ 500 W, Replacing ≥ 1,000 W HID	392
2895	High Bay Fluorescent Lighting, T5HO 8L ≤ 500 W, Replacing ≥ 1,000 W HID	392
2896	High Bay Fluorescent Lighting, T5HO (2) 4L ≤ 500 W, Replacing ≥ 1,000 W HID	392
2897	High Bay Fluorescent Lighting, T5HO (2) 6L ≤ 800 W, Replacing ≥ 1,000 W HID	392
2905	Solar Thermal, Electric	632
2906	Solar Thermal, NG	632
2955	Refrigerator, Recycling and Replacement	621
2956	Freezer, Recycling and Replacement	621
2984	LED Fixture, Downlights, Accent Lights and Monopoint ≤ 18 Watts, Common Area	345
2989	ECM, Furnace or Air Handler	609
2990	Furnace and A/C, with ECM, 95%+ AFUE, ≥ 16 SEER	538
2992	Air Source Heat Pump, ≥ 16 SEER	612
3001	Delamping, 200 - 399 Watt Fixture	286
3002	Delamping, ≥ 400 Watt Fixture	286
3017	Retail Store Markdown, Low-Flow Showerheads	500
3018	Waterer, Livestock, Energy Free	9
3019	Lighting Fixture, Agricultural Daylighting, ≤ 155 Watts	207
3020	Lighting Fixture, Agricultural Daylighting, 156 - 250 Watts	207
3021	Lighting Fixture, Agricultural Daylighting, 251 - 365 Watts	207
3022	A/C Split or Packaged System, High Efficiency	121
3023	Reduced Wattage Lamps, Replacing Standard T5	248
3024	Reduced Wattage Lamps, Replacing Standard T5HO	248
3025	Faucet Aerator, 1.5 GPM, Kitchen, NG	485
3026	Faucet Aerator, 1.5 GPM, Kitchen, Electric	485
3027	Faucet Aerator, 1.5 GPM, Bathroom, NG	485
3028	Faucet Aerator, 1.5 GPM, Bathroom, Electric	485
3029	Faucet Aerator, 1.5 GPM, Shower, NG	485
3030	Faucet Aerator, 1.5 GPM, Shower, Electric	485
3031	CFL, Reduced Wattage, Pin Based, 18 Watt, Replacing CFL	545
3032	CFL, Reduced Wattage, Pin Based, 26 Watt, Replacing CFL	545

MMID	Measure Name	Page #
3033	CFL, Reduced Wattage, Pin Based, 32 Watt, Replacing CFL	545
3034	CFL, Reduced Wattage, Pin Based, 42 Watt, Replacing CFL	545
3036	HID, Reduced Wattage, Exterior, Replacing 1,000 Watt HID	301
3037	HID, Reduced Wattage, Exterior, Replacing 400 Watt HID	301
3038	HID, Reduced Wattage, Exterior, Replacing 320 Watt HID	301
3039	HID, Reduced Wattage, Exterior, Replacing 250 Watt HID	301
3040	HID, Reduced Wattage, Exterior, Replacing 175 Watt HID	301
3045	Water Heater, High Usage, ≥ 90% TE, NG	50
3046	Water Heater, High Usage, ≥ 0.82 EF, Tankless, NG	50
3047	Water Heater, High Usage, ≥ 2 EF, Heat Pump Storage, Electric	50
3056	LED Fixture, Replacing 320 Watt HID, Parking Garage	261
3059	Air Conditioning Unit Tune Up, Coil Cleaning, < 10 Tons	141
3060	Air Conditioning Unit Tune Up, Coil Cleaning, > 20 Tons	141
3061	Air Conditioning Unit Tune Up, Coil Cleaning, 10-20 Tons	141
3062	Air Conditioning Unit Tune Up, Refrigerant Charge Correction, < 10 Tons	144
3063	Air Conditioning Unit Tune Up, Refrigerant Charge Correction, > 20 Tons	144
3064	Air Conditioning Unit Tune Up, Refrigerant Charge Correction, 10-20 Tons	144
3066	Economizer Optimization	103
3067	HID, Reduced Wattage, Interior, Replacing 1,000 Watt HID	301
3068	HID, Reduced Wattage, Interior, Replacing 175 Watt HID	301
3069	HID, Reduced Wattage, Parking Garage, Replacing 175 Watt HID	301
3070	HID, Reduced Wattage, Interior, Replacing 250 Watt HID	301
3071	HID, Reduced Wattage, Parking Garage, Replacing 250 Watt HID	301
3072	HID, Reduced Wattage, Interior, Replacing 320 Watt HID	301
3073	HID, Reduced Wattage, Interior, Replacing 400 Watt HID	301
3074	Induction, 750 Watt, Replacing 1,000 Watt HID, High Bay	406
3075	High Bay – Induction, PSMH, CMH Fixtures, ≤ 250 Watt, Replacing 320-400 Watt HID	406
3076	High Bay – Induction, PSMH, CMH Fixtures, ≤ 250 Watt, Replacing 400 Watt HID	406
3077	High Bay – Induction, PSMH, CMH Fixtures, ≤ 365 Watt, Replacing 400 Watt HID	406
3078	Induction, PSMH/CMF or Linear Fluorescent, Exterior, Replacing 150-175 Watt HID	398
3079	Induction, PSMH/CMH, or Linear Fluorescent, Parking Garage, Replacing 150-175 Watt HID, 24 Hour	402
3080	Induction, PSMH/CMH, or Linear Fluorescent, Parking Garage, Replacing 150-175 Watt HID, Dusk to Dawn	402
3081	Induction, PSMH/CMF or Linear Fluorescent, Exterior, Replacing 250 Watt HID	398
3082	Induction, PSMH/CMH, or Linear Fluorescent, Parking Garage, Replacing 250 Watt HID, 24 Hour	402
3083	Induction, PSMH/CMH, or Linear Fluorescent, Parking Garage, Replacing 250 Watt HID, Dusk to Dawn	402

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3086	Induction, PSMH/CMF or Linear Fluorescent, Exterior, Replacing 400 Watt HID	398
3087	Induction, PSMH/CMF or Linear Fluorescent, Exterior, Replacing 70-100 Watt HID	398
3088	Induction, PSMH/CMH, or Linear Fluorescent, Parking Garage, Replacing 70-100 Watt HID, 24 Hour	402
3089	Induction, PSMH/CMH, or Linear Fluorescent, Parking Garage, Replacing 70-100 Watt HID, Dusk to Dawn	402
3090	High Bay – Induction, PSMH, CMH Fixtures, Replacing 250 Watt HID	406
3091	LED Fixture, High Bay, < 155 Watts, Replacing 250 Watt HID	331
3092	LED Fixture, High Bay, < 250 Watts, Replacing 320-400 Watt HID	331
3093	LED Fixture, High Bay, < 250 Watts, Replacing 400 Watt HID	331
3094	LED Fixture, High Bay, < 365 Watts, Replacing 400 Watt HID	331
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3096	LED Fixture, High Bay, < 800 Watts, Replacing 1,000 Watt HID	331
3097	LED Fixture, Bi-Level, Stairwell and Passageway	277
3099	LED Fixture, Exterior, Replacing 150-175 Watt HID	398
3099	LED Fixture, Exterior, Replacing 150-175 Watt HID	325
3100	LED Fixture, Replacing 150-175 Watt HID, Parking Garage, 24 Hour	261
3101	LED Fixture, Replacing 150-175 Watt HID, Parking Garage, Dusk to Dawn	261
3102	LED Fixture, Exterior, Replacing 250 Watt HID	398
3103	LED Fixture, Replacing 250 Watt HID, Parking Garage, 24 Hour	261
3104	LED Fixture, Replacing 250 Watt HID, Parking Garage, Dusk to Dawn	261
3105	LED Fixture, Exterior, Replacing 320 Watt HID	325
3106	LED Fixture, Exterior, Replacing 320-400 Watt HID	325
3107	LED Fixture, Exterior, Replacing 400 Watt HID	325
3108	LED Fixture, Exterior, Replacing 70-100 Watt HID	325
3109	LED Fixture, Replacing 70-100 Watt HID, Parking Garage, 24 Hour	261
3110	LED Fixture, Replacing 70-100 Watt HID, Parking Garage, Dusk to Dawn	261
3111	LED Troffer, 2x4, Replacing 4-Foot 3-4 Lamp T8 Troffer	307
3112	LED Lamp Replacing Incandescent Lamp ≤ 40 Watts	375
3113	LED Lamp Replacing Incandescent Lamp > 40 Watts	378
3114	LED, Horizontal Case Lighting	335
3118	Oven, Combination, ENERGY STAR, Electric	68
3119	Oven, Combination, ENERGY STAR, NG	68
3120	Programmable Thermostat, RTU Optimization Advanced	117
3121	Programmable Thermostat, RTU Optimization Standard	117
3122	T8, 2-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12, 1-Lamp, 8-Foot, 0.78 < BF < 1.00	241
3123	T8, 2-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12, 1-Lamp, 8-Foot, BF ≤ 0.78	241

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3124	T8, 2-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO, 1-Lamp, 8-Foot, 0.78 < BF < 1.00	241
3125	T8, 2-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO, 1-Lamp, 8-Foot, BF ≤ 0.78	241
3126	T8, 2-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO, 1-Lamp, 8-Foot, BF > 1.00	241
3127	T8, 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12, 2-Lamp, 8-Foot, 0.78 < BF < 1.00	241
3128	T8, 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12, 2-Lamp, 8-Foot, BF ≤ 0.78	241
3129	T8, 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO, 2-Lamp, 8-Foot, 0.78 < BF < 1.00	241
3130	T8, 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO, 2-Lamp, 8-Foot, BF ≤ 0.78	241
3131	T8, 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO, 2-Lamp, 8-Foot, BF > 1.00	241
3132	T8, 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12VHO, 2-Lamp, 8-Foot, 0.78 < BF < 1.00	241
3133	T8, 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12VHO, 2-Lamp, 8-Foot, BF ≤ 0.78	241
3134	T8, 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12VHO, 2-Lamp, 8-Foot, BF > 1.00	241
3135	T8, Low-Watt Relamp, 8-Foot	255
3136	Dishwasher, High Temp, Electric Booster, Pots/Pans Type, ENERGY STAR, Electric	56
3137	Dishwasher, High Temp, Electric Booster, Pots/Pans Type, ENERGY STAR, NG	56
3138	Dishwasher, High Temp, Natural Gas Booster, Pots/Pans Type, ENERGY STAR, NG	56
3140	Dishwasher, Low Temp, Pots/Pans Type, ENERGY STAR, NG	56
3144	T8 2-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12 1-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	570
3145	T8 2-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12 1-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	570
3146	T8 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12 2-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	570
3147	T8 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12 2-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	570
3148	T8 2-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO 1-Lamp, 8-Foot, BF > 1.00, Parking Garage	570
3149	T8 2-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO 1-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	570
3150	T8 2-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO 1-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	570
3151	T8 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO 2-Lamp, 8-Foot, BF > 1.00, Parking Garage	570
3152	T8 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO 2-Lamp, 8-Foot, 0.78 < BF < 1.00, Parking Garage	570
3153	T8 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO 2-Lamp, 8-Foot, BF ≤ 0.78, Parking Garage	570
3154	T8 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12VHO 2-Lamp, 8-Foot, BF > 1.00, Parking Garage	570
3155	T8 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12VHO 2-Lamp, 8-Foot, 0.78 < BF < 1.00,	570

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3157	ENERGY STAR LED Porch Fixtures	606
3158	LED Fixture, Downlights, Accent Lights and Monopoint ≤ 18 Watts, In Unit	345
3159	LED, ENERGY STAR, Replacing Incandescent > 40 Watts, In Unit	601
3160	LED, ENERGY STAR, Replacing Incandescent > 40 Watts, Common Area	601
3161	LED, ENERGY STAR, Replacing Incandescent ≤ 40 Watts, In Unit	598
3162	LED, ENERGY STAR, Replacing Incandescent ≤ 40 Watts, Common Area	598
3183	Strip Curtains for Walk-In Freezers and Coolers	444
3184	Delamping, T12 to T8, 8-Foot	281
3195	Linear Fluorescent, 2-Lamp, 4-Foot, RWT8 Replacements, 24 Hours, CALP	575
3196	Linear Fluorescent, 2-Lamp, 4-Foot, RWT8 Replacements, 12 Hours, CALP	578
3197	CFL Fixture, Interior or Exterior, 24 Hours, CALP	556
3198	CFL Fixture, 12 Hours, CALP, Interior	233
3199	CFL Fixture, 12 Hours, CALP, Exterior	233
3201	Occupancy Sensor, ≤ 200 Watts, Wall or Ceiling Mount, CALP	228
3202	Occupancy Sensor > 200 Watts, Wall or Ceiling Mount, CALP	228
3206	Exterior Lighting Optimization, CMH Lamp, 330 Watts, Replacing 400-Watt HID	293
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3208	Exterior Lighting Optimization, CMH Lamp, 205 Watts, Replacing 250-Watt HID	293
3209	Exterior Lighting Optimization, CMH Lamp With Controls, 205 Watts, Replacing 250-Watt HID	293
3210	Exterior Lighting Optimization, CMH System, 210-220 Watts, Replacing 400-Watt HID	293
3211	Exterior Lighting Optimization, CMH System With Controls, 210-220 Watts, Replacing 400-Watt HID	293
3212	Exterior Lighting Optimization, CMH System, 140-150 Watts, Replacing 250-Watt HID	293
3213	Exterior Lighting Optimization, CMH System With Controls, 140-150 Watts, Replacing 250-Watt HID	293
3214	Exterior Lighting Optimization, CMH System, 90 Watts, Replacing 150-175 Watt HID	293
3215	Exterior Lighting Optimization, CMH System With Controls, 90 Watts, Replacing 150-175 Watt HID	293
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3219	Exterior Lighting Optimization, LED With Controls, ≤ 125 Watts, Replacing 250-Watt HID	293
3220	Exterior Lighting Optimization, LED, ≤ 60 Watts, Replacing 150-175 Watt HID	293
3221	Exterior Lighting Optimization, LED With Controls, ≤ 60 Watts, Replacing 150-175 Watt	293

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3232	LED, 2x4, Replacing T12 2 Lamp	272
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3238	LED, 2x2, Replacing T12 2 Lamp U-Tube, SBP After A La Carte	268
3239	LED, 2x2, Replacing T8 2 Lamp U-Tube	268
3240	T8 2-Foot Lamps, Replacing Single T12 U-Tube Lamp	289
3241	T8 2-Foot Lamps, Replacing Double T12 U-Tube Lamp	289
3242	T8 2-Foot Lamps, Replacing Single T8 U-Tube	289
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3254	Occupancy Sensor, High Bay Fixtures, Gymnasium	221
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3263	Bi Level Controls, High Bay Fixtures, Warehouse	215
3264	Bi Level Controls, High Bay Fixtures, Public Assembly	215
3265	Bi Level Controls, High Bay Fixtures, Other	215
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3274	LED, Direct Install, 12 Watts	338
3275	Boiler Plant Retrofit, Hybrid Plant, >1 MMBh	17
3277	Boiler, Hot Water, Near Condensing, ≥ 85% AFUE, ≥ 300 MBh	14
3279	LED, Direct Install, 9.5 Watt	581
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3284	Strip Curtains for Walk-In Freezers and Coolers, SBP A La Carte	444
3285	LED Fixture, High Bay, < 155 Watts, Replacing 250 Watt HID	331
3287	LED Fixture, High Bay, < 250 Watts, Replacing 400 Watt HID	331
3288	LED Fixture, High Bay, < 365 Watts, Replacing 400 Watt HID	331
3289	LED Fixture, Exterior, Replacing 150-175 Watt HID	325
3291	LED Troffer, 2x4, Replacing 4-Foot 3-4 Lamp T8 Troffer, SBP A La Carte	307
3301	LED Fixture, Exterior, Replacing 250 Watt HID	325

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3304	LED Fixture, Exterior, Replacing 70-100 Watt HID	325
3307	T8, 2-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12, 1-Lamp, 8-Foot, 0.78 < BF < 1.00, SBP A La Carte	241
3309	T8, 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12, 2-Lamp, 8-Foot, 0.78 < BF < 1.00, SBP A La Carte	241
3312	T8, 2-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO, 1-Lamp, 8-Foot, 0.78 < BF < 1.00, SBP A La Carte	241
3314	T8, 4-Lamp, 4-Foot, HPT8 or RWT8, Replacing T12HO, 2-Lamp, 8-Foot, 0.78 < BF < 1.00, SBP A La Carte	241
3320	Delamping, T12 to T8, 8-Foot	281
3321	Delamping, 200 - 399 Watt Fixture	286
3322	Delamping, ≥ 400 Watt Fixture	286
3323	LED, 2x2, Replacing T12 2 Lamp U-Tube, SBP A La Carte	268
3325	T8 2-Foot Lamps, Replacing Single T12 U-Tube Lamp	289
3326	T8 2-Foot Lamps, Replacing Double T12 U-Tube Lamp	289
3329	High Bay Fluorescent Lighting, T8 4L Replacing 250-399 W HID	392
3330	High Bay Fluorescent Lighting, T5HO 2L Replacing 250-399 W HID	392
3331	High Bay Fluorescent Lighting, T8 6L Replacing 400-999 W HID	392
3332	High Bay Fluorescent Lighting, T5HO 4L Replacing 400-999 W HID	392
3333	High Bay Fluorescent Lighting, T8 8L ≤ 500 W, Replacing ≥ 1,000 W HID	392
3334	High Bay Fluorescent Lighting, T5HO 6L ≤ 500 W, Replacing ≥ 1,000 W HID	392
3335	LED, Horizontal Case Lighting	335
3347	LED, Direct Install, 12 Watts	338
3348	LED Troffer, 2x4, Replacing 4-Foot 3-4 Lamp T8 Troffer, SBP Package	307
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3357	Occupancy Sensor, >=200 Watts, Wall Mount, SBP Package	228
3361	Occupancy Sensor, ≤ 200 Watts, Wall Mount, SBP Package	228
3366	LED, 2x2, Replacing T12 2 Lamp U-Tube, SBP Package	268
3385	LED, Direct Install, 13.5 Watt	589
3386	Grain Dryer, Energy Efficient, Hybrid	2
3387	LED, 1x4, Replacing T8 or T12, 2-Lamp	356
3388	LED, 1x4, Replacing T8 or T12, 2-Lamp	356
3389	LED, 1x4, Replacing T8 or T12, 2-Lamp	356
3390	HPT8, 1-Foot by 4-Foot, Replacing T12 or T8, 2 Lamp, SBP After A La Carte, 3390	236
3391	HPT8, 1-Foot by 4-Foot, Replacing T12 or T8, 2 Lamp, SBP A La Carte	236
3392	HPT8, 1-Foot by 4-Foot, Replacing T12 or T8, 2 Lamp, SBP Package	236
3393	LED Fixture, ≤ 180 Watts, Replacing 4 Lamp T5 or 6 Lamp T8, High Bay, DLC Listed	311
3394	LED Fixture, Downlights, ≤ 18 Watts Replacing 1 Lamp Pin-Based CFL Downlight	315

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3396	LED Fixture, Downlights ≤ 100 Watts, ≥ 4,000 Lumens, Interior	348
3397	LED Fixture, Downlights ≤ 100 Watts, ≥ 4,000 Lumens, Exterior	348
3398	LED Fixture, Downlights ≥ 6,000 Lumens, Interior	348
3399	LED Fixture, Downlights ≥ 6,000 Lumens, Exterior	348
3400	LED Fixture, 2x2, Low Output, DLC Listed	388
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3402	LED Lamp, ENERGY STAR, Exterior, Replacing Incandescent Lamp ≤ 40 Watts	328
3403	LED Lamp, ENERGY STAR, Exterior, Replacing Incandescent Lamp > 40 Watts	328
3404	Exterior LED Downlights Luminaires > 18 Watts	322
3405	LED Fixture, Downlights, ≤ 18 Watts, Replacing Incandescent Downlight, Exterior	319
3406	Daylighting Control	211
3407	LED Fixture, Replacing 1,000 Watt HID, Exterior	262
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3409	Retrofit Open Multi-Deck Cases with Doors	440
3413	CFL, Direct Install, 13 Watt	554
3414	Ice Machine, CEE Tier 2, Air Cooled, Self Contained, 0-499 lbs/day	64
3415	Ice Machine, CEE Tier 2, Water Cooled, Self Contained, 0-499 lbs/day	64
3416	Ice Machine, CEE Tier 2, Air Cooled, Ice Making Head, 0-499 lbs/day	64
3417	Ice Machine, CEE Tier 2, Air Cooled, Ice Making Head, 500-999 lbs/day	64
3418	Ice Machine, CEE Tier 2, Air Cooled, Ice Making Head, ≥1,000 lbs/day	64
3419	Ice Machine, CEE Tier 2, Water Cooled, Ice Making Head, <500 lbs/day	64
3420	Ice Machine, CEE Tier 2, Water Cooled, Ice Making Head, 500-999 lbs/day	64
3421	Ice Machine, CEE Tier 2, Water Cooled, Ice Making Head, ≥1,000 lbs/day	64
3422	Ice Machine, CEE Tier 2, Air Cooled, Remote Condensing, 0-499 lbs/day	64
3423	Ice Machine, CEE Tier 2, Air Cooled, Remote Condensing, 500-999 lbs/day	64
3424	Ice Machine, CEE Tier 2, Air Cooled, Remote Condensing, ≥1,000 lbs/day	64
3425	LED, 8-Foot, Replacing T12 or T8, 1 Lamp	360
3426	LED, 8-Foot, Replacing T12 or T8, 1 Lamp	360
3427	LED, 8-Foot, Replacing T12 or T8, 1 Lamp	360
3428	LED, 8-Foot, Replacing T12 or T8, 2 Lamp	360
3429	LED, 8-Foot, Replacing T12 or T8, 2 Lamp	360
3430	LED, 8-Foot, Replacing T12 or T8, 2 Lamp	360
3432	LED, 8-Foot, Replacing T12HO or T8HO, 1 Lamp	360
3433	LED, 8-Foot, Replacing T12HO or T8HO, 1 Lamp	360
3435	LED, 8-Foot, Replacing T12HO or T8HO, 2 Lamp	360
3436	LED, 8-Foot, Replacing T12HO or T8HO, 2 Lamp	360
3439	LED, Direct Install, 13.5 Watt	589

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3443	Natural Gas Furnace, With ECM, 95+ AFUE (Existing), Enhanced Rewards	534
3461	LED, Recessed Downlight, Replacing Incandescent, ENERGY STAR, In Unit	364
3462	LED, Recessed Downlight, Replacing Incandescent, ENERGY STAR, Common Area	364
3463	LED, Recessed Downlight, Replacing CFL, ENERGY STAR, In Unit	364
3464	LED, Recessed Downlight, Replacing CFL, ENERGY STAR, Common Area	364
3487	CFL, Direct Install, 20 Watt	552
3488	LED, Direct Install, 10 Watt	587
3493	Parking Garage Ventilation Controls	94
3494	Variable Speed ECM Pump, Domestic Hot Water Recirculation, < 100 Watts Max Input	201
3495	Variable Speed ECM Pump, Domestic Hot Water Recirculation, 100 - 500 Watts Max Input	201
3496	Variable Speed ECM Pump, Domestic Hot Water Recirculation, > 500 Watts Max Input	201
3497	Variable Speed ECM Pump, Heating Water Circulation, < 100 Watts Max Input	201
3498	Variable Speed ECM Pump, Heating Water Circulation, 100 - 500 Watts Max Input	201
3499	Variable Speed ECM Pump, Heating Water Circulation, > 500 Watts Max Input	201
3500	Variable Speed ECM Pump, Cooling Water Circulation, < 100 Watts Max Input	201
3501	Variable Speed ECM Pump, Cooling Water Circulation, 100 - 500 Watts Max Input	201
3502	Variable Speed ECM Pump, Cooling Water Circulation, > 500 Watts Max Input	201
3503	Variable Speed ECM Pump, Water Loop Heat Pump Circulation, < 100 Watts Max Input	201
3504	Variable Speed ECM Pump, Water Loop Heat Pump Circulation, 100 - 500 Watts Max Input	201
3505	Variable Speed ECM Pump, Water Loop Heat Pump Circulation, > 500 Watts Max Input	201
3506	Faucet Aerator, 1.0 GPM, Kitchen, Electric	485
3507	Faucet Aerator, 1.0 GPM, Kitchen, NG	485
3508	Faucet Aerator, 0.5 GPM, Bathroom, NG	485
3509	Faucet Aerator, 0.5 GPM, Kitchen, Electric	485
3510	Faucet Aerator, 0.5 GPM, Kitchen, NG	485
3511	LED Replacement of 4-Foot T8 Lamps with Integral or External Driver	371
3512	LED Replacement of 4-Foot T8 Lamps Using Existing Ballast	367
3514	Steam Trap Repair, 50-125 psig, General Heating, Prescriptive, 3/8" or Larger	129
3515	Steam Trap Repair, 50-125 psig, General Heating, Prescriptive, 5/16"	129
3516	Steam Trap Repair, 50-125 psig, General Heating, Prescriptive, 7/32" or Smaller	129
3517	Steam Trap Repair, 126-225 psig, General Heating, Prescriptive, 1/4"	129
3518	Steam Trap Repair, 126-225 psig, General Heating, Prescriptive, 3/8" or Larger	129
3519	Steam Trap Repair, 126-225 psig, General Heating, Prescriptive, 5/16"	129
3520	Steam Trap Repair, 126-225 psig, General Heating, Prescriptive, 7/32" or Smaller	129
3521	Steam Trap Repair, > 225 psig, General Heating, Prescriptive, 1/4"	129

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3522	Steam Trap Repair, > 225 psig, General Heating, Prescriptive, 3/8" or Larger	129
3523	Steam Trap Repair, > 225 psig, General Heating, Prescriptive, 5/16"	129
3524	Steam Trap Repair, > 225 psig, General Heating, Prescriptive, 7/32" or Smaller	129
3548	CFL, Standard Bulb, Retail Store Markdown, 310-749 Lumens	564
3549	CFL, Standard Bulb, Retail Store Markdown, 750-1,049 Lumens	564
3550	CFL, Standard Bulb, Retail Store Markdown, 1,050-1,489 Lumens	564
3551	CFL, Standard Bulb, Retail Store Markdown, 1,490-2,600 Lumens	564
3552	CFL, Reflector, 15 Watt, Retail Store Markdown	561
3553	LED, Omnidirectional, Retail Store Markdown, 310-749 Lumens	584
3554	LED, Omnidirectional, Retail Store Markdown, 750-1,049 Lumens	584
3555	LED, Omnidirectional, Retail Store Markdown, 1,050-1,489 Lumens	584
3556	LED, Omnidirectional, Retail Store Markdown, 1,490-2,600 Lumens	584
3557	LED, Reflector, 12 Watt, Retail Store Markdown	591
3558	Insulation, Attic, R-19 to R-38	474
3559	Combination Boiler, Natural Gas, AFUE ≤ 0.95	466
3560	Occupancy Sensor, Fixture Mount, > 60 Watts	228
3561	Occupancy Sensor, Fixture Mount, ≤ 60 Watts	228
3567	LED, Direct Install, 10 Watt	587
3569	Furnace and A/C, with ECM, 95% + AFUE, ≥ 16 SEER, Enhanced Rewards	538
3570	Insulation and Air Sealing, Attic, R-11 to R-38	474
3577	LED, Direct Install, > 12 Watts	338
3578	LED, Direct Install, > 12 Watts	338
3579	LED, Direct Install, > 16 Watt	338
3580	LED, Direct Install, > 16 Watt	338
3582	LED Tube Retrofit of 4-Foot T12 or T8 Fixtures	381
3583	Steam Trap Repair, 50-125 psig, General Heating, Prescriptive, 1/4"	129
3584	Condensing Water Heater, NG, 90%+, Claim Only	509
3585	Water Heater, Indirect, Claim Only	516
3586	Water Heater, Electric, EF ≥ 0.93, Claim Only	516
3588	Water Heater, ≥ 0.82 EF, Tankless, Residential, NG, Claim Only	516
3596	LED Fixture, Bi-Level, Stairwell and Passageway, SBP A La Carte	277
3597	LED Fixture, Bi-Level, Stairwell and Passageway, SBP After A La Carte	277
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3604	LED Fixture, Interior, 24 Hours, CALP	594
3605	Occupancy Sensor, ≤ 200 Watts, Fixture Mount, CALP	228
3606	Occupancy Sensor > 200 Watts, Fixture Mount, CALP	228
3609	Smart Thermostat, Existing NG Boiler	520