Technical Reference Manual 3.2

Prepared for

Idaho Power Company

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1. Overview and Purpose of Deemed Savings Method

This Technical Reference Manual (TRM) is a compilation of stipulated algorithms and values for various energy efficiency measures implemented by Idaho Power Company's commercial demand side management programs and serves the New Construction and Retrofit programs by providing up to date savings estimates for the energy efficiency measures offered by the programs. This manual is intended to facilitate the cost effectiveness screening, planning, tracking, and energy savings reporting for the New Construction and Retrofit Energy Efficiency incentive programs. While the algorithms and stipulated values contained in this TRM are derived using best practices, the stipulated values should be reviewed and revised according to relevant industry research and impact evaluation findings as necessary to ensure that they remain accurate for the New Construction and Retrofit programs. The following sections describe many of the processes and cross-cutting assumptions used to derive the measure level savings estimates found in Section 2.

1.1. Purpose

This manual is intended to facilitate the cost effectiveness screening, planning, tracking, and energy savings reporting for the New Construction and Retrofit energy efficiency incentive programs. This document is intended to be a living document in which the stipulated values are revised according to relevant industry research and impact evaluation findings.

1.2. Methodology and Framework

The algorithms and stipulated values contained in this TRM are derived using current industry standard engineering best practices. Current relevant research, recent impact evaluations, and Technical Reference Manuals developed for other states and/or regions are referenced where appropriate. All energy savings algorithms in this TRM are designed to be applied using the simple engineering formulas defined for each measure in conjunction with the included stipulated values.

Each measure is presented first with a summary of the technology and typical expected (per unit) energy savings, expected useful life, and incremental cost estimates. The ‘typical’ per unit values leverage basic assumptions regarding the geographic distribution of program participants (e.g. weather zone) as well as participant demographics (for example distribution of building types, efficiency of current building stock, etc.). Each measure is accompanied by a spreadsheet calculator containing live formulas and all weights used to derive the typical per-unit estimates. It is expected that as better information is made available regarding program participants, or as program designs are adjusted these numbers will be updated accordingly.

Following the measure summary information, each measure section provides a description of its scope and the spectrum of eligible projects/equipment to which the algorithms and values apply. When applicable, a discussion of code compliance topics (for new construction projects) is included.

1.3. Weather Data Used for *Weather Sensitive* Measures

The service territory for Idaho Power Company covers much of southern Idaho and stretches into eastern Oregon. This is illustrated in Figure 1-1.In order to normalize expected annual energy savings and peak demand reductions for annual variations in weather patterns, all stipulated values for weather sensitive measures were derived using the industry standard Typical Meteorological Year (TMY3) weather data. While there are many weather stations in Idaho for which TMY3 data is available, it was determined that averaging the TMY3 weather across stations in two ASHRAE weather zones (zones 5 and 6) provided sufficient resolution without adding too many separate variations for stipulated values reported in the TRM.

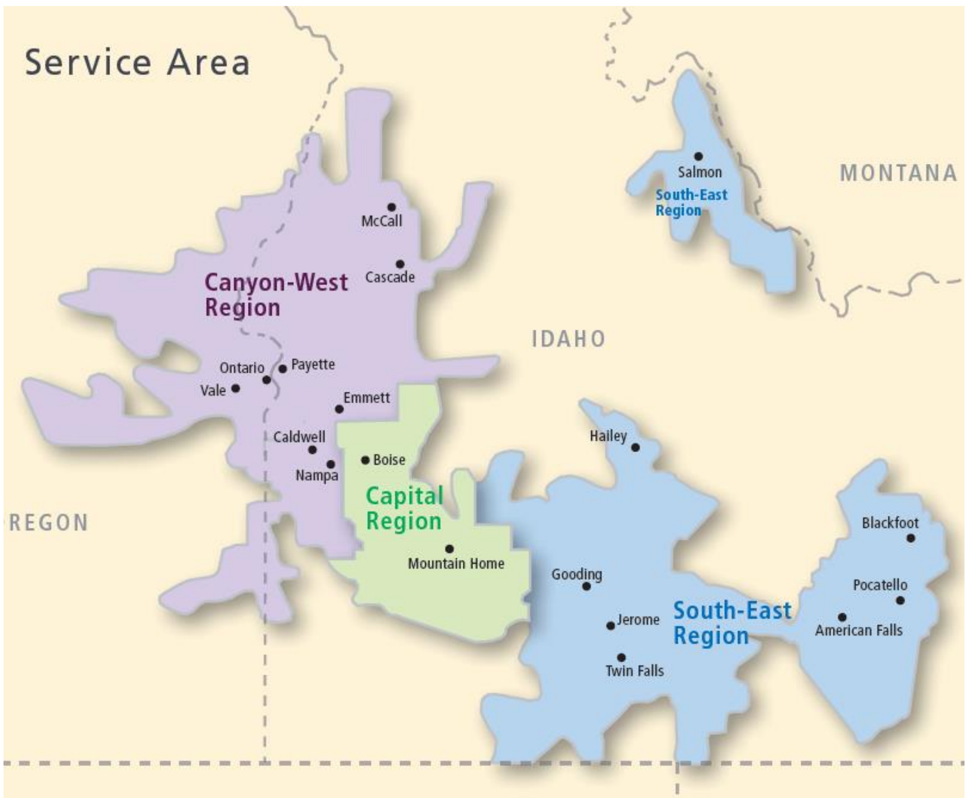

Figure 1-1 Map of Idaho Power Company Service Territory[1]

All stipulated values for weather sensitive measures (e.g. Equivalent Full Load Cooling Hours) are based on 'typical' weather data and provided separately for each of these two weather zones. A map of the ASHRAE weather zones is provided in Figure 1-2. When separate savings estimates are provided for different weather zones, the project location should be used to determine which of the values are applicable. The 'typical' energy savings values reported at the beginning of each measure's section assumes a weighted average between the two weather zones using weights of 80% and 20% for Zones 5 and 6 respectively.

[1] Map represents service territory at the time of this publication.

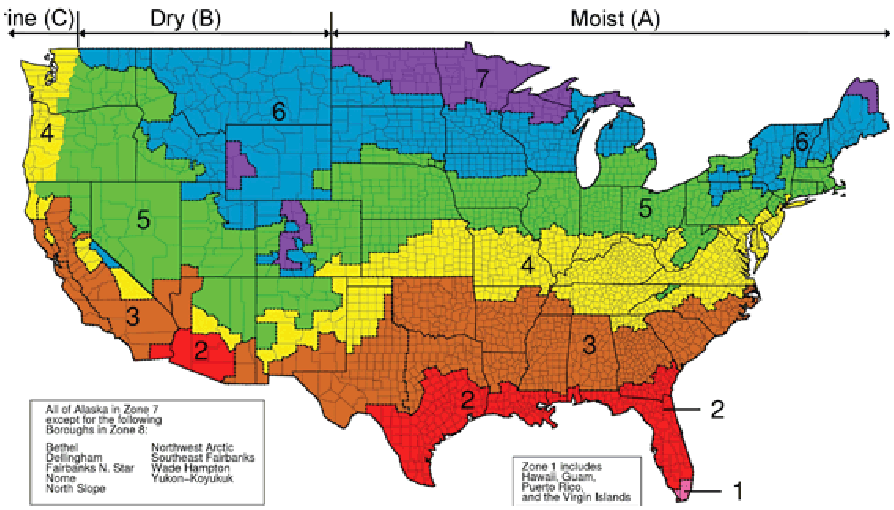

Figure 1-2 Map Illustrating ASHRAE Weather Zones[2]

While reviewing the weather data it was noted that while both weather zones are 'heating dominated' Weather Zone 6 is on average cooler that Weather Zone 5. Therefore, energy conservation measures targeting heating efficiency tend to perform much better in Zone 6. However; measures which result in a heating penalty tend to perform better in Zone 5. Monthly average dry bulb temperatures are compared for both weather zones in Figure 1-3.

[2] Note how Idaho is bisected by Zones 5 and 6

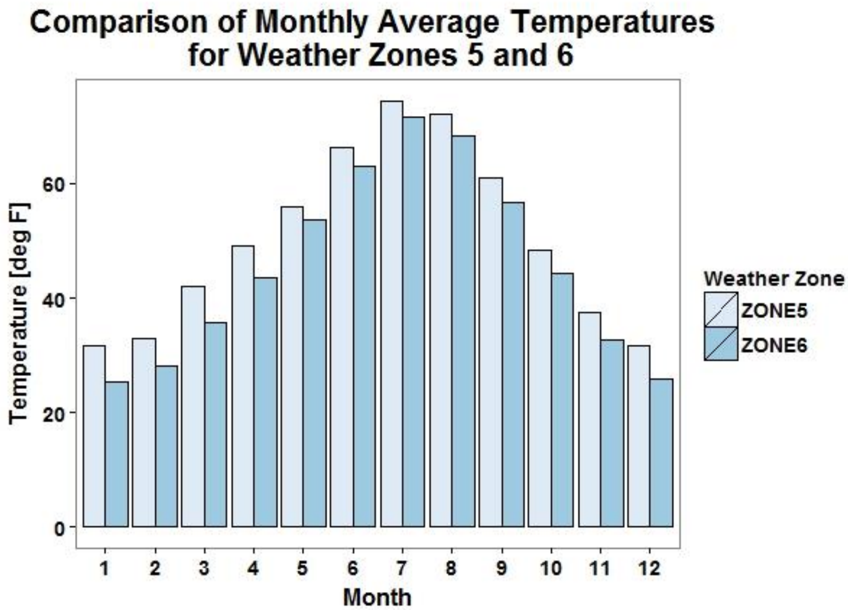

Figure 1-3 Comparison of Monthly Average Temperatures

1.4. Peak Demand Savings and Peak Demand Window Definition

Where applicable peak demand savings estimates are derived using Idaho Power Company's peak period definition of: *weekdays from 12:00 PM to 8:00 PM, June 1 through August 31*. Hourly savings estimates are averaged over the aforementioned time period to report peak savings.

Coincidence Factors for Lighting

Coincidence factors are defined as the percentage of the demand savings which occur during Idaho Power Company's peak period (defined above). When hourly data are available these are calculated by averaging the hourly demand savings over the peak period definition. This is exemplified in Figure 1-4 which illustrates a hypothetical hourly savings profile. The highlighted region bounds the peak period definition and the CF is calculated by taking the average demand reduction during that period divided by the max demand reduction

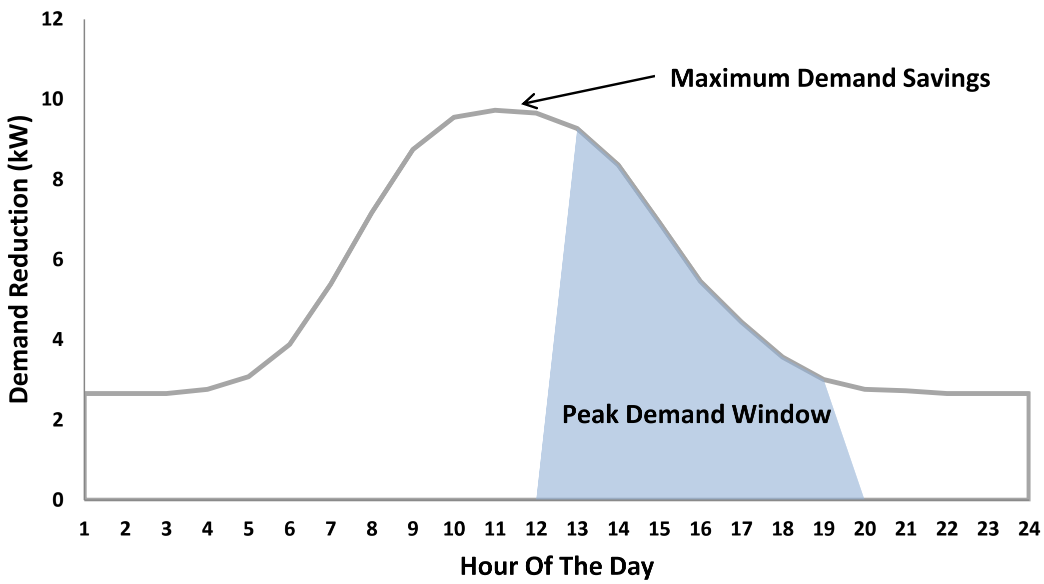

Figure 1-4 Hypothetical Hourly Savings Profile Used to Illustrate Calculation of Coincidence Factor

Thus in the example above let's suppose that the maximum Demand savings are 10 kW and the average kW reduction in the shaded area is 6 kW. The coincidence factor is calculated as follows:

$$Coincidence\ Factor = \frac{Average\ Reduction}{Max\ Reduction} = \frac{6\ kW}{10\ kW} = .6$$

1.5. Description of Prototypical Building Simulation Models

The estimated energy impacts for many of the measures in this TRM were developed using the help of building energy simulation modeling. All of the building simulations were performed using the DOE2.2 simulation software to simulation prototypical building models developed for the Database for Energy Efficiency Resources (DEER). A complete description of these models can be found in the DEER final report – though some aspects will be heighted here as they relate to the TRM.[3]

5 different *vintages* of 23 non-residential prototypical building models were developed for the DEER. These models include the following:

- Assembly,
- Education – Primary School,
- Education – Secondary School,
- Education – Community College,
- Education – University,

[3] Southern California Edison, Database for Energy Efficiency Resources (DEER) Update Study. 2005

- Education – Relocatable Classroom,
- Grocery,
- Health/Medical – Hospital,
- Health/Medical – Nursing Home,
- Lodging – Hotel,
- Lodging – Motel,
- Manufacturing – Bio/Tech,
- Manufacturing – Light Industrial,
- Office – Large,
- Office – Small,
- Restaurant – Sit-Down,
- Restaurant – Fast-Food,
- Retail – 3-Story Large,
- Retail – Single-Story Large,
- Retail – Small,
- Storage – Conditioned,
- Storage – Unconditioned, and
- Storage – Refrigerated Warehouse.

A complete set of these models was pulled from the DEER for use in simulating various weather sensitive measures (including heating and cooling interactive factors for lighting). All simulations were run using the (2) Idaho specific weather data-set described in Section 1.3 for the buildings for which a measure was applicable. The hourly results were then compiled and typically normalized using the building conditioned area (ft^2) or installed cooling/heating capacity (Tons). Note that the newest vintage of a building type was selected for simulating impacts for *new construction* while the most applicable vintage was selected for retrofit.[4]

1.6. Application of Stacking Effects in the TRM

Often energy conservation projects involve ‘packages’ of measures implemented together. As measures are ‘stacked’ on top of one another, each add to the overall project energy savings, however; individual measure impacts are not always directly additive. This is because, unless otherwise noted, the ‘typical’ savings values reported within this TRM assumes that the measure is implemented on its own. When measures interact with each other this can cause the total energy savings to be less than the individual savings added together, labeled as the stacking effect. The stacking effect will apply to all measures that are implemented in the same space and have the same end-use category. All overlapping measures will have a discount factor applied to the saving depending on the measure order, see Table 1-1.

[4] The specific vintage selected was a function of the expected distribution of buildings of that type in the Idaho Power Service Territory.

Table 1-1 Stacking Effect Discount Factors

Measure Order	Discount Factor
1	1
2	.85
3	.74
4	.67
5	.62
6	.59

1.6.1. Step by Step Guide to Applying the Stacking Effect

Step one: Arrange the measures

Measures will be arranged by the estimated savings from highest savings to lowest savings.

Step Two: Identify End-uses

For each measure, identify the end-uses that will affect the savings and that will affect other measures.

Note: A measure can have more than one end-use.

Step Three: Discount factor

Recognize where any overlap in end-use occurs and apply the discount factor based on the number of measures with the same end-use above it.

Step Four: Adjust Energy Savings

Multiply measure savings by the associated discount factor to obtain the adjusted measure savings.

1.6.2. Stacking Effect Example

Let's assume that a project involved the following energy conservation measures:

Order Implemented	Measure	Relative Savings	End-Use
1	Efficient Interior Lighting	5%	Cooling & Lighting
2	High Efficiency Chilled Water Pumps	4%	Pumps & Auxiliary
3	High Efficiency Chiller	10%	Cooling
4	Water-side economizer	2%	Cooling

Step One: Arrange the Measures

The measures are arranged with the highest savings being applied first and decrease in savings down the list. This arrangement can be done using the relative savings as shown or using the individual measure projected kWh savings.

Order	Measure	Relative Savings	End-Use
1	High Efficiency Chiller	10%	Cooling
2	Efficient Interior Lighting	5%	Cooling & Lighting
3	High Efficiency Chilled Water Pumps	4%	Pumps & Auxiliary
4	Water-side economizer	2%	Cooling

Step Two: Identify End-uses

Use the TRM to record all the measure end-uses. Find where the end-uses overlap and make sure that the installed equipment actually overlaps by being in the same space or working on the same system.

Order	Measure	Relative Savings	End-Use
1	High Efficiency Chiller	10%	**Cooling**
2	Efficient Interior Lighting	5%	**Cooling** & Lighting
3	High Efficiency Chilled Water Pumps	4%	Pumps & Auxiliary
4	Water-side economizer	2%	**Cooling**

Step Three: Discount Factors

Apply a discount factor to all measures based on the number of overlapping measures above. Note that the chilled water pump does not overlap so has a discount factor of 1 and the water-side economizer is the third cooling end-use so has a discount factor of 0.74.

Order	Measure	Relative Savings	End-Use	Discount Factor
1	High Efficiency Chiller	10%	Cooling	1
2	Efficient Interior Lighting	5%	Cooling & Lighting	0.85
3	High Efficiency Chilled Water Pumps	4%	Pumps & Auxiliary	1
4	Water-side economizer	2%	Cooling	0.74

Step Four: Adjust Energy Savings

Apply the discount factor to all relevant measures by multiplying the discount factor by the individual measure energy savings.

Order	Measure	Relative Savings	End-Use	Individual Energy Savings	Discount Factor	Adjusted Energy Savings
1	High Efficiency Chiller	10%	Cooling	300,000 kWh	1	300,000 kWh
2	Efficient Interior Lighting	5%	Cooling & Lighting	150,000 kWh	0.85	127,500 kWh
3	High Efficiency Chilled Water Pumps	4%	Pumps & Auxiliary	120,000 kWh	1	120,000 kWh
4	Water-side economizer	2%	Cooling	60,000 kWh	0.74	44,400 kWh
					Project Total:	591,900 kWh

1.6.3. Special Cases

There are a few cases that require more explanation.

Stacking effect integrated into the TRM Savings:

Two measures in the TRM already have stacking effects integrated into the typical savings stated as the measure interacts with itself.

1) High efficiency lighting and lighting controls
2) HVAC Controls

These two measures should be treated the same as all other measures once the correct typical savings has been decided. For example, the HVAC control measure there are many levels of savings based on the number of controls implemented that interact with each other. For this reason, savings for one control measure can not be multiplied by the number of controls implemented. However, once the correct typical savings value is selected the measure should be used in the stacking effect calculation as previously described.

Measures that have the same end-use but are installed in different areas:

Two or more measures can have the same end-use without needing a discount factor applied if the measures are not in the same space and will not interact with each other. For example: if an office replaces AC unit #2 and improves the LPD in a space served by AC unit #1 than these measures will not stack. Any instances of this needs to be well documented.

Measure has multiple end-uses that cause stacking effect:

Some measures have multiple end-uses which can cause it to stack with multiple measures. When a measure with multiple end-uses where both end-uses will stack with other measures in the program than each end-use should be evaluated separately and the measure should use the lowest discount factor calculated. For example, a program has four measures and in order from greatest savings to least savings are: two cooling only measures, one lighting only measure and the last one is lighting and cooling. In this case the final measure is the third cooling measure for discount factor of 0.74 and the second lighting measures for a discount factor of 0.85. A discount factor of 0.74 should be used since it is the lower number.

1.7. Building Type by Measure

This TRM estimates the facility energy savings for each measure using deemed values where applicable. Because of how various measure savings are sourced and calculated, all building types are not present for all measures. When applying for measure savings, the building type that most closely resembles the stated facility should be used and should be consistent for all measures being implemented at the same facility. Table 1-2 helps combine the building types listed for HVAC and Lighting measures. This table can be used to select a single building type from either list and lookup the appropriate building type label in the other measure.

Table 1-2 Building Type

Building Type	HVAC Measures	Lighting Measures	Lighting EFLH	HVAC Cooling EFLH	HVAC Heating EFLH
Assembly	Assembly	Assembly	2,700	855	985
Education - Primary School	Education - Primary School	School, Primary	2,500	197	321
Education - Secondary School	Education - Secondary School	School, Secondary	2,500	223	428
Education - Community College	Education - Community College	College	2,100	551	352
Education - University	Education - University	University	2,100	702	363
Grocery	Grocery	Retail Supermarket	6,800	544	1,862

Building Type	HVAC Measures	Lighting Measures	Lighting EFLH	HVAC Cooling EFLH	HVAC Heating EFLH
Health/Medical - Hospital	Health/Medical - Hospital	Hospital	4,200	1,575	625
Health/Medical - Nursing Home	Health/Medical - Nursing Home	Other Health, Nursing, Medical Clinic	4,300	1,016	1,450
Lodging - Hotel	Lodging - Hotel	Lodging, Hotel	3,500	1,112	653
Lodging - Motel	Lodging - Motel	Lodging, Motel	3,500	970	705
Industrial Plant - 1/2 Shift	Manufacturing - Light Industrial	Industrial Plant with One/Two Shift	5,500	507	777
Industrial Plant - 3 Shift	Manufacturing - Light Industrial	Industrial Plant with Three Shifts	7,000	507	777
Office - Large	Office - Large	Office >100,000 sf	3,300	733	207
Library	Office - Small	Library	3,000	599	277
Office <20,000 sf	Office - Small	Office <20,000 sf	2,600	599	277
Office 20,000 to 100,000 sf	Office - Small	Office 20,000 to 100,000 sf	3,300	599	277
Restaurant - Sit-Down	Restaurant - Sit-Down	Restaurant, Sit-Down	4,900	792	641
Restaurant - Fast-Food	Restaurant - Fast-Food	Restaurant, Fast-Food	4,900	827	737
Retail - 3-Story Large	Retail - 3-Story Large	Retail Anchor Store >50,000 sf Multistory	4,400	741	816
Retail 5,000 to 50,000 sf	Retail - Single-Story Large	Retail 5,000 to 50,000 sf	3,900	694	884
Retail Big Box > 50,000 sf One-story	Retail - Single-Story Large	Retail Big Box >50,000 sf One-Story	6,000	694	884
Retail Mini Mart	Retail - Small	Retail Mini Mart	7,200	705	936
Retail Boutique <5,000 sf	Retail - Small	Retail Boutique <5,000 sf	2,500	705	936
Automotive Repair	Storage - Conditioned	Automotive Repair	3,100	316	748
Warehouse	Storage - Conditioned	Warehouse	2,600	316	748
Other	Other	Other	3,800	635	726

2. Commercial and Industrial Deemed Savings Measures

This chapter contains the protocols and stipulated values for commercial and industrial measures covered by this TRM. Spreadsheets were developed for each measure and contain any calculations used to derive stipulated values (or deemed savings estimates). Each measure is presented first with a summary of the technology and typical expected (per unit) energy savings, expected useful life, and incremental cost estimates. The 'typical' per unit values leverage basic assumptions regarding the geographic distribution of program participants (e.g. weather zone) as well as participant demographics (for example distribution of building types, efficiency of current building stock, etc.) and are intended for use in cost effectiveness screening – not as deemed savings estimates (given their generality). Where applicable, deemed savings estimates are provided for various scenario in tables at the end of each measure's section.

Each measure is accompanied by a spreadsheet calculator containing live formulas and all weights used to derive the typical per-unit estimates. It is expected that as better information is made available regarding program participants, or as program designs are adjusted these numbers will be updated accordingly. Following the measure summary information, each measure section provides a description of its scope and the spectrum of eligible projects/equipment to which the algorithms and values apply. When applicable, a discussion of code compliance topics (for new construction projects) is included. It should also be noted that while savings estimates are provided for a multitude of measures (both for retrofit and new construction) a custom engineering analysis should be preferred for significantly large projects when possible. This is particularly true for projects involving VFDs, HVAC controls, and/or large 'packages' of multiple measures.

2.1. Efficient Interior Lighting and Controls (New Construction)

The following algorithms and assumptions are applicable to interior lighting systems installed in commercial and industrial spaces which are more efficient than required by prevailing codes and standards. This measure applies only to projects which represent new construction or major renovations.[5] The following tables summarize the 'typical' expected (per ft^2) energy impacts for lighting power density improvements and controls additions. Typical values are based on the algorithms and stipulated values described below and data from past program participants.[6]

Table 2-1 Typical Savings Estimates for 10% Interior LPD Improvement (New Construction)

	Retrofit	New Construction
Deemed Savings Unit	n/a	ft^2
Average Unit Energy Savings	n/a	.43 kWh
Average Unit Peak Demand Savings	n/a	.09 W
Expected Useful Life	n/a	14 Years
Average Incremental Cost[7]	n/a	$0.13
Stacking Effect End-Use	HVAC, Lighting	

Table 2-2 Typical Savings Estimates for 20% Interior LPD Improvement

	Retrofit	New Construction
Deemed Savings Unit	n/a	ft^2
Average Unit Energy Savings	n/a	.86 kWh
Average Unit Peak Demand Savings	n/a	.17 W
Expected Useful Life	n/a	14 Years
Average Incremental Cost[8]	n/a	$0.25
Stacking Effect End-Use	HVAC, Lighting	

[5] Major renovations are defined to be any renovation or facility expansion project in which building permits were required and the lighting system had to be demonstrated to comply with a particular code or standard.

[6] See spreadsheet "1-TypicalCalcs_HighEffLight_v7.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

[7] Stated costs only apply to the increased cost of materials and do not account for the additional design costs associated with this measure.

[8] See previous footnote

Table 2-3 Typical Savings Estimates for >= 30% Interior LPD Improvement[9]

	Retrofit	New Construction
Deemed Savings Unit	n/a	ft^2
Average Unit Energy Savings	n/a	1.95 kWh
Average Unit Peak Demand Savings	n/a	.39 W
Expected Useful Life	n/a	14 Years
Average Incremental Cost[10]	n/a	$0.58
Stacking Effect End-Use	HVAC, Lighting	

Table 2-4 Typical Savings Estimates for 60% Interior LPD Improvement

	Retrofit	New Construction
Deemed Savings Unit	n/a	ft^2
Average Unit Energy Savings	n/a	2.57 kWh
Average Unit Peak Demand Savings	n/a	.52 W
Expected Useful Life	n/a	14 Years
Average Incremental Cost[11]	n/a	$0.76
Stacking Effect End-Use	HVAC, Lighting	

[9] Note that the values listed for this measure assume the "typical" improvement in this category is a 45.5% reduction in interior LPD. This is based on observed lighting load reductions from past program participants. Note that an average % reduction was taken for participants whose LPD reduction fell within this category.

[10] Stated costs only apply to the increased cost of materials and do not account for the additional design costs associated with this measure.

[11] See previous footnote.

Table 2-5 Typical Savings Estimates for Occupancy Sensors (New Construction)[12]

	Retrofit	New Construction
Deemed Savings Unit	n/a	Sensor
Average Unit Energy Savings	n/a	329 kWh
Average Unit Peak Demand Savings	n/a	66 W
Expected Useful Life	n/a	8 Years
Average Incremental Cost	n/a	$134
Stacking Effect End-Use	HVAC, Lighting	

Table 2-6 Typical Savings Estimates for Efficient Exit Signs[13]

	Retrofit	New Construction
Deemed Savings Unit	n/a	Sign
Average Unit Energy Savings	n/a	28 kWh
Average Unit Peak Demand Savings	n/a	3.6 W
Expected Useful Life	n/a	16 Years
Average Incremental Cost	n/a	$10.83
Stacking Effect End-Use	HVAC	

2.1.1. Definition of Eligible Equipment

All above-code interior lighting systems (fixtures, lamps, ballasts, etc.) are eligible. Eligibility is determined by calculating the lighting power density (LPD) for the installed system. If the LPD is at least 10% lower than allowed by code (see Section 2.1.2) then the system is eligible. Efficient equipment may include florescent fixtures, LED lamps, LED exit signs, compact florescent light bulbs, high intensity discharge lamps, etc.

In addition to efficient lighting fixtures, lighting controls are eligible under this measure. Eligible controls include: occupancy sensors (wall mounted and fixture mounted), dimmers, and bi-level switches. Lighting controls are only eligible when not already required by the building code standard to which a project is permitted.

Occupancy sensor lighting controls are required in all spaces types stated in Table 2-14. Lighting controls must: automatically turn off lights within 30 minutes of occupants leavings the space, be manual on or controlled to automatically turn lighting on to no more than 50% power, and incorporate a manual off control[14]. Warehouse spaces shall be controlled as follows: in aisleways and open areas the controls will turn down lighting power to no less than 50% when unoccupied

[12] Occupancy sensor savings are based on the assumption that each sensor will control 300 Watts

[13] Note that the energy savings for exit signs are the same for both code standards.

[14] Warehouse spaces shall be controlled based on section C405.2.1.2.

and each aisleway will be controlled independently with the aisle sensor not controlling lighting beyond the aisleway.

Photocontrol sensors are not eligible for new construction savings and have been removed from the TRM. The building code requires photocontrols on all lights in areas that received natural lighting and therefore are not eligible for savings.

Exit signs are required to be less than 2 watts per face.

2.1.2. Definition of Baseline Equipment

There are two possible project baseline scenarios – retrofit and new construction. This measure currently only addresses the new construction scenario.

Retrofit (Early Replacement)

This measure does not apply to retrofit or early replacement.

New Construction (Includes Major Remodel & Replace on Burn-Out)

Baseline equipment for this measure is defined as an installed lighting system with a maximum allowable LPD. The maximum allowable LPD is defined by the building code according to which the project was permitted. Recently Idaho adopted IECC 2018 as the energy efficiency standard for new construction from the previous standard IECC 2015.

Two paths are available for code compliance – the Building Area Method (IECC 2018, C405.4.2.1) and the Space-by-Space Method (IECC 2018, C405.4.2.2). Either can be used to determine baseline power density provided it is consistent with the method used by the project for code compliance.

Code Compliance Considerations for Lighting Controls

Section C405.2 of the IECC 2018 Standard specifies mandatory automatic lighting controls in certain space types with a few exceptions and are listed in Table 2-14. If the building or space is not exempt from these mandatory provisions, then the least efficient mandatory control strategy shall be assumed as baseline equipment. Note that prescriptive lighting control requirements have changed between the 2015 and 2018 versions of IECC.

2.1.3. Algorithms

Two sets of algorithms are provided for this measure. The first are algorithms for Lighting Power Density (LPD) reductions and/or for the addition of lighting controls. The second set of algorithms are included for high efficiency exit signs (which are treated separately by ASHRAE 90.1):

Algorithm 1 (Lighting Power Density Reduction and Controls Additions):

$$\Delta kWh = kWh_{base} - kWh_{Installed}$$

$$= A_{SF} * [LPD_{base} - LPD_{Installed} * (1 – CSF)] * HOU * HCIF_{Energy}$$

$$\Delta kW = (kW_{base} - kW_{Installed}) * CF$$

$$= ASF * [LPD_{base} - LPD_{Installed} * (1 – CSF)] * HCIF_{Demand} * CF$$

$$kWh/Unit_{Typical} = \Sigma (\Delta kWh/Unit_{building\ i} * W_{building\ i})$$

$$kWh/Unit_{building,\ i} = [LPD_{building\ i,\ base} - LPD_{building\ i,\ Installed} * (1 – CSF)] * HCIF_{Demand}$$

The above equations for *ΔkWh* and *ΔkW* can be simplified to the following if a project involves only a lighting power density reduction or lighting controls addition:

Power density reduction only: $\Delta kWh = A_{SF} * [LPD_{base} - LPD_{Installed}] * HOU * HCIF_{Energy}$

Controls installation only: $\Delta kWh = A_{SF} * LPD_{Installed} * CSF * HOU * HCIF_{Energy}$

Algorithm 2 (High Efficiency Exit Signs):

$$\Delta kWh = kWh_{base} – kWh_{Installed}$$

$$= (W_{base} - W_{Installed}) * 8760 * HCIF_{Energy} * N_{Signs}$$

$$\Delta kW = (W_{base} - W_{Installed}) * N_{Signs}$$

2.1.4. Definitions

ΔkWh	Expected energy savings between baseline and installed equipment.
ΔkW	Expected demand reduction between baseline and installed equipment.
HOU	Annual operating hours for the lighting system. Values for various building types are stipulated in Table 2-7. When available, actual system hours of use should be used.
LPD	Lighting power density baseline (base) and installed (meas) systems. This is defined as the total lighting system connected load divided by the lighted area. The Building Area method baseline LPD is defined by Table 2-8. The

	Space-By-Space method the LPD is defined by Table 2-9 through Table 2-10.
W	Exit Sign *base* and *installed* wattage. Note that the *base* wattage is defined by IECC to be 5 watts. Note exit sign wattage is the same for IECC 2015 and 2018. See Table 2-15 for stipulated wattages.
CF	Peak coincidence factor. Represents the % of the connected load reduction which occurs during Idaho Power's peak period. For Exit signs the coincidence factor is defined to be unity.
HCIF	Heating and Cooling Interactive Factors. These account for the secondary impacts reductions in internal loads effect on HVAC systems by representing the expected "typical' impacts a reduction in the lighting power density will effect on electric space conditioning equipment. These are defined in Table 2-11 for various building types and climate zones.
CSF	Controls Savings Factor. This is defined as the % reduction in system hours of use (HOU) due do installed lighting controls. Stipulated values for this variable are provided in Table 2-13.
$kWh/Unit_{Typical}$	Typical measure savings on a per unit basis.
$kWh/Unit_{building,\ i}$	Typical measure savings for building type i on a per unit basis. Uses the baseline LPD for building type i as defined in Table 2-8. Measure LPD for building i is defined as the average installed LPD for past program participants of that building type.
$W_{building,i}$	Population weight for building type i. This is defined to be the square footage of building type i in past program participants divided by the total square footage of past participant building space

2.1.5. Sources

- IECC 2015, Chapter 4.
- IECC 2018, Chapter 4.
- Regional Technical Forum, draft Standard Protocol Calculator for Non-Residential Lighting improvements, https://rtf.nwcouncil.org/standard-protocol/non-residential-lighting-retrofits
- California DEER Prototypical Simulation models (modified), eQUEST-DEER 3-5.[15]

[15] Prototypical building energy simulations were used to generate Idaho specific Heating and Cooling Interactive Factors and Coincidence factors for various building and heating fuel types.

- California DEER Effective Useful Life worksheets: EUL_Summary_10-1-08.xls
- Acker, B., Van Den Wymelenberg, K., 2010. Measurement and Verification of Daylighting Photocontrols; Technical Report 20090205-01, Integrated Design Lab, University of Idaho, Boise, ID.

2.1.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Table 2-7 Stipulated Lighting Hours of Use (HOU) by Building Type[16]

Building Type	Hours of Use
Assembly	2,700
Automotive Repair	3,100
College	2,100
University	2,100
Exterior 24 Hour Operation	8,766
Hospital	4,200
Industrial Plant with One Shift	5,500
Industrial Plant with Three Shifts	7,000
Industrial Plant with Two Shifts	5,500
Library	3,000
Lodging, Hotel	3,500
Lodging, Motel	3,500
Manufacturing	5,500
Office <20,000 sf	2,600
Office >100,000 sf	3,300
Office 20,000 to 100,000 sf	3,300
Other Health, Nursing, Medical Clinic	4,300
Parking Garage	6,300
Restaurant, Sit-Down	4,900
Restaurant, Fast-Food	4,900
Retail 5,000 to 50,000 sf	3,900
Retail Anchor Store >50,000 sf Multistory	4,400
Retail Big Box >50,000 sf One-Story	6,000
Retail Boutique <5,000 sf	2,500
Retail Mini Mart	7,200
Retail Supermarket	6,800
School, Primary	2,500
School, Secondary	2,500
Street & Area Lighting (Photo Sensor Controlled)	4,383
Warehouse	2,600
Other	3,800

[16] The values in this table are based on the most recent Regional Technical Forum draft Standard Protocol Calculator for Non-Residential Lighting improvements: x https://rtf.nwcouncil.org/standard-protocol/non-residential-lighting-retrofits version 4.2

Table 2-8 Baseline Lighting Power Densities by Building Type – Building Area Method[17]

Building Area Type	IECC 2018 LPD (W/ft2)
Automotive facility	0.71
Convention center	0.76
Courthouse	0.9
Dining: bar lounge/leisure	0.9
Dining: cafeteria/fast food	0.79
Dining: family	0.78
Dormitory	0.61
Exercise center	0.65
Gymnasium	0.53
Health-care clinic	0.68
Hospital	0.82
Hotel	1.05
Library	0.75
Manufacturing facility	0.78
Motel	0.9
Motion picture theater	0.83
Multifamily	0.68
Museum	1.06
Office	0.79
Parking garage	0.15
Penitentiary	0.75
Performing arts theater	1.18
Police/fire station	0.8
Post office	0.67
Religious building	0.94
Retail	1.26
School/university	0.81
Sports arena	0.87
Town hall	0.8
Transportation	0.61
Warehouse	0.48
Workshop	0.9

[17] These values are from Tables C405.4.2(1) in IECC 2018.

Table 2-9 Baseline LPD For Common Spaces - Space-by-Space Method (IECC 2018)

Common Space Type[18] (2018)	LPD (W/ft2)
Atrium - Less than 40 feet in height	0.03 per foot in height
Atrium - Greater than 40 feet in height	0.4 + 0.02 per foot in total height
Audience/seating area - Permanent	
In an auditorium	0.63
In a convention center	0.82
In a gymnasium	0.65
In a motion picture theater	1.14
In a penitentiary	0.28
In a performing arts theater	2.03
In a religious building	1.53
In a sports arena	0.43
Otherwise	0.43
Banking activity area	0.86
Breakroom (see Lounge/breakroom)	
Classroom/lecture hall/training room	
In a penitentiary	1.34
Otherwise	0.96
Conference/meeting/multipurpose	1.33
Copy/print room	1.07
Corridor	
In a facility for the visually impaired (and not used primarily by the staff)	0.92
In a hospital	0.92
In a manufacturing facility	0.29
Otherwise	0.66
Courtroom	1.39
Computer room	0.93
Dining area	
In a penitentiary	0.96
In a facility for the visually impaired (and not used primarily by the staff)	2
In a bar/lounge or leisure dining	0.93
In cafeteria or fast food dining	0.63
In a family dining area	0.71
Otherwise	0.63
Electrical/mechanical	0.43

[18] In cases where both a common space type and a building specific type are listed, the building specific space type shall apply.

Common Space Type[18] (2018)	LPD (W/ft2)
Emergency vehicle garage	0.41
Food preparation	1.06
Guest room	0.77
Laboratory	
In or as a classroom	1.2
Otherwise	1.45
Laundry/washing area	0.43
Loading dock, interior	0.58
Lobby	
In a facility for the visually impaired (and not used primarily by the staff)	2.03
Otherwise	0.85
Sales area	1.22
Seating area, general	0.42
Stairway (see space containing stairway)	
Stairwell	0.58
Storage room	0.46
Vehicular maintenance	0.56
Workshop	1.14

Table 2-10 Baseline LPD for Specific Spaces - Space-by-Space Method (IECC 2018)

Building Specific Space Types (2018)	LPD (W/ft2)
Facility for the visually impaired	
In a chapel (and not used primarily by the staff)	1.06
In a recreation room (and not used primarily by the staff)	1.8
Automotive - (See Vehicular maintenance, above)	
Convention center - Exhibit space	0.88
Dormitory living quarters	0.54
Fire stations - Sleeping quarters	0.2
Gymnasium/fitness center	
In an exercise area	0.5
In a playing area	0.82
Health care facility	
In an exam/treatment room	1.68
In an imaging room	1.06
In a medical supply room	0.54
In a nursery	1
In a nurse's station	0.81

Building Specific Space Types (2018)	LPD (W/ft2)
In an operating room	2.17
In a patient room	0.62
In a physical therapy room	0.84
In a recovery room	1.03
Library	
In a reading area	0.82
In the stacks	1.2
Manufacturing facility	
In a detailed manufacturing area	0.93
In an equipment room	0.65
In an extra high bay area (greater than 50-foot floor-to-ceiling height)	1.05
In a high bay area (25 - 50-foot floor-to-ceiling height)	0.75
In a low bay (< 25-foot floor-to-ceiling height)	0.96
Museum	
In a general exhibition area	1.05
In a restoration room	0.85
Performing arts theater dressing/fitting room	0.36
Post office - Sorting area	0.68
Religious buildings	
In a fellowship hall	0.55
In a worship/pulpit/choir area	1.53
Retail facilities	
In a dressing/fitting room	0.5
In a mall concourse	0.9
Sports arena - Playing area	
For a Class 1 facility	2.47
For a Class 2 facility	1.96
For a Class 3 facility	1.7
For a Class 4 facility	1.13
Transportation	
In a baggage/carousel area	0.45
In an airport concourse	0.31
At a terminal ticket counter	0.62
Warehouse - Storage area	
For medium to bulky palletized items	0.35
For smaller, hand-carried items	0.69

Table 2-11 Heating and Cooling Interactive Factors by Building Type and Weather Zone[19]

Building Type	Weather Zone 5		Weather Zone 6	
	kWh	*kW*	*kWh*	*kW*
Primary School	1.04	1.2	1.03	1.17
Secondary School	1.04	1.14	1.02	1.12
Community College	1.11	1.16	1.08	1.15
University	1.13	1.14	1.14	1.14
Hospital	1.09	1.04	1.08	1.06
Nursing Home	1.09	1.29	1.08	1.26
Hotel	1.15	1.16	1.14	1.15
Motel[20]	0.74	1.29	0.66	1.28
Light Manufacturing	1.05	1.25	1.04	1.23
Small Office	1.06	1.26	1.06	1.24
Large Office	1.08	1.14	1.07	1.14
Full Service Restaurant (Sit-Down)	1.06	1.25	1.05	1.22
Fast Food	1.05	1.2	1.04	1.19
Small Retail	1.07	1.29	1.06	1.25
Large 1-story Retail	1.07	1.3	1.06	1.27
3-story Retail	1.05	1.14	1.05	1.13
Conditioned Storage	1.03	1.09	1.01	1.02
Multi Family	1.03	1.26	1.02	1.24
Other	1.05	1.2	1.04	1.18

[19] Factors generated using DOE2.2 simulations based on the prototypical building models developed for the California Database for Energy Efficiency Resources using weather data based on the two Idaho weather zones. The values in this table make assumptions regarding 'typical' fuel sources and efficiencies for heating and cooling equipment. These numbers represent the expected "typical" impacts a reduction in the lighting power density will effect on electric space conditioning equipment.

[20] Note that these figures assume Motel HVAC systems are either heat-pumps or use electric resistance heating. If it is known that a particular motel uses gas heating then use the values for Hotel instead.

Table 2-12 Peak Demand Coincidence Factors by Building Type[21]

Building Type	CF
Primary School	0.48
Secondary School	0.48
Community College	0.6
University	0.76
Hospital	0.92
Nursing Home	0.9
Hotel	0.89
Motel	0.89
Light Manufacturing	0.98
Small Office	0.71
Large Office	0.85
Full Service Restaurant (Sit-Down)	0.95
Fast Food	0.95
Small Retail	0.47
Large 1-story Retail	0.78
3-story Retail	0.56
Conditioned Storage	0.8
Multi Family	0.43
Other	0.73

[21] Factors generated using prototypical lighting schedules found in the DEER building models and the definition for the Idaho Power Company's peak period (12 pm to 8 pm on weekdays between June 1st and August 31st).

Table 2-13 Controls Savings Factors by Building and Control Type[22]

Space Type	Occupancy Sensor	Daylight Sensor	Bi-level Switching	Dimmers, Wireless on/off Switches	Occupancy & Daylight
Assembly	36%	36%	6%	6%	40%
Break Room	20%	20%	6%	6%	40%
Classroom	18%	29%	6%	6%	34%
Computer Room	35%	18%	6%	6%	34%
Conference	35%	18%	35%	35%	40%
Dining	35%	18%	6%	6%	40%
Gymnasium	35%	35%	6%	6%	40%
Hallway	15%	15%	6%	6%	34%
Hospital Room	45%	27%	6%	6%	35%
Industrial	45%	0%	35%	35%	40%
Kitchen	30%	0%	6%	6%	34%
Library	15%	18%	6%	6%	34%
Lobby	25%	18%	6%	6%	40%
Lodging (Guest Rooms)	45%	0%	35%	35%	40%
Open Office	22%	27%	35%	35%	40%
Parking Garage	15%	18%	35%	0%	0%
Private Office	22%	27%	35%	35%	40%
Process	45%	0%	6%	6%	34%
Public Assembly	36%	36%	6%	6%	40%
Restroom	40%	0%	6%	6%	40%
Retail	15%	29%	6%	6%	34%
Stairs	25%	0%	0%	0%	18%
Storage	45%	0%	6%	6%	40%
Technical Area	35%	18%	6%	6%	34%
Warehouses	31%	28%	35%	35%	40%
Other	7%	18%	6%	6%	34%

[22] The values in this table are based on the most recent Regional Technical Forum draft Standard Protocol Calculator for Non-Residential Lighting improvements: https://rtf.nwcouncil.org/standard-protocol/non-residential-lighting-retrofits version 4.2

Table 2-14 Mandatory Lighting Control Space Types, IECC 2018

Space Type	Occupancy Sensor Exceptions	Time-Switch Control Exceptions
Classrooms/lecture/training rooms	Areas designated as security or emergency areas that are required to be continuously lighted	Spaces where patient care is directly provided
Conference/meeting/multipurpose rooms	Interior exit stairways, interior exit ramps and exit passageways	Spaces where automatic shutoff would endanger occupant safety or security
Copy/print rooms	Emergency egress lighting that is normally off	Lighting intended for continuous operations
Lounges		Shop and laboratory classrooms
Employee lunch and break rooms		
Private offices		
Restrooms		
Storage rooms		
Locker rooms		
Other spaces 300 square feet or less that are enclosed by floor-to-ceiling height partitions		
Warehouses		

Table 2-15 Stipulated Fixture Wattages for Various LED Exit Signs

Fixture Description	***Base*** **Fixture Wattage**	***Installed*** **Fixture Wattage**
LED Exit Sign, 0.5 Watt Lamp, Single Sided	5 W	0.5 W
LED Exit Sign, 1.5 Watt Lamp, Single Sided	5 W	1.5 W
LED Exit Sign, 2 Watt Lamp, Single Sided	5 W	2 W
LED Exit Sign, 0.5 Watt Lamp, Double Sided	10 W	1 W
LED Exit Sign, 1.5 Watt Lamp, Double Sided	10 W	3 W
LED Exit Sign, 2 Watt Lamp, Double Sided	10 W	4 W
Other/Unknown LED	5 W	2 W

2.2. Exterior Lighting Upgrades (New Construction)

The following algorithms and assumptions are applicable to exterior lighting systems installed in commercial and industrial spaces which are more efficient than required by prevailing codes and standards. This measure applies only to projects which represent new construction or major renovations.[23] The following table summarizes the 'typical' expected (per kW reduction) energy impacts for lighting power density improvements and controls additions. Typical values are based on the algorithms and stipulated values described below and data from past program participants.[24]

Table 2-16 Typical Savings Estimates for Exterior LPD Improvement (New Construction)

	Retrofit	New Construction
Deemed Savings Unit	n/a	kW (reduced)
Average Unit Energy Savings	n/a	4,059 kWh
Average Unit Peak Demand Savings	n/a	0 W
Expected Useful Life	n/a	15 Years
Average Material & Labor Cost	n/a	n/a
Average Incremental Cost	n/a	$ 287
Stacking Effect End-Use	n/a	

2.2.1. Definition of Eligible Equipment

All above-code Exterior lighting systems (fixtures, lamps, ballasts, etc.) are eligible. Eligibility is determined by calculating the lighting power density (LPD) for the installed system. If the LPD is at least 15% lower than allowed by code (see Table 2-17 and Table 2-18) then the system is eligible. Efficient equipment may include florescent fixtures, LED lamps, LED exit signs, compact florescent light bulbs, high intensity discharge lamps, etc.

2.2.2. Definition of Baseline Equipment

There are two possible project baseline scenarios – retrofit and new construction. This measure currently only addresses the new construction scenario.

Retrofit (Early Replacement)

n/a

[23] Major renovations are defined to be any renovation or facility expansion project in which building permits were required and the lighting system had to be demonstrated to comply with a particular code or standard.

[24] See spreadsheet "2-TypicalCalcs_ExtLight_v4.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

New Construction (Includes Major Remodel & Replace on Burn-Out)

Baseline equipment for this measure is defined as an installed lighting system with a maximum allowable LPD. The maximum allowable LPD is defined by the building code according to which the project was permitted. Current applicable standards are defined by IECC 2018.2019.

Code Compliance Considerations for Lighting Controls

Sections C405.4 Exterior lighting power requirements specify energy efficiency and lighting power density requirements for non-exempt exterior lighting. Table C405.4.2(2) and C405.4.2(3) list the power density requirements for various building exteriors.

2.2.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta kWh = kWh_{base} - kWh_{meas}$$

$$= A_{SF} * [LPD_{base} - LPD_{meas} * (1 - CSF)\ ] * HOU$$

$$\Delta kW = 0$$

$$kWh/Unit_{Typical} = \Sigma\ (\Delta kWh/Unit_{building\ i} * W_{building\ i})$$

2.2.4. Definitions

ΔkWh	Expected energy savings between baseline and installed equipment.
ΔkW	Expected demand reduction between baseline and installed equipment.
HOU	Stipulated to be 4,059 hours.[25]
LPD	Lighting power density baseline (base) and installed (meas) systems. This is defined as the total lighting system connected load divided by the lighted area (or as defined by code). See Table 2-17 and Table 2-18
$kWh/Unit_{Typical}$	Typical measure savings on a per unit basis.
$W_{building,i}$	Population weight for application type *i*. This is defined to be the % of application type *i* in past program participants.

[25] Value is sourced from https://www.idahopower.com/AboutUs/RatesRegulatory/Tariffs/tariffPDF.cfm?id=39

2.2.5. Sources

2.2.6. IECC 2018, Chapter 4.Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Table 2-17 Baseline Power Densities for Exterior Lighting – Tradable Surfaces[26](IECC 2018)

Area Type	Location	LPD	Units
Uncovered Parking Areas	Parking Lots and Drives	0.08	W/Ft^2
Building Grounds	Walkways less than 10 feet wide	0.7	W/ Linear Foot
	Walkways 10 feet wide or greater	0.14	W/Ft^2
	Dining areas	0.95	W/Ft^2
	Stairways	0.7	W/Ft^2
	Pedestrian tunnels	0.21	W/Ft^2
	Landscaping	0.04	W/Ft^2
Building Entrances and Exits	Pedestrian and vehicular entrances and exits	21	W/ Linear Foot of Door Width
	Entry canopies	0.4	W/Ft^2
	Loading docks	0.35	W/Ft^2
Canopies and Overhangs	Canopies (free standing and attached and overhangs)	0.6	W/Ft^2
Outdoor Sales	Open Areas (including vehicle sales lots)	0.35	W/Ft^2
	Street frontage for vehicle sales lots in addition to "open area" allowance	7	W/ Linear Foot

[26] These values are from Tables C405.4.2(2) in IECC 2018

Table 2-18 Baseline Power Densities for Exterior Lighting – Non-Tradable Surfaces[27] (IECC 2018)

Area Type	LPD
Building Facades	0.15 W/ft² for each illuminated wall or surface or 5.0 W/linear foot for each illuminated wall or surface length
Automated teller machines and night depositories	135 W per location plus 45 W per additional ATM per location
Uncovered entrances and gatehouse inspection stations at guarded facilities	0.5 W/ft² of uncovered area (covered areas are included in the "Canopies and Overhangs" section of "Tradable Surfaces")
Uncovered Loading areas for law enforcement, fire, ambulances and other emergency service vehicles	0.35 W/ft² of uncovered area (covered areas are included in the "Canopies and Overhangs" section of "Tradable Surfaces")
Drive-up windows at fast food restaurants	200 W per drive-through
Parking near 24-hour retail entrances	400 W per main entry

[27] These values are from Tables C405.4.2(3) in IECC 2018

2.3. Efficient Vending Machines

The measure relating to the installation of ENERGY STAR qualified new and rebuilt vending has been deemed standard practice and is no longer offered in the incentive program. Refer to version 2.2 of the Idaho Power TRM for previous assumptions.

2.4. Vending Machine Controls

The measure relating to the installation of new controls on refrigerated beverage vending machines, non-refrigerated snack vending machines, and glass front refrigerated coolers has been deemed standard practice and is no longer offered in the incentive program. Refer to version 2.2 of the Idaho Power TRM for previous assumptions.

2.5. Efficient Washing Machines

This protocol discusses the calculation methodology and the assumptions regarding baseline equipment, efficient equipment, and usage patterns used to estimate annual energy savings expected from the replacement of a standard clothes washer with an ENERGY STAR or high efficiency clothes washer.

Table 2-19 and Table 2-20 summarizes the expected (per machine) energy impacts for this measure assuming an electric dryer. Typical values are based on the algorithms and stipulated values described below.

Table 2-19 Summary Deemed Savings Estimates for Laundromat Efficient Washing Machines[28]

Laundromat	Retrofit	New Construction[29]
Deemed Savings Unit	Machine	Machine
Average Unit Energy Savings	1,579 kWh	1,019 kWh
Average Unit Peak Demand Savings	0.79 kW	0.51 kW
Expected Useful Life	7 Years	7 Years
Average Material & Labor Cost	$ 1,582	n/a
Average Incremental Cost	n/a	$400
Stacking Effect End-Use	n/a	

Table 2-20 Summary Deemed Savings Estimates for Multi-family Efficient Washing Machines[30]

Multi-family	Retrofit	New Construction[31]
Deemed Savings Unit	Machine	Machine
Average Unit Energy Savings	1,161kWh	610 kWh
Average Unit Peak Demand Savings	0.58 kW	0.30 kW
Expected Useful Life	11 Years	11Years
Average Material & Labor Cost	$ 1582	n/a
Average Incremental Cost	n/a	$400
Stacking Effect End-Use	n/a	

2.5.1. Definition of Eligible Equipment

The eligible equipment is clothes washers meeting ENERGY STAR or better efficiency in small commercial applications and can have either electric or gas water heating (DHW) and electric

[28] See spreadsheet "5-TypicalCalcs_EffWshMcn_v4.xlsx" for assumptions and calculations used to estimate the typical unit energy savings, EUL, and incremental costs.

[29] Laundromat new construction deemed savings are based on units with an MEF>2.2

[30] See spreadsheet "5-TypicalCalcs_EffWshMcn_v4.xlsx" for assumptions and calculations used to estimate the typical unit energy savings, EUL, and incremental costs.

[31] Multi-family new construction deemed savings are based on an average of all sizes with electric dryers.

dryers. For all setup combinations, use Table 2-21 and Table 2-22 for savings estimates. Currently, only front-loading clothes washers meet the ENERGY STAR standards.

2.5.2. Definition of Baseline Equipment

Baseline equipment for this measure is determined by the nature of the project. There are two possible scenarios: retrofit (early replacement) or new construction.

Retrofit (Early Replacement)

The retrofit baseline condition is a standard efficiency washing machine.

New Construction (Includes Major Remodel & Replace on Burn-Out)

For new construction the baseline is the Federal efficiency standard MEF ≥1.60 (ft3/kWh/cycle) and WF ≤ 8.5 (gal/ft^3/cycle) for Top Loading washers and MEF ≥2.0 (ft3/kWh/cycle)/ (kWh) and WF ≤ 5.5 (gal/ft^3/cycle) for Front Loading washers. The RTF only designates savings for Front Loading washers.

2.5.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta kWh = \Delta kWh/Unit * N_{Units}$$

$$\Delta kWh/Unit_{Typical} = \sum (\Delta kWh/Unit_i * W_i)$$

$$\Delta kWh/Unit_{i,Intalled} = \Delta kWh_{Dryer} + \Delta kWh_{Water\ heat} + \Delta kWh_{Water\ treatment}$$

$$\Delta kWh_{Water\ heat} = Cap * 0.058 * WF^{1.3593} * C_P * M_{Water} * \Delta T/ (\eta_{Elec} * 3,412) * N_{Cycles}$$

$$\Delta kWh_{Water\ treatment} = Cap * WF * N_{Cycles} * kWh_{aeration}$$

$$\Delta kW = \Delta kW/Unit * N_{Units}$$

$$\Delta kW/Unit_{Typical} = \sum (\Delta kW/Unit_i * UF * W_i)$$

2.5.4. Definitions

Δ kWh	Expected energy savings between baseline and installed equipment.
Δ kW	Demand energy savings between baseline and installed equipment.
Δ kWh/Unit	Per unit energy savings as stipulated in Table 2-21 and Table 2-22. If retrofit and capacity & WF are known, this can be calculated using the equation for $\Delta kWh/Unit_{i,Installed}$ above.
$\Delta kWh/Unit_{Typical}$	Typical measure energy savings on a per unit basis.
$\Delta kWh/Unit_{i,Installed}$	Calculated energy savings on a per unit basis for retrofit projects.

$\Delta kW/Unit$	Per unit demand savings as stipulated in Table 2-21 and Table 2-22.
$\Delta kW/Unit_{Typical}$	Typical measure demand savings on a per unit basis.
W_i	Population weight for each $\Delta kWh/Unit_i$ and $\Delta kW/Unit_i$. Values used are from DOE's Commercial Clothes Washers Final Rule Technical Support Document
UF	Utilization Factor. This is defined to be 0.000499[32]
N_{Units}	Number of Machines
N_{Cycles}	Number of Cycles
Cap	Compartment Capacity of Washer (ft^3)
WF	Manufacturer rated water factor
kWh_{Dryer}	Dryer energy savings from washer lessening remaining moisture content
$\Delta kWh_{Water\ heat}$	Water heating savings from washer using less hot water
$\Delta kWh_{Water\ treatment}$	Energy savings from reduced wastewater aeration
$\Delta kWh_{Aeration}$	Aeration energy usage = 5.3 kWh/1000gal[33]
C_P	Specific Heat of water = 1 Btu/lb-F
M_{Water}	Mass of water = 8.3149 lbs/gallon
ΔT	Delta temperature. This is defined to be 80 (degree F)
η_{Elec}	Electric Water Heating Efficiency = 98%

[32] See spreadsheet "5-TypicalCalcs_EffWshMcn_v4.xlsx" for assumptions and calculations used to estimate the UF.

[33] From Regional Technical Forum measure workbook

2.5.5. Sources

- Regional Technical Forum measure workbook: http://rtf.nwcouncil.org/measures/com/Com ClothesWasher_v5.1
- Department of Energy (DOE) Technical Support Document, 2009: http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/46
- California Energy Commission, appliance list: https://cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx

2.5.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Table 2-21 Unit Energy Savings Efficient Washing Machines - New Construction

Facility Type	Dryer Type	DHW Source Type	Size	kWh/Unit	kW/Unit
Laundromat	Electric Dryer	Electric Hot Water	MEF J2 from 2.00 to 2.19	813	0.41
			MEF J2 of 2.20 or greater	1244	0.62
		Gas Hot Water	MEF J2 from 2.00 to 2.19	482	0.24
			MEF J2 of 2.20 or greater	794	0.40
	Gas Dryer	Electric Hot Water	MEF J2 from 2.00 to 2.19	381	0.19
			MEF J2 of 2.20 or greater	510	0.25
		Gas Hot Water	MEF J2 from 2.00 to 2.19	50	0.03
			MEF J2 of 2.20 or greater	60	0.03
Multifamily	Electric Dryer	Electric Hot Water	MEF J2 from 2.00 to 2.19	595	0.30
			MEF J2 of 2.20 or greater	910	0.45
		Gas Hot Water	MEF J2 from 2.00 to 2.19	353	0.18
			MEF J2 of 2.20 or greater	581	0.29
	Gas Dryer	Electric Hot Water	MEF J2 from 2.00 to 2.19	279	0.14
			MEF J2 of 2.20 or greater	373	0.19
		Gas Hot Water	MEF J2 from 2.00 to 2.19	37	0.02
			MEF J2 of 2.20 or greater	44	0.02

Table 2-22 Unit Energy Savings Efficient Washing Machines - Retrofit

Facility Type	Dryer Type	DHW Source Type	kWh/Unit	kW/Unit
Laundromat	Electric Dryer	Electric Hot Water	1,915	0.96
		Gas Hot Water	1,244	0.62
	Gas Dryer	Electric Hot Water	756	0.38
		Gas Hot Water	85	0.04
Multifamily	Electric Dryer	Electric Hot Water	1,407	0.70
		Gas Hot Water	916	0.46
	Gas Dryer	Electric Hot Water	559	0.28
		Gas Hot Water	68	0.03

Retrofit table does not include savings based on unit size because the CEC database used to create the baseline did not have enough unit types to create a baseline based on the unit size.

2.6. Wall Insulation

The following algorithms and assumptions are applicable to wall insulation installed in commercial spaces which are more efficient than existing insulation or prevailing codes and standards.

Wall insulation is rated by its R-value. An R-value indicates its resistance to heat flow, a higher R-value mean greater insulating effectiveness. The R-value depends on the type of insulation including its material, thickness, and density. When calculating the R-value of a multilayered installation, add the R-values of the individual layers.

Table 2-23 and Table 2-24 summarize the 'typical' expected (per insulation square foot) energy impacts for this measure for *cooling only* and *cooling + heating* impacts respectively. These tables show the average savings for the two scenarios calculated, R-2.5 to R-11 and R-19 for retrofit and R-19 to R-26 and R-30 for new construction. Typical and deemed values are based on the algorithms and stipulated values described below[34]. The typical and deemed values reported in this chapter are based on a weighted average across multiple building types. The cooling savings assume either DX or Hydronic cooling (depending on what is considered 'typical' for that building type) while the heating component assumes DX air-cooled heat pumps.

Table 2-23 Typical Savings Estimates for Wall Insulation (Cooling Only)

	Retrofit	**New Construction**
Deemed Savings Unit	Insulation ft2	Insulation ft2
Average Unit Energy Savings	0.022 kWh	0.001 kWh
Average Unit Peak Demand Savings	0.017 W	0.002 W
Expected Useful Life	25 Years	25 Years
Average Material & Labor Cost	$ 0.74	n/a
Average Incremental Cost	n/a	$ 0.13
Stacking Effect End-Use	HVAC	

[34] See spreadsheet "6-TypicalCalcs_WallInsul_v4.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs for cooling savings.

Table 2-24 Typical Savings Estimates for Wall Insulation (Cooling & Heating)

	Retrofit	New Construction
Deemed Savings Unit	Insulation ft2	Insulation ft2
Average Unit Energy Savings	3.01 kWh	0.130 kWh
Average Unit Peak Demand Savings	2.10 W	0.092 W
Expected Useful Life	25 Years	25 Years
Average Material & Labor Cost	$ 0.74	n/a
Average Incremental Cost	n/a	$ 0.13
Stacking Effect End-Use	HVAC	

2.6.1. Definition of Eligible Equipment

Eligible wall area is limited to the treated wall area of exterior walls (gross wall area, less window and door) where the insulation has been installed to the proposed R-value. Insulation must be installed in buildings, or portions of buildings, with central mechanical air conditioning or PTAC/PTHP systems. Qualifying wall insulation can be rigid foam, fiberglass bat, blown-in fiberglass or cellulose, assuming it meets or exceeds the required R-value. Radiant barriers will not be allowed as a substitute for insulation. The savings estimates for retrofit projects assume the baseline building has no wall insulation (e.g., an empty cavity).

2.6.2. Definition of Baseline Equipment

Baseline equipment for this measure is determined by the nature of the project. There are two possible scenarios: retrofit (early replacement) or new construction. Note that heating savings are only applicable for facilities with electric heating.

Retrofit (Early Replacement)

If the project is retrofitting pre-existing insulation and the project does not represent a major renovation, then the baseline efficiency is defined by the pre-existing insulation.

New Construction (New Construction, Replace on Burnout)

For New Construction, the baseline efficiency is defined as the minimum allowable R-value by the prevailing building energy code or standard according to which the project was permitted. Recently Idaho adopted IECC 2018 as the energy efficiency standard for new construction from the previous standard ASHRAE 90.1-2019. Given the recent adoption the program expects to see participants permitted to either of these standards so stipulated code values for both are provided.

2.6.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta kWh = \Delta kWh_{cool} + \Delta kWh_{heat}$$

$$\Delta kWh_{cool} = A * (CDD * 24)/(SEER * 3412) * (1/R_{base} – 1/R_{meas})$$

$$\Delta kWh_{heat} = A * (HDD * 24)/(HSPF * 3412) * (1/R_{base} – 1/R_{meas})$$

$$\Delta kW_{peak} = \Delta kWh_{cool} / EFLH_{cool} X CF$$

2.6.4. Definitions

A	Area of the insulation that was installed in square feet
HDD	Heating degree days, refer to Table 2-29 for typical heating degree days for different buildings. When possible, actual base temperatures should be used to calculate the HDD
CDD	Cooling degree days refer to Table 2-29 for typical cooling degree days for different buildings. When possible, actual base temperatures should be used to calculate the CDD.
R_{base}	The R-value of the insulation and support structure before the additional insulation is installed
R_{meas}	The total measure R-value of all insulation after the additional insulation is installed
EFLH	Annual equivalent full load cooling hours for the air conditioning unit. Values for various building types are stipulated in Table 2-31. When available, actual system hours of use should be used.
SEER	Seasonal Energy efficiency ratio of the air conditioning unit. This is defined as the ratio of the Annual cooling provided by the air conditioner (in BTUs), to the total electrical input (in Watts). Note that the IEER is an appropriate equivalent. If the SEER or IEER are unknown or unavailable use the following formula to estimate from the EER: [35] $SEER = .0507 * EER^2 + .5773 * EER + .4919$
HSPF	Heating Season Performance Factor. This is identical to the SEER (described above) as applied to Heat Pumps in heating mode. If only the heat pump COP is available, then use the following: $HSPF = .5651 * COP^2 + .464 * COP + .4873$
CF	Peak coincidence factor. Represents the % of the connected load reduction which occurs during Idaho Power's peak period.
$\Delta kWh/Unit_{Retrofit}$	Typical measure savings on a per unit basis.

[35] Note that this formula is an approximation and should only be applied to EER values up to 15 EER.

$\Delta kWh_{New\ Const}$	Savings reflecting the most efficient unit upgrading to the least efficient qualifying unit representing a conservative savings estimate for the measure.

2.6.5. Sources

- ASHRAE, Standard 90.1-2019.
- California DEER Prototypical Simulation models (modified), eQUEST-DEER 3-5.36
- California DEER Effective Useful Life worksheets: EUL_Summary_10-1-08.xls37
- IECC 2018

2.6.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Table 2-25 Deemed Energy Savings for Wall Insulation - Retrofit[38]

	W/ft2	kWh/ft^2	Cost/ft^2
	R-2.5 to R-11		
Cooling	0.016	0.021	$0.64
Heating	1.956	2.82	$0.64
Cooling & Heating	1.973	2.84	$0.64
	R-2.5 to R-19		
Cooling	0.018	0.023	$0.85
Heating	2.199	3.16	$0.85
Cooling & Heating	2.217	3.19	$0.85

[36] Prototypical building energy simulations were used to generate Idaho specific Heating and Cooling Interactive Factors and Coincidence factors for various building and heating fuel types.

[37] After reviewing the sources feeding into the DEER value of 20 years it was found that the 20 year determination was based on a DEER policy for maximum EUL. Since DEER sources supported a higher EUL the higher EUL is used here.

[38] See spreadsheet "6-TypicalCalcs_WallInsul_v4.xlsx" for assumptions and calculations used to estimate the deemed unit energy savings.

Table 2-26 Deemed Energy Savings for Wall Insulation – New Construction[39]

	W/ft2	kWh/ft^2	Cost/ft^2
R-13 to R-19			
Cooling	0.002	0.001	$0.10
Heating	0.076	0.109	$0.10
Cooling & Heating	0.078	0.110	$0.10
R-13 to R-21			
Cooling	0.003	0.001	$0.15
Heating	0.103	0.149	$0.15
Cooling & Heating	0.106	0.150	$0.15

Table 2-27 Wall Insulation: Code Minimum R-values for Nonresidential Buildings in Zone 5[40]

Climate Zone 5	Opaque Element	ASHRAE 90.1 2019 Insulation Min. R-Value	IECC 2018
Walls, Above-Grade	Mass	R-11.4 c.i	R-11.4 c.i
	Metal Building	R-0 + R-19 c.i	R-13 + R-13 c.i
	Steel-Framed	R-13.0 + R-10 c.i	R-13 + R-7.5 c.i
	Wood-Framed and Other	R-13.0 + R-7.5 c.i OR R-19 + R-5 c.i	R-13 + R-3.8 c.i OR R-20
Wall, Below-Grade	Below-Grade Wall	R-7.5 c.i	R-7.5 c.i

[39] See spreadsheet “6-TypicalCalcs_WallInsul_v4.xlsx” for assumptions and calculations used to estimate the deemed unit energy savings.

[40] Values stipulated from Table 5.5-5 ASHRAE 2019. c.i. = continuous insulation, NR = no requirement

Table 2-28 Wall Insulation: Code Minimum R-values for Nonresidential Buildings in Zone 6[41]

Climate Zone 6	Opaque Element	ASHRAE 90.1 2019 Insulation Min. R-Value	IECC 2018
Walls, Above-Grade	Mass	R-13.3 c.i	R-13.3 c.i
	Metal Building	R-0 + R-19 ci	R-13 + R-13 c.i
	Steel-Framed	R-13.0 + R-12.5 c.i	R-13 + R-7.5 c.i
	Wood-Framed and Other	R-13.0 + R-7.5 c.i OR R-19 + R-5 ci	-13 + R-75 c.i OR R-20 + R-3.8 c.i
Wall, Below-Grade	Below-Grade Wall	R-10 c.i	R-7.5 c.i

Table 2-29 Stipulated Heating and Cooling Degree Days by Building Type[42]

	Zone 5		Zone 6	
Building Type	**HDD**	**CDD**	**HDD**	**CDD**
Assembly	5,866	229	7,325	170
Education - Community College	5,866	187	7,325	134
Education - Primary School	5,866	187	7,325	134
Education - Secondary School	5,866	187	7,325	134
Education - University	5,866	187	7,325	134
Grocery	6,329	284	7,809	216
Health/Medical - Hospital	7,628	278	9,169	210
Health/Medical - Nursing Home	7,690	413	9,233	321
Lodging - Hotel	7,690	517	9,233	405
Lodging - Motel	7,690	286	9,233	216
Manufacturing - Light Industrial	5,700	159	7,140	124
Office - Large	6,430	253	7,912	189
Office - Small	5,759	159	7,206	124
Restaurant - Fast-Food	6,901	286	8,407	216
Restaurant - Sit-Down	6,901	286	8,407	216
Retail - 3-Story Large	6,329	284	7,809	216
Retail - Single-Story Large	6,329	284	7,809	216
Retail - Small	6,545	286	8,042	216
Storage - Conditioned	5,700	159	7,140	124

[41] Values stipulated from Table 5.5-6 in ASHRAE 2019. c.i. = continuous insulation, NR = no requirement

[42] Values obtained from simulations of the DEER input models using eQuest to obtain typical baseline temperatures for each building. TMY3 weather data was collected and averaged over the ASHRAE weather Zones 5 and 6 to create heating and cooling degree days using the typical baseline temperatures.

Table 2-30 HVAC Coincidence Factors by Building Type

Building Type	Coincidence Factor
Assembly	0.47
Education - Community College	0.54
Education - Primary School	0.1
Education - Secondary School	0.1
Education - University	0.53
Grocery	0.54
Health/Medical - Hospital	0.82
Health/Medical - Nursing Home	0.49
Lodging - Hotel	0.67
Lodging - Motel	0.63
Manufacturing - Light Industrial	0.46
Office - Large	0.58
Office - Small	0.51
Restaurant - Fast-Food	0.48
Restaurant - Sit-Down	0.46
Retail - 3-Story Large	0.66
Retail - Single-Story Large	0.56
Retail - Small	0.49
Storage - Conditioned	0.41

Table 2-31 Heating and Cooling Equivalent Full Load Hours (EFLH) by Building Type[43]

	Zone 5		Zone 6		Weighted Average[44]	
Building Type	EFLH Cooling	EFLH Heating	EFLH Cooling	EFLH Heating	EFLH Cooling	EFLH Heating
Assembly	879	966	758	1059	855	985
Education - Primary School	203	299	173	408	197	321
Education - Secondary School	230	406	196	514	223	428
Education - Community College	556	326	530	456	551	352
Education - University	697	341	721	449	702	363
Grocery	564	1825	460	2011	544	1862
Health/Medical - Hospital	1616	612	1409	679	1575	625
Health/Medical - Nursing Home	1049	1399	884	1653	1016	1450
Lodging - Hotel	1121	621	1075	780	1112	653
Lodging - Motel	978	682	937	796	970	705
Manufacturing - Light Industrial	530	699	415	1088	507	777
Office - Large	746	204	680	221	733	207
Office - Small	607	256	567	360	599	277
Restaurant - Sit-Down	811	624	716	709	792	641
Restaurant - Fast-Food	850	722	734	796	827	737
Retail - 3-Story Large	765	770	644	998	741	816
Retail - Single-Story Large	724	855	576	998	694	884
Retail - Small	726	886	619	1138	705	936
Storage - Conditioned	335	688	242	989	316	748

[43] Prototypical building energy simulations were used to generate Idaho specific heating and cooling equivalent full load hours for various buildings.

[44] EFLH average values are weighted 80% zone 5 and 20% zone 6.

2.7. Ceiling Insulation

The following algorithms and assumptions are applicable to ceiling insulation installed in commercial spaces which are more efficient than existing insulation or prevailing codes and standards.

Ceiling insulation is rated by its R-value. An R-value indicates its resistance to heat flow (where a higher the R-value indicates a greater insulating effectiveness). The R-value depends on the type of insulation including its material, thickness, and density. When calculating the R-value of a multilayered installation, add the R-values of the individual layers.

Table 2-32 and Table 2-33 summarizes the 'typical' expected (per insulation ft^2 square foot) energy impacts for this measure. Table 2-33 is the average deemed energy savings for all of the specific insulation upgrades cited in Table 2-35 and Table 2-36. Typical and deemed values are based on the algorithms and stipulated values described below. The typical and deemed values reported in this chapter are based on a weighted average across multiple building types. The cooling savings assume either DX or Hydronic cooling (depending on what is considered 'typical' for that building type) while the heating component assumes DX air-cooled heat pumps.

Table 2-32 Typical Savings Estimates for Ceiling Insulation (Cooling Only)[45]

	Retrofit	New Construction
Deemed Savings Unit	Insulation ft2	Insulation ft2
Average Unit Energy Savings	0.003 kWh	0.0003 kWh
Average Unit Peak Demand Savings	.002 W	.0002 W
Expected Useful Life	25 Years	25 Years
Average Material & Labor Cost	$ 1.45	n/a
Average Incremental Cost	n/a	$ 0.20
Stacking Effect End-Use	HVAC	

[45] See spreadsheet "7-TypicalCalcs_CeilingInsul_v4.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs for cooling savings. Note that the reported gas impacts assume that if savings are being claimed for cooling only the facility is gas heated. If the facility is electrically heated then these gas impacts are not applicable and savings should be based on the following table.

Table 2-33 Typical Savings Estimates for Ceiling Insulation (Cooling & Heating)[46]

	Retrofit	New Construction
Deemed Savings Unit	Insulation ft2	Insulation ft2
Average Unit Energy Savings	0.386 kWh	0.044 kWh
Average Unit Peak Demand Savings	0.268 W	0.03 W
Expected Useful Life	25 Years	25 Years
Average Material & Labor Cost	$ 1.45	n/a
Average Incremental Cost	n/a	$ 0.20
Stacking Effect End-Use	HVAC	

Table 2-34 shows the retrofit savings for cooling only and cooling & heating for retrofit averaging only R11 to R38 and R11 to R49 together.

Table 2-34 Typical Savings Estimates for Ceiling Insulation Retrofit from R11 to R38/R49[47]

	Cooling Only	Cooling & Heating
Deemed Savings Unit	Insulation ft2	Insulation ft2
Average Unit Energy Savings	.004 kWh	0.591 kWh
Average Unit Peak Demand Savings	.003 W	.410 W
Expected Useful Life	25 Years	25 Years
Average Material & Labor Cost	$ 1.45	$ 1.45
Average Incremental Cost	n/a	n/a
Stacking Effect End-Use	HVAC	

2.7.1. Definition of Eligible Equipment

Eligible roof/ceiling area is limited to buildings or potions of buildings with central mechanical air conditioning or PTAC systems. Qualifying ceiling insulation can be rigid foam, fiberglass bat, or blown-in fiberglass or cellulose a long as material is eligible, assuming it meets or exceeds the required R-value. The insulation must upgrade from R11 or less to a minimum of R24 or from R19 or less to a minimum of R38.

2.7.2. Definition of Baseline Equipment

Baseline equipment for this measure is determined by the nature of the project. There are two possible scenarios: retrofit (early replacement) or new construction.

Retrofit (Early Replacement)

[46] See spreadsheet “7-TypicalCalcs_CeilingInsul_v4.xlsx” for assumptions and calculations used to estimate the typical unit energy savings and incremental costs for cooling and heating savings.

[47] See spreadsheet “7-TypicalCalcs_CeilingInsul_v4.xlsx” for assumptions and calculations used to estimate the typical unit energy savings and incremental costs for cooling and heating savings.

If the project is retrofitting pre-existing insulation, then the baseline efficiency is defined by the pre-existing insulation.

New Construction (New Construction, Replace on Burnout)

For New Construction, the baseline efficiency is defined as the minimum allowable R-value by the prevailing building energy code or standard according to which the project was permitted. Recently Idaho adopted IECC 2018 as the energy efficiency standard for new construction from the previous standard ASHRAE 90.1-2019. Given the recent adoption the program expects to see participants permitted to either of these standards so stipulated code values for both are provided.

2.7.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta kWh = \Delta kWh_{cool} + \Delta kWh_{heat}$$

$$\Delta kWh_{cool} = A * (CDD * 24)/(SEER * 3412) * (1/R_{base} – 1/R_{meas})$$

$$\Delta kWh_{heat} = A * (HDD * 24)/(HSPF * 3412) * (1/R_{base} – 1/R_{meas})$$

$$\Delta kW_{peak} = \Delta kWh_{cool} / EFLH_{cool} * CF$$

2.7.4. Definitions

A	Area of the insulation that was installed in square feet
HDD	Heating degree days, refer to Table 2-40 for typical heating degree days for different buildings. When possible, actual base temperatures should be used to calculate the HDD
CDD	Cooling degree days refer to Table 2-40 for typical cooling degree days for different buildings. When possible, actual base temperatures should be used to calculate the CDD.
R_{base}	The R-value of the insulation and support structure before the additional insulation is installed
R_{meas}	The total measure R-value of all insulation after the additional insulation is installed
EFLH	Annual equivalent full load cooling hours for the air conditioning unit. Values for various building types are stipulated in Table 2-42. When available, actual system hours of use should be used.
SEER	Seasonal Energy efficiency ratio of the air conditioning unit. This is defined as the ratio of the Annual cooling provided by the air conditioner (in BTUs), to the total electrical input (in Watts). Note that the IEER is an appropriate equivalent. If the SEER or IEER are unknown or unavailable use the following formula to estimate from the EER:

$$SEER^{48} = .0507 * EER^2 + .5773 * EER + .4919$$

HSPF	Heating Season Performance Factor. This is identical to the SEER (described above) as applied to Heat Pumps in heating mode. If only the heat pump COP is available, then use the following: $HSPF = .5651 * COP^2 + .464 * COP + .4873$
CF	Peak coincidence factor. Represents the % of the connected load reduction which occurs during Idaho Power's peak period.
$\Delta kWh/Unit_{Retrofit}$	Typical measure savings on a per unit basis.
$\Delta kWh_{New\ Const}$	Savings reflecting the most efficient unit upgrading to the least efficient qualifying unit representing a conservative savings estimate for the measure.

2.7.5. Sources

- ASHRAE, Standard 90.1-2019.
- California DEER Prototypical Simulation models (modified), eQUEST-DEER 3-5.49
- California DEER Effective Useful Life worksheets: EUL_Summary_10-1-08.xls50
- IECC 2018

2.7.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Table 2-35 Deemed Energy Savings for Ceiling Insulation - Retrofit[51]

Insulation Values	W/ft2			kWh/ft2		
	Cooling	Heating	Cooling & Heating	Cooling	Heating	Cooling & Heating
R-11 to R-24	0.002	0.297	0.299	0.003	0.427	0.430
R-11 to R-38	0.003	0.390	0.392	0.004	0.561	0.565
R-11 to R-49	0.003	0.425	0.428	0.004	0.612	0.616
R-19 to R-38	0.001	0.159	0.160	0.002	0.228	0.230
R-19 to R-49	0.001	0.194	0.196	0.002	0.280	0.282
Weighted:	0.002	0.266	0.268	0.003	0.383	0.386

[48] Note that this formula is an approximation and should only be applied to EER values up to 15 EER.

[49] Prototypical building energy simulations were used to generate Idaho specific Heating and Cooling Interactive Factors and Coincidence factors for various building and heating fuel types.

[50] After reviewing the sources feeding into the DEER value of 20 years it was found that the 20-year determination was based on a DEER policy for maximum EUL. Since DEER sources supported a higher EUL the higher EUL is used here.

[51] See spreadsheet "7-TypicalCalcs_CeilingInsul_v4.xlsx" for assumptions and calculations used to estimate the deemed unit energy savings.

Table 2-36 Deemed Energy Savings for Ceiling Insulation – New Construction[52]

	W/ft2	kWh/ft2
R-38 to R-49		
Cooling	.0002	0.0003
Heating	0.03	0.043
Cooling & Heating	0.030	0.044

Table 2-37 ASHRAE Baseline R–values for Nonresidential Buildings in Zone 5[53]

Zone 5	Nonresidential 2019
Opaque Element	Insulation Min. R-Value
Insulation Entirely Above Deck	R-30.0 c.i.
Metal Building	R-19.0 + R-11 Ls or R-25 + R-8 Ls
Attic and Other	R-49

Table 2-38 ASHRAE Baseline R–values for Nonresidential Buildings in Zone 6[54]

Zone 6	Nonresidential 2019
Opaque Element	Insulation Min. R-Value
Insulation Entirely Above Deck	R-30.0 c.i.
Metal Building	R-25 + R-11 Ls
Attic and Other	R-49

Table 2-39 International Energy Conservation Code 2018 Chapter 4[55]

	Zone 5	Zone 6
Opaque Element	Insulation Min. R-Value	Insulation Min. R-Value
Insulation Entirely Above Deck	R-30 ci	R-30 ci
Metal Building	R-19 + R-11 LS	R-25 + R-11 LS
Attic and Other	R-38	R-49

[52] See spreadsheet "7-TypicalCalcs_CeilingInsul_v4.xlsx" for assumptions and calculations used to estimate the deemed unit energy savings.

[53] Values stipulated from ASHRAE 90.1 2019 Table 5.5-5

[54] Values stipulated from ASHRAE 90.1 2019 Table 5.5-6

[55] Values stipulated from the International Energy Conservation Code 2018 Chapter 4 Table C402.1.4

Table 2-40 Base Heating and Cooling Degree Days by Building Type[56]

	Zone 5		Zone 6	
Building Type	HDD	CDD	HDD	CDD
Assembly	5,866	229	7,325	170
Education - Community College	5,866	187	7,325	134
Education - Primary School	5,866	187	7,325	134
Education - Secondary School	5,866	187	7,325	134
Education - University	5,866	187	7,325	134
Grocery	6,329	284	7,809	216
Health/Medical - Hospital	7,628	278	9,169	210
Health/Medical - Nursing Home	7,690	413	9,233	321
Lodging - Hotel	7,690	517	9,233	405
Lodging - Motel	7,690	286	9,233	216
Manufacturing - Light Industrial	5,700	159	7,140	124
Office - Large	6,430	253	7,912	189
Office - Small	5,759	159	7,206	124
Restaurant - Fast-Food	6,901	286	8,407	216
Restaurant - Sit-Down	6,901	286	8,407	216
Retail - 3-Story Large	6,329	284	7,809	216
Retail - Single-Story Large	6,329	284	7,809	216
Retail - Small	6,545	286	8,042	216
Storage - Conditioned	5,700	159	7,140	124

[56] Values obtained from simulations of the DEER input models using eQuest to obtain typical baseline temperatures for each building. TMY3 weather data was collected and averaged over the ASHRAE weather Zones 5 and 6 to create heating and cooling degree days using the typical baseline temperatures.

Table 2-41 HVAC Coincidence Factors by Building Type

Building Type	Coincidence Factor
Assembly	0.47
Education - Community College	0.54
Education - Primary School	0.10
Education - Secondary School	0.10
Education - University	0.53
Grocery	0.54
Health/Medical - Hospital	0.82
Health/Medical - Nursing Home	0.49
Lodging - Hotel	0.67
Lodging - Motel	0.63
Manufacturing - Light Industrial	0.46
Office - Large	0.58
Office - Small	0.51
Restaurant - Fast-Food	0.48
Restaurant - Sit-Down	0.46
Retail - 3-Story Large	0.66
Retail - Single-Story Large	0.56
Retail - Small	0.49
Storage - Conditioned	0.41

Table 2-42 Stipulated Equivalent Full Load Hours (EFLH) by Building Type[57]

	Zone 5		Zone 6		Weighted values	
Building Type	EFLH Cooling	EFLH Heating	EFLH Cooling	EFLH Heating	EFLH Cooling	EFLH Heating
Assembly	879	966	758	1059	855	985
Education - Primary School	203	299	173	408	197	321
Education - Secondary School	230	406	196	514	223	428
Education - Community College	556	326	530	456	551	352
Education - University	697	341	721	449	702	363
Grocery	564	1825	460	2011	544	1862
Health/Medical - Hospital	1616	612	1409	679	1575	625
Health/Medical - Nursing Home	1049	1399	884	1653	1016	1450
Lodging - Hotel	1121	621	1075	780	1112	653
Lodging - Motel	978	682	937	796	970	705
Manufacturing - Light Industrial	530	699	415	1088	507	777
Office - Large	746	204	680	221	733	207
Office - Small	607	256	567	360	599	277
Restaurant - Sit-Down	811	624	716	709	792	641
Restaurant - Fast-Food	850	722	734	796	827	737
Retail - 3-Story Large	765	770	644	998	741	816
Retail - Single-Story Large	724	855	576	998	694	884
Retail - Small	726	886	619	1138	705	936
Storage - Conditioned	335	688	242	989	316	748

[57] Prototypical building energy simulations were used to generate Idaho specific heating and cooling equivalent full load hours for various buildings.

2.8. Reflective Roof

This section covers installation of “cool roof” roofing materials in commercial buildings. Energy and demand saving are realized through reductions in the building cooling loads. The approach utilizes DOE-2.2 simulations on a series of commercial DEER prototypical building models.

Table 2-43 and Table 2-44 summarize the ‘typical’ expected (per ft^2) e*nergy impacts for this measure.* Typical values are based on the algorithms and stipulated values described below.

Table 2-43 Summary Deemed Savings Estimates for Low-Slope Roof (2:12 or less) Reflective Roof

	Retrofit	New Construction
Deemed Savings Unit	ft^2	ft^2
Average Unit Energy Savings	0.116 kWh	0.116 kWh
Average Unit Peak Demand Savings	0.095 W	0.095 W
Expected Useful Life[58]	15 Years	15 Years
Average Material & Labor Cost[59]	$ 7.84	n/a
Average Incremental Cost[60]	n/a	$ 0.05
Stacking Effect End-Use	HVAC	

Table 2-44 Summary Deemed Savings Estimates for Steep-Slope Roof (>2:12) Reflective Roof

	Retrofit	New Construction
Deemed Savings Unit	ft^2	ft^2
Average Unit Energy Savings	0.021 kWh	0.021 kWh
Average Unit Peak Demand Savings	0.017 W	0.017 W
Expected Useful Life[58]	15 Years	15 Years
Average Material & Labor Cost[59]	$ 7.90	n/a
Average Incremental Cost[60]	n/a	$0.11
Stacking Effect End-Use	HVAC	

2.8.1. Definition of Eligible Equipment

Eligible equipment includes all reflective roofing materials when applied to the roof above a space with central mechanical air conditioning or PTAC systems. The roof treatment must be Energy Star rated or tested through a Cool Roof Rating Council (CRRC) accredited laboratory. For low-slope (2:12 or less) roofs, the roof products must have a solar reflectivity of at least 0.70 and

[58] From 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, “Effective/Remaining Useful Life Values”, California Public Utilities Commission, December 16, 2008

[59] Labor costs from 2005 Database for Energy-Efficiency Resources (DEER), Version 2005.2.01, “Technology and Measure Cost Data”, California Public Utilities Commission, October 26, 2005

[60] Material costs from common roof types found in EPA’s Reducing Urban Heat Islands: Compendium of Strategies: http://www.epa.gov/heatisld/resources/pdf/CoolRoofsCompendium.pdf

thermal emittance of 0.75. For steep slope (greater than 2:12) roofs, minimum solar reflectance is 0.25. Note that facilities with pre-existing cool roofs are not eligible for this measure.

2.8.2. Definition of Baseline Equipment

There are two possible project baseline scenarios – retrofit and new construction.

Retrofit (Early Replacement)

The baseline equipment for retrofit projects is the pre-existing (non-cool roof) roofing material.

New Construction (Includes Major Remodel & Replace on Burn-Out)

The baseline for new construction projects is established by the constructions and materials typically employed for similar new construction buildings and roof constructions. For the purposes of calculating typical energy savings for this measure it is assumed that the baseline roofing material has a reflectance of 0.15.[61]

2.8.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta kWh = \Delta kWh/Unit * A$$

$$\Delta kW = \Delta kW/Unit * A$$

2.8.4. Definitions

ΔkWh	Expected energy savings between baseline and installed equipment.
ΔkW	Expected demand reduction between baseline and installed equipment.
ΔkWh/Unit	Per unit energy savings as stipulated in Table 2-45 and Table 2-46 according to building type and climate zone.
ΔkW/Unit	Per unit demand reduction as stipulated in Table 2-45 and Table 2-46 according to building type and climate zone.
A	Area of cool roofing material installed [ft^2]

2.8.5. Sources

- ASHRAE, Standard 90.1-2019.

[61] Value derived using common roof types performance specifications found in the EPA publication Reducing Urban Heat Islands: Compendium of Strategies: http://www.epa.gov/heatisld/resources/pdf/CoolRoofsCompendium.pdf

- California DEER Prototypical Simulation models, eQUEST-DEER 3-5.62
- ASHRAE. 2006. Weather data for building design standards. ANSI/ASHRAE Standard 169-2006.
- 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study. December 2005
- 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008
- 2005 Database for Energy-Efficiency Resources (DEER), Version 2005.2.01, "Technology and Measure Cost Data", California Public Utilities Commission, October 26, 2005

2.8.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Table 2-45 Unit Energy Savings for Low-Slope (<= 2:12) Reflective Roof[63]

Building Type	Weather Zone 5		Weather Zone 6	
	kWh	W	kWh	W
Primary School	0.082	0.076	0.062	0.059
Secondary School	0.088	0.060	0.052	0.046
Community College	0.392	0.075	0.449	0.068
University	0.148	0.092	0.141	0.083
Hospital	0.086	0.050	0.076	0.052
Nursing Home	0.120	0.096	0.101	0.087
Hotel	0.137	0.054	0.124	0.049
Motel	0.099	0.152	-0.014	0.135
Light Manufacturing	0.078	0.069	0.062	0.062
Small Office	0.102	0.089	0.089	0.083
Large Office	0.202	0.227	0.167	0.183
Full Service Restaurant (Sit-Down)	0.119	0.098	0.092	0.084
Fast Food	0.072	0.046	0.053	0.041
Small Retail	0.117	0.099	0.095	0.084
Large 1-story Retail	0.140	0.112	0.112	0.095
3-story Retail	0.087	0.057	0.098	0.049
Conditioned Storage	0.049	0.051	0.018	0.014

[62] Prototypical building energy simulation models were used to obtain U-Factor and SHGC values for each building type.

[63] See spreadsheet "8-TypicalCalcs_CoolRoof.xlsx" for assumptions and calculations used to estimate the typical unit energy savings.

Table 2-46 Unit Energy Savings for Steep-Slope (> 2:12) Reflective Roof[64]

Building Type	Weather Zone 5		Weather Zone 6	
	kWh	W	kWh	W
Primary School	0.015	0.014	0.012	0.011
Secondary School	0.015	0.012	0.009	0.009
Community College	0.076	0.013	0.071	0.011
University	0.027	0.016	0.021	0.014
Hospital	0.014	0.008	0.013	0.008
Nursing Home	0.022	0.017	0.019	0.016
Hotel	0.026	0.009	0.028	0.008
Motel	0.017	0.026	-0.002	0.024
Light Manufacturing	0.014	0.012	0.011	0.011
Small Office	0.018	0.016	0.016	0.015
Large Office	0.037	0.038	0.032	0.030
Full Service Restaurant (Sit-Down)	0.021	0.017	0.017	0.015
Fast Food	0.013	0.008	0.010	0.007
Small Retail	0.021	0.018	0.017	0.015
Large 1-story Retail	0.025	0.020	0.020	0.017
3-story Retail	0.013	0.011	0.018	0.009
Conditioned Storage	0.010	0.012	0.006	0.005

[64] See spreadsheet “8-TypicalCalcs_CoolRoof.xlsx” for assumptions and calculations used to estimate the typical unit energy savings.

2.9. Efficient Windows

The following algorithm and assumptions are applicable to efficient windows in commercial spaces which provide a lower U-value than existing windows or prevailing codes and standards. Savings will be realized through reductions in the buildings cooling and heating loads. Note that window films and windows with too low an SHGC value can for many buildings increase the heating loads (unless the building has a significant internal load as is the case for example in hospitals and/or data centers). In a heating dominated climate such as Idaho the increase in heating loads can negate any reduction in the cooling loads. Energy impacts for this measure are largely due to the improved U-Value and care should be taken when selecting windows to ensure that the SHGC values are appropriate for the building and climate.

Table 2-47 and Table 2-50 summarize the 'typical' expected (per window ft^2) energy impacts for this measure. Typical values are based on the algorithms and stipulated values described below.[65]

Table 2-47 Typical Savings Estimates for Efficient Windows (Cooling Only)

	Retrofit	**New Construction**
Deemed Savings Unit	ft^2 Window Glass	ft^2 Window Glass
Average Unit Energy Savings	1.50 kWh	n/a
Average Unit Peak Demand Savings	0.62 W	n/a
Average Gas Impacts[66]	0.53 Therms	n/a
Expected Useful Life	25 Years	n/a
Average Material & Labor Cost	$ 20.66	n/a
Average Incremental Cost	n/a	n/a
Stacking Effect End-Use	HVAC	

Table 2-48 Typical Savings Estimates for Efficient Windows (Heating and Cooling)

	Retrofit	**New Construction**
Deemed Savings Unit	ft^2 Window Glass	ft^2 Window Glass
Average Unit Energy Savings	9.13 kWh	n/a
Average Unit Peak Demand Savings	0.44 W	n/a
Expected Useful Life	25 Years	n/a
Average Material & Labor Cost	$ 20.66	n/a
Average Incremental Cost	n/a	n/a
Stacking Effect End-Use	HVAC	

[65] Average unit energy and peak demand cooling savings are based on a weighted average of electric resistance and heat pump savings only. Average unit energy and peak demand cooling savings are based on a weighted average of chiller and dx cooling only. See spreadsheet "9-TypicalCalcs_Windows_v6.xlsx" for additional assumptions and calculations, EUL, and incremental cost.

[66] Note that the reported gas impacts assume that if savings are being claimed for cooling only the facility is gas heated. If the facility is electrically heated then these gas impacts are not applicable and savings should be based on the following table.

Table 2-49 Typical Savings Estimates for Premium Windows (Cooling Only)

	Retrofit	New Construction
Deemed Savings Unit	ft^2 Window Glass	ft^2 Window Glass
Average Unit Energy Savings	2.22 kWh	0.07 kWh
Average Unit Peak Demand Savings	0.62 W	0.10 W
Average Gas Impacts[67]	0.63 Therms	0.48 Therms
Expected Useful Life	25 Years	25 Years
Average Material & Labor Cost	$ 22.08	n/a
Average Incremental Cost	n/a	$ 5.92
Stacking Effect End-Use	HVAC	

Table 2-50 Typical Savings Estimates for Premium Windows (Cooling and Heating)

	Retrofit	New Construction
Deemed Savings Unit	ft^2 Window Glass	ft^2 Window Glass
Average Unit Energy Savings	11.23 kWh	6.93 kWh
Average Unit Peak Demand Savings	0.62 W	0.10 W
Expected Useful Life	25 Years	25 Years
Average Material & Labor Cost	$ 22.08	n/a
Average Incremental Cost	n/a	$ 5.92
Stacking Effect End-Use	HVAC	

2.9.1. Definition of Eligible Equipment

To be considered eligible equipment windows must be independently tested and certified according to the standards established by the National Fenestration Rating Council (NFRC). While the NFRC does provide such testing and certification - any NFRC-licensed independent certification and inspection agency can provide certification. One example of such a body is the American Architectural Manufacturers Association (AAMA). In addition, eligible windows must meet or exceed the following performance ratings:

Efficient Windows:	SHGC = any and U-factor <= 0.42
Premium Windows:	SHGC = any and U-factor <= 0.3

Window films and shades are not eligible under this measure as they reduce the SHGC without providing an appreciable improvement in the U-Value and in many circumstances their addition would result in an increased heating load which negates or exceeds the reduction in cooling loads.

[67] Note that the reported gas impacts assume that if savings are being claimed for cooling only the facility is gas heated. If the facility is electrically heated then these gas impacts are not applicable and savings should be based on the following table.

Retrofit equipment replacement must include replacing the glass and window frame together.

2.9.2. Definition of Baseline Equipment

Baseline equipment for this measure is determined by the nature of the project. There are two possible scenarios: retrofit (early replacement) or new construction.

Retrofit (Early Replacement)

If the project is retrofitting pre-existing equipment than the baseline efficiency is defined by the pre-existing windows.

New Construction (Includes Major Remodel & Replace on Burn-Out)

For new construction, the baseline efficiency is defined as the minimum allowable window performance in the prevailing building energy code or standard to which the project was permitted. Recently Idaho adopted IECC 2018 and ASHRAE 90.1 2019 as the energy efficiency standard for new construction from the previous standards of IECC 2015 and ASHRAE 90.1 2007.

2.9.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta kWh = \Delta kWh_{Heating} + \Delta kWh_{Cooling}$$

$$\Delta kWh_{Heating} = A * ((U_{base} - U_{meas}) * (HDD \times 24) - (SHGC_{base} - SHGC_{meas}) * E_{t,Heating}) / HSPF / 1000$$

$$\Delta kWh_{Cooling} = A * ((U_{base} - U_{meas}) * (CDD \times 24) + (SHGC_{base} - SHGC_{meas}) * E_{t,Cooling}) / SEER / 1000$$

$$\Delta kW_{peak} = A * ((U_{base} - U_{meas}) * \Delta T_{peak} + (SHGC_{base} - SHGC_{meas}) * E_{t,Cooling\ peak}) / EER / 1000 * CF$$

2.9.4. Definitions

ΔkWh	Expected energy savings between baseline and installed equipment.
$\Delta kWh_{Heating/Cooling}$	Non-coincident energy reduction for the *Heating* and *Cooling* end-uses.
A	Total area of the windows being installed in the same orientation.
U_{base}	Coefficient of heat transfer (U-Factor) of the window being replaced.
U_{meas}	Coefficient of heat transfer (U-Factor) of the replacement window installed.
HDD	Heating degree days, refer to Table 2-29 for typical heating degree days for different buildings. When possible, actual base temperatures should be used to calculate the HDD
CDD	Cooling degree days refer to Table 2-29 for typical cooling degree days for different buildings. When possible, actual base temperatures should be used to calculate the CDD.
$SHGC_{base}$	Solar heat gain coefficient of the window being replaced.
$SHGC_{meas}$	Solar heat gain coefficient of the replacement window installed.

$E_{t\ heating}$	Total irradiance for heating found in Table 2-53 and Table 2-54.
$E_{t\ cooling}$	Total irradiance for cooling found in Table 2-53 and Table 2-54.
SEER	Seasonal Energy efficiency ratio of the air conditioning unit. This is defined as the ratio of the Annual cooling provided by the air conditioner (in BTUs), to the total electrical input (in Watts). Note that the IEER is an appropriate equivalent. If the SEER or IEER are unknown or unavailable use the following formula to estimate from the EER: [68] $SEER \approx .0507 * EER^2 + .5773 * EER + .4919$
EER	Energy efficiency ratio of the air conditioning unit. This is defined as the ratio of the cooling capacity of the air conditioner in British Thermal Units per hour, to the total electrical input in watts. Since ASHRAE does not provide EER requirements for air-cooled air conditioners < 65,000 Btu/h, assume the following conversion: $EER \approx -0.02 * SEER^2 + 1.12 * SEER$
HSPF	Heating Season Performance Factor. This is identical to the SEER (described above) as applied to Heat Pumps in heating mode. If only the heat pump COP is available, then use the following: $HSPF = .5651 * COP^2 + .464 * COP + .4873$
ΔkW_{peak}	Expected demand reduction between baseline and installed equipment.
ΔT_{peak}	Difference between indoor and outdoor air temperature during peak periods.
CF	Peak coincidence factor. Represents the % of the connected load reduction which occurs during Idaho Power’s peak period which can be found in Table 2-58

2.9.5. Sources

- IECC 2019
- ASHRAE Fundamentals 2007
- ASHRAE 90.1 2007
- ASHRAE 90.1 2019

2.9.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

[68] Note that this formula is an approximation and should only be applied to EER values up to 15 EER.

Table 2-51 Retrofit Deemed Savings per Sq. Ft.

Orientation	Savings Type	Premium Windows		Efficient Windows	
		kWh/sq. ft.	W/sq. ft.	kWh/sq. ft.	W/sq. ft.
North	Heating	15.87	n/a	12.21	n/a
	Cooling	0.16	0.000	0.12	0.000
	Heating and Cooling	16.02	0.000	12.33	0.000
South	Heating	1.99	n/a	2.95	n/a
	Cooling	3.48	0.001	2.34	0.001
	Heating and Cooling	5.47	0.001	5.29	0.001
West	Heating	10.15	n/a	8.39	n/a
	Cooling	3.21	0.001	2.16	0.001
	Heating and Cooling	13.36	0.001	10.55	0.001
East	Heating	8.01	n/a	6.97	n/a
	Cooling	2.05	0.000	1.38	0.000
	Heating and Cooling	10.06	0.000	8.35	0.000
Average	Heating	9.00	n/a	7.63	n/a
	Cooling	2.22	0.62	1.50	0.44
	Heating and Cooling	11.23	0.62	9.13	0.44

Table 2-52 New Construction Deemed Savings per Sq. Ft.

Orientation	Savings Type	Premium Windows	
		kWh/sq. ft.	*kW/sq. ft.*
North	Heating	6.87	n/a
	Cooling	0.07	0.000
	Heating and Cooling	6.93	0.000
South	Heating	6.87	n/a
	Cooling	0.07	0.000
	Heating and Cooling	6.93	0.000
West	Heating	6.87	n/a
	Cooling	0.07	0.000
	Heating and Cooling	6.93	0.000
East	Heating	6.87	n/a
	Cooling	0.07	0.000
	Heating and Cooling	6.93	0.000
Average	Heating	6.87	n/a
	Cooling	0.07	0.10
	Heating and Cooling	6.93	0.10

Table 2-53 Calculated Heating/Cooling E_{ti} for Zone 5 each Building Type[69]

	South		North		East		West	
Building Type	Heating	Cooling	Heating	Cooling	Heating	Cooling	Heating	Cooling
Assembly	260,105	177,133	0	0	142,974	99,777	116,398	169,977
Community College	200,825	194,884	0	0	108,124	111,238	75,997	183,584
Conditioned Storage	260,105	149,214	0	0	142,974	73,103	116,398	152,829
Fast Food Restaurant	262,047	177,133	0	0	144,369	99,777	118,314	169,977
Full Service Restaurant	274,518	162,841	0	0	154,606	87,595	125,788	160,668
High School	254,575	188,124	0	0	139,313	107,248	112,118	178,031
Hospital	40,575	402,123	0	0	21,586	224,975	7,842	282,306
Hotel	191,629	251,070	0	0	101,745	144,817	70,866	219,282
Large Retail 1 Story	233,102	205,178	0	0	127,168	117,394	96,662	191,023
Large Retail 3 Story	235,662	177,133	0	0	128,424	99,777	97,898	169,977
Large Office	200,825	226,315	0	0	108,124	128,810	75,997	204,378
Light Manufacturing	233,102	200,609	0	0	127,168	113,761	96,662	187,701
Medical Clinic	282,540	160,159	0	0	161,835	84,727	131,473	158,675
Motel	167,419	275,280	0	0	86,070	160,491	57,636	232,512
Multi Family	183,563	200,609	0	0	96,926	113,761	66,061	187,701
Nursing Home	305,929	136,769	0	0	184,449	62,113	145,638	144,510
Primary School	251,624	191,075	0	0	137,733	108,829	109,974	180,174
Small Office	192,687	227,580	0	0	102,380	129,336	71,411	206,160

[69] See spreadsheet "9-TypicalCalcs_Windows_v6.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

Table 2-54 Calculated Heating/Cooling E_{ti} for Zone 6 each Building Type[70]

	South		North		East		West	
Building Type	Heating	Cooling	Heating	Cooling	Heating	Cooling	Heating	Cooling
Assembly	262,986	173,414	0	0	167,824	105,991	107,377	148,196
Community College	193,984	186,789	0	0	107,504	116,779	68,321	156,324
Conditioned Storage	289,002	140,600	0	0	192,527	74,804	122,625	127,893
Fast Food Restaurant	274,343	162,057	0	0	180,165	93,650	114,209	141,364
Full Service Restaurant	289,002	147,398	0	0	192,527	81,289	122,625	132,949
High School	289,002	147,398	0	0	192,527	81,289	122,625	132,949
Hospital	294,217	173,881	0	0	197,428	106,399	126,416	148,883
Hotel	252,573	183,827	0	0	159,558	114,258	100,494	155,080
Large Retail 1 Story	248,700	187,700	0	0	155,902	117,914	98,689	156,885
Large Retail 3 Story	262,986	171,120	0	0	167,824	103,629	107,377	147,068
Large Office	225,978	213,687	0	0	133,520	143,492	85,976	171,490
Light Manufacturing	261,774	174,626	0	0	166,188	107,628	106,217	149,357
Medical Clinic	294,217	142,183	0	0	197,428	76,388	126,416	129,158
Motel	277,829	158,571	0	0	183,925	89,890	115,674	139,900
Multi Family	228,602	142,183	0	0	136,561	76,388	87,526	129,158
Nursing Home	302,373	134,027	0	0	202,521	71,295	132,991	122,582
Primary School	280,394	156,006	0	0	187,079	86,737	117,379	138,195
Small Office	240,556	193,253	0	0	147,531	124,286	94,487	159,873

[70] See spreadsheet “9-TypicalCalcs_Windows_v6.xlsx” for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

Table 2-55 Baseline U-Factor and SHGC for Each Building[71]

Building	U-Factor	North Facing SHGC	Non-North Facing SHGC
Assembly	0.81	0.70	0.65
Education - Primary School	0.81	0.70	0.65
Education - Secondary School	0.81	0.70	0.65
Education - Community College	0.81	0.70	0.64
Education - University	1.04	0.83	0.84
Grocery	0.81	0.71	0.70
Health/Medical - Hospital	0.81	0.70	0.65
Health/Medical - Nursing Home	0.81	0.70	0.64
Lodging - Hotel	0.81	0.70	0.64
Lodging - Motel	0.81	0.70	0.64
Manufacturing - Bio/Tech	0.81	0.71	0.70
Manufacturing - Light Industrial	0.81	0.71	0.70
Office - Large	0.81	0.71	0.70
Office - Small	0.81	0.71	0.70
Restaurant - Sit-Down	0.81	0.71	0.70
Restaurant - Fast-Food	0.81	0.71	0.70
Retail - 3-Story Large	0.81	0.71	0.70
Retail - Single-Story Large	0.81	0.71	0.70
Retail - Small	0.81	0.71	0.70
Storage - Conditioned	0.81	0.71	0.70
Storage - Unconditioned	0.81	0.71	0.70
Warehouse - Refrigerated	0.81	0.71	0.70

Table 2-56 Average Heating/Cooling COP[72]

Heating		Cooling	
Electric Resistance	Heat Pump	Chiller	DX
2.6	3.6	5.1	2.9

[71] See spreadsheet "9-TypicalCalcs_Windows_v6.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

[72] Average COP by heating/cooling type stipulated in ASHRAE 90.1 2019 code baseline efficiencies.

Table 2-57 Stipulated Equivalent Full Load Hours (EFLH) by Building Type[73]

Building Type	Zone 5		Zone 6		Weighted values	
	EFLH Cooling	EFLH Heating	EFLH Cooling	EFLH Heating	EFLH Cooling	EFLH Heating
Assembly	879	966	758	1059	855	985
Education - Primary School	203	299	173	408	197	321
Education - Secondary School	230	406	196	514	223	428
Education - Community College	556	326	530	456	551	352
Education - University	697	341	721	449	702	363
Grocery	564	1825	460	2011	544	1862
Health/Medical - Hospital	1616	612	1409	679	1575	625
Health/Medical - Nursing Home	1049	1399	884	1653	1016	1450
Lodging - Hotel	1121	621	1075	780	1112	653
Lodging - Motel	978	682	937	796	970	705
Manufacturing - Light Industrial	530	699	415	1088	507	777
Office - Large	746	204	680	221	733	207
Office - Small	607	256	567	360	599	277
Restaurant - Sit-Down	811	624	716	709	792	641
Restaurant - Fast-Food	850	722	734	796	827	737
Retail - 3-Story Large	765	770	644	998	741	816
Retail - Single-Story Large	724	855	576	998	694	884
Retail - Small	726	886	619	1138	705	936
Storage - Conditioned	335	688	242	989	316	748

[73] Prototypical building energy simulations were used to generate Idaho specific heating and cooling equivalent full load hours for various buildings.

Table 2-58 HVAC Coincidence Factors by Building Type

Building Type	CF
Assembly	0.47
Education - Community College	0.54
Education - Primary School	0.1
Education - Secondary School	0.1
Education - University	0.53
Grocery	0.54
Health/Medical - Hospital	0.82
Health/Medical - Nursing Home	0.49
Lodging - Hotel	0.67
Lodging - Motel	0.63
Manufacturing - Light Industrial	0.46
Office - Large	0.58
Office - Small	0.51
Restaurant - Fast-Food	0.48
Restaurant - Sit-Down	0.46
Retail - 3-Story Large	0.66
Retail - Single-Story Large	0.56
Retail - Small	0.49
Storage - Conditioned	0.41

2.10. HVAC Controls

This section covers the implementation of HVAC controls in commercial buildings. HVAC controls include economizers, demand controlled ventilation (DCV), and EMS controls. The discussion of eligible equipment provides more detail regarding the individual measures. HVAC controls garner energy savings by optimizing the algorithms by which HVAC equipment are operated. The approach used in this TRM to estimate energy impacts from such measures is based on DOE-2.2 simulations of prototypical commercial building models.[74]

The controls measures included in this chapter do not encompass equipment optimization, retro-commissioning, or commissioning. Such projects are demonstrated to have significant variance in energy impacts and short measure lives (lack of persistence). They are more suitable for a custom approach and are not included in the TRM. Measures of this nature include: temperature set-point and equipment staging optimization, thermostat set-back overrides, and behavioral or maintenance oriented measures.

Table 2-59 though Table 2-65 summarize 'typical' expected (per ton of cooling) energy impacts for this measure. Typical values are based on the algorithms and stipulated values described below.[75]

Table 2-59 Typical Savings Estimates for Air-Side Economizer Only (New and Retrofit[76])

	Retrofit	**New Construction**
Deemed Savings Unit	Ton of cooling	Ton of cooling
Average Unit Energy Savings	279 kWh	197 kWh
Average Unit Peak Demand Savings	.0130 kW	.0059 kW
Average Unit Gas Savings	0 Therms	0 Therms
Expected Useful Life	15 Years	15 Years
Average Material & Labor Cost	\$ 155.01 (New) \$ 73.65 (Repair)	n/a
Average Incremental Cost	n/a	\$81.36
Stacking Effect End-Use	HVAC	

[74] The prototypical building models are sourced from the DEER 2008.

[75] See spreadsheet "10-TypicalCalcs_HVACcntrls_v6.xlsx" to read six HVAC EMS measures for assumptions and calculations used to estimate the typical unit energy savings and incremental costs. Also note that the savings figures represented in these tables give equal weight to the eleven HVAC system types discussed later in this chapter

[76] Retrofit can be repairing an existing economizer or replacing a new one.

Table 2-60 Typical Deemed Savings Estimates for EMS Controls w/1 Strategy Implemented[77]

	Retrofit	**New Construction**
Deemed Savings Unit	Ton of cooling	Ton of cooling
Average Unit Energy Savings	372 kWh	227 kWh
Average Unit Peak Demand Savings	.10 kW	.06 kW
Average Unit Gas Savings	8 Therms	6 Therms
Expected Useful Life	15 Years	15 Years
Average Material & Labor Cost	$198	n/a
Average Incremental Cost	n/a	$162
Stacking Effect End-Use	HVAC	

Table 2-61 Typical Deemed Savings Estimates for EMS Controls w/ 2 Strategies Implemented[78]

	Retrofit	**New Construction**
Deemed Savings Unit	Ton of cooling	Ton of cooling
Average Unit Energy Savings	622 kWh	409 kWh
Average Unit Peak Demand Savings	.10 kW	.07 kW
Average Unit Gas Savings	6 Therms	6 Therms
Expected Useful Life	15 Years	15 Years
Average Material & Labor Cost	$233	n/a
Average Incremental Cost	n/a	$198
Stacking Effect End-Use	HVAC	

[77] Assumes that one (1) control measure is implemented on average.

[78] Assumes that two (2) control measures are implemented on average.

Table 2-62 Typical Deemed Savings Estimates for EMS Controls w/ 3 Strategies Implemented[79]

	Retrofit	New Construction
Deemed Savings Unit	Ton of cooling	Ton of cooling
Average Unit Energy Savings	811 kWh	473 kWh
Average Unit Peak Demand Savings	.13 kW	.07 kW
Average Unit Gas Savings	18 Therms	10 Therms
Expected Useful Life	15 Years	15 Years
Average Material & Labor Cost	$269	n/a
Average Incremental Cost	n/a	$233
Stacking Effect End-Use	HVAC	

Table 2-63 Typical Deemed Savings Estimates for EMS Controls w/ 4 Strategies Implemented[80]

	Retrofit	New Construction
Deemed Savings Unit	Ton of cooling	Ton of cooling
Average Unit Energy Savings	1,728 kWh	567 kWh
Average Unit Peak Demand Savings	.26 kW	.03 kW
Average Unit Gas Savings	96 Therms	21 Therms
Expected Useful Life	15 Years	15 Years
Average Material & Labor Cost	$304	n/a
Average Incremental Cost	n/a	$269
Stacking Effect End-Use	HVAC	

Table 2-64 Typical Deemed Savings Estimates for EMS Controls w/ 5 Strategies Implemented[81]

	Retrofit	New Construction
Deemed Savings Unit	Ton of cooling	Ton of cooling
Average Unit Energy Savings	1,796 kWh	617 kWh
Average Unit Peak Demand Savings	.31 kW	.06 kW
Average Unit Gas Savings	97 Therms	21 Therms
Expected Useful Life	15 Years	15 Years
Average Material & Labor Cost	$340	n/a
Average Incremental Cost	n/a	$304
Stacking Effect End-Use	HVAC	

[79] Assumes that three (3) control measures are implemented on average.

[80] Assumes that four (4) control measures are implemented on average.

[81] Assumes that five (5) control measures are implemented on average.

Table 2-65 Typical Deemed Savings Estimates for EMS Controls w/ 6 Strategies Implemented [82]

	Retrofit	New Construction
Deemed Savings Unit	Ton of cooling	Ton of cooling
Average Unit Energy Savings	1,816 kWh	643 kWh
Average Unit Peak Demand Savings	.32 kW	.08 kW
Average Unit Gas Savings	97 Therms	21 Therms
Expected Useful Life	15 Years	15 Years
Average Material & Labor Cost	$375	n/a
Average Incremental Cost	n/a	$340
Stacking Effect End-Use	HVAC	

2.10.1. Definition of Eligible Equipment

Eligible equipment is based on applicable HVAC system type (note that any building with a system type that isn't included in Table 2-66 should follow a custom path) and appropriately implementing the controls measures listed in Table 2-67. Note that evaporative cooling equipment is not eligible for this measure.

Table 2-66 HVAC System Types

Item	System Type
1	VAV with chilled water coils
2	Packaged Variable Air Volume System (PVAVS)
3	Packaged Variable Air Volume System (PVAVS) Gas Heat
4	Packaged Variable Air Volume System (PVAVS) Electric Reheat
5	Packaged Variable Volume and Temperature (PVVT)
6	Packaged Variable Volume and Temperature (PVVT) Heat Pump
7	Water Source Heat Pump (WSHP)[83]
8	Ground Source Heat Pump (GSHP)[84]
9	Packaged Rooftop Unit / Split System
10	Packaged Rooftop Heat Pump Unit
11	Chilled water coils without VAV units

Note that detailed descriptions for each of the above system types can be found in *ASHRAE Handbook – Systems*. A summary of the system types, their typical configurations, and how

[82] Assumes the six (6) control measures are implemented on average.

[83] Water source heat pumps rely on water as the heat source and sink.

[84] Ground source heat pumps transfer heat to or from the ground. They use the earth as the heat source and sink.

they are modeled in eQuest[85] can be found in *Building Energy Use and Cost Analysis Program Volume 3: Topics*.[86]

Table 2-67 EMS Measures

Item	Measure
1	Optimum Start/Stop
2	Economizer Controls
3	Demand Controlled Ventilation (DCV)
4	Supply Air Reset
5	Chilled Water Reset
6	Condenser Water Reset

Eligibility requirements for each of the control strategies listed above are as follows:

Optimum Start/Stop	The optimum start strategy with restrict unit heating and cooling start times to startup as late as possible to still reach the desired temperature at the specified timeframe. The optimum stop strategy with shut off mechanical heating and cooling before the scheduled unoccupied periods based on internal thermal loads and outside air temperatures. Optimum stop strategy will allow the fan and outdoor air damper to remain open for building ventilation.
Economizer Controls	The economizer is enabled to modulate the outside air intake ventilation based on the outside air enthalpy, dry-bulb temperature or combination of the two to allow for free-cooling when applicable.
Demand Controlled Ventilation (DCV)	The minimum outside air fraction is varied based on a DCV sensor.
Supply Air Reset	The air temperature leaving the system cooling coil is adjusted based on outdoor or zone return air temperature.
Chilled Water Reset	The supply chilled water temperature can rise during low loads.
Condenser Water Reset	The cooling tower temperature floats with the load and wet-bulb temperature

2.10.2. Definition of Baseline Equipment

Baseline equipment for this measure is determined by the nature of the project. There are two possible scenarios: retrofit (early replacement) or new construction.

Retrofit (Early Replacement)

The baseline equipment for retrofit projects is an existing mechanical HVAC system (see list in Table 2-66 for eligible systems) that has not implemented the control strategy (or strategies)

[85] The software package used to simulate energy impacts for this measure.

[86] http://doe2.com/download/DOE-22/DOE22Vol3-Topics.pdf

claimed in the project. See Table 2-67 for a list of eligible control strategies. Note that evaporative cooling equipment is not eligible for this measure.

New Construction (Includes Major Renovations)

The baseline equipment for new construction projects is an HVAC system (see list in Table 2-66 for eligible systems) that meets the local building energy codes and standards. Many of the measures listed in Table 2-67 are required by IECC 2018 except for certain exceptions. These exceptions are reproduced in Appendix B and represent the only cases in which the measures are eligible. Savings for all strategies and building types are calculated assuming the measure qualifies for the exceptions stated in appendix B and are therefore not required by building code.

2.10.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta kWh = \Delta kWh/ton * Cap$$

$$\Delta kW = \Delta kW/ton * Cap$$

2.10.4. Definitions

ΔkWh	Expected energy savings between baseline and installed equipment.
ΔkW	Expected demand reduction between baseline and installed equipment.
ΔkWh/ton	Energy savings on a per unit basis as stipulated in Table 2-68 though Table 2-77.
ΔkW/ton	Demand reduction on a per unit basis as stipulated in Table 2-68 though Table 2-77.
Cap	Capacity (in Tons) of the HVAC system on which the HVAC control(s) are installed.

2.10.5. Sources

- U.S. Bureau of Labor Statistics: http://www.bls.gov/data/inflation_calculator.htm
- Database for Energy Efficiency Resources (DEER) 2008.

2.10.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Table 2-68 Energy Savings for Retrofit EMS Controls Climate Zone 5

# of Measures Implemented	HVAC System Type	kWh/Ton	kW/Ton
1	VAV with chilled water coils	501	0.077
2	VAV with chilled water coils	1,160	0.079
3	VAV with chilled water coils	1,715	0.249
4	VAV with chilled water coils	1,739	0.266
5	VAV with chilled water coils	1,805	0.309
6	VAV with chilled water coils	1,825	0.319
1	Packaged Variable Air Volume System (PVAVS)	353	0.151
2	Packaged Variable Air Volume System (PVAVS)	750	0.153
3	Packaged Variable Air Volume System (PVAVS)	790	0.168
4	Packaged Variable Air Volume System (PVAVS)	n/a	n/a
5	Packaged Variable Air Volume System (PVAVS)	n/a	n/a
6	Packaged Variable Air Volume System (PVAVS)	n/a	n/a
1	Packaged Variable Air Volume System (PVAVS) Gas Heat	221	0.100
2	Packaged Variable Air Volume System (PVAVS) Gas Heat	341	0.100
3	Packaged Variable Air Volume System (PVAVS) Gas Heat	329	0.108
4	Packaged Variable Air Volume System (PVAVS) Gas Heat	n/a	n/a
5	Packaged Variable Air Volume System (PVAVS) Gas Heat	n/a	n/a
6	Packaged Variable Air Volume System (PVAVS) Gas Heat	n/a	n/a
1	Packaged Variable Air Volume System (PVAVS) Electric Reheat	942	0.098
2	Packaged Variable Air Volume System (PVAVS) Electric Reheat	1,050	0.100
3	Packaged Variable Air Volume System (PVAVS) Electric Reheat	1,601	0.106
4	Packaged Variable Air Volume System (PVAVS) Electric Reheat	n/a	n/a
5	Packaged Variable Air Volume System (PVAVS) Electric Reheat	n/a	n/a
6	Packaged Variable Air Volume System (PVAVS) Electric Reheat	n/a	n/a
1	Packaged Variable Volume and Temperature (PVVT)	219	0.102
2	Packaged Variable Volume and Temperature (PVVT)	407	0.104
3	Packaged Variable Volume and Temperature (PVVT)	411	0.114
4	Packaged Variable Volume and Temperature (PVVT)	n/a	n/a
5	Packaged Variable Volume and Temperature (PVVT)	n/a	n/a
6	Packaged Variable Volume and Temperature (PVVT)	n/a	n/a
1	Packaged Variable Volume and Temperature (PVVT) Heat Pump	372	0.103

# of Measures Implemented	HVAC System Type	kWh/Ton	kW/Ton
2	Packaged Variable Volume and Temperature (PVVT) Heat Pump	560	0.105
3	Packaged Variable Volume and Temperature (PVVT) Heat Pump	677	0.114
4	Packaged Variable Volume and Temperature (PVVT) Heat Pump	n/a	n/a
5	Packaged Variable Volume and Temperature (PVVT) Heat Pump	n/a	n/a
6	Packaged Variable Volume and Temperature (PVVT) Heat Pump	n/a	n/a
1	Water Source Heat Pump (WSHP)	251	0.101
2	Water Source Heat Pump (WSHP)	494	0.103
3	Water Source Heat Pump (WSHP)	552	0.113
4	Water Source Heat Pump (WSHP)	n/a	n/a
5	Water Source Heat Pump (WSHP)	n/a	n/a
6	Water Source Heat Pump (WSHP)	n/a	n/a
1	Ground Source Heat Pump (GSHP)	247	0.079
2	Ground Source Heat Pump (GSHP)	422	0.083
3	Ground Source Heat Pump (GSHP)	483	0.088
4	Ground Source Heat Pump (GSHP)	n/a	n/a
5	Ground Source Heat Pump (GSHP)	n/a	n/a
6	Ground Source Heat Pump (GSHP)	n/a	n/a
1	Packaged Rooftop Unit / Split System	227	0.114
2	Packaged Rooftop Unit / Split System	464	0.116
3	Packaged Rooftop Unit / Split System	n/a	n/a
4	Packaged Rooftop Unit / Split System	n/a	n/a
5	Packaged Rooftop Unit / Split System	n/a	n/a
6	Packaged Rooftop Unit / Split System	n/a	n/a
1	Packaged Rooftop Heat Pump Unit	391	0.114
2	Packaged Rooftop Heat Pump Unit	610	0.116
3	Packaged Rooftop Heat Pump Unit	739	0.122
4	Packaged Rooftop Heat Pump Unit	n/a	n/a
5	Packaged Rooftop Heat Pump Unit	n/a	n/a
6	Packaged Rooftop Heat Pump Unit	n/a	n/a

Table 2-69 Energy Savings for New Construction EMS Controls Climate Zone 5

# of Measures Implemented	HVAC System Type	kWh/Ton	kW/Ton
1	VAV with chilled water coils	163	0.011
2	VAV with chilled water coils	536	0.013
3	VAV with chilled water coils	565	0.026
4	VAV with chilled water coils	568	0.026
5	VAV with chilled water coils	618	0.063
6	VAV with chilled water coils	644	0.075
1	Packaged Variable Air Volume System (PVAVS)	225	0.096
2	Packaged Variable Air Volume System (PVAVS)	530	0.098
3	Packaged Variable Air Volume System (PVAVS)	578	0.113
4	Packaged Variable Air Volume System (PVAVS)	n/a	n/a
5	Packaged Variable Air Volume System (PVAVS)	n/a	n/a
6	Packaged Variable Air Volume System (PVAVS)	n/a	n/a
1	Packaged Variable Air Volume System (PVAVS) Gas Heat	174	0.066
2	Packaged Variable Air Volume System (PVAVS) Gas Heat	276	0.067
3	Packaged Variable Air Volume System (PVAVS) Gas Heat	169	0.077
4	Packaged Variable Air Volume System (PVAVS) Gas Heat	n/a	n/a
5	Packaged Variable Air Volume System (PVAVS) Gas Heat	n/a	n/a
6	Packaged Variable Air Volume System (PVAVS) Gas Heat	n/a	n/a
1	Packaged Variable Air Volume System (PVAVS) Electric Reheat	457	0.066
2	Packaged Variable Air Volume System (PVAVS) Electric Reheat	556	0.067
3	Packaged Variable Air Volume System (PVAVS) Electric Reheat	757	0.066
4	Packaged Variable Air Volume System (PVAVS) Electric Reheat	n/a	n/a
5	Packaged Variable Air Volume System (PVAVS) Electric Reheat	n/a	n/a
6	Packaged Variable Air Volume System (PVAVS) Electric Reheat	n/a	n/a
1	Packaged Variable Volume and Temperature (PVVT)	134	0.070
2	Packaged Variable Volume and Temperature (PVVT)	299	0.072
3	Packaged Variable Volume and Temperature (PVVT)	303	0.083
4	Packaged Variable Volume and Temperature (PVVT)	n/a	n/a
5	Packaged Variable Volume and Temperature (PVVT)	n/a	n/a
6	Packaged Variable Volume and Temperature (PVVT)	n/a	n/a
1	Packaged Variable Volume and Temperature (PVVT) Heat Pump	265	0.071
2	Packaged Variable Volume and Temperature (PVVT) Heat Pump	430	0.072
3	Packaged Variable Volume and Temperature (PVVT) Heat Pump	545	0.084
4	Packaged Variable Volume and Temperature (PVVT) Heat Pump	n/a	n/a
5	Packaged Variable Volume and Temperature (PVVT) Heat Pump	n/a	n/a
6	Packaged Variable Volume and Temperature (PVVT) Heat Pump	n/a	n/a
1	Water Source Heat Pump (WSHP)	151	0.011

# of Measures Implemented	HVAC System Type	kWh/Ton	kW/Ton
2	Water Source Heat Pump (WSHP)	312	0.012
3	Water Source Heat Pump (WSHP)	371	0.023
4	Water Source Heat Pump (WSHP)	n/a	n/a
5	Water Source Heat Pump (WSHP)	n/a	n/a
6	Water Source Heat Pump (WSHP)	n/a	n/a
1	Ground Source Heat Pump (GSHP)	164	0.055
2	Ground Source Heat Pump (GSHP)	283	0.055
3	Ground Source Heat Pump (GSHP)	340	0.061
4	Ground Source Heat Pump (GSHP)	n/a	n/a
5	Ground Source Heat Pump (GSHP)	n/a	n/a
6	Ground Source Heat Pump (GSHP)	n/a	n/a
1	Packaged Rooftop Unit / Split System	186	0.096
2	Packaged Rooftop Unit / Split System	371	0.097
3	Packaged Rooftop Unit / Split System	n/a	n/a
4	Packaged Rooftop Unit / Split System	n/a	n/a
5	Packaged Rooftop Unit / Split System	n/a	n/a
6	Packaged Rooftop Unit / Split System	n/a	n/a
1	Packaged Rooftop Heat Pump Unit	349	0.096
2	Packaged Rooftop Heat Pump Unit	535	0.098
3	Packaged Rooftop Heat Pump Unit	638	0.103
4	Packaged Rooftop Heat Pump Unit	n/a	n/a
5	Packaged Rooftop Heat Pump Unit	n/a	n/a
6	Packaged Rooftop Heat Pump Unit	n/a	n/a

Table 2-70 Energy Savings for Retrofit EMS Controls Climate Zone 6

# of Measures Implemented	HVAC System Type	kWh/Ton	kW/Ton
1	VAV with chilled water coils	490	0.074
2	VAV with chilled water coils	1,182	0.083
3	VAV with chilled water coils	1,765	0.263
4	VAV with chilled water coils	1,685	0.253
5	VAV with chilled water coils	1,761	0.295
6	VAV with chilled water coils	1,781	0.305
1	Packaged Variable Air Volume System (PVAVS)	307	0.127
2	Packaged Variable Air Volume System (PVAVS)	660	0.134
3	Packaged Variable Air Volume System (PVAVS)	730	0.147
4	Packaged Variable Air Volume System (PVAVS)	n/a	n/a
5	Packaged Variable Air Volume System (PVAVS)	n/a	n/a
6	Packaged Variable Air Volume System (PVAVS)	n/a	n/a
1	Packaged Variable Air Volume System (PVAVS) Gas Heat	204	0.076
2	Packaged Variable Air Volume System (PVAVS) Gas Heat	301	0.081
3	Packaged Variable Air Volume System (PVAVS) Gas Heat	264	0.087
4	Packaged Variable Air Volume System (PVAVS) Gas Heat	n/a	n/a
5	Packaged Variable Air Volume System (PVAVS) Gas Heat	n/a	n/a
6	Packaged Variable Air Volume System (PVAVS) Gas Heat	n/a	n/a
1	Packaged Variable Air Volume System (PVAVS) Electric Reheat	1,025	0.083
2	Packaged Variable Air Volume System (PVAVS) Electric Reheat	1,114	0.088
3	Packaged Variable Air Volume System (PVAVS) Electric Reheat	1,622	0.090
4	Packaged Variable Air Volume System (PVAVS) Electric Reheat	n/a	n/a
5	Packaged Variable Air Volume System (PVAVS) Electric Reheat	n/a	n/a
6	Packaged Variable Air Volume System (PVAVS) Electric Reheat	n/a	n/a
1	Packaged Variable Volume and Temperature (PVVT)	198	0.080
2	Packaged Variable Volume and Temperature (PVVT)	364	0.096
3	Packaged Variable Volume and Temperature (PVVT)	367	0.104
4	Packaged Variable Volume and Temperature (PVVT)	n/a	n/a
5	Packaged Variable Volume and Temperature (PVVT)	n/a	n/a
6	Packaged Variable Volume and Temperature (PVVT)	n/a	n/a
1	Packaged Variable Volume and Temperature (PVVT) Heat Pump	420	0.080
2	Packaged Variable Volume and Temperature (PVVT) Heat Pump	587	0.096
3	Packaged Variable Volume and Temperature (PVVT) Heat Pump	750	0.104
4	Packaged Variable Volume and Temperature (PVVT) Heat Pump	n/a	n/a
5	Packaged Variable Volume and Temperature (PVVT) Heat Pump	n/a	n/a

# of Measures Implemented	HVAC System Type	kWh/Ton	kW/Ton
6	Packaged Variable Volume and Temperature (PVVT) Heat Pump	n/a	n/a
1	Water Source Heat Pump (WSHP)	244	0.080
2	Water Source Heat Pump (WSHP)	466	0.096
3	Water Source Heat Pump (WSHP)	542	0.100
4	Water Source Heat Pump (WSHP)	n/a	n/a
5	Water Source Heat Pump (WSHP)	n/a	n/a
6	Water Source Heat Pump (WSHP)	n/a	n/a
1	Ground Source Heat Pump (GSHP)	254	0.067
2	Ground Source Heat Pump (GSHP)	410	0.078
3	Ground Source Heat Pump (GSHP)	488	0.080
4	Ground Source Heat Pump (GSHP)	n/a	n/a
5	Ground Source Heat Pump (GSHP)	n/a	n/a
6	Ground Source Heat Pump (GSHP)	n/a	n/a
1	Packaged Rooftop Unit / Split System	185	0.089
2	Packaged Rooftop Unit / Split System	406	0.106
3	Packaged Rooftop Unit / Split System	n/a	n/a
4	Packaged Rooftop Unit / Split System	n/a	n/a
5	Packaged Rooftop Unit / Split System	n/a	n/a
6	Packaged Rooftop Unit / Split System	n/a	n/a
1	Packaged Rooftop Heat Pump Unit	376	0.089
2	Packaged Rooftop Heat Pump Unit	599	0.106
3	Packaged Rooftop Heat Pump Unit	789	0.108
4	Packaged Rooftop Heat Pump Unit	n/a	n/a
5	Packaged Rooftop Heat Pump Unit	n/a	n/a
6	Packaged Rooftop Heat Pump Unit	n/a	n/a

Table 2-71 Energy Savings for New Construction EMS Controls Climate Zone 6

# of Measures Implemented	HVAC System Type	kWh/Ton	kW/Ton
1	VAV with chilled water coils	162	0.014
2	VAV with chilled water coils	537	0.018
3	VAV with chilled water coils	560	0.027
4	VAV with chilled water coils	563	0.027
5	VAV with chilled water coils	612	0.065
6	VAV with chilled water coils	639	0.079
1	Packaged Variable Air Volume System (PVAVS)	201	0.081
2	Packaged Variable Air Volume System (PVAVS)	468	0.087
3	Packaged Variable Air Volume System (PVAVS)	563	0.099
4	Packaged Variable Air Volume System (PVAVS)	n/a	n/a
5	Packaged Variable Air Volume System (PVAVS)	n/a	n/a
6	Packaged Variable Air Volume System (PVAVS)	n/a	n/a
1	Packaged Variable Air Volume System (PVAVS) Gas Heat	160	0.056
2	Packaged Variable Air Volume System (PVAVS) Gas Heat	241	0.060
3	Packaged Variable Air Volume System (PVAVS) Gas Heat	108	0.067
4	Packaged Variable Air Volume System (PVAVS) Gas Heat	n/a	n/a
5	Packaged Variable Air Volume System (PVAVS) Gas Heat	n/a	n/a
6	Packaged Variable Air Volume System (PVAVS) Gas Heat	n/a	n/a
1	Packaged Variable Air Volume System (PVAVS) Electric Reheat	494	0.056
2	Packaged Variable Air Volume System (PVAVS) Electric Reheat	573	0.060
3	Packaged Variable Air Volume System (PVAVS) Electric Reheat	753	0.055
4	Packaged Variable Air Volume System (PVAVS) Electric Reheat	n/a	n/a
5	Packaged Variable Air Volume System (PVAVS) Electric Reheat	n/a	n/a
6	Packaged Variable Air Volume System (PVAVS) Electric Reheat	n/a	n/a
1	Packaged Variable Volume and Temperature (PVVT)	122	0.057
2	Packaged Variable Volume and Temperature (PVVT)	263	0.070
3	Packaged Variable Volume and Temperature (PVVT)	266	0.078
4	Packaged Variable Volume and Temperature (PVVT)	n/a	n/a
5	Packaged Variable Volume and Temperature (PVVT)	n/a	n/a
6	Packaged Variable Volume and Temperature (PVVT)	n/a	n/a
1	Packaged Variable Volume and Temperature (PVVT) Heat Pump	292	0.057
2	Packaged Variable Volume and Temperature (PVVT) Heat Pump	433	0.070
3	Packaged Variable Volume and Temperature (PVVT) Heat Pump	592	0.078
4	Packaged Variable Volume and Temperature (PVVT) Heat Pump	n/a	n/a
5	Packaged Variable Volume and Temperature (PVVT) Heat Pump	n/a	n/a
6	Packaged Variable Volume and Temperature (PVVT) Heat Pump	n/a	n/a
1	Water Source Heat Pump (WSHP)	166	0.109

# of Measures Implemented	HVAC System Type	kWh/Ton	kW/Ton
2	Water Source Heat Pump (WSHP)	307	0.119
3	Water Source Heat Pump (WSHP)	381	0.126
4	Water Source Heat Pump (WSHP)	n/a	n/a
5	Water Source Heat Pump (WSHP)	n/a	n/a
6	Water Source Heat Pump (WSHP)	n/a	n/a
1	Ground Source Heat Pump (GSHP)	170	0.045
2	Ground Source Heat Pump (GSHP)	273	0.052
3	Ground Source Heat Pump (GSHP)	342	0.055
4	Ground Source Heat Pump (GSHP)	n/a	n/a
5	Ground Source Heat Pump (GSHP)	n/a	n/a
6	Ground Source Heat Pump (GSHP)	n/a	n/a
1	Packaged Rooftop Unit / Split System	168	0.075
2	Packaged Rooftop Unit / Split System	334	0.088
3	Packaged Rooftop Unit / Split System	n/a	n/a
4	Packaged Rooftop Unit / Split System	n/a	n/a
5	Packaged Rooftop Unit / Split System	n/a	n/a
6	Packaged Rooftop Unit / Split System	n/a	n/a
1	Packaged Rooftop Heat Pump Unit	339	0.075
2	Packaged Rooftop Heat Pump Unit	504	0.088
3	Packaged Rooftop Heat Pump Unit	674	0.091
4	Packaged Rooftop Heat Pump Unit	n/a	n/a
5	Packaged Rooftop Heat Pump Unit	n/a	n/a
6	Packaged Rooftop Heat Pump Unit	n/a	n/a

Table 2-72 Energy Savings for Retrofit Economizer Controls Only Climate Zone 5

HVAC System Type	kWh/Ton	kW/Ton
VAV with chilled water coils	836	0.0030
Packaged Variable Air Volume System (PVAVS)	450	0.0020
Packaged Variable Air Volume System (PVAVS) Gas Heat	130	0.0020
Packaged Variable Air Volume System (PVAVS) Electric Reheat	122	0.0020
Packaged Variable Volume and Temperature (PVVT)	203	0.0049
Packaged Variable Volume and Temperature (PVVT) Heat Pump	203	0.0049
Water Source Heat Pump (WSHP)	272	0.0059
Ground Source Heat Pump (GSHP)	197	0.0059
Packaged Rooftop Unit / Split System	260	0.0906
Packaged Rooftop Heat Pump Unit	261	0.0054

Table 2-73 Energy Savings for New Construction Economizer Controls Only Climate Zone 5

HVAC System Type	kWh/Ton	kW/Ton
VAV with chilled water coils	437	0.0013
Packaged Variable Air Volume System (PVAVS)	344	0.0020
Packaged Variable Air Volume System (PVAVS) Gas Heat	112	0.0020
Packaged Variable Air Volume System (PVAVS) Electric Reheat	106	0.0020
Packaged Variable Volume and Temperature (PVVT)	167	0.0039
Packaged Variable Volume and Temperature (PVVT) Heat Pump	167	0.0039
Water Source Heat Pump (WSHP)	166	0.0059
Ground Source Heat Pump (GSHP)	131	0.0020
Packaged Rooftop Unit / Split System	189	0.0044
Packaged Rooftop Heat Pump Unit	190	0.0044

Table 2-74 Energy Savings for Retrofit Economizer Controls Only Climate Zone 6

HVAC System Type	kWh/Ton	kW/Ton
VAV with chilled water coils	878	0.0119
Packaged Variable Air Volume System (PVAVS)	404	0.0068
Packaged Variable Air Volume System (PVAVS) Gas Heat	107	0.0068
Packaged Variable Air Volume System (PVAVS) Electric Reheat	101	0.0059
Packaged Variable Volume and Temperature (PVVT)	179	0.0185
Packaged Variable Volume and Temperature (PVVT) Heat Pump	179	0.0185
Water Source Heat Pump (WSHP)	247	0.0205
Ground Source Heat Pump (GSHP)	174	0.0146
Packaged Rooftop Unit / Split System	240	0.0202
Packaged Rooftop Heat Pump Unit	240	0.0202

Table 2-75 Energy Savings for New Construction Economizer Controls Only Climate Zone 6

HVAC System Type	kWh/Ton	kW/Ton
VAV with chilled water coils	441	0.0040
Packaged Variable Air Volume System (PVAVS)	304	0.0068
Packaged Variable Air Volume System (PVAVS) Gas Heat	93	0.0059
Packaged Variable Air Volume System (PVAVS) Electric Reheat	88	0.0059
Packaged Variable Volume and Temperature (PVVT)	144	0.0156
Packaged Variable Volume and Temperature (PVVT) Heat Pump	144	0.0156
Water Source Heat Pump (WSHP)	161	0.0702
Ground Source Heat Pump (GSHP)	114	0.0088
Packaged Rooftop Unit / Split System	169	0.0161
Packaged Rooftop Heat Pump Unit	169	0.0161

Table 2-76 Energy Savings for Retrofit DCV Only Climate Zone 6

HVAC System Type	kWh/Ton	W/Ton
VAV with chilled water coils	1,087.93	230.743
Packaged Variable Air Volume System (PVAVS)	85.82	23.336
Packaged Variable Air Volume System (PVAVS) Gas Heat	-59.24	7.306
Packaged Variable Air Volume System (PVAVS) Electric Reheat	813.65	-4.160
Packaged Variable Volume and Temperature (PVVT)	1.69	7.238
Packaged Variable Volume and Temperature (PVVT) Heat Pump	310.27	7.162
Water Source Heat Pump (WSHP)	362.76	20.808
Ground Source Heat Pump (GSHP)	283.42	11.174
Packaged Rooftop Unit / Split System	-37.77	1.807
Packaged Rooftop Heat Pump Unit	368.07	1.614

Table 2-77 Unit Energy Savings for New Construction DCV Only Climate Zone 6

HVAC System Type	kWh/Ton	W/Ton
VAV with chilled water coils	17.85	11.096
Packaged Variable Air Volume System (PVAVS)	111.17	20.412
Packaged Variable Air Volume System (PVAVS) Gas Heat	-231.17	7.282
Packaged Variable Air Volume System (PVAVS) Electric Reheat	344.25	-4.160
Packaged Variable Volume and Temperature (PVVT)	1.38	6.654
Packaged Variable Volume and Temperature (PVVT) Heat Pump	286.08	6.685
Water Source Heat Pump (WSHP)	275.05	74.587
Ground Source Heat Pump (GSHP)	216.50	10.118
Packaged Rooftop Unit / Split System	-36.97	1.739
Packaged Rooftop Heat Pump Unit	374.14	1.620

2.11. Hotel/Motel Guestroom Energy Management Systems

The following algorithms and assumptions are applicable to occupancy based Guest Room Energy Management Systems (GREM) installed in motel and hotel guest rooms. These systems use one or more methods to determine whether the guest room is occupied. If the room is un-occupied for a predetermined amount of time (typically 15 - 30 min) the thermostat set-point is set-back.

Table 2-78 through Table 2-80 summarize the 'typical' expected (per Ton) energy impacts for this measure. Typical values are based on the algorithms and stipulated values described below and data from past program participants.[87]

Table 2-78 Typical Savings Estimates for GREM (w/o Housekeeping Set-Backs)

	Retrofit	**New Construction** IECC 2018
Deemed Savings Unit	Unit	Unit
Average Unit Energy Savings	1,063 kWh	917 kWh
Average Unit Peak Demand Savings	0 kW	0 kW
Expected Useful Life	11 Years	11 Years
Average Material & Labor Cost	$150.61	n/a
Average Incremental Cost	n/a	$57.50
Stacking Effect End-Use	HVAC	

Table 2-79 Typical Savings Estimates for GREM (With Housekeeping Set-Backs)

	Retrofit	**New Construction** IECC 2018
Deemed Savings Unit	Unit	Unit
Average Unit Energy Savings	223 kWh	183 kWh
Average Unit Peak Demand Savings	0 kW	0 kW
Expected Useful Life	11 Years	11 Years
Average Material & Labor Cost	$150.61	n/a
Average Incremental Cost	n/a	$57.50
Stacking Effect End-Use	HVAC	

[87] See spreadsheet "11-TypicalCalcs_GREM_v4xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs. Note that due to the limited savings available for gas heated facilities the numbers in these tables account only for electric heating fuel system types (e.g. heat-pumps and electric resistance coils).

Table 2-80 Typical Savings Estimates for GREM (Average)[88]

	Retrofit	New Construction IECC 2018
Deemed Savings Unit	Unit	Unit
Average Unit Energy Savings	643 kWh	550 kWh
Average Unit Peak Demand Savings	0 kW	0 kW
Expected Useful Life	11 Years	11 Years
Average Material & Labor Cost	$150.61	n/a
Average Incremental Cost	n/a	$57.50
Stacking Effect End-Use	HVAC	

2.11.1. Definition of Eligible Equipment

Eligible systems include any occupancy based thermostatic set-back controls controlling an electrically heated system. Systems can be centralized or local controls. Systems must set-back room space temperatures by a minimum of 8 degrees F when the room is determined to be unoccupied. Temperature set-back must occur no longer than 30 minutes after the room is determined unoccupied. Eligible systems include, thermostat based controls, room key-card controls, and system check-in/check-out controls.

2.11.2. Definition of Baseline Equipment

There are two possible project baseline scenarios – retrofit and new construction. However, there are currently no building energy code requirements (as defined in ASHRAE 90.1) which mandate installation of Guestroom Occupancy Control Systems. As such the baseline for retrofit and new construction projects only differ in the efficiency of the existing HVAC systems and building envelope.

Retrofit (Early Replacement)

Baseline equipment for this measure is defined as a non-occupant based room thermostat (either manual or programmable) installed in the existing room.

New Construction (Includes Major Remodel)

Baseline equipment for this measure is defined as a non-occupant based room thermostat (either manual or programmable) installed in the designed room.

2.11.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

[88] The savings represented in this table give equal weight to the two prevailing baseline conditions (e.g. with and without a housekeeping set-back).

$$\Delta kWh = kWh/Unit * NUnits$$

$$\Delta kWhUnit_{typical} = \Sigma(\Delta kWh/Unit_i * W_i)$$

2.11.4. Definitions

ΔkWh	Expected energy savings between baseline and installed equipment.
ΔkWh/Unit	Per unit energy savings as stipulated in Table 2-81 through Table 2-82 according to case temperatures.
$\Delta kWh/Unit_{typical}$	Typical measure savings on a per unit basis.
$\Delta kWh/Unit_i$	Unit savings for combination i of building type (Hotel or Motel), housekeeping practices, weather zone, and heating fuel source.
W_i	Population weight for each ΔkWh/Unit. Calculated by dividing the expected number of participants with ΔkWh/Uniti by the total number of expected participants.

2.11.5. Sources

- Prototypical hotel and motel simulation models were developed in EnergyPlus by ADM Associates Inc. for this measure.
- U.S. Department of Energy Report on PTAC and PTHP energy use in Lodging facilities: http://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/ptac_pthps_tsd_ch7_09-30-08.pdf
- Kidder Mathews, Real Estate Market Review (Seattle Hotel). 2010
- IECC 2015
- IECC 2018

2.11.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.[89]

[89] Savings values are based on an assumed 46% annual average guestroom vacancy rate. This assumption is based on real estate market research for Boise, Idaho Falls, and Post Falls in 2010.

Table 2-81 Unit Energy Savings for GREM Systems - Retrofit

Housekeeping Setback	***Weather Zone 5***			***Weather Zone 6***		
	Heat-Pump	Gas	Electric Resistance	Heat-Pump	Gas	Electric Resistance
Yes	131	35	398	173	29	498
No	741	200	1,706	875	149	1,930

Table 2-82 Unit Energy Savings for GREM Systems – New Construction (IECC 2018)

Housekeeping Setback	***Weather Zone 5***			***Weather Zone 6***		
	Heat-Pump	Gas	Electric Resistance	Heat-Pump	Gas	Electric Resistance
Yes	95	24	352	129	21	447
No	599	153	1,551	726	116	1,793

2.12. High Efficiency Air Conditioning

The following algorithms and assumptions are applicable to energy efficient air conditioning units installed in commercial spaces. This measure applies to projects which represent either equipment retrofit or new construction (including major renovations).

Table 2-83 through Table 2-85 summarizes the 'typical' expected (per ton) unit energy impacts for this measure.[90] Typical values are based on algorithms and stipulated values described below and data from past program participants. Note that Table 2-83 reports the incremental savings and costs associated with going from CEE Tier 1 to CEE Tier 2 and are therefore additive with the appropriate baseline value based on the product.

Table 2-83 Typical Savings Estimates for High Efficiency, Air Cooled Air Conditioning – CEE Code Standard Incremental

	Retrofit to Tier 1	New Construction to Tier 1	Tier 1 to Tier 2	Tier 2 to Advanced Tier
Deemed Savings Unit	Tons	Tons	Tons	Tons
Average Unit Energy Savings	152 kWh	47 kWh	41 kWh	66 kWh
Average Unit Peak Demand Savings	140 W	44 W	15 W	10 W
Expected Useful Life	15 Years	15 Years	15 Years	15 Years
Average Material & Labor Cost	$940	n/a	n/a	n/a
Average Incremental Cost	n/a	$79	$44	$27
Stacking Effect End-Use	HVAC			

Table 2-84 Typical Savings Estimates for High Efficiency, Water Cooled Air Conditioning – CEE Code Standard Incremental

	Retrofit to Tier 1	New Construction to Tier 1
Deemed Savings Unit	Tons	Tons
Average Unit Energy Savings	130 kWh	28 kWh
Average Unit Peak Demand Savings	148 W	62 W
Expected Useful Life	15 Years	15 Years
Average Material & Labor Cost	$1237	n/a
Average Incremental Cost	n/a	$135
Stacking Effect End-Use	HVAC	

[90] See spreadsheet "12-TypicalCalcs_HighEffAC_v5.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

Table 2-85 Typical Savings Estimates for High Efficiency, Variable Refrigerant Flow – CEE Code Standard Incremental

	Retrofit to Tier 1	**New Construction to Tier 1**	**Tier 1 to Tier 2***
Deemed Savings Unit	Tons	Tons	Tons
Average Unit Energy Savings	129 kWh	31 kWh	32 kWh
Average Unit Peak Demand Savings	141 W	43 W	18 W
Expected Useful Life	15 Years	15 Years	15 Years
Average Material & Labor Cost	$1,078	n/a	n/a
Average Incremental Cost	n/a	$93	$15
Stacking Effect End-Use	HVAC		

*Tier 1 to Tier 2 savings are only applicable for units less than 5 tons

Table 2-86 through Table 2-87 summarize the 'typical' expected (per ton) unit energy impacts for this measure assuming the baseline installed equipment are the less efficient air cooled air conditioner. The tier 1 to tier 2 savings remains the same as the tables above since this savings value represents the same. These tables only apply to new construction.

Table 2-86 Typical Savings Estimates for High Efficiency, Water Cooled Air Conditioning with Air Cooled Baseline – CEE Code Standard Incremental

	New Construction to Tier 1
Deemed Savings Unit	Tons
Average Unit Energy Savings	67 kWh
Average Unit Peak Demand Savings	111 W
Expected Useful Life	15 Years
Average Material & Labor Cost	n/a
Average Incremental Cost	$225
Stacking Effect End-Use	HVAC

Table 2-87 Typical Savings Estimates for High Efficiency, Variable Refrigerant Flow with Air Cooled Baseline – CEE Code Standard Incremental

	New Construction to Tier 1	Tier 1 to Tier 2*
Deemed Savings Unit	Tons	Tons
Average Unit Energy Savings	87 kWh	32 kWh
Average Unit Peak Demand Savings	43 W	n/a
Expected Useful Life	15 Years	15 Years
Average Material & Labor Cost	n/a	n/a
Average Incremental Cost	$93	$15
Stacking Effect End-Use	HVAC	

*Tier 1 to Tier 2 savings are only applicable for units less than 5 tons

2.12.1. Definition of Eligible Equipment

All commercial unitary and split air conditioning system are eligible (This includes Package Terminal Air Conditioners) provided the installed equipment meets or exceeds current 2019 Consortium for Energy Efficiency (CEE) Tier 1 efficiencies. High efficiency chillers are not eligible under this measure but are included as a separate measure in this document. Note that projects replacing pre-existing AC units with A/C only are eligible under this measure – though no impacts are considered for the heating component. Eligibility is determined by calculating the EER, SEER, and/or the IEER for the installed unit.

2.12.2. Definition of Baseline Equipment

Baseline equipment for this measure is determined by the nature of the project. There are two possible scenarios: retrofit (early replacement) or new construction.

Retrofit (Early Replacement)

If the project is retrofitting pre-existing equipment in working condition, then the baseline efficiency is defined by the pre-existing equipment. If the equipment being replaced is not in working order, then this is considered "replace on burn-out" and the baseline becomes new construction. Note that units replacing window/wall mounted air-conditioners, room air-conditioners, and/or evaporative cooling are not eligible for early replacement and are considered "New Construction."

New Construction (Includes Major Remodel & Replace on Burn-Out)

For New Construction, the baseline efficiency is defined as the minimum allowable SEER and EER by the prevailing building energy code or standard according to which the project was permitted. Recently Idaho adopted IECC 2018 as the energy efficiency standard for new construction.

2.12.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta kWh = Cap * (1/SEER_{base} – 1/SEER_{Installed}) / 1000 * EFLH$$

$$\Delta kW = Cap * (1/EER_{base} – 1/EER_{Installed}) / 1000 * CF$$

2.12.4. Definitions

ΔkWh	Expected energy savings between baseline and installed equipment.
ΔkW_{peak}	Expected peak demand savings.
EFLH	Equivalent full load cooling hours of. Idaho specific EFLH are by weather zone and building in Table 2-92.
CF	Peak coincidence factor. Represents the % of the connected load reduction which occurs during Idaho Power's peak period.
EER	Energy Efficiency Ratio for *base* and *installed* systems. This is defined as the ratio of the cooling capacity of the air conditioner in British Thermal Units per hour, to the total electrical input in watts. Since ASHRAE does not provide EER requirements for air-cooled air conditioners < 65,000 Btu/h, assume the following conversion: $EER \approx -0.02 * SEER^2 + 1.12 * SEER$
SEER	Seasonal Energy efficiency ratio of the air conditioning unit. This is defined as the ratio of the Annual cooling provided by the air conditioner (in BTUs), to the total electrical input (in Watts). Note that the IEER is an appropriate equivalent. If the SEER or IEER are unknown or unavailable use the following formula to estimate from the EER: [91] $SEER = .0507 * EER^2 + .5773 * EER + .4919$
Cap	Nominal cooling capaity in kBTU/Hr (1 ton = 12,000BTU/Hr)

2.12.5. Sources

- ASHRAE, Standard 90.1-2019.
- California DEER Prototypical Simulation models (modified), eQUEST-DEER 3-5.[92]
- California DEER Effective Useful Life worksheets: EUL_Summary_10-1-08. California DEER Incremental Cost worksheets: Revised DEER Measure Cost Summary (05_30_2008) Revised (06_02_2008).xls
- 2019 CEE Building Efficiency Standards
- IECC 2018

[91] Note that this formula is an approximation and should only be applied to EER values up to 15 EER.

[92] Prototypical building energy simulations were used to generate Idaho specific Heating and Cooling Interactive Factors and Coincidence factors for various building and heating fuel types.

2.12.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Table 2-88 Deemed Savings for High Efficiency A/C – Retrofit Baseline to CEE Tier 1

Measure Description	Expected Savings [kW/Ton]	Expected Savings [kWh/Ton]	Measure Cost [$/Ton]
AC Air Cooled <65,000 Btu/h	0.16	156	$1,438
AC Air Cooled ⩾65,000 Btu/h and <135,000 Btu/h	0.14	158	$873
AC Air Cooled ⩾135,000 Btu/h and <240,000 Btu/h	0.15	148	$762
AC Air Cooled ⩾240,000 Btu/h and <760,000 Btu/h	0.14	153	$848
AC Air Cooled ⩾760,000 Btu/h	0.12	144	$782
AC Water Cooled <65,000 Btu/h	0.15	106	$748
AC Water Cooled ⩾65,000 Btu/h and <135,000 Btu/h	0.15	150	$1,512
AC Water Cooled ⩾135,000 Btu/h	0.14	133	$1,452
VRF <65,000 Btu/h	0.15	117	$1,609
VRF ⩾65,000 Btu/h and <135,000 Btu/h	0.12	135	$925
VRF ⩾135,000 Btu/h and <240,000 Btu/h	0.14	139	$822
VRF ⩾240,000 Btu/h	0.15	126	$958
PTAC	0.14	231	$1,571

Table 2-89 Deemed Savings for High Efficiency A/C – New Construction (IECC 2018) Baseline to CEE 2019 Tier 1

Measure Description	Expected Savings [kW/Ton]	Expected Savings [kWh/Ton]	Incremental Cost [$/Ton]
AC Air Cooled <65,000 Btu/h	0.06	57	$143
AC Air Cooled ⩾65,000 Btu/h and <135,000 Btu/h	0.04	52	$55
AC Air Cooled ⩾135,000 Btu/h and <240,000 Btu/h	0.05	38	$41
AC Air Cooled ⩾240,000 Btu/h and <760,000 Btu/h	0.03	38	$87
AC Air Cooled ⩾760,000 Btu/h	0.01	24	$34
AC Water Cooled <65,000 Btu/h	0.07	0	$74
AC Water Cooled ⩾65,000 Btu/h and <135,000 Btu/h	0.07	51	$189
AC Water Cooled ⩾135,000 Btu/h	0.05	34	$143
VRF <65,000 Btu/h	0.06	25	$159
VRF ⩾65,000 Btu/h and <135,000 Btu/h	0.03	38	$43
VRF ⩾135,000 Btu/h and <240,000 Btu/h	0.04	39	$34

Measure Description	Expected Savings [kW/Ton]	Expected Savings [kWh/Ton]	Incremental Cost [$/Ton]
VRF ⩾240,000 Btu/h	0.04	22	$137
PTAC	0.05	58	$164

Table 2-90 Deemed Savings for High Efficiency A/C – CEE 2019 Tier 1 to Tier 2[93]

Base Description	Expected Savings [kW/Ton]	Expected Savings [kWh/Ton]	Incremental Cost [$/Ton]
AC Air Cooled <65,000 Btu/h	0.01	32	$27
AC Air Cooled ⩾65,000 Btu/h and <135,000 Btu/h	0.00	30	$0
AC Air Cooled ⩾135,000 Btu/h and <240,000 Btu/h	0.00	41	$0
AC Air Cooled ⩾240,000 Btu/h and <760,000 Btu/h	0.02	43	$52
AC Air Cooled ⩾760,000 Btu/h	0.03	38	$85
VRF <65,000 Btu/h	0.02	32	$60
PTAC	0.04	48	$164

Table 2-91 Deemed Savings for High Efficiency A/C – New Construction (IECC 2018) Air Cooled Baseline to CEE 2019 Tier 1

Measure Description	Expected Savings [kW/Ton]	Expected Savings [kWh/Ton]	Incremental Cost [$/Ton]
AC Water Cooled <65,000 Btu/h	0.11	0	$110
AC Water Cooled ⩾65,000 Btu/h and <135,000 Btu/h	0.11	99	$279
AC Water Cooled ⩾135,000 Btu/h	0.12	101	$286
VRF <65,000 Btu/h	0.06	78	$159
VRF ⩾65,000 Btu/h and <135,000 Btu/h	0.03	94	$43
VRF ⩾135,000 Btu/h and <240,000 Btu/h	0.04	96	$34
VRF ⩾240,000 Btu/h	0.04	82	$137
PTAC	0.05	58	$164

Table 2-92 Stipulated Equivalent Full Load Cooling and Heating Hours (EFLH) by Building Type[94]

	Zone 5		Zone 6		Weighted values	
Building Type	EFLH Cooling	EFLH Heating	EFLH Cooling	EFLH Heating	EFLH Cooling	EFLH Heating

[93] Note that CEE Tier 2 savings are the incremental savings (and cost) between Tier 1 and Tier 2.

[94] Prototypical building energy simulations were used to generate Idaho specific heating and cooling equivalent full load hours for various buildings.

	Zone 5		Zone 6		Weighted values	
Assembly	879	966	758	1059	855	985
Education - Primary School	203	299	173	408	197	321
Education - Secondary School	230	406	196	514	223	428
Education - Community College	556	326	530	456	551	352
Education - University	697	341	721	449	702	363
Grocery	564	1825	460	2011	544	1862
Health/Medical - Hospital	1616	612	1409	679	1575	625
Health/Medical - Nursing Home	1049	1399	884	1653	1016	1450
Lodging - Hotel	1121	621	1075	780	1112	653
Lodging - Motel	978	682	937	796	970	705
Manufacturing - Light Industrial	530	699	415	1088	507	777
Office - Large	746	204	680	221	733	207
Office - Small	607	256	567	360	599	277
Restaurant - Sit-Down	811	624	716	709	792	641
Restaurant - Fast-Food	850	722	734	796	827	737
Retail - 3-Story Large	765	770	644	998	741	816
Retail - Single-Story Large	724	855	576	998	694	884
Retail - Small	726	886	619	1138	705	936
Storage - Conditioned	335	688	242	989	316	748

Table 2-93 HVAC Coincidence Factors by Building Type

Building Type	Coincidence Factor
Assembly	0.47
Education - Community College	0.54
Education - Primary School	0.1
Education - Secondary School	0.1
Education - University	0.53
Grocery	0.54
Health/Medical - Hospital	0.82
Health/Medical - Nursing Home	0.49
Lodging - Hotel	0.67
Lodging - Motel	0.63
Manufacturing - Light Industrial	0.46
Office - Large	0.58
Office - Small	0.51
Restaurant - Fast-Food	0.48
Restaurant - Sit-Down	0.46
Retail - 3-Story Large	0.66
Retail - Single-Story Large	0.56
Retail - Small	0.49

Building Type	Coincidence Factor
Storage - Conditioned	0.41

Table 2-94 CEE 2019 Minimum Efficiencies by Unit Type for All Tiers[95]

Equipment Type	Size Category	Heating Section Type	Subcategory	CEE Tier 1	CEE Tier 2	Advanced Tier
Air Conditioners, Air Cooled (Cooling Mode)	<65,000 Btu/h	All	Split System	15.0 SEER 12.5 EER	16.0 SEER 13.0 EER	18.0 SEER 13.0 EER
			Single Package	15.0 SEER 12.0 EER	16.0 SEER 12.0 EER	17.0 SEER 12.5 EER
	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	12.2 EER 14 IEER	12.2 EER 14.8 IEER	12.6 EER 18.0 IEER
		All Other	Split System and Single Package	12 EER 13.8 IEER	12.0 EER 14.6 IEER	12.4 EER 17.8 IEER
	≥135,000 Btu/h and <240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	12.2 EER 13.2 IEER	12.2 EER 14.2 IEER	12.2 EER 17 IEER
		All Other	Split System and Single Package	12 EER 13 IEER	12.0 EER 14.0 IEER	12.0 EER 16.8 IEER
	≥240,000 Btu/h and <760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.5 EER 12.3 IEER	10.8 EER 13.2 IEER	10.8 EER 14.5 IEER
		All Other	Split System and Single Package	10.3 EER 12.1 IEER	10.6 EER 13 IEER	10.6 EER 14.3 IEER
	≥760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.9 EER 11.6 IEER	10.4 EER 12.3 IEER	NA NA
		All Other	Split System and Single Package	9.7 EER 11.4 IEER	10.2 EER 12.1 IEER	NA NA
Air Conditioners, Water Cooled	<65,000 Btu/h	All	Split System and Single Package	14.0 EER	NA	NA*
	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	14.0 EER 15.3 IEER	NA NA	NA* NA*
		All Other	Split System and Single Package	13.8 EER 15.1 IEER	NA NA	NA* NA*
	≥135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	14.0 EER 14.8 IEER	NA NA	NA* NA*
		All Other		13.8 EER	NA	NA*

[95] Values obtained from 2019 CEE building efficiency standards for unitary air conditioning units.

			Split System and Single Package	14.6 IEER	NA	NA*
Air Conditioners, Evaporatively Cooled	<65,000 Btu/h	All	Split System and Single Package	14 EER	NA	NA*
	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	14 EER 15.3 IEER	NA	NA*
		All Other	Split System and Single Package	13.8 EER 15.1 IEER	NA	NA*
	≥135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.7 EER 14.4 IEER	NA	NA*
Variable Refrigerant Flow Air Cooled (cooling Mode)	<65,000 Btu/h	All	Multisplit System	12.5 EER	13 EER	NA
				15 SEER	16 SEER	NA
	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance (or None)	Multisplit System	11.7 EER	NA	NA
				14.9 IEER	NA	NA
	≥135,000 Btu/h and <240,000 Btu/h	Electric Resistance (or None)	Multisplit System	11.7 EER	NA	NA
				14.4 IEER	NA	NA
	240,000 Btu/h	Electric Resistance (or None)	Multisplit System	10.5 EER	NA	NA

*The advanced tier should not be considered a level of performance that is currently being met by several manufacturers in all nominal sizes. Instead, the advanced tier is an aspirational level that acknowledges and provides recognition for manufacturers who have developed the most efficient systems available in the market today.

2.13. High Efficiency Heat Pumps

The following algorithms and assumptions are applicable to energy efficient heat pump units installed in commercial spaces. This measure applies to projects which represent either equipment retrofit or new construction (including major renovations).

Table 2-95 through Table 2-98 summarize the 'typical' expected (per ton) unit energy impacts for this measure. Typical values are based on algorithms and stipulated values described below and data from past program participants.[96] Note that the values listed in the tables below are averaged across each of the system efficiency and tonnage categories offered by the program. Table 2-102 through Table 2-108 at the end of this section provide individual savings and materials/labor costs.

Table 2-95 Typical Savings Estimates for High Efficiency Heat Pumps – Air-cooled

	Retrofit to Tier 1	New Construction to Tier 1	Tier 1 to Tier 2*
Deemed Savings Unit	Tons	Tons	Tons
Average Unit Energy Savings (Cooling)	187 kWh	72 kWh	32 kWh
Average Unit Energy Savings (Heating)	356 kWh	82 kWh	57 kWh
Average Unit Energy Savings (Combined)	543 kWh	154 kWh	89 kWh
Average Unit Peak Demand Savings (Cooling)	129 W	30 W	18 W
Expected Useful Life	15 Years	15 Years	15 Years
Average Material & Labor Cost	$888	n/a	n/a
Average Incremental Cost	n/a	$36	$31
Stacking Effect End-Use		HVAC	

*Tier 1 to Tier 2 savings are only applicable for units less than 5 tons

[96] See spreadsheet "13-TypicalCalcs_HeatPumps_v6.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

Table 2-96 Typical Savings Estimates for High Efficiency Heat Pumps – Water-cooled

	Retrofit to Tier 1	New Construction to Tier 1
Deemed Savings Unit	Tons	Tons
Average Unit Energy Savings (Cooling)	129 kWh	47 kWh
Average Unit Energy Savings (Heating)	195 kWh	79 kWh
Average Unit Energy Savings (Combined)	324 kWh	126 kWh
Average Unit Peak Demand Savings (Cooling)	111 W	33 W
Expected Useful Life	15 Years	15 Years
Average Material & Labor Cost	$971	n/a
Average Incremental Cost	n/a	$370
Stacking Effect End-Use	HVAC	

Table 2-97 Typical Savings Estimates for High Efficiency Heat Pumps – Air Cooled VRF

	Retrofit to Tier 1	New Construction to Tier 1	Tier 1 to Tier 2*
Deemed Savings Unit	Tons	Tons	Tons
Average Unit Energy Savings (Cooling)	143 kWh	51 kWh	32 kWh
Average Unit Energy Savings (Heating)	342 kWh	92 kWh	57 kWh
Average Unit Energy Savings (Combined)	485 kWh	143 kWh	89 kWh
Average Unit Peak Demand Savings (Cooling)	126 W	27 W	18 W
Expected Useful Life	15 Years	15 Years	n/a
Average Material & Labor Cost	$999	n/a	n/a
Average Incremental Cost	n/a	$36	$35
Stacking Effect End-Use	HVAC		

* Tier 1 to Tier 2 savings are only applicable for condenser units with a capacity less than 5 tons

Table 2-98 Typical Savings Estimates for High Efficiency Heat Pumps – Water Cooled VRF

	Retrofit to Tier 1	New Construction to Tier 1	Tier 1 to Tier 2*
Deemed Savings Unit	Tons	Tons	n/a
Average Unit Energy Savings (Cooling)	75 kWh	2 kWh	n/a
Average Unit Energy Savings (Heating)	1,422 kWh	1,106 kWh	n/a
Average Unit Energy Savings (Combined)	1,497 kWh	1,108 kWh	n/a
Average Unit Peak Demand Savings (Cooling)	108 W	30 W	n/a
Expected Useful Life	15 Years	15 Years	n/a
Average Material & Labor Cost	$1,187	n/a	n/a
Average Incremental Cost	n/a	$62	n/a
Stacking Effect End-Use	HVAC		

* Tier 1 to Tier 2 savings are only applicable for condenser units with a capacity less than 5 tons

Table 2-99 through Table 2-101 summarize the 'typical' expected (per ton) unit energy impacts for this measure assuming the baseline installed equipment are the less efficient air cooled air conditioner. The tier 1 to tier 2 savings remain the same as the tables above since this savings value represents the same. These tables only apply to new construction.

Table 2-99 Typical Savings Estimates for High Efficiency Heat Pumps using Baseline Air Cooled Air-Conditioners to Tier 1 Water-cooled Air-Conditioners

	Retrofit to Tier 1	New Construction to Tier 1
Deemed Savings Unit	n/a	Tons
Average Unit Energy Savings (Cooling)	n/a	133 kWh
Average Unit Energy Savings (Heating)	n/a	79 kWh
Average Unit Energy Savings (Combined)	n/a	211 kWh
Average Unit Peak Demand Savings (Cooling)	n/a	79 W
Expected Useful Life	n/a	15 Years
Average Material & Labor Cost	n/a	n/a
Average Incremental Cost	n/a	$370
Stacking Effect End-Use	HVAC	

Table 2-100 Typical Savings Estimates for Air Cooled VRF using an Air Cooled Baseline

	Retrofit to Tier 1	New Construction to Tier 1	Tier 1 to Tier 2*
Deemed Savings Unit	n/a	Tons	Tons
Average Unit Energy Savings (Cooling)	n/a	97 kWh	32 kWh
Average Unit Energy Savings (Heating)	n/a	92 kWh	57 kWh
Average Unit Energy Savings (Combined)	n/a	190 kWh	89 kWh
Average Unit Peak Demand Savings (Cooling)	n/a	27 W	18 W
Expected Useful Life	n/a	15 Years	15 Years
Average Material & Labor Cost	n/a	n/a	n/a
Average Incremental Cost	n/a	$36	$35
Stacking Effect End-Use		HVAC	

*Tier 1 to Tier 2 savings are only applicable for units less than 5 tons

Table 2-101 Typical Savings Estimates for Water Cooled VRF using an Air Cooled Baseline

	Retrofit to Tier 1	New Construction to Tier 1	Tier 1 to Tier 2*
Deemed Savings Unit	n/a	Tons	n/a
Average Unit Energy Savings (Cooling)	n/a	128 kWh	n/a
Average Unit Energy Savings (Heating)	n/a	1,106 kWh	n/a
Average Unit Energy Savings (Combined)	n/a	1,234 kWh	n/a
Average Unit Peak Demand Savings (Cooling)	n/a	76 W	n/a
Expected Useful Life	n/a	15 Years	n/a
Average Material & Labor Cost	n/a	n/a	n/a
Average Incremental Cost	n/a	$145	n/a
Stacking Effect End-Use		HVAC	

2.13.1. Definition of Eligible Equipment

All heat pump systems are eligible provided the installed equipment meets or exceeds 2019 Consortium for Energy Efficiency (CEE) Tier 1 efficiencies. Note that projects replacing pre-existing A/C only units with heat-pump units are eligible under this measure. In such project the heating component must use a *new construction baseline* whereas the cooling component can use either (retrofit or new construction) baselines as deemed appropriate. Eligibility is determined by calculating the EER, SEER, IEER, and/or HSPF as appropriate for the installed unit.

2.13.2. Definition of Baseline Equipment

Baseline equipment for this measure is determined by the nature of the project. There are two possible scenarios: retrofit (early replacement) or New construction.

Retrofit (Early Replacement)

If the project is retrofitting pre-existing equipment in working condition, then the baseline efficiency is defined by the pre-existing equipment. If the equipment being replaced is not in working order, then this is considered “replace on burn-out” and the baseline becomes new construction.

New Construction (Includes Major Remodel & Replace on Burn-Out)

For New Construction, the baseline efficiency is defined as the minimum allowable EER by the prevailing building energy code or standard according to which the project was permitted. Current applicable standards are defined by ASHRAE 90.1-2019. Recently Idaho adopted IECC 2018 as the energy efficiency standard for new construction.

2.13.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta kWh = \Delta kWh_{Cool} + \Delta kWh_{Heat}$$

$$= Cap * (1/SEER_{base,\ cool} - 1/SEER_{Installed,\ cool}) / 1000 * EFLH_{Cool} +$$
$$Cap * (1/HSPF_{base,\ Heat} - 1/HSPF_{Installed,\ Heat}) / 1000 * EFLH_{Heat}$$

$$\Delta kW_{peak} = Cap * (1/EER_{base,\ cool} - 1/EER_{Installed,\ cool}) / 1000 * CF$$

2.13.4. Definitions

ΔkWh Expected energy savings between baseline and installed equipment.

ΔkW_{peak} Expected peak demand savings.

EFLH Equivalent full load cooling hours of. Idaho specific EFLH are by weather zone and building in Table 2-106.

CF Peak coincidence factor. Represents the % of the connected load reduction which occurs during Idaho Power’s peak period.

EER Energy Efficiency Ratio for *base* and *installed* systems in *cooling* and *heating* modes. This is defined as the ratio of the cooling capacity of the air conditioner in British Thermal Units per hour, to the total electrical input in watts. Since ASHRAE does not provide EER requirements for air-cooled air conditioners < 65,000 Btu/h, assume the following conversion:

$$EER \approx -0.02 * SEER^2 + 1.12 * SEER$$

SEER Seasonal Energy efficiency ratio of the air conditioning unit. This is defined as the ratio of the Annual cooling provided by the air conditioner (in BTUs), to the total electrical input (in Watts). Note that the IEER is an appropriate equivalent. If the SEER or IEER are unknown or unavailable use the following formula to estimate from the EER: [97]

$$SEER = .0507 * EER^2 + .5773 * EER + .4919$$

HSPF Heating Season Performance Factor. This is identical to the SEER (described above) as applied to Heat Pumps in heating mode. If only the heat pump COP is available, then use the following:

$$HSPF = .5651 * COP^2 + .464 * COP + .4873$$

Cap Nominal cooling capaity in kBTU/Hr (1 ton = 12,000BTU/Hr)

2.13.5. Sources

- Consortium for Energy Efficiency, High Efficiency Commercial Air Conditioning and Heat Pumps Initiative 2019
- ASHRAE, Standard 90.1-2019.
- California DEER Prototypical Simulation models (modified), eQUEST-DEER 3-5.98
- California DEER Effective Useful Life worksheets: EUL_Summary_10-1-08. California DEER Incremental Cost worksheets: Revised DEER Measure Cost Summary (05_30_2008) Revised (06_02_2008).xls
- IECC 2018

2.13.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

[97] Note that this formula is an approximation and should only be applied to EER values up to 15 EER.

[98] Prototypical building energy simulations were used to generate Idaho specific Heating and Cooling Interactive Factors and Coincidence factors for various building and heating fuel types.

Table 2-102 Deemed Energy Savings for Efficient Heat Pumps – Retrofit to CEE 2019Tier 1[99]

Measure Description	Demand Savings - Cooling [kW/Ton]	Energy Savings - Cooling [kWh/Ton]	Energy Savings - Heating [kWh/Ton]	Energy Savings - All [kWh/Ton]	Measure Cost
HP Air Cooled <65,000 Btu/h	0.11	133	219	351	$812
HP Air Cooled ⩾65,000 Btu/h and <135,000 Btu/h	0.13	190	403	594	$770
HP Air Cooled ⩾135,000 Btu/h and <240,000 Btu/h	0.12	178	400	578	$745
HP Air Cooled ⩾240,000 Btu/h and <760,000 Btu/h	0.16	249	400	649	$690
HP Water Cooled <135,000 Btu/h	0.11	129	195	324	$600
VRF <65,000 Btu/h	0.12	74	219	293	$918
VRF ⩾65,000 Btu/h and <135,000 Btu/h	0.11	146	403	550	$870
VRF ⩾135,000 Btu/h and <240,000 Btu/h	0.12	149	373	522	$842
VRF ⩾240,000 Btu/h	0.16	204	373	577	$780
VRF Water Source <135,000 Btu/h	0.11	75	1422	1497	$994

Table 2-103 Deemed Energy Savings for Efficient Heat Pumps – New Construction (IECC 2018) Base to CEE 2019 Tier 1

Measure Description	Demand Savings - Cooling [kW/Ton]	Energy Savings - Cooling [kWh/Ton]	Energy Savings - Heating [kWh/Ton]	Energy Savings - All [kWh/Ton]	Incr.Cost
HP Air Cooled <65,000 Btu/h	0.02	36	32	68	$27
HP Air Cooled ⩾65,000 Btu/h and <135,000 Btu/h	0.04	76	126	202	$49
HP Air Cooled ⩾135,000 Btu/h and <240,000 Btu/h	0.02	63	84	147	$18
HP Air Cooled ⩾240,000 Btu/h and <760,000 Btu/h	0.05	114	84	198	$49
HP Water Cooled <135,000 Btu/h	0.03	47	79	126	$370
VRF <65,000 Btu/h	0.03	-13	37	24	$48
VRF ⩾65,000 Btu/h and <135,000 Btu/h	0.01	42	126	167	$21
VRF ⩾135,000 Btu/h and <240,000 Btu/h	0.02	42	57	99	$21
VRF ⩾240,000 Btu/h	0.05	81	57	138	$55
VRF Water Source <135,000 Btu/h	0.03	1	1106	1107	$62

[99] Retrofit equipment estimated to be 15% worse than current IECC Code. See spreadsheet “13-TypicalCalcs_HeatPumps_v6.xlsx” for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

Table 2-104 Deemed Energy Savings for Efficient Heat Pumps – New Construction (IECC 2018) Air Cooled Baseline to CEE 2019 Tier 1

Measure Description	Demand Savings - Cooling [kW/Ton]	Energy Savings - Cooling [kWh/Ton]	Energy Savings - Heating [kWh/Ton]	Energy Savings - All [kWh/Ton]	Incr.Cost
HP Water Cooled <135,000 Btu/h	0.08	133	79	211	$370
VRF <65,000 Btu/h	0.03	36	37	74	$48
VRF ≥65,000 Btu/h and <135,000 Btu/h	0.01	100	126	226	$21
VRF ≥135,000 Btu/h and <240,000 Btu/h	0.02	103	57	160	$21
VRF ≥240,000 Btu/h	0.05	150	57	208	$55
VRF Water Source <135,000 Btu/h	0.08	128	1106	1234	$62

Table 2-105 Deemed Energy Savings for Efficient Heat Pumps – CEE 2019 Tier 1 to Tier 2

Measure Description	Demand Savings - Cooling [kW/Ton]	Energy Savings - Cooling [kWh/Ton]	Energy Savings - Heating [kWh/Ton]	Energy Savings - All [kWh/Ton]	Incr. Cost
HP Air Cooled <65,000 Btu/h	0.01	32	28	60	$15
VRF <65,000 Btu/h	0.02	32	57	89	$35

Table 2-106 Stipulated Equivalent Full Load Hours (EFLH) by Building Type[100]

	Zone 5		Zone 6		Weighted values	
Building Type	EFLH Cooling	EFLH Heating	EFLH Cooling	EFLH Heating	EFLH Cooling	EFLH Heating
Assembly	879	966	758	1059	855	985
Education - Primary School	203	299	173	408	197	321
Education - Secondary School	230	406	196	514	223	428
Education - Community College	556	326	530	456	551	352
Education - University	697	341	721	449	702	363
Grocery	564	1825	460	2011	544	1862
Health/Medical - Hospital	1616	612	1409	679	1575	625
Health/Medical - Nursing Home	1049	1399	884	1653	1016	1450
Lodging - Hotel	1121	621	1075	780	1112	653
Lodging - Motel	978	682	937	796	970	705
Manufacturing - Light Industrial	530	699	415	1088	507	777
Office - Large	746	204	680	221	733	207
Office - Small	607	256	567	360	599	277
Restaurant - Sit-Down	811	624	716	709	792	641
Restaurant - Fast-Food	850	722	734	796	827	737
Retail - 3-Story Large	765	770	644	998	741	816
Retail - Single-Story Large	724	855	576	998	694	884
Retail - Small	726	886	619	1138	705	936
Storage - Conditioned	335	688	242	989	316	748

[100] Prototypical building energy simulations were used to generate Idaho specific heating and cooling equivalent full load hours for various buildings.

Table 2-107 HVAC Coincidence Factors by Building Type

Building Type	Coincidence Factor
Assembly	0.47
Education - Community College	0.54
Education - Primary School	0.1
Education - Secondary School	0.1
Education - University	0.53
Grocery	0.54
Health/Medical - Hospital	0.82
Health/Medical - Nursing Home	0.49
Lodging - Hotel	0.67
Lodging - Motel	0.63
Manufacturing - Light Industrial	0.46
Office - Large	0.58
Office - Small	0.51
Restaurant - Fast-Food	0.48
Restaurant - Sit-Down	0.46
Retail - 3-Story Large	0.66
Retail - Single-Story Large	0.56
Retail - Small	0.49
Storage - Conditioned	0.41

Table 2-108 CEE 2019 Baseline Efficiency by Unit Type

Equipment Type	Size Category	Heating Section Type	Subcategory	Tier 1	Tier 2
Air Conditioners, Air Cooled (Cooling Mode)	<65,000 Btu/h	All	Split System	15 SEER 12.5 EER	16 SEER 13 EER
			Single Package	15 SEER 12 EER	16 SEER 12 EER
	≥65,000 and <135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.8 EER 13.6 IEER	NA* NA*
		All Other	Split System and Single Package	11.6 EER 13.4 IEER	NA* NA*
	≥135,000 and <240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.9 EER 12.8 IEER	NA* NA*
		All Other	Split System and Single Package	10.7 EER 12.8 IEER	NA* NA*
	≥240,000 and <760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.3 EER 11.8 IEER	NA* NA*
		All Other	Split System and Single Package	10.1 EER 11.6 IEER	NA* NA*

Equipment Type	Size Category	Heating Section Type	Subcategory	Tier 1	Tier 2
Air Cooled (Heating Mode)	<65,000 Btu/h	-	Split System	8.5 HSPF	9.0 HSPF
		-	Single Package	8.2 HSPF	8.2 HSPF
	≥65,000 and <135,000 Btu/h	-	47oF db/43oF wb Outdoor Air	3.4 COP	NA*
		-	17oF db/15oF wb Outdoor Air	2.4 COP	NA*
	≥135,000 Btu/h	-	47oF db/43oF wb Outdoor Air	3.3 COP	NA*
		-	17oF db/15oF wb Outdoor Air	2.1 COP	NA*
Water Source (Cooling Mode)	<135,000 Btu/h	All	86oF Entering Water	14.0 EER	NA*
Water Source (Heating Mode)	<135,000 Btu/h	-	68oF Entering Water	4.6 COP	NA*
VRF Air Cooled (Cooling Mode)	<65,000 Btu/h	All	Multisplit System	15 SEER 12.5 EER	16 SEER 13 EER
	≥65,000 and <135,000 Btu/h	Electric Resistance (or None)	Multisplit System	11.3 EER 14.2 IEER	NA*
	≥135,000 and <240,000 Btu/h	Electric Resistance (or None)	Multisplit System	11.1 EER 13.7 IEER	NA*
	>240,000 Btu/h	Electric Resistance (or None)	Multisplit System	10.1 EER 12.3 IEER	NA*
VRF Air Cooled (Heating Mode)	<65,000 Btu/h		Multisplit System	8.5 HSPF	9.0 HSPF
	≥65,000 Btu/h and <135,000 Btu/h		47°F db/43°F wb Outdoor Air	3.4 COP	NA*
			17°F db/15°F wb Outdoor Air	2.4 COP	NA*
	≥135,000 Btu/h		47°F db/43°F wb Outdoor Air	3.2 COP	NA*
			17°F db/15°F wb Outdoor Air	2.1 COP	NA*
VRF Water Source (Cooling Mode)	<135,000 Btu/h	All	Multisplit System 86°F Entering Water	14 EER	NA*
			Multisplit System with Heat Recovery 86°F Entering Water	13.8 IEER	NA*
VRF Water Source (Heating Mode)	<135,000 Btu/h		60°F Entering Water	4.6 COP	NA*

2.14. High Efficiency Chillers

The following algorithms and assumptions are applicable to Electric Chillers installed in commercial spaces. This measure applies to projects which represent either equipment retrofit or new construction (including major renovations).

Table 2-109 through Table 2-110 summarizes the 'typical' expected unit energy impacts for this measure. Typical values are based on algorithms and stipulated values described below and data from past program participants. Note that the values listed in the table below are averaged across each of the system efficiency and tonnage categories offered by the program. Table 2-111 through Table 2-115 at the end of this section provide individual savings and materials/labor costs.

Table 2-109 Typical Savings Estimates for High Efficiency Chillers[101](air cooled)

	IECC 2018	
	Retrofit	**New Construction**
Deemed Savings Unit	Tons	Tons
Average Unit Energy Savings	154 kWh	102 kWh
Average Unit Peak Demand Savings	0.12 kW	0.08 kW
Expected Useful Life	20 Years	20 Years
Average Material & Labor Cost	$ 784	n/a
Average Incremental Cost	n/a	$ 209
Stacking Effect End-Use	HVAC	

Table 2-110 Typical Savings Estimates for High Efficiency Chillers[102](water cooled)

	IECC 2018	
	Retrofit	**New Construction**
Deemed Savings Unit	Tons	Tons
Average Unit Energy Savings	91 kWh	61 kWh
Average Unit Peak Demand Savings	0.07 kW	0.05 kW
Expected Useful Life	20 Years	20 Years
Average Material & Labor Cost	$596	n/a
Average Incremental Cost	n/a	$103
Stacking Effect End-Use	HVAC	

[101] See spreadsheet "14-TypicalCalcs_HighEffChillers_v5.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

[102] See spreadsheet "15-TypicalCalcs_HighEffChillers_v5.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

2.14.1. Definition of Eligible Equipment

All commercial chiller units are eligible provided the installed equipment exceeds current federal minimum efficiencies by at least 10%. Eligibility is determined by calculating the Integrated Part Load Value (IPLV) for the installed unit. The algorithms and stipulated assumptions stipulated for High Efficiency Chillers apply only to like-for-like chiller replacements and are not suited for addition of variable speed drives (VSDs) or plant optimization.

Only primary chillers will qualify. Chillers intended for backup service only are not eligible. Air-cooled chiller efficiencies must include condenser-fan energy consumption. Efficiency ratings for IPLV must be based on ARI standard rating conditions per AHRI 550/590-2015.

2.14.2. Definition of Baseline Equipment

Baseline equipment for this measure is determined by the nature of the project. There are two possible scenarios: retrofit (early replacement) or new construction.

Retrofit (Early Replacement)

If the project is retrofitting pre-existing equipment in working condition, then the baseline efficiency is defined by the pre-existing equipment. If the equipment being replaced is not in working order, then this is considered “replace on burn-out” and the baseline becomes new construction.

New Construction (Includes Major Remodel & Replace on Burn-Out)

For New Construction, the baseline efficiency is defined as the minimum allowable COP and IPLV by the prevailing building energy code or standard according to which the project was permitted. Recently Idaho adopted IECC 2018 as the energy efficiency standard for new construction.

2.14.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta kWh = Cap * (IPLVbase - IPLVmeas) * EFLH$$

$$\Delta kW = Cap * (IPLVbase - IPLVmeas) * CF$$

$$\Delta kWh/Unit_i = (IPLVbase - IPLVmeas) * EFLHi$$

2.14.4. Definitions

ΔkWh	Expected energy savings between baseline and installed equipment.
ΔkW	Expected peak demand savings.

IPLV[103]	Efficiency of high efficiency equipment expressed as Integrated Part Load Value in units of kW/Ton
Cap[104]	Chiller nominal cooling capacity in units of Tons
CF	Peak coincidence factor. Represents the % of the connected load reduction which occurs during Idaho Power's peak period.
EFLH	Annual Equivalent Full Load cooling hours for chiller. Values for various building types are stipulated in Table 2-114. When available, actual system hours of use should be used.
$\Delta kWh/Unit_i$	Typical measure savings on a per unit basis per kBTU/hr.

2.14.5. Sources

- ASHRAE, Standard 90.1-2019.
- California DEER Prototypical Simulation models (modified), eQUEST-DEER 3-5.105
- California DEER Effective Useful Life worksheets: EUL_Summary_10-1-08.xls
- SCE workpaper SCE17HC030 revision 1 Air-Cooled Chiller
- SWHC workpaper SWHC005 revision 1 Water-Cooled Chiller
- IECC 2018

2.14.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

[103] Integrated Part Load Value is a seasonal average efficiency rating calculated in accordance with ARI Standard 550/590. It may be presented using one of several sets of units: EER, kW/ton, or COP.

[104] Units for the capacity must match the units for the IPLV.

[105] Prototypical building energy simulations were used to generate Idaho specific heating and cooling equivalent full load hours for various buildings.

Table 2-111 Deemed Measure Savings for Retrofit, IECC 2018

Deemed Savings		kW/Ton	kWh/Ton	Measure Cost [$/Ton]
Air-Cooled Chiller with Condenser	< 150 Tons	0.12	155	$842
	≥ 150 Tons	0.12	152	$725
Air-Cooled Chiller without Condenser, electrically operated	< 150 Tons	0.12	155	$842
	≥ 150 Tons	0.12	152	$725
Water Cooled Chiller electronically operated, positive displacement	< 75 Tons	0.08	105	$964
	≥ 75 and < 150 Tons	0.08	100	$650
	≥ 150 and < 300 Tons	0.07	94	$436
	≥ 300 and < 600 Tons	0.07	89	$325
	≥ 600 Tons	0.07	84	$318
Water Cooled Chiller electronically operated, centrifugal	< 150 Tons	0.07	94	$855
	≥ 150 and < 300 Tons	0.07	91	$957
	≥ 300 and < 400 Tons	0.07	87	$676
	≥ 400 and < 600 Tons	0.07	84	$356
	≥ 600 Tons	0.07	84	$427

Table 2-112 Deemed Measure Savings for New Construction, IECC 2018

Deemed Savings		kW/Ton	kWh/Ton	Incremental Cost [$/Ton]
Air-Cooled Chiller with Condenser	< 150 Tons	0.08	103	$253
	≥ 150 Tons	0.08	101	$164
Air-Cooled Chiller without Condenser, electrically operated	< 150 Tons	0.08	103	$253
	≥ 150 Tons	0.08	101	$164
Water Cooled Chiller electronically operated, positive displacement	< 75 Tons	0.05	70	$127
	≥ 75 and < 150 Tons	0.05	67	$0
	≥ 150 and < 300 Tons	0.05	62	$0
	≥ 300 and < 600 Tons	0.05	59	$0
	≥ 600 Tons	0.04	56	$0
Water Cooled Chiller electronically operated, centrifugal	< 150 Tons	0.05	63	$12
	≥ 150 and < 300 Tons	0.05	60	$442
	≥ 300 and < 400 Tons	0.05	58	$303
	≥ 400 and < 600 Tons	0.04	56	$0
	≥ 600 Tons	0.04	56	$143

Table 2-113 Baseline Code Requirements, IECC 2018

Equipment Type	Size Category	Units	Minimum Efficiency 2019 Path A (Full-Load Optimized Applications)	Minimum Efficiency 2019 Path B (Part-Load Optimized Applications)
Air-cooled	<150 Tons	EER (Btu/W)	≥10.10 FL	≥9.70 FL
			≥13.70 IPLV	≥15.80 IPLV
Air-cooled	≥150 Tons	EER (Btu/W)	≥10.10 FL	≥9.70 FL
			≥14.00 IPLV	≥16.10 IPLV
Water-cooled, electrically operated positive displacement	<75 Tons	kW/t	≤0.75 FL	≤0.78 FL
			≤0.60 IPLV	≤0.50 IPLV
Water-cooled, electrically operated positive displacement	≥75 and <150 Tons	kW/t	≤0.72 FL	≤0.75 FL
			≤0.56 IPLV	≤0.49 IPLV
Water-cooled, electrically operated positive displacement	≥150 and <300 Tons	kW/t	≤0.66 FL	≤0.68 FL
			≤0.54 IPLV	≤0.44 IPLV
Water-cooled, electrically operated positive displacement	≥300 and <600 Tons	kW/t	≤0.61 FL	≤0.625 FL
			≤0.52 IPLV	≤0.41 IPLV
Water-cooled, electrically operated positive displacement	≥600 Tons	kW/t	≤0.56 FL	≤0.585 FL
			≤0.50 IPLV	≤0.38 IPLV
Water-cooled, electrically operated centrifugal	<150 Tons	kW/t	≤0.61 FL	≤0.695 FL
			≤0.55 IPLV	≤0.44 IPLV
Water-cooled, electrically operated centrifugal	≥150 and <300 Tons	kW/t	≤0.61 FL	≤0.635 FL
			≤0.55 IPLV	≤0.40 IPLV
Water-cooled, electrically operated centrifugal	≥300 and <400 Tons	kW/t	≤0.56 FL	≤0.595 FL
			≤0.52 IPLV	≤0.39 IPLV
Water-cooled, electrically operated centrifugal	≥400 and <600 Tons	kW/t	≤0.56 FL	≤0.585 FL
			≤0.50 IPLV	≤0.38 IPLV
Water-cooled, electrically operated centrifugal	≥600 Tons	kW/t	≤0.56 FL	≤0.585 FL
			≤0.50 IPLV	≤0.38 IPLV

Table 2-114 Stipulated Equivalent Full Load Hours (EFLH) by Building Type[106]

	Zone 5		Zone 6		Weighted values	
Building Type	EFLH Cooling	EFLH Heating	EFLH Cooling	EFLH Heating	EFLH Cooling	EFLH Heating
Assembly	879	966	758	1059	855	985
Education - Primary School	203	299	173	408	197	321
Education - Secondary School	230	406	196	514	223	428
Education - Community College	556	326	530	456	551	352
Education - University	697	341	721	449	702	363
Grocery	564	1825	460	2011	544	1862
Health/Medical - Hospital	1616	612	1409	679	1575	625
Health/Medical - Nursing Home	1049	1399	884	1653	1016	1450
Lodging - Hotel	1121	621	1075	780	1112	653
Lodging - Motel	978	682	937	796	970	705
Manufacturing - Light Industrial	530	699	415	1088	507	777
Office - Large	746	204	680	221	733	207
Office - Small	607	256	567	360	599	277
Restaurant - Sit-Down	811	624	716	709	792	641
Restaurant - Fast-Food	850	722	734	796	827	737
Retail - 3-Story Large	765	770	644	998	741	816
Retail - Single-Story Large	724	855	576	998	694	884
Retail - Small	726	886	619	1138	705	936
Storage - Conditioned	335	688	242	989	316	748

[106] Prototypical building energy simulations were used to generate Idaho specific heating and cooling equivalent full load hours for various buildings.

Table 2-115 HVAC Coincidence Factors by Building Type

Building Type	Coincidence Factor
Assembly	0.47
Education - Community College	0.54
Education - Primary School	0.10
Education - Secondary School	0.10
Education - University	0.53
Grocery	0.54
Health/Medical - Hospital	0.82
Health/Medical - Nursing Home	0.49
Lodging - Hotel	0.67
Lodging - Motel	0.63
Manufacturing - Light Industrial	0.46
Office - Large	0.58
Office - Small	0.51
Restaurant - Fast-Food	0.48
Restaurant - Sit-Down	0.46
Retail - 3-Story Large	0.66
Retail - Single-Story Large	0.56
Retail - Small	0.49
Storage - Conditioned	0.41

2.15. Evaporative Coolers (Direct and Indirect)

Evaporative coolers provide an effective space cooling alternative to direct expansion units in dry climates such as found in Idaho. Evaporative coolers can be designed in direct and indirect configurations.

A direct evaporative cooler represents the simplest and most efficient approach by pulling air directly through a wetted media to cool the air before dispersing it into the space. A direct evaporative cooler will also humidify the incoming air which, depending on the ambient conditions, can lead to high indoor humidity levels.

Indirect evaporative coolers employ heat exchangers to cool dry outside air on one side with evaporatively cooled moist air on the other. The two air streams are kept separate and the moist air exhausted outside while the dry cool air is supplied indoors. These systems are more complex and often much larger than direct systems because they require more space for large heat exchangers. However; indirect coolers do not increase the indoor humidity levels.[107]

Table 2-116 through Table 2-117 summarize the 'typical' expected unit energy impacts for this measure. Typical values are based on the algorithms and stipulated values described below.

Table 2-116 Typical Savings Estimates for Evaporative Coolers (Direct)[108]

	Retrofit	**New Construction**
Deemed Savings Unit	Ton	Ton
Average Unit Energy Savings	350 kWh	315 kWh
Average Unit Peak Demand Savings	0.25 kW	0.23kW
Expected Useful Life	15 Years	15 Years
Average Material & Labor Cost	$1,178	n/a
Average Incremental Cost	n/a	$364
Stacking Effect End-Use	HVAC	

[107] Except by the normal relationship between temperature and relative humidity.

[108] Ibid. Note that these values are for Direct Evaporative units only.

Table 2-117 Typical Savings Estimates for Evaporative Coolers (Indirect)[109]

	Retrofit	New Construction
Deemed Savings Unit	Ton	Ton
Average Unit Energy Savings	250 kWh	225 kWh
Average Unit Peak Demand Savings	0.22 kW	0.20 kW
Expected Useful Life	15 Years	15 Years
Average Material & Labor Cost	$2,367	n/a
Average Incremental Cost	n/a	$1,553
Stacking Effect End-Use	HVAC	

2.15.1. Definition of Eligible Equipment

Eligible equipment includes any direct or indirect evaporative cooler systems used to supplant direct expansion (DX) system of equivalent size (or greater). Evaporatively pre-cooled DX systems do not qualify under this measure.

2.15.2. Definition of Baseline Equipment

Baseline equipment for this measure is determined by the nature of the project. There are two possible scenarios: retrofit (early replacement) or new construction.

Retrofit (Early Replacement)

Baseline equipment for retrofit projects is the pre-existing DX system.

New Construction (Includes Major Remodel)

Baseline equipment for New Construction projects is a new DX system meeting federal or local building energy code (whichever is applicable) minimum efficiency requirements. Recently Idaho adopted IECC 2018 as the energy efficiency standard for new construction.

2.15.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta kWh = kWh/Unit * Cap$$

$$\Delta kW = kW/Unit * Cap$$

2.15.4. Definitions

ΔkWh Expected energy savings between baseline and installed equipment.

[109] Ibid. Note that these values are for Indirect Evaporative units only.

ΔkW Expected peak demand savings between baseline and installed equipment.

Cap Nominal capacity (in Tons) of the air-cooled equipment

kWh/Unit Per unit energy savings as stipulated in Table 2-118 and Table 2-119.

kW/Unit Per unit demand savings as stipulated in Table 2-118 and Table 2-119.

2.15.5. Sources

- California Energy Commission. Advanced Evaporative Cooling White Paper. 2004
- Southwest Energy Efficiency Project & UC Davis Western Cooling Efficiency Center. SWEEP / WCEC Workshop on Modern Evaporative Cooling Technologies. 2007
- 3012-14 Non-DEER Ex Ante measure work papers submitted by Southern California Edison and Pacific Gas and Electric. http://www.deeresources.com/
- IECC 2015
- IECC 2018

2.15.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Table 2-118 Unit Energy Savings for Evaporative Coolers – Weather Zone 5

	Retrofit		*New Construction (IECC 2018)*	
Measure	kWh / Unit	kW / Unit	kWh / Unit	kW / Unit
Direct Evaporative Cooler	360kWh	0.25 kW	324kWh	0.23 kW
Indirect Evaporative Cooler	257 kWh	0.18 kW	232 kWh	0.16 kW

Table 2-119 Unit Energy Savings for Evaporative Coolers – Weather Zone 6

	Retrofit		*New Construction (IECC 2018)*	
Measure	kWh / Unit	kW / Unit	kWh / Unit	kW / Unit
Direct Evaporative Cooler	309 kWh	0.25 kW	278kWh	0.25kW
Indirect Evaporative Cooler	221 kWh	0..18 kW	199 kWh	0.16 kW

2.16. Evaporative Pre-Cooler (For Air-Cooled Condensers)

Evaporative pre-coolers, when added to an air-cooled condenser coil, can improve both equipment capacity and energy efficiency. The algorithms and assumptions for this measure are applicable to retrofits in which a separate evaporative cooling system is added onto an air-cooled condenser. Such systems include saturated media, water nozzles (and associated water piping), and a rigid frame. The additional equipment is used to evaporatively pre-cool ambient air before it reaches the air-cooled condenser. This not a replacement of an air-cooled condenser with an evaporative condenser. Typical applications include refrigeration systems and air-cooled chillers.

The tables below summarize the 'typical' expected unit energy impacts for this measure. Typical values are based on the algorithms and stipulated values described below.

Table 2-120 Typical Savings Estimates for Evaporative Pre-Cooler (Installed on Chillers)[110]

	Retrofit	New Construction
Deemed Savings Unit	Ton	Ton
Average Unit Energy Savings	63 kWh	63 kWh
Average Unit Peak Demand Savings	.05 kW	.05 kW
Expected Useful Life	15 Years	15 Years
Average Material & Labor Cost	$ 173	$ 173
Average Incremental Cost	n/a	n/a
Stacking Effect End-Use	HVAC	

Table 2-121 Typical Savings Estimates for Evaporative Pre-Cooler (Installed on Refrigeration Systems)[111]

	Retrofit	New Construction
Deemed Savings Unit	Ton	Ton
Average Unit Energy Savings	110 kWh	110 kWh
Average Unit Peak Demand Savings	.09 kW	.09 kW
Expected Useful Life	15 Years	15 Years
Average Material & Labor Cost	$ 173	$ 173
Average Incremental Cost	Refrigeration	Refrigeration

2.16.1. Definition of Eligible Equipment

Eligible equipment includes retrofits in which equipment is added to an existing air-cooled condenser to evaporatively cool the ambient air temperature before reaching the condenser coils.

[110] See spreadsheet "16-TypicalCalcs_EvapPreCool_v2.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

[111] See spreadsheet "16-TypicalCalcs_EvapPreCool_v2.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

Self-contained evaporative condensing coils are not eligible as part of this measure. Eligible systems must be purchased and installed by a qualified contractor. Eligible equipment must have a minimum performance efficiency of 75%. Must have enthalpy controls to control pre-cooler operation. Water supply must have chemical or mechanical water treatment. Magnetic water treatment does not qualify for this measure.

2.16.2. Definition of Baseline Equipment

Baseline equipment for this measure is determined by the nature of the project. There are two possible scenarios: retrofit (early replacement) or new construction.

Retrofit (Early Replacement)

The baseline equipment for retrofit projects is the existing air-cooled condenser coil in a properly working and maintained condition.

New Construction (Includes Major Remodel & Replace on Burn-Out)

The baseline equipment for new construction projects is defined to be a properly working and maintained air-cooled condenser coil with all required fan and head pressure controls as defined by the local energy codes and standards.

2.16.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta kWh = kWh/Unit * Cap$$

$$\Delta kW = kW/Unit * Cap$$

2.16.4. Definitions

ΔkWh	Expected energy savings between baseline and installed equipment.
ΔkW	Expected peak demand savings between baseline and installed equipment.
Cap	Nominal capacity (in Tons) of the air-cooled equipment
kWh/Unit	Per unit energy savings as stipulated in Table 2-120 and Table 2-121.
kW/Unit	Per unit demand savings as stipulated in Table 2-120 and Table 2-121.

2.16.5. Sources

- Bisbee, Dave & Mort, Dan. Evaporative Precooling System: Customer Advanced Technologies Program Report Technology Evaluation Report. 2010[112]

[112] https://www.smud.org/en/business/save-energy/energy-management-solutions/documents/evapercool-tech-aug10.pdf

- Shen, B., et. al., Energy and Economics Analyses of Condenser Evaporative Precooling for Various Climates, Buildings and Refrigerants. Oak Ridge National Laboratory. Energies 2019, 12(11), 2079One other internal monitoring study was referenced when deriving savings values for this measure; however, has not been made public.

2.17. Variable Frequency Drives (For HVAC Applications)

The following algorithms and assumptions are applicable to Variable Frequency Drives (VFDs) on HVAC fans and pumps installed in commercial spaces. This measure applies to projects which represent either equipment retrofit or new construction (including major renovations).

Table 2-122 summarizes the ‘typical’ expected unit energy impacts for this measure. Typical values are based on algorithms and stipulated values described below and data from past program participants.

Table 2-122 Summary Deemed Savings Estimates for VFD

	Retrofit	New Construction
Deemed Savings Unit	HP	HP
Average Unit Energy Savings	622 kWh	582 kWh
Average Unit Peak Demand Savings	0 kW	0 kW
Expected Useful Life	15 Years	15 Years
Average Material & Labor Cost	$184.55	n/a
Average Incremental Cost	n/a	$153.91
Stacking Effect End-Use	HVAC	

2.17.1. Definition of Eligible Equipment

ALL VFDs installed on variably loaded motors, less than 300 horsepower, in HVAC applications are eligible under this measure. New construction projects must meet or exceeds current federal minimum requirements and VFDs must not be required by the applicable building codes. Retrofit projects must remove or permanently disable any pre-existing throttling or flow control device(s), and cannot replace a pre-existing VFD.

This measure can be combined with sections 2.10, 2.12 and 2.13 if the HVAC system is being replaced and VFD controls are added. Note when combining savings for this measure and 2.12/2.13, this measure can only be applied for if the HVAC fan motor VFD is an addition to the unit and has not already been included in the HVAC unit SEER used for 2.12/2.13. This measure can be combined with sections 2.38 without including any interactive factor penalty. Additionally, ECMs installed with modulating controls qualify for savings associated with this measure.

2.17.2. Definition of Baseline Equipment

Baseline equipment for this measure is determined by the nature of the project. There are two possible scenarios: retrofit or new construction.

Retrofit (Early Replacement)

If the project is retrofitting pre-existing equipment with a variable frequency drive, then the baseline control strategy is defined by the pre-existing control strategy.

New Construction (Includes Major Remodel & Replace on Burn-Out)

For facilities that are installing VFDs during a new construction project the minimum HVAC fan/pump controls strategy is dictated by the prevailing building energy code or standard according to which the project was permitted. Current applicable control standards are defined by IECC 2018.

<u>Code Compliance Considerations for HVAC VFDs</u>

The International Energy Conservation Code (IECC) specifies that fan motors used in VAV systems must have variable speed controls if equal to or greater than a specified horsepower. As such, fan motors in VAV systems are only eligible under this measure if they are less than 7.5 HP when permitted to IECC 2018.

2.17.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta kWh = .746 * HP * LF / \eta_{motor} * HRS * ESF$$

$$\Delta kW = 0$$

2.17.4. Definitions

ΔkWh	Expected energy savings between baseline and installed equipment.
ΔkW	Peak demand savings are defined to be zero for this measure.
HP	Manufacturer name plate rated horsepower of the motor.
LF	Load Factor. Ratio between the actual load and the rated load. Motor efficiency curves typically result in motors being most efficient at approximately 75% of the rated load. The default value is 0.75.
η_{motor}	Manufacturer name plate efficiency of the motor at full load.
HRS	Annual operating hours of VFD. Values for various building types and end uses are stipulated in Table 2-123.
ESF	Energy Savings Factor. Percent of baseline energy consumption saved by installing a VFD. The appropriate ESF can be found in Table 2-124.

2.17.5. Sources

- ASHRAE, Standard 90.1-2019.
- California DEER Effective Useful Life worksheets: EUL_Summary_10-1-08.xls
- California DEER Incremental Cost worksheets: Revised DEER Measure Cost Summary (05_30_2008) Revised (06_02_2008).xls

- Illinois TRM Version 8.0

2.17.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Table 2-123 Stipulated Hours of Use for Commercial HVAC Motors

Building Type	Motor Usage Group	Zone 5	Zone 6
Assembly	Chilled Water Pump	2,111	1,877
	Heating Hot Water Pump	6,133	6,610
	Condenser Water Pump	2,111	1,877
	HVAC Fan	6,132	1,753
	Cooling Tower Fan	1,050	851
Education – Primary School	Chilled Water Pump	649	584
	Heating Hot Water Pump	6,133	6,610
	Condenser Water Pump	649	584
	HVAC Fan	3,454	1,752
	Cooling Tower Fan	711	559
Education – Secondary School	Chilled Water Pump	649	584
	Heating Hot Water Pump	6,133	6,610
	Condenser Water Pump	649	584
	HVAC Fan	3,454	1,752
	Cooling Tower Fan	711	559
Education – Community College	Chilled Water Pump	1,861	1,694
	Heating Hot Water Pump	6,133	6,610
	Condenser Water Pump	1,861	1,694
	HVAC Fan	4,795	1,752
	Cooling Tower Fan	1,050	851
Education – University	Chilled Water Pump	1,861	1,694
	Heating Hot Water Pump	6,133	6,610
	Condenser Water Pump	1,861	1,694
	HVAC Fan	4,795	1,752
	Cooling Tower Fan	1,050	851
Grocery	Chilled Water Pump	1,861	1,694
	Heating Hot Water Pump	6,133	6,610
	Condenser Water Pump	1,861	1,694
	HVAC Fan	5,423	1,752
	Cooling Tower Fan	1,050	851
Health/Medical – Hospital	Chilled Water Pump	2,485	2,028
	Heating Hot Water Pump	6,133	6,610
	Condenser Water Pump	2,485	2,028
	HVAC Fan	8,760	1,753

Building Type	Motor Usage Group	Zone 5	Zone 6
	Cooling Tower Fan	1,050	851
Health/Medical – Nursing Home	Chilled Water Pump	2,485	2,028
	Heating Hot Water Pump	6,133	6,610
	Condenser Water Pump	2,485	2,028
	HVAC Fan	8,760	1,753
	Cooling Tower Fan	1,050	851
Lodging – Hotel	Chilled Water Pump	2,485	2,028
	Heating Hot Water Pump	6,133	6,610
	Condenser Water Pump	2,485	2,028
	HVAC Fan	8,760	1,753
	Cooling Tower Fan	1,050	851
Lodging – Motel	Chilled Water Pump	1,861	1,694
	Heating Hot Water Pump	6,133	6,610
	Condenser Water Pump	1,861	1,694
	HVAC Fan	5,423	1,752
	Cooling Tower Fan	1,050	851
Manufacturing – Light Industrial	Chilled Water Pump	1,418	1,306
	Heating Hot Water Pump	6,133	6,610
	Condenser Water Pump	1,418	1,306
	HVAC Fan	4,672	1,752
	Cooling Tower Fan	1,050	851
Office – Large	Chilled Water Pump	1,612	1,472
	Heating Hot Water Pump	6,133	6,610
	Condenser Water Pump	1,612	1,472
	HVAC Fan	5,047	1,752
	Cooling Tower Fan	1,050	851
Office – Small	Chilled Water Pump	1,612	1,472
	Heating Hot Water Pump	6,133	6,610
	Condenser Water Pump	1,612	1,472
	HVAC Fan	5,047	1,752
	Cooling Tower Fan	1,050	851
Restaurant – Sit Down	Chilled Water Pump	1,861	1,694
	Heating Hot Water Pump	6,133	6,610
	Condenser Water Pump	1,861	1,694
	HVAC Fan	5,423	1,752
	Cooling Tower Fan	1,050	851
Restaurant – Fast Food	Chilled Water Pump	1,861	1,694
	Heating Hot Water Pump	6,133	6,610
	Condenser Water Pump	1,861	1,694
	HVAC Fan	5,423	1,752
	Cooling Tower Fan	1,050	851
Retail – 3 Story	Chilled Water Pump	1,861	1,694

Building Type	Motor Usage Group	Zone 5	Zone 6
	Heating Hot Water Pump	6,133	6,610
	Condenser Water Pump	1,861	1,694
	HVAC Fan	5,423	1,752
	Cooling Tower Fan	1,050	851
Retail – Single Story	Chilled Water Pump	1,861	1,694
	Heating Hot Water Pump	6,133	6,610
	Condenser Water Pump	1,861	1,694
	HVAC Fan	5,423	1,752
	Cooling Tower Fan	1,050	851
Retail – Small	Chilled Water Pump	1,861	1,694
	Heating Hot Water Pump	6,133	6,610
	Condenser Water Pump	1,861	1,694
	HVAC Fan	5,423	1,752
	Cooling Tower Fan	1,050	851
Storage – Conditioned	Chilled Water Pump	1,418	1,306
	Heating Hot Water Pump	6,133	6,610
	Condenser Water Pump	1,418	1,306
	HVAC Fan	4,672	1,752
	Cooling Tower Fan	1,050	851

Table 2-124 Stipulated Energy Savings Factors (ESF) for Commercial HVAC VFD Installations

Building Type	Motor Usage Group	Zone 5	Zone 6
Assembly	Chilled Water Pump	0.313	0.300
	Heating Hot Water Pump	0.411	0.401
	Condenser Water Pump	0.313	0.300
	HVAC Fan	0.297	0.284
	Cooling Tower Fan	0.301	0.278
Education – Primary School	Chilled Water Pump	0.363	0.357
	Heating Hot Water Pump	0.301	0.384
	Condenser Water Pump	0.363	0.357
	HVAC Fan	0.258	0.254
	Cooling Tower Fan	0.324	0.311
Education – Secondary School	Chilled Water Pump	0.363	0.357
	Heating Hot Water Pump	0.301	0.384
	Condenser Water Pump	0.363	0.357
	HVAC Fan	0.258	0.254
	Cooling Tower Fan	0.324	0.311
Education – Community College	Chilled Water Pump	0.319	0.306
	Heating Hot Water Pump	0.309	0.395
	Condenser Water Pump	0.319	0.306
	HVAC Fan	0.303	0.289
	Cooling Tower Fan	0.310	0.286
Education – University	Chilled Water Pump	0.319	0.306
	Heating Hot Water Pump	0.309	0.395
	Condenser Water Pump	0.319	0.306
	HVAC Fan	0.303	0.289
	Cooling Tower Fan	0.310	0.286
Grocery	Chilled Water Pump	0.319	0.306
	Heating Hot Water Pump	0.309	0.395
	Condenser Water Pump	0.319	0.306
	HVAC Fan	0.303	0.289
	Cooling Tower Fan	0.310	0.286
Health/Medical – Hospital	Chilled Water Pump	0.294	0.285
	Heating Hot Water Pump	0.331	0.429
	Condenser Water Pump	0.294	0.285
	HVAC Fan	0.278	0.269
	Cooling Tower Fan	0.279	0.268
Health/Medical – Nursing Home	Chilled Water Pump	0.294	0.285
	Heating Hot Water Pump	0.331	0.429
	Condenser Water Pump	0.294	0.285
	HVAC Fan	0.278	0.269
	Cooling Tower Fan	0.279	0.268

Building Type	Motor Usage Group	Zone 5	Zone 6
Lodging – Hotel	Chilled Water Pump	0.294	0.285
	Heating Hot Water Pump	0.331	0.429
	Condenser Water Pump	0.294	0.285
	HVAC Fan	0.278	0.269
	Cooling Tower Fan	0.279	0.268
Lodging – Motel	Chilled Water Pump	0.319	0.306
	Heating Hot Water Pump	0.309	0.395
	Condenser Water Pump	0.319	0.306
	HVAC Fan	0.303	0.289
	Cooling Tower Fan	0.310	0.286
Manufacturing – Light Industrial	Chilled Water Pump	0.317	0.303
	Heating Hot Water Pump	0.307	0.396
	Condenser Water Pump	0.317	0.303
	HVAC Fan	0.300	0.287
	Cooling Tower Fan	0.307	0.280
Office – Large	Chilled Water Pump	0.319	0.305
	Heating Hot Water Pump	0.307	0.395
	Condenser Water Pump	0.319	0.305
	HVAC Fan	0.302	0.289
	Cooling Tower Fan	0.309	0.285
Office – Small	Chilled Water Pump	0.319	0.305
	Heating Hot Water Pump	0.307	0.395
	Condenser Water Pump	0.319	0.305
	HVAC Fan	0.302	0.289
	Cooling Tower Fan	0.309	0.285
Restaurant – Sit Down	Chilled Water Pump	0.319	0.306
	Heating Hot Water Pump	0.309	0.395
	Condenser Water Pump	0.319	0.306
	HVAC Fan	0.303	0.289
	Cooling Tower Fan	0.310	0.286
Restaurant – Fast Food	Chilled Water Pump	0.319	0.306
	Heating Hot Water Pump	0.309	0.395
	Condenser Water Pump	0.319	0.306
	HVAC Fan	0.303	0.289
	Cooling Tower Fan	0.310	0.286
Retail – 3 Story	Chilled Water Pump	0.319	0.306
	Heating Hot Water Pump	0.309	0.395
	Condenser Water Pump	0.319	0.306
	HVAC Fan	0.303	0.289
	Cooling Tower Fan	0.310	0.286
Retail – Single Story	Chilled Water Pump	0.319	0.306
	Heating Hot Water Pump	0.309	0.395

Building Type	Motor Usage Group	Zone 5	Zone 6
	Condenser Water Pump	0.319	0.306
	HVAC Fan	0.303	0.289
	Cooling Tower Fan	0.310	0.286
Retail – Small	Chilled Water Pump	0.319	0.306
	Heating Hot Water Pump	0.309	0.395
	Condenser Water Pump	0.319	0.306
	HVAC Fan	0.303	0.289
	Cooling Tower Fan	0.310	0.286
Storage – Conditioned	Chilled Water Pump	0.317	0.303
	Heating Hot Water Pump	0.307	0.396
	Condenser Water Pump	0.317	0.303
	HVAC Fan	0.300	0.287
	Cooling Tower Fan	0.307	0.280

2.18. Water-Side Economizers

The following algorithms and assumptions are applicable to water-side economizer units installed in commercial spaces. This measure applies to projects which represent either equipment retrofit or new construction (including major renovations).

Table 2-125 summarizes the 'typical' expected (per combined chillers tonnage) unit energy impacts for this measure. Typical values are based on algorithms and stipulated values described below and data from past program participants.

Table 2-125 Typical Savings Estimates for Water-Side Economizers

	Retrofit	New Construction
Deemed Savings Unit	Ton (Chillers)	Ton (Chillers)
Average Unit Energy Savings	153 kWh	153 kWh
Average Unit Peak Demand Savings	0 kW	0 kW
Expected Useful Life	10 Years	10 Years
Average Material & Labor Cost	$ 725.82	n/a
Average Incremental Cost	n/a	$ 725.82
Stacking Effect End-Use	HVAC	

2.18.1. Definition of Eligible Equipment

Eligibility is determined by the installed cooling system. A water cooled chilled water plant must be present and a separate cooling tower installed dedicated to providing free cooling to the chilled water loop. The installed water-side economizer shall comply with IECC 2018 section C403.5.4 and have a design capacity to provide 100 percent of the system cooling load at temperatures of no greater than 50 ℉ dry bulb and 40 ℉ wet bulb.

2.18.2. Definition of Baseline Equipment

Baseline equipment for this measure is determined by the nature of the project. There are two possible scenarios: retrofit (early replacement) or new construction. For both cases the assumed baseline is a water cooled chilled water plant with no water-side free cooling capabilities.

Retrofit (Early Replacement)

If the project is adding water-side economizing capabilities to a pre-existing chilled water system, then it is considered a retrofit except when the project involves an expansion of capacity of the chilled water plant.

New Construction (Includes Major Remodel & Replace on Burn-Out)

Water-side economizer additions on new chilled water plants and on pre-existing plants undergoing expansion are considered new construction for the purposes of this measure. Recently Idaho adopted IECC 2018 as the energy efficiency standard for new construction. Part of IECC 2018 code compliance is that chilled-water systems greater than 1,320,000 Btu/h and district chilled-water systems greater than 1,720,000 Btu/h require either air or water side economizer control. Projects that exceed the stated size without an air-side economizer are not eligible for this measure. Exceptions are listed in Appendix B section 4.2.

2.18.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta kWh = Cap_{supplanted} * \Delta kWh/Ton$$

2.18.4. Definitions

ΔkWh	Expected energy savings between baseline and installed equipment.
ΔkWh/Ton	Per unit energy savings as stipulated by weather zone.
$Cap_{supplanted}$	The combined rated capacities of all the chillers supplanted by the water-side economizer.

2.18.5. Sources

- California DEER Prototypical Simulation models (modified), eQUEST-DEER 3-5002E[113]
- IECC 2018
- 2010-2012 WO017 Ex Ante Measure Cost Study Final Report.

2.18.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Table 2-126 Water Side Economizer Savings[114]

Building Type	Zone 5 (ΔkWh/Ton)	Zone 6 (ΔkWh/Ton)
Community College	57.8	69.7
University	137.8	153.5
Hospital	341.8	323.0
Large Office	76.2	84.4
3-Story Retail	93.9	96.2
Average	*141.5*	*145.3*

[113] Prototypical building energy simulations were used to generate Idaho specific kWh savings for various buildings.

[114] See “18-TypicalCalcs_WaterEcono_v2.xlsx” for assumptions and calculations used to estimate the typical unit energy savings.

2.19. Kitchen: Refrigerators/Freezers

The following algorithms and assumptions are applicable to the installation of a new reach-in commercial refrigerator, or freezer meeting ENERGY STAR 4.0 efficiency standards. ENERGY STAR labeled commercial refrigerators and freezers are more energy efficient because they are designed with components such as ECM evaporator and condenser fan motors, hot gas anti-sweat heaters, and/or high-efficiency compressors, which will significantly reduce energy consumption.

Table 2-127 and Table 2-128 summarize 'typical' expected (per unit) energy impacts for this measure can be found. Typical values are based on the algorithms and stipulated values described below.[115] Note, there is not a difference between new construction and retrofit because the retrofit baseline is at least as efficient as that required by federal equipment standards.

Table 2-127 Typical Savings Estimates for ENERGY STAR Refrigerators (< 30 ft^3)[116]

	Retrofit	New Construction
Deemed Savings Unit	Refrigerator	Refrigerator
Average Unit Energy Savings	208 kWh	208 kWh
Average Unit Peak Demand Savings	22 W	22 W
Expected Useful Life	12 Years	12 Years
Average Material & Labor Cost	$2,905	n/a
Average Incremental Cost	n/a	$537
Stacking Effect End-Use	Refrigeration	

Table 2-128 Typical Savings Estimates for ENERGY STAR Refrigerators (≥ 30 ft^3)

	Retrofit	New Construction
Deemed Savings Unit	Refrigerator	Refrigerator
Average Unit Energy Savings	463 kWh	463 kWh
Average Unit Peak Demand Savings	50 W	50 W
Expected Useful Life	12 Years	12 Years
Average Material & Labor Cost	$2,905	n/a
Average Incremental Cost	n/a	$1,350
Stacking Effect End-Use	Refrigeration	

[115] See spreadsheet "19-TypicalCalcs_KitchFrigFrzrIce_v3.xlsx" for assumptions and calculations used to estimate the typical unit energy savings, EUL, and incremental costs.

[116] These numbers do not include chest refrigerators. Inclusion of chest refrigerators would increase the 'typical' savings estimates.

Table 2-129 Typical Savings Estimates for ENERGY STAR Freezers (< 30 ft^3)

	Retrofit	New Construction
Deemed Savings Unit	Freezer	Freezer
Average Unit Energy Savings	337 kWh	337 kWh
Average Unit Peak Demand Savings	36 W	36 W
Expected Useful Life	12 Years	12 Years
Average Material & Labor Cost	$3,718	n/a
Average Incremental Cost	n/a	$653
Stacking Effect End-Use	Refrigeration	

Table 2-130 Typical Savings Estimates for ENERGY STAR Freezers (≥ 30 ft^3)

	Retrofit	New Construction
Deemed Savings Unit	Freezer	Freezer
Average Unit Energy Savings	994 kWh	994 kWh
Average Unit Peak Demand Savings	56 W	56 W
Expected Useful Life	12 Years	12 Years
Average Material & Labor Cost	$3,718	n/a
Average Incremental Cost	n/a	$1,729
Stacking Effect End-Use	Refrigeration	

2.19.1. Definition of Eligible Equipment

The eligible equipment is a new commercial vertical solid, glass door refrigerator or freezer, or vertical chest freezer meeting the minimum ENERGY STAR 4.0 efficiency level standards.

2.19.2. Definition of Baseline Equipment

The baseline equipment used to establish energy savings estimates for this measure is established by the Regional Technical Forum (RTF). The RTF uses an existing solid or glass door refrigerator or freezer meeting the minimum federal manufacturing standards effective as of March 27, 2017. The RTF sources a market potential study for and uses a baseline that is more efficient than *code*. Consequently, there is no distinction between baselines for new construction and retrofit projects.

Retrofit (Early Replacement)

See explanation above.

New Construction (Includes Major Remodel & Replace on Burn-Out)

See explanation above.

2.19.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta kWh = \Delta kWh/Unit * N_{units}$$

$$\Delta kW = \Delta kW/Unit * N_{units}$$

$$= \Delta kWh/Unit * CF / Hours$$

2.19.4. Definitions

ΔkWh	Expected energy savings between baseline and installed equipment.
ΔkW	Demand energy savings between baseline and installed equipment.
kWh/Unit	Per unit energy savings as stipulated in Table 2-131 and Table 2-132.
kW/Unit	Per unit demand savings.
$\Delta kW/Unit_i$	Unit demand savings for combination of type, harvest rate, and/or volume.
CF	Coincidence Factor = 0.937
Hours	Annual operating hours = 8760
N_{Units}	Number of refrigerators or freezers

2.19.5. Sources

- Regional Technical Forum measure workbooks: http://rtf.nwcouncil.org/measures/com/ComFreezer_v3.xlsm & http://rtf.nwcouncil.org/measures/com/ComRefrigerator_v3.xlsm
- Regional Technical Forum measure workbook: https://nwcouncil.box.com/v/ComRefrigeratorFreezerv4-2
- Illinois TRM Version 8.0
- ENERGY STAR Certified Commercial Refrigerators and Freezers Database

2.19.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Table 2-131 Unit Energy and Demand Savings for Units less than 15 cu.ft

Measure Category	Energy Savings (kWh/yr)	Peak Reduction (W)
Solid Door Refrigerator	229	24.46
Glass Door Refrigerator	168	17.96
Chest Refrigerator (Solid)	230	24.6
Chest Refrigerator (Glass)	43	4.63
Solid Door Freezers	204	21.77
Glass Door Freezers	335	35.85
Chest Freezer (Solid)	220	23.48
Chest Freezer (Glass)	N/A	N/A

Table 2-132 Unit Energy and Demand Savings for Units 15 to 30 cu.ft.

Measure Category	Energy Savings (kWh/yr)	Peak Reduction (W)
Solid Door Refrigerator	260	27.77
Glass Door Refrigerator	295	31.6
Chest Refrigerator (Solid)	230	24.6
Chest Refrigerator (Glass)	N/A	N/A
Solid Door Freezers	404	43.19
Glass Door Freezers	632	67.63
Chest Freezer (Solid)	229	24.49
Chest Freezer (Glass)	N/A	N/A

Table 2-133 Unit Energy and Demand Savings for Units 30 to 50 cu.ft.

Measure Category	Energy Savings (kWh/yr)	Peak Reduction (W)
Solid Door Refrigerator	250	26.74
Glass Door Refrigerator	564	60.37
Chest Refrigerator (Solid)	N/A	N/A
Chest Refrigerator (Glass)	N/A	N/A
Solid Door Freezers	468	50.1
Glass Door Freezers	1113	119.03
Chest Freezer (Solid)	N/A	N/A
Chest Freezer (Glass)	N/A	N/A

Table 2-134 Unit Energy and Demand Savings for Units greater than 50 cu.ft.

Measure Category	Energy Savings (kWh/yr)	Peak Reduction (W)
Solid Door Refrigerator	445	47.55
Glass Door Refrigerator	594	63.5
Chest Refrigerator (Solid)	N/A	N/A
Chest Refrigerator (Glass)	N/A	N/A
Solid Door Freezers	785	83.94
Glass Door Freezers	1610	172.24
Chest Freezer (Solid)	N/A	N/A
Chest Freezer (Glass)	N/A	N/A

Table 2-135 List of Incremental Cost Data for Refrigerators and Freezers.[117]

Equipment Type	Federal Cost	Energy Star Cost	Incremental Cost
Vertical Transparent Door Refrigerator	$3,216	$4,430	$1,214
Vertical Transparent Door Freezer	$4,395	$6,013	$1,617
Vertical Solid Door Refrigerator	$1,913	$3,099	$1,186
Vertical Solid Door Freezer	$2,322	$3,812	$1,490
Horizontal Transparent Door Refrigerator	$964	$1,468	$504
Horizontal Transparent Door Freezer	$1,047	$1,718	$670
Horizontal Solid Door Refrigerator	$783	$1,186	$404
Horizontal Solid Door Freezer	$796	$1,330	$534

[117] From RTF Workbook: http://rtf.nwcouncil.org/measures/com/ComRefrigeratorFreezer_v4_2

2.20. Kitchen: Ice Machines

The following algorithms and assumptions are applicable to the installation of a new commercial ice machine meeting ENERGY STAR 3.0 efficiency standards. The ENERGY STAR label is applied to air-cooled, cube-type ice machines including ice-making head, self-contained, and remote-condensing units.

Table 2-136 and Table 2-137 summarize the ‘typical’ expected (per unit) energy impacts for this measure. Typical values are based on the algorithms and stipulated values described below. [118] Note there is not a difference between new construction and retrofit because the retrofit baseline is at least as efficient as that required by federal equipment standards.

Table 2-136 Typical Savings Estimates for Ice Machines (<200 lbs/day)

	Retrofit	New Construction
Deemed Savings Unit	Machine	Machine
Average Unit Energy Savings	285 kWh	285 kWh
Average Unit Peak Demand Savings	0.05 kW	0.05 kW
Expected Useful Life	9 Years	9 Years
Average Material & Labor Cost	$2,775	n/a
Average Incremental Cost	n/a	$311
Stacking Effect End-Use	n/a	

Table 2-137 Typical Savings Estimates for Ice Machines (≥200 lbs/day)

	Retrofit	New Construction
Deemed Savings Unit	Machine	Machine
Average Unit Energy Savings	2608 kWh	2608 kWh
Average Unit Peak Demand Savings	0.49 kW	0.49 kW
Expected Useful Life	9 Years	9 Years
Average Material & Labor Cost	$3,130	n/a
Average Incremental Cost	n/a	$311
Stacking Effect End-Use	n/a	

2.20.1. Definition of Eligible Equipment

The eligible equipment is a new commercial ice machine meeting the minimum ENERGY STAR 3.0 efficiency level standards.

[118] See spreadsheet “20-TypicalCalcs_KitchIceMcn_v3.xlsx” for assumptions and calculations used to estimate the typical unit energy savings, EUL, and incremental costs.

2.20.2. Definition of Baseline Equipment

The baseline condition for retrofit and new construction is established by the RTF. The RTF uses a commercial ice machine meeting federal equipment standard effective January 1, 2018. The RTF sources a market potential study for and uses a baseline that is more efficient than *code*. Consequently, there is no distinction between baselines for new construction and retrofit projects.

Retrofit (Early Replacement)

See explanation above.

New Construction (Includes Major Remodel & Replace on Burn-Out)

See explanation above.

2.20.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta kWh = \Delta kWh/Unit * N_{Units}$$

$$= [(kWh_{base} - kWh_{Installed}) /100 * H * DC * 365.25] * N_{Units}$$

$$\Delta kW = \Delta kW/Unit * N_{Units}$$

$$= \Delta kWh/Unit_{i,ice} * CF / Hours$$

2.20.4. Definitions

ΔkWh	Expected energy savings between baseline and installed equipment.
ΔkW	Demand energy savings between baseline and installed equipment.
ΔkWh/Unit	Per unit energy savings as stipulated in Table 2-138.
ΔkW/Unit	Per unit demand savings as stipulated in Table 2-138.
$kWh_{base/Installed}$	Daily energy usage per 100 pounds of ice for *base* (baseline) or *installed* ice machines.
$\Delta kWh_{wastewater}$	Annual savings from reduced water usage.
CF	Coincidence Factor = 0.9[119]
H	Harvest Rate (pounds of ice made per day)

[119] From SDGE Workpaper: WPSDGENRCC0004 Revision 3

DC	Duty Cycle of the ice Machine[120]
N_{Units}	Number of refrigerators or freezers

2.20.5. Sources

- Regional Technical Forum measure workbooks: http://rtf.nwcouncil.org/measures/com/ComIceMaker_v1_2.xlsx
- SDG&E Work Paper: WPSDGENRCC0004, “Commercial Ice Machines” Revision 3
- Illinois TRM Version 8.0
- ENERGY STAR Automatic Commercial Ice Makers Version 3.0 Specification

2.20.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Ice Making Head (IMH): automatic commercial ice makers that do not contain integral storage bins but are generally designed to accommodate a variety of bin capacities. Storage bins entail additional energy use not included in the reported energy consumption figures for these units.[121]

Remote Condensing Unit (RSU): A type of automatic commercial ice maker in which the ice-making mechanism and condenser or condensing unit are in separate sections. This includes ice makers with and without remote compressor.[122]

Self-Contained Unit (SCU): A type of automatic commercial ice maker in which the ice-making mechanism and storage compartment are in an integral cabinet.[123]

[120] Value from Illinois Technical Reference Manual 4.2.10

[121] ENERGY STAR Automatic Commercial Ice Makers Version 3.0 Specification

[122] ENERGY STAR Automatic Commercial Ice Makers Version 3.0 Specification

[123] ENERGY STAR Automatic Commercial Ice Makers Version 3.0 Specification

Table 2-138 Unit Energy Savings for Ice Machine[124]

Measure	kWh per Unit Savings	kW per Unit Savings
Air-cooled Batched IMH < 200 lb	147	0.03
Air-cooled Batched IMH ≥ 200 lb	1072	0.20
Air-cooled Batched RCU < 200 lb	215	0.04
Air-cooled Batched RCU ≥ 200 lb	1771	0.33
Air-cooled Batched SCU < 200 lb	320	0.06
Air-cooled Batched SCU ≥ 200 lb	4214	0.79
Air-cooled Continuous IMH < 200 lb	250	0.05
Air-cooled Continuous IMH ≥ 200 lb	2620	0.49
Air-cooled Continuous RCU < 200 lb	380	0.07
Air-cooled Continuous RCU ≥ 200 lb	3288	0.62
Air-cooled Continuous SCU < 200 lb	304	0.06
Air-cooled Continuous SCU ≥ 200 lb	2001	0.38

Table 2-139 Unit Incremental Cost for Ice Machines[125]

Harvest Rate (H)	New Construction & ROB	Retrofit - ER
100-200 lb ice machine	$311	$2,775
201-300 lb ice machine	$311	$2,775
301-400 lb ice machine	$266	$2,673
401-500 lb ice machine	$266	$2,673
501-1000 lb ice machine	$249	$4,561
1001-1500 lb ice machine	$589	$4,688
>1500 lb ice machine	$939	$8,130

[124] Values given are based on assumed weights for harvest rates. Savings vary significantly between harvest rates.

[125] Values from SDGE Workpaper: WPSDGENRCC0004 Revision 3

2.21. Kitchen: Efficient Dishwashers

The measure relating to the installation of an efficient dish washer is no longer offered in the incentive program since the Regional Technical Forum has deactivated this measure based on current building standard practices. Refer to version 2.2 of the Idaho Power TRM for previous assumptions.

2.22. Refrigeration: Efficient Refrigerated Cases

The measure relating to the installation of efficient refrigerated case has been deemed standard practice and is no longer offered in the incentive program. Refer to version 2.2 of the Idaho Power TRM for previous assumptions.

2.23. Refrigeration: ASH Controls

Anti-sweat heater (ASH) controls turn off door heaters when there is little or no risk of condensation. There are two commercially available control strategies that achieve “on-off” control of door heaters based on either: (1) the relative humidity of the air in the store or (2) the “conductivity” of the door (which drops when condensation appears). In the first strategy, the system activates door heaters when the relative humidity in a store rises above a specific set-point and turns them off when the relative humidity falls below that set-point. In the second strategy, the sensor activates the door heaters when the door conductivity falls below a certain set-point and turns them off when the conductivity rises above that set-point. Without controls, anti-sweat heaters run continuously whether they are necessary or not. Savings are realized from the reduction in energy used by not having the heaters running continuously. In addition, secondary savings result from reduced cooling load on the refrigeration unit when the heaters are off.

The following algorithms and assumptions are applicable to ASH controls installed on commercial glass door coolers and freezers.

Table 2-140 summarizes the ‘typical’ expected (per linear ft. of case) energy impacts for this measure. Typical values are based on the algorithms and stipulated values described below.

Table 2-140 Typical Savings Estimates for ASH Controls[126]

	Retrofit	New Construction
Deemed Savings Unit	linear ft. of case	n/a
Average Unit Energy Savings	256 kWh	n/a
Average Unit Peak Demand Savings	29.2 W	n/a
Expected Useful Life	8 Years	n/a
Average Material & Labor Cost	$ 77.26[127]	n/a
Average Incremental Cost	n/a	n/a
Stacking Effect End-Use	Refrigeration	

2.23.1. Definition of Eligible Equipment

The eligible equipment is assumed to be a door heater control on a commercial glass door cooler or refrigerator utilizing humidity or conductivity control. This does not apply to special doors with low/no anti-sweat heat.

2.23.2. Definition of Baseline Equipment

There are two possible project baseline scenarios – retrofit and new construction. This measure currently only addresses the retrofit scenario.

[126] See spreadsheet “23-TypicalCalcs_ASH_v4.xlsx” for assumptions and calculations used to estimate the typical unit energy savings, expected useful life, and incremental costs.

[127] The cost is based on the most recent Regional Technical Forum Measure Workbook for this measure: http://rtf.nwcouncil.org/measures/Com/ComGroceryAntiSweatHeaters_v4.3.xlsm.

Retrofit (Early Replacement)

The baseline condition is assumed to be a commercial glass door cooler or refrigerator with a standard heated door with no controls installed.

New Construction (Includes Major Remodel & Replace on Burn-Out)

New construction is not eligible for this measure as this measure is assumed to be standard practice.

2.23.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta kWh = [\,(W_{Installed} * F_{waste} * 3.413 * 8760 * F_{Sav} / (\,EER * DF * 1000\,)) + (W_{Installed} * 8760 * F_{Sav} / 1000\,)\,] * L$$

$$\Delta kW = \Delta kWh / 8760$$

2.23.4. Definitions

ΔkWh	Expected energy savings between baseline and installed equipment.
ΔkW	Expected demand reduction between baseline and installed equipment.
$W_{Installed}$	Connected load (kW) for typical reach-in refrigerator or freezer door and frame with a heater.
L	Length of the cases in linear feet.
EER	Energy Efficiency Ratio for the annual average refrigeration system.
DF	Degradation Factor accounts for the refrigeration and HVAC systems ages, condenser cleanliness and condition, and evaporative or air cooled condenser.
F_{waste}	Waste Heat Factor. Defined as the percentage of ASH energy use that is converted into heat in the case and must be removed by the refrigeration system. Stipulated values for this figure are provided in Table 2-141.
F_{Sav}	ASH run-time reduction Factor. Stipulated values for this figure are provided in Table 2-141.

2.23.5. Sources

- June 2001 edition of ASHRAE Journal

- Regional Technical Forum, Measure Workbooks http://rtf.nwcouncil.org/measures/com/ComGroceryAntiSweatHeaterControls_v4.3.xlsm
- PG&E Work Paper PGEREF108: Anti-Sweat Heat (ASH) Control

2.23.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Table 2-141 Connected Load for Typical Reach-In Case[128]

Case Type	kW_{Base}	EER	DF	F_{waste}	F_{Sav}	ΔW/linear ft. case	ΔkWh/linear ft. case
Low Temperature	55.20	4.10	0.98	35%	47%	33.4	292
Medium Temperature	23.68	10.56	0.98	35%	95%	25.1	220
Average	39.44	7.33	0.98	35%	71%	29.2	256

[128] The values are based on the most recent Regional Technical Forum Measure Workbook for this measure. http://rtf.nwcouncil.org/measures/Com/ComGroceryAntiSweatHeaters_v4.3.xlsm

2.24. Refrigeration: Auto-Closer

Auto-closers on freezers and coolers can reduce the amount of time that doors are open, thereby reducing infiltration and refrigeration loads.

The following algorithms and assumptions are applicable to auto-closers installed on reach-in and walk-in coolers and freezers.

Table 2-142 through Table 2-145 summarize the 'typical' expected (per door) energy impacts for this measure. Typical values are based on the algorithms and stipulated values described below. [129]

Table 2-142 Typical Savings Estimates for Auto-Closers (Walk-In, Low-Temp)

	Retrofit	New Construction
Deemed Savings Unit	Door	n/a
Average Unit Energy Savings	2,509 kWh	n/a
Average Unit Peak Demand Savings	0.27 kW	n/a
Expected Useful Life	8 Years	n/a
Average Material & Labor Cost	$ 736	n/a
Average Incremental Cost	n/a	n/a
Stacking Effect End-Use	Refrigeration	

Table 2-143 Typical Savings Estimates for Auto-Closers (Walk-In, Med-Temp)

	Retrofit	New Construction
Deemed Savings Unit	Door	n/a
Average Unit Energy Savings	562 kWh	n/a
Average Unit Peak Demand Savings	0.14 kW	n/a
Expected Useful Life	8 Years	n/a
Average Material & Labor Cost	$ 736	n/a
Average Incremental Cost	n/a	n/a
Stacking Effect End-Use	Refrigeration	

[129] See spreadsheet "24-TypicalCalcs_AutoCloser_v4.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

Table 2-144 Typical Savings Estimates for Auto-Closers (Reach-In, Low-Temp)

	Retrofit	New Construction
Deemed Savings Unit	Door	n/a
Average Unit Energy Savings	326 kWh	n/a
Average Unit Peak Demand Savings	0.04 kW	n/a
Expected Useful Life	8 Years	n/a
Average Material & Labor Cost	$736	n/a
Average Incremental Cost	n/a	n/a
Stacking Effect End-Use	Refrigeration	

Table 2-145 Typical Savings Estimates for Auto-Closers (Reach-In, Med-Temp)

	Retrofit	New Construction
Deemed Savings Unit	Door	n/a
Average Unit Energy Savings	243 kWh	n/a
Average Unit Peak Demand Savings	0.04 kW	n/a
Expected Useful Life	8 Years	n/a
Average Material & Labor Cost	$ 736	n/a
Average Incremental Cost	n/a	n/a
Stacking Effect End-Use	Refrigeration	

2.24.1. Definition of Eligible Equipment

The eligible equipment is an auto-closer that must be able to firmly close the door when it is within one inch of full closure.

2.24.2. Definition of Baseline Equipment

There are two possible project baseline scenarios – retrofit and new construction. This measure currently only addresses the retrofit scenario.

Retrofit (Early Replacement)

The baseline equipment is doors not previously equipped with functioning auto-closers and assumes the walk-in doors have strip curtains. Walk-in doors without strip curtains are still available to apply for this measure incentive but there is no additional savings calculated based on the lack of strip curtains. Additionally, walk-in doors without auto-closers and strip curtains can apply for both Refrigeration: Auto Closers AND Refrigeration Strip Curtains without any interactive effect penalty.

New Construction (Includes Major Remodel & Replace on Burn-Out)

New construction is not eligible for this measure as this measure is assumed to be standard practice.

2.24.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta kWh = \Delta kWh/Unit * N_{Units}$$

$$\Delta kW = \Delta kW/Unit * N_{Units}$$

2.24.4. Definitions

ΔkWh	Expected energy savings between baseline and installed equipment.
ΔkW	Expected demand reduction between baseline and installed equipment.
ΔkWh/Unit	Unit energy savings estimates. Stipulated values for this input are provided in Table 2-146 based on case type and temperature.
ΔkW/Unit	Unit demand savings estimates. Stipulated values for this input are provided in Table 2-146 based on case type and temperature.
N_{Units}	Number of doors onto which this measure is installed.

2.24.5. Sources

- Regional Technical Forum, Measure Workbooks
  http://rtf.nwcouncil.org/measures/com/ComGroceryAutoCloser_v1_2.xlsm
  http://rtf.nwcouncil.org/measures/com/ComGroceryDisplayCaseECMs_v2_2.xlsm
- Workpaper PGECOREF110.7 – Auto-Closers for Main Cooler or Freezer Doors
- DEER Measure Cost Summary:
  http://www.deeresources.com/deer0911planning/downloads/DEER2008_Costs_ValuesAndDocumentation_080530Rev1.zip

2.24.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Table 2-146 Unit Energy and Demand Savings Estimates

Case Temperature	ΔkWh/Unit	ΔkW/Unit
Low Temperature (Reach-in)	326	0.04
Medium Temperature (Reach-in)	243	0.04
Low Temperature (Walk-in)	2,509	0.27
Medium Temperature (Walk-in)	562	0.14

2.25. Refrigeration: Condensers

The following algorithms and assumptions are applicable to efficient air and evaporative cooled refrigeration condensers. Condensers can be oversized to take maximum advantage of low ambient dry-bulb (for air-cooled) or wet-bulb (for evaporative cooled) temperatures.

Table 2-147 summarizes the 'typical' expected (per ton) energy impacts for this measure. Typical values are based on the algorithms and stipulated values described below.

Table 2-147 Summary Deemed Savings Estimates for Efficient Refrigeration Condenser

	Retrofit	New Construction
Deemed Savings Unit	Ton	ton
Average Unit Energy Savings	120 kWh	114 kWh
Average Unit Peak Demand Savings	0.118 kW	0.112 kW
Expected Useful Life	15 Years	15 Years
Average Material & Labor Cost	$ 912[130]	n/a
Average Incremental Cost	n/a	$ 192[131]
Stacking Effect End-Use	Refrigeration	

2.25.1. Definition of Eligible Equipment

Efficient condenser retrofits must have floating head pressure controls, staged or VSD controlled fans, must operate with subcooling of 5°F or more at design conditions and have a TD of 8°F of less for low-temp systems, 13°F or less for med-temp systems and 18°F or less for evaporative condensers.

2.25.2. Definition of Baseline Equipment

Baseline equipment for this measure is determined by the nature of the project. There are two possible scenarios: retrofit (early replacement) or new construction.

Retrofit (Early Replacement)

The baseline equipment for retrofit projects is the existing condenser coil in a properly working and maintained condition.

New Construction (Includes Major Remodel & Replace on Burn-Out)

The baseline equipment for new construction projects is defined to be a properly working and maintained condenser coil with all required fan and head pressure controls as defined by the local energy codes and standards.

130 SWCR022 Version 1 Refrigeration Efficient Adiabatic Condenser

131 SWCR022 Version 1 Refrigeration Efficient Adiabatic Condenser

2.25.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta kWh = \Delta kWh/Unit * N_{Units}$$

$$\Delta kW = \Delta kW/Unit * N_{units}$$

2.25.4. Definitions

ΔkWh	Expected energy savings between baseline and installed equipment.
ΔkW	Expected demand reduction between baseline and installed equipment.
ΔkWh/Unit	Per unit energy savings as stipulated in Table 2-148.
ΔkW/Unit	Per unit demand savings as stipulated in Table 2-148.
N_{units}	Number of condensers installed on individual systems

2.25.5. Sources

- Ameren Missouri Technical Resource Manual Version 2.0
- SWCR022 Version 1 Refrigeration Efficient Adiabatic Condenser
- DEER 2011 database

2.25.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Table 2-148 Unit Energy Savings for Efficient Refrigeration Condenser[132]

Measure	kWh/Ton	kW/Ton
Energy Efficient Condenser - Retrofit	120	0.118
Energy Efficient Condenser – New Construction	114	0.112

[132] From Ameren Missouri Technical Resource Manual

2.26. Refrigeration: Controls

Floating-head pressure controls take advantage of low outside air temperatures to reduce the amount of work for the compressor by allowing the head pressure to drop and rise along with outdoor conditions. Dropping the head pressure during low outdoor ambient temperature conditions (less than 70 degrees F) reduces compressor energy consumption and overall runtime. Floating suction pressure requires controls to reset refrigeration system target suction temperature based on refrigerated display case or walk-in temperature, rather than operating at a fixed suction temperature set-point. This also reduces compressor energy consumption and overall runtime.

Table 2-149 through Table 2-151 the ‘typical’ expected (per unit) energy impacts for this measure. Typical values are based on the algorithms and stipulated values described below.

Table 2-149 Typical Savings Estimates for Floating Suction Pressure Controls (Only)

	Retrofit	**New Construction**
Deemed Savings Unit	HP	HP
Average Unit Energy Savings	104 kWh	77 kWh
Average Unit Peak Demand Savings	19 W	10 W
Expected Useful Life	16 Years	16 Years
Average Material & Labor Cost	$86.91	n/a
Average Incremental Cost	n/a	$53.75
Stacking Effect End-Use	Refrigeration	

Table 2-150 Typical Savings Estimates for Floating Head Pressure Controls (Only)

	Retrofit	**New Construction**
Deemed Savings Unit	HP	HP
Average Unit Energy Savings	440 kWh	225 kWh
Average Unit Peak Demand Savings	17 W	11 W
Expected Useful Life	16 Years	16 Years
Average Material & Labor Cost	$311.90	n/a
Average Incremental Cost	n/a	$171.90
Stacking Effect End-Use	Refrigeration	

Table 2-151 Typical Savings Estimates for Floating Head and Suction Pressure Controls

	Retrofit	New Construction
Deemed Savings Unit	HP	HP
Average Unit Energy Savings	544 kWh	302 kWh
Average Unit Peak Demand Savings	36 W	21 W
Expected Useful Life	16 Years	16 Years
Average Material & Labor Cost	$398.81	n/a
Average Incremental Cost	n/a	$225.65
Stacking Effect End-Use	Refrigeration	

2.26.1. Definition of Eligible Equipment

Refrigeration systems having compressors with motors rated 1 horsepower or larger are eligible. A head pressure control valve (flood-back control valve) must be installed to lower minimum condensing head pressure from fixed position (180 psig for R-22; 210 psig for R-404a) to a saturated pressure equivalent to 70 degrees F or less. Either a balanced-port or electronic expansion valve that is sized to meet the load requirement at a 70 degree condensing temperature must be installed. Alternatively, a device may be installed to supplement refrigeration feed to each evaporator attached to condenser that is reducing head pressure. Equipment eligibility is based on the requirements stated in the most recent Reginal Technical Forum measure for Floating Head Pressure Controls and should be referenced for me details on eligible equipment.

2.26.2. Definition of Baseline Equipment

There are two possible project baseline scenarios – retrofit and new construction.

Retrofit (Early Replacement)

The baseline equipment for retrofit projects is the existing refrigeration system without floating head and/or suction pressure controls.

New Construction (Includes Major Remodel & Replace on Burn-Out)

The baseline equipment for New Construction projects is a refrigeration system meeting current federal energy efficiency requirements and without floating head and/or suction pressure controls.

Recently Idaho adopted IECC 2018 as the energy efficiency standard for new construction. IECC 2018 standards now requires that compressors include a floating suction pressure control logic and therefore are not eligible for that part of this measure savings.

Exception: Controls are not required for the following:

- Single-compressor systems that do not have variable capacity capability.
- Suction groups that have a design saturated suction temperature of 30° F or higher, suction groups that comprise the high stage of a two-stage or cascade system, or suction groups that primarily serve chillers for secondary cooling fluids.

2.26.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta kWh = \Delta kWh/Unit * Cap$$

$$\Delta kW = \Delta kW/Unit * Cap$$

2.26.4. Definitions

ΔkWh	Expected energy savings between baseline and installed equipment.
ΔkW	Expected demand reduction between baseline and installed equipment.
ΔkWh/Unit	Per unit energy savings as stipulated in Table 2-152 and Table 2-153 according to building type, building vintage, and baseline refrigeration system type.
ΔW/Unit	Per unit demand savings (in Watts) as stipulated in Table 2-152 and Table 2-153 according to building type, building vintage, and baseline refrigeration system type.
Cap	The capacity (in Tons) of the refrigeration system(s) onto which controls are being installed.

2.26.5. Sources

- DEER Database for Energy-Efficient Resources. Version 2011 4.01
- DEER Measure Cost Summary: http://www.deeresources.com/deer0911planning/downloads/DEER2008_Costs_ValuesAndDocumentation_080530Rev1.zip
- Regional Technical Forum UES workbook for Floating Head Pressure Controls: http://rtf.nwcouncil.org/measures/com/ComGroceryFHPCSingleCompressor_v2_1.xls
- IECC 2018

2.26.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Table 2-152 Unit Energy and Demand Savings estimates for Retrofit Projects

Measure Description	ΔkWh/HP	ΔW/HP
Grocery, Floating Suction Pressure	104	17.27
Grocery, Floating Head Pressure, Fixed Setpoint (air-cooled)	325	-0.81
Grocery, Floating Head Pressure, Fixed Setpoint (evap-cooled)	466	4.59
Grocery, Floating Head Pressure, Variable Setpoint (air-cooled)	345	9.05
Grocery, Floating Head Pressure, Variable Setpoint (evap-cooled)	484	26.89
Grocery, Floating Head Pressure, Variable Setpt & Speed (air-cooled)	520	21.90
Grocery, Floating Head Pressure, Variable Setpt & Speed (evap-cooled)	515	30.85
Ref Warehse, Floating Suction Pressure	115	57.89
Ref Warehse, Floating Head Pressure, Fixed Setpoint (evap-cooled)	351	45.10
Ref Warehse, Floating Head Pressure, Variable Setpoint (evap-cooled)	351	45.10
Ref Warehse, Floating Head Pressure, Variable Setpt & Speed (evap-cooled)	467	45.10

Table 2-153 Unit Energy and Demand Savings estimates for New Construction Projects

Measure Description	ΔkWh/HP	ΔW/HP
Grocery, Floating Suction Pressure	78	9.62
Grocery, Floating Head Pressure, Fixed Setpoint (air-cooled)	120	0.00
Grocery, Floating Head Pressure, Fixed Setpoint (evap-cooled)	184	-23.55
Grocery, Floating Head Pressure, Variable Setpoint (air-cooled)	169	16.24
Grocery, Floating Head Pressure, Variable Setpoint (evap-cooled)	190	0.62
Grocery, Floating Head Pressure, Variable Setpt & Speed (air-cooled)	411	63.16
Grocery, Floating Head Pressure, Variable Setpt & Speed (evap-cooled)	226	4.96
Ref Warehse, Floating Suction Pressure	70	12.31
Ref Warehse, Floating Head Pressure, Fixed Setpoint (evap-cooled)	352	28.06
Ref Warehse, Floating Head Pressure, Variable Setpoint (evap-cooled)	352	28.06
Ref Warehse, Floating Head Pressure, Variable Setpt & Speed (evap-cooled)	438	28.06

2.27. Refrigeration: Door Gasket

The measure relating to the installation of door gasket for refrigeration has been deemed standard practice and is no longer offered in the incentive program. Refer to version 2.2 of the Idaho Power TRM for previous assumptions.

2.28. Refrigerator: Evaporator Fans

This measure has been removed from the TRM because it is deemed standard practice for new construction and for retrofit there are too many restrictions to the unit size and fitting that most new models fail to qualify as viable replacements for existing units. This difficulty to find a qualifying retrofit unit results in poor customer experience and reduces participation in other TRM measures.

2.29. Refrigeration: Insulation

This measure applies to installation of insulation on existing bare suction lines (the larger diameter lines that run from the evaporator to the compressor) that are located outside of the refrigerated space. Insulation impedes heat transfer from the ambient air to the suction lines, thereby reducing undesirable system superheat. This decreases the load on the compressor, resulting in decreased compressor operating hours, and energy savings. Table 2-154 and Table 2-155 summarize the 'typical' expected (per foot) energy impacts for this measure. Typical values are based on the algorithms and stipulated values described below.

Table 2-154 Typical Savings Estimates for Suction Line Insulation for Medium-Temperature Coolers[133]

	Retrofit	New Construction
Deemed Savings Unit	Linear Foot	n/a
Average Unit Energy Savings	7.5 kWh	n/a
Average Unit Peak Demand Savings	1.5 W	n/a
Expected Useful Life	7 Years	n/a
Average Material & Labor Cost	$ 6.45	n/a
Average Incremental Cost	n/a	n/a
Stacking Effect End-Use	Refrigeration	

Table 2-155 Typical Savings Estimates for Suction Line Insulation for Low-Temperature Freezers[134]

	Retrofit	New Construction
Deemed Savings Unit	Linear Foot	n/a
Average Unit Energy Savings	12 kWh	n/a
Average Unit Peak Demand Savings	2.3 W	n/a
Expected Useful Life	7 Years	n/a
Average Material & Labor Cost	$ 7.35	n/a
Average Incremental Cost	n/a	n/a
Stacking Effect End-Use	Refrigeration	

2.29.1. Definition of Eligible Equipment

Insulation must insulate bare refrigeration suction lines of 2-1/4 inches in diameter or less on existing equipment only. Medium temperature lines require 3/4 inch of flexible, closed-cell, nitrite rubber or an equivalent insulation. Low temperature lines require 1-inch of insulation that is in compliance with the specifications above. Insulation exposed to the outdoors must be protected from the weather (i.e. jacketed with a medium-gauge aluminum jacket).

[133] From SCE Work Paper: SCE17RN003.2

[134] From SCE Work Paper: SCE17RN003.2

2.29.2. Definition of Baseline Equipment

There are two possible project baseline scenarios – retrofit and new construction. This measure currently only addresses the retrofit scenario.

Retrofit (Early Replacement)

The baseline condition is an un-insulated (bare) refrigeration suction line.

New Construction (Includes Major Remodel & Replace on Burn-Out)

New construction is not eligible since installation of insulation on refrigerant suction line is standard practice.

2.29.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta kWh = \Delta kWh/Length * L$$

$$\Delta kW = \Delta kW/Length * L$$

2.29.4. Definitions

ΔkWh	Expected energy savings between baseline and installed equipment.
ΔkW	Expected demand reduction between baseline and installed equipment.
ΔkWh/Length	Energy savings per unit of length. Stipulated values for this input are listed in Table 2-156.
ΔkW/Length	Energy savings per unit of length. Stipulated values for this input are listed in Table 2-156.
L	Length of insulation installed.

2.29.5. Sources

- Southern California Edison Company, "Insulation of Bare Refrigeration Suction Lines", Work Paper SCE17RN003 Revision 2
- Regional Technical Forum, Measure Workbooks: http://rtf.nwcouncil.org/measures/com/ComGroceryWalkinECM_v3_1.xlsm

2.29.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Table 2-156 Unit Energy Savings for Suction Line Insulation[135]

Case Type	***ΔkW/ft***	***ΔkWh/ft***
Medium-Temperature Coolers	0.001548	7.5
Low-Temperature Freezers	0.00233	12

[135] See spreadsheet "29-TypicalCalcs_RefIns_v3.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs. Unit energy savings are referenced from the DEER for California climate zone 16 (which exhibits the most similar weather to Idaho). Note that these savings do not exhibit significant sensitivity to outdoor weather.

2.30. Refrigeration: Night Covers

Night covers are deployed during facility unoccupied hours to reduce refrigeration energy consumption. These types of display cases are typically found in all size grocery stores. The inside display case air temperature for low-temperature is below 10°F, for medium-temperature between 10°F to 30°F and for high-temperature between 30°F to 55°F. The main benefit of using night covers on open display cases is a reduction of infiltration and radiation cooling loads. It is recommended that these covers have small, perforated holes to decrease moisture buildup. The following algorithms and assumptions are applicable to night covers installed on existing open-type refrigerated display cases.

Table 2-157 summarizes the 'typical' expected (per ft. of the opening width) energy impacts for this measure. Typical values are based on the algorithms and stipulated values described below.

Table 2-157 Typical Savings Estimates for Night Covers

	Retrofit	New Construction
Deemed Savings Unit	ft. of case	n/a
Average Unit Energy Savings	158 kWh	n/a
Average Unit Peak Demand Savings	0.0 kW	n/a
Expected Useful Life	5 Years	n/a
Average Material & Labor Cost	$ 42.20	n/a
Average Incremental Cost	n/a	n/a
Stacking Effect End-Use	Refrigeration	

2.30.1. Definition of Eligible Equipment

The eligible equipment is assumed to be a refrigerated case with a continuous cover deployed during overnight periods. Characterization assumes covers are deployed for six hours daily.

2.30.2. Definition of Baseline Equipment

There are two possible project baseline scenarios – retrofit and new construction. This measure currently only addresses the retrofit scenario.

Retrofit (Early Replacement)

The baseline equipment is assumed to be an open refrigerated case with no continuous covering deployed during overnight periods.

New Construction (Includes Major Remodel & Replace on Burn-Out)

New construction is not eligible for this measure as this measure is assumed to be standard practice.

2.30.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta kWh = \Delta kWh/Unit * L$$

$$\Delta kW = 0$$

2.30.4. Definitions

ΔkWh	Expected energy savings between baseline and installed equipment.
ΔkW	Defined to be zero for this measure. Demand savings are zero because it is assumed that the covers aren't used during the peak period.
ΔkWh/Unit	Per unit energy savings as stipulated in Table 2-158 according to case temperature and climate zone.

2.30.5. Sources

- PGE Workpaper. "Night Covers for Display Cases Revision #6", PGECOREF101 vision 6.0
- DEER Measure Cost Summary: http://www.deeresources.com/deer0911planning/downloads/DEER2008_Costs_ValuesAndDocumentation_080530Rev1.zip
- Arkansas TRM Version 8.0

2.30.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Table 2-158 Unit Energy Savings for Refrigeration: Night Covers

Case Type	Savings (kWh/ft)
Low Temperature	197
Medium Temperature	119

2.31. Refrigeration: No-Heat Glass

New low/no heat door designs incorporate heat reflective coatings on the glass, gas inserted between the panes, non-metallic spacers to separate the glass panes, and/or non-metallic frames (such as fiberglass). This protocol documents the energy savings attributed to the installation of special glass doors with low/no anti-sweat heaters for low temp cases. Table summarizes the 'typical' expected (per door) energy impacts for this measure. Typical values are based on the algorithms and stipulated values described below.

Table 2-159 Typical Savings Estimates for Low/No Heat Doors[136]

	Retrofit	New Construction
Deemed Savings Unit	Door	Door
Average Unit Energy Savings	779 kWh	675 kWh
Average Unit Peak Demand Savings	0.16 kW	0.14 kW
Expected Useful Life	12 Years	12 Years
Average Material & Labor Cost	$664	n/a
Average Incremental Cost	n/a	$544
Stacking Effect End-Use	Refrigeration	

2.31.1. Definition of Eligible Equipment

The eligible equipment is a no-heat/low-heat clear glass on an upright display case. It is limited to door heights of 57 inches or more. Doors must have either heat reflective treated glass, be gas filled, or both. This measure applies to low temperature cases only—those with a case temperature below 0°F. Doors must have 3 or more panes. Total door rail, glass, and frame heater wattage cannot exceed 54 Watts per door for low temperature display cases.

2.31.2. Definition of Baseline Equipment

There are two possible project baseline scenarios – retrofit and new construction.

Retrofit (Early Replacement)

The baseline condition is assumed to be a commercial glass door that consists of two-pane glass, aluminum doorframes and door rails, and door and frame heaters. For the purposes of calculating typical energy savings for this measure it is assumed that the baseline door and frame heaters consume 214 Watts per door.

New Construction (Includes Major Remodel & Replace on Burn-Out)

The baseline for new construction projects is established by the typically commercial glass door employed. For the purposes of calculating typical energy savings for this measure it is assumed that the baseline door and frame heaters consume 193 Watts per door.

[136] See spreadsheet "31-TypicalCalcs_NoHeatGlass_v4.xlsx" for assumptions and calculations used to estimate the typical unit energy savings, EUL, and incremental cost.

2.31.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta kWh = \Delta kWh/Unit * N_{Units}$$

$$\Delta kW = \Delta kW/Unit * N_{Units}$$

2.31.4. Definitions

ΔkWh	Expected energy savings between baseline and installed equipment.
ΔkW	Expected demand reduction between baseline and installed equipment.
ΔkWh/Unit	Per unit energy savings. Stipulated values for this input can be found in Table 2-160.
ΔkW/Unit	Per unit peak reduction. Stipulated values for this input can be found in Table 2-160.
N_{Units}	Total number of doors installed.

2.31.5. Sources

- Southern California Edison. Low ASH Display Doors Work Paper: SCE13RN018.0
- Pacific Gas & Electric Company. Low ASH Display Doors Work Paper: PGECOREF123 Revision 3
- Southern California Edison Company, "Insulation of Bare Refrigeration Suction Lines", Work Paper SCE17RN003 Revision 0
- South West Coastal Region "Low-Temperature Display Case Doors with No Anti-sweat Heaters", SWCR002 Revision 1
- DEER EUL/RUL Values: http://www.deeresources.com/deer0911planning/downloads/EUL_Summary_10-1-08.xls

2.31.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Table 2-160 Stipulated Energy and Demand Savings Estimates for "No-Heat Glass"

	Baseline Usage (W/door)	Measure Usage (W/door)	Demand Savings (kW)	Energy Savings (kWh/year)
Retrofit	214	54	.16	779
New Construction	193	54	.14	675

2.32. PC Management Software

This measure has been removed from the TRM because of the Regional Technical Forum has deactivated this measure based on current technologies having power management software built in to new equipment and most commercial IT departments assuming this as standard practice.

2.33. Variable Frequency Drives (Process Applications)

This measure has been removed from the TRM because of the large variability associated with motor runtime and motor speed making a deemed savings value unreliable. See sections 2.40 and 2.43 for specific process VFD savings.

2.34. Refrigeration: Automatic High Speed Doors

High speed doors are flexible doors composed of a soft material that can either roll up or bi-part for instant access to a facility. Automatic high speed doors can provide energy savings by decreasing the amount of time a door will remain open compared to a traditional warehouse door. Traditional warehouse doors are generally left open for longer periods of time than necessary since it takes extra time to open and close these doors every time. The savings potential for automatic high speed doors is variable and depends upon its location and time left open. The method below can be used to assess energy impacts for projects in which an automatic high speed door is installed on a freezer or refrigerated space. Automatic high speed doors will have an additional benefit of reduced man hours required to operate a typical door.

Table 2-161 through Table 2-163 summarizes the 'typical' expected energy impacts for this measure. Typical values are based on the algorithms and stipulated values described below.

Table 2-161 Typical Saving Estimate for Automatic High Speed Doors: Refrigerated Space to Dock[137]

	Retrofit	New Construction
Deemed Savings Unit	Square Foot of Door Opening	Square Foot of Door Opening
Average Unit Energy Savings	400 kWh	360 kWh
Average Unit Peak Demand Savings	0.42 kW	0.38 kW
Expected Useful Life	16 Years	16 Years
Average Material & Labor Cost	$188	n/a
Average Incremental Cost	n/a	$167
Stacking Effect End-Use	Refrigeration	

Table 2-162 Typical Savings Estimate for Automatic High Speed Doors: Freezer to Dock

	Retrofit	New Construction
Deemed Savings Unit	Square Foot of Door Opening	Square Foot of Door Opening
Average Unit Energy Savings	2,812 kWh	2,531 kWh
Average Unit Peak Demand Savings	2.79 kW	2.51 kW
Expected Useful Life	16 Years	16 Years
Average Material & Labor Cost	$188	n/a
Average Incremental Cost	n/a	$167
Stacking Effect End-Use	Refrigeration	

[137] See spreadsheet "34-TypicalCalcs_HighSpeedDoor_v3.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

Table 2-163 Typical Savings Estimate for Automatic High Speed Doors: Freezer to Refrigerated Space

	Retrofit	New Construction
Deemed Savings Unit	Square Foot	Square Foot
Average Unit Energy Savings	2,032 kWh	1,829 kWh
Average Unit Peak Demand Savings	2.02 kW	1.82 kW
Expected Useful Life	16 Years	16 Years
Average Material & Labor Cost	$188	n/a
Average Incremental Cost	n/a	$167
Stacking Effect End-Use	Refrigeration	

2.34.1. Definition of Eligible Equipment

Eligible equipment will replace a manual or electric door with an automatic door that will open and close. New door controls should decrease the amount of time the door remains open throughout the day. Savings will not be realized if doors are rarely opened or personnel are already diligent about ensuring door is only open when needed. Qualifying automatic door closers will be able fully open or fully close within 7.5 seconds and will remain open for less than 3 minutes.[138]

2.34.2. Definition of Baseline Equipment

Baseline equipment are manual or electronic doors that require personnel input to open and close the doors. Baseline door openings should either have strip curtains that block a majority of door area or is typically closed during business hours. During times of traffic, primary doors are left open, leaving just the strip curtains as open-doorway protection.

Retrofit (Early Replacement)

The baseline equipment for retrofit projects is the existing refrigeration system and manual or electronic warehouse doors.

New Construction (Includes Major Remodel & Replace on Burn-Out)

The baseline equipment for New Construction projects is a refrigeration system meeting current federal energy efficiency requirements and manual or electronic warehouse doors.

2.34.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta \text{ MMBtu/h} = 60 * V * A * (h_i - h_r) * \rho * D_t / CF_1$$

[138] ASHRAE, “Refrigerated –Facility Loads”, in Refrigeration Handbook 2014: ASHRAE, 2014, 24.11 and 24.6.

$$\Delta\ kWh = (MMBtu/h * CF_1) / (CF_2 * COP)$$

$$\Delta\ kW = kWh / EFLH$$

2.34.4. Definitions

ΔMMBtu/h	Expected heat savings between baseline and installed equipment.
ΔkWh	Expected energy savings between baseline and installed equipment.
ΔkW	Expected demand reduction between baseline and installed equipment.
V	Face air velocity across the door opening (ft/min).
A	Area of the door opening (ft^2).
h_i	Enthalpy of the infiltration air (Btu/lb).
h_r	Enthalpy of the refrigerated air (Btu/lb).
Ρ	Air density of the refrigerated air (lb/ft^3).
D_t	Annual duration of time door is open (hours/year).
CF_1	Conversion factor 1,000,000 Btu/MMBtu.
CF_2	Conversion factor 3,413 Btu/kWh.
COP	Coefficient of Performance of the refrigeration system

2.34.5. Sources

- ASHRAE Refrigeration Handbook 2010
- Oregon State University, Energy Efficiency Center Research: (http://eeref.engr.oregonstate.edu/Opportunity_Templates/High_Speed_Door)
- RTF: Commercial Grocery Floating Head Pressure v2.1

2.34.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Table 2-164 Typical Freezer and Refrigerated Space Properties

Measure	Freezer	Refrigerated Space
Temperature (°C)	-18	0
Enthalpy (Btu/lb)	-16.2	9.477
Air Density (lbs/ft^3)	0.0863	0.0806
Retrofit COP[139]	1.26	2.295
New Construction COP[140]	1.4	2.55

[139] Retrofit COP is assumed to be 10% less efficient than the new construction efficiency

[140] New Construction COP is from the RTF for Commercial Grocery Floating Head Pressure

2.35. High Volume Low Speed Fans

High Volume Low Speed (HVLS) Fans provide greater air flow for the same amount of energy compared to a standard fan. This increased air flow provided can reduce the number of fans necessary to properly circulate air compared to the standard fan. Circulation fans are used to provide air movement for thermal comfort in large open spaces or an open ceiling area with partial wall dividers. Energy savings are realized by being able to reduce the number of fans necessary to achieve the same desired air circulation volume.

Table 2-165 summarizes the ‘typical’ expected energy impacts for this measure. Typical values are based on the algorithms and stipulated values described below.

Table 2-165 Typical Saving Estimate for High Volume Low Speed Fans in Unconditioned Spaces[141]

	Retrofit	New Construction
Deemed Savings Unit	Fan	Fan
Average Unit Energy Savings	16,105 kWh	16,105 kWh
Average Unit Peak Demand Savings	4.23 kW	4.23 kW
Expected Useful Life	15 Years	15 Years
Average Material & Labor Cost	$4,185	n/a
Average Incremental Cost	n/a	$3,185
Stacking Effect End-Use	n/a	

Table 2-166 Typical Savings Estimate for High Volume Low Speed Fans in Conditioned Spaces[142]

	Retrofit	New Construction
Deemed Savings Unit	Fan	Fan
Average Unit Energy Savings	17,360 kWh	17,360 kWh
Average Unit Peak Demand Savings	4.56 kW	4.56 kW
Expected Useful Life	15 Years	15 Years
Average Material & Labor Cost	$4,185	n/a
Average Incremental Cost	n/a	$3,185
Stacking Effect End-Use	HVAC	

[141] See spreadsheet “35-TypicalCalcs_HVLSFans_v2.xlsx” for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

[142] See spreadsheet “35-TypicalCalcs_HVLSFans_v2.xlsx” for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

2.35.1. Definition of Eligible Equipment

Eligible equipment will replace standard high speed fans with fewer high volume low speed fans. HVLS fans should operate only during business hours (either turned off automatically or by a manual switch) and only when needed for thermal comfort. Eligible equipment should follow AMCA 230-15 performance testing standards and meet the minimum energy efficiency (CFM/Watt) requirement for large diameter ceiling fans set by Electronic Code of Federal Regulations (e-CFR) Part 430 C Energy and Water Conservation Standards. The minimum energy efficiency is estimated with the following equation:

$$\text{Minimum Energy Efficiency (CFM/Watt)} = 0.91D\text{ (inch)} - 30.00$$[143]

Where:

D is the ceiling fan's blade span, in inches.

2.35.2. Definition of Baseline Equipment

Baseline equipment are standard 48 inch high speed fans operating to provide thermal comfort in an unconditioned space.

Retrofit (Early Replacement)

The baseline equipment for retrofit projects are the existing standard high speed fans in unconditioned spaces.

New Construction (Includes Major Remodel & Replace on Burn-Out)

The baseline equipment for New Construction projects are standard high speed fans in unconditioned spaces.

2.35.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta kW = (\sum W_b - \sum W_{ee})$$

$$\Delta kWh = \Delta kW * Hours * CIF$$

2.35.4. Definitions

ΔkWh	Expected annual energy savings between baseline and installed equipment.
ΔkW	Expected demand reduction between baseline and installed equipment.

[143] Title 10 – Energy Electronic Code of Federal Regulations (e- CFR) 430.32 Energy and water conservation standards (i)

W_b	Baseline fan wattage (Watts)
W_{ee}	Installed HVLS fan wattage (Watts)
Hours	Total annual operating hours (hours)
CIF	Cooling interactive factor (CIF=1 for unconditioned spaces)

2.35.5. Sources

- Illinois TRM Version 8.0 Measure 4.1.2
- Minnesota TRM Version 2.1
- Pennsylvania PUC TRM
- Wisconsin Focus on Energy 2019 TRM
- Energy Electronic Code of Federal Regulations 430.32 - Energy and water conservation standards

2.35.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Table 2-167 Fan Replacement Wattage by Fan Diameter

Fan Diameter (ft)	HVLS Watts	Baseline Fans Watts	kW Savings
16	761	4124	3.36
18	850	4640	3.79
20	940	5155	4.21
22	940	5671	4.73
24	1119	6186	5.07

Table 2-168 Average Savings by Fan Diameter in Unconditioned Space

Fan Diameter	Demand Savings	Annual Savings
16	3.4	12,795
18	3.8	14,418
20	4.2	16,036
22	4.7	17,998
24	5.1	19,278
Average	4.23	16,105

Table 2-169 Fan Hours by Building Type

Building Type	Annual Operating Hours	Daily Hours	Hours Above 50	
			CZ5	CZ6
Warehouse	4746	13.00	3877	3310
Manufacturing	5200	14.25	4011	3389
Other/Misc	4576	12.54	3877	3310

Table 2-170 Estimated Savings for Conditioned Spaces

Building Type	Fan kWh Savings	Fan Demand Savings	HCIF	kW Savings	kWh Savings
Process Facility	16,105	4.23	1.05	4.44	16,910
Conditioned Warehouse	16,105	4.23	1.05	4.44	16,910
Refrigerated Warehouse (35 Degrees)	16,105	4.23	1.13	4.80	18,261
Cold Storage Warehouse (0 Degrees)	16,105	4.23	1.17	4.95	18,814

2.36. HVAC Fan Motor Belts

Cogged and Synchronous fan motor belts provide greater motor transfer efficiency compared to a standard fan belt. The cogged belt can be used directly on a standard fan motor without any motor retrofits. Energy savings are realized by more efficiently transferring power from the fan motor when in operation. A standard fan belt loses efficiency over time as the belt stretches and wears down with an average of 93% energy transfer rate. The cogged fan belt takes longer to wear out but still requires the occasional maintenance to tighten and averages a 95% energy transfer rate. The synchronous belt is toothed and requires the fan to be retrofitted to function but once installed it does not require the same amount of maintenance since the toothed design prohibits slippage as the belt stretches and therefore maintains a high average of 98% energy transfer rate.

Note, savings can only be realized if the motor speed is adjusted to run slower based on improved belt efficiency.

Table 2-171 and Table 2-172 summarizes the 'typical' expected energy impacts for this measure. Typical values are based on the algorithms and stipulated values described below.

Table 2-171 Typical Saving Estimate for Cogged HVAC Fan Belts[144]

	Retrofit	**New Construction**
Deemed Savings Unit	HP	n/a
Average Unit Energy Savings	83 kWh	n/a
Average Unit Peak Demand Savings	0.02 kW	n/a
Expected Useful Life[145]	4 years	n/a
Average Material & Labor Cost	$4.40	n/a
Average Incremental Cost	n/a	n/a
Stacking Effect End-Use	HVAC	

Table 2-172 Typical Saving Estimate for Synchronous HVAC Fan Belts

	Retrofit	**New Construction**
Deemed Savings Unit	HP	n/a
Average Unit Energy Savings	213 kWh	n/a
Average Unit Peak Demand Savings	0.04 kW	n/a
Expected Useful Life[146]	4 years	n/a
Average Material & Labor Cost	$67	n/a
Average Incremental Cost	n/a	n/a
Stacking Effect End-Use	HVAC	

[144] See spreadsheet "36-TypicalCalcs_HVACBelt_v2.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

[145] Expected Useful Life (EUL) is based on the typical building HVAC runtime and a belt life of 24,000 hours.

[146] Expected Useful Life (EUL) is based on the typical building HVAC runtime and a belt life of 24,000 hours.

2.36.1. Definition of Eligible Equipment

Eligible equipment will replace standard fan motor belts with either a cogged belt or a synchronous belt.

2.36.2. Definition of Baseline Equipment

The baseline equipment for this measure is the same for retrofit and new construction. This measure currently only addresses the retrofit scenario.

Retrofit (Early Replacement)

The baseline equipment for retrofit measure is a standard fan belt.

New Construction (Includes Major Remodel & Replace on Burn-Out)

New Construction is not eligible for this measure since the fan belt will be included in the HVAC efficiency and therefore covered in the HVAC efficiency measures.

2.36.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$kWh = kW * EFLH * ESF$$

$$kW = HP * 0.746 * LF / Eff$$

2.36.4. Definitions

kWh	Expected annual energy savings between baseline and installed equipment.
kW	Expected demand reduction between baseline and installed equipment.
HP	Fan motor rated horsepower
LF	Load factor (default 80%)
Eff	Fan motor efficiency
EFLH	Effective full load hours
ESF	Energy savings factor based on the type of belt being installed

2.36.5. Sources

- Gates Corporation Announces New EPDM Molded Notch V-Belts
- Baldor, Synchronous Belt Drives Offer Low Cost Energy Savings
- Gates, Energy Savings from Synchronous Belts
- NREL, Replace V-Belts with Cogged or Synchronous Belt Drives
- US Department of Energy, EERE, Replace V-Belts with Notched or Synchronous Belt Drives
- SWH Workpaper SWHC024 Revision 1 Cogged-V-Belt for HVAC Fan, Commercial
- Illinois TRM Version 8.0DEER EUL Table 2/4/2014

2.36.6. Stipulated Values

Table 2-173 Energy Savings Factor by Belt Replacement

	Cogged	Synchronous
ESP	2%	5.1%

Table 2-174 Typical Occupancy Hours by Building Type

DEER Building Prototype	Occupancy Hours
Assembly	5,517
Education – Community College*	4,336
Education – Primary School	2,998
Education – Secondary School*	4,165
Education – University*	4,684
Education – Relocatable Classroom	3,374
Grocery	8,760
Health/Medical – Hospital *	8,760
Lodging – Hotel*	8,760
Lodging – Motel*	8,760
Manufacturing - Bio/Tech	3,664
Manufacturing – Light Industrial	3,946
Health/Medical – Nursing Home*	8,760
Office – Large*	3,547
Office – Small	3,848
Restaurant - Fast-Food	6,935
Restaurant - Sit-Down	5,111
Retail - Multistory Large*	5,155
Retail - Single-Story Large	5,508
Retail – Small	4,855
Storage – Conditioned	4,985

2.37. Refrigeration Strip Curtains

Strip curtain on walk-in freezers and coolers help keep the conditioned air inside of the space while still allowing for easy travel through the door. Energy savings are realized by reducing that amount of energy loss from the space which will reduce the amount of energy required by the refrigeration cooling system.

Table 2-175 and Table 2-176 summarizes the 'typical' expected energy impacts for this measure. Typical values are based on the algorithms and stipulated values described below.

Table 2-175 Typical Saving Estimate for Freezer Strip Curtains[147]

	Retrofit	New Construction
Deemed Savings Unit	Sq ft	n/a
Average Unit Energy Savings	210 kWh	n/a
Average Unit Peak Demand Savings	33 W	n/a
Expected Useful Life	4 years	n/a
Average Material & Labor Cost	$9	n/a
Average Incremental Cost	n/a	n/a
Stacking Effect End-Use	Refrigeration	

Table 2-176 Typical Saving Estimate for Cooler Strip Curtains[148]

	Retrofit	New Construction
Deemed Savings Unit	Sq ft	n/a
Average Unit Energy Savings	78 kWh	n/a
Average Unit Peak Demand Savings	7 W	n/a
Expected Useful Life	4 years	n/a
Average Material & Labor Cost	$9	n/a
Average Incremental Cost	n/a	n/a
Stacking Effect End-Use	Refrigeration	

2.37.1. Definition of Eligible Equipment

Eligible equipment will replace a standard unobstructed door opening of a cooler or freezer.

2.37.2. Definition of Baseline Equipment

The baseline equipment for this measure is the same for retrofit and new construction.

[147] See spreadsheet "37-TypicalCalcs_StripCurtains_v2.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

[148] Average savings estimate excludes the estimation for refrigerated warehouse doors since the cross area of a warehouse door is estimated at 120 square feet compared to the standard door area of 21 square feet.

Retrofit (Early Replacement)

The baseline equipment for retrofit measure is a standard doorway without any protective barrier.

New Construction (Includes Major Remodel & Replace on Burn-Out)

The baseline equipment for this new construction measure is a standard doorway without any protective barrier.

2.37.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

kWh = kWh/ft^2 * Area

kW = kWh / Hours

2.37.4. Definitions

kWh	Expected annual energy savings between baseline and installed equipment.
kW	Expected demand reduction between baseline and installed equipment.
kWh/ft^2	Estimated energy saving per square foot of open area
Area	Area of the doorway in square feet
Hours	Annual operating hours and time the doorway will be open

2.37.5. Sources

- RTF ComGroceryStripCurtain Version 2.1

2.37.6. Illinois TRM Version 8.0Stipulated Values

Table 2-177 Typical Savings Parameters by Building Type

Space Type	kWh/ft^2	Area	kWh Savings	Hours	kW Savings
Grocery Store - Freezer	490	21	10,290	6,482	1.587
Grocery Store - Cooler	120	21	2,520	8,482	0.297
Convenience Store - Freezer	30	21	420	6,887	0.061
Convenience Store - Cooler	20	21	420	6,887	0.061
Restaurant - Freezer	110	21	2,310	5,509	0.419
Restaurant - Cooler	20	21	420	5,509	0.076
Refrigerated Warehouse	150	120	18,000	2,525	7.129

2.38. Electronically Commutated Motor in HVAC Units

Existing standard efficiency airflow fan motors in small HVAC units can be retrofit with high-efficiency motors. There are four types of HVAC fan motors covered in this measure: Shaded Pole (SP) motor, Permanent Split Capacitor (PSC) motor, Electronically Commutated Motor (ECM), and Permanent Magnet Synchronous Motor (PMSM). The ECM and PMSM have the higher efficiency and can replace the PSC or SP motor. A PSC can only replace a SP motor. Savings are realized by requiring less energy to provide the same amount of airflow.

Table 2-178 summarizes the 'typical' expected energy impacts for this measure. Typical values are based on the algorithms and stipulated values described below.

Table 2-178 Typical Saving Estimate for Fan Motors in HVAC Units[149] (ECM)

	Retrofit (PSC to ECM)	Retrofit (SP to ECM)	Retrofit (SP to PSC)	New Construction
Deemed Savings Unit	HP	HP	HP	n/a
Average Unit Energy Savings	6,126 kWh	11,044 kWh	4,918 kWh	n/a
Average Unit Peak Demand Savings	1.15 kW	2.08 kW	0.93 kW	n/a
Expected Useful Life	15 years	15 years	15 years	n/a
Average Material & Labor Cost	$255	$255	$227	n/a
Average Incremental Cost	n/a	n/a	n/a	n/a
Stacking Effect End-Use	HVAC			

Table 2-179 Typical Saving Estimate for Fan Motors in HVAC Units (PMSM)

	Retrofit (PSC to PMSM)	Retrofit (SP to PMSM)	New Construction
Deemed Savings Unit	HP	HP	n/a
Average Unit Energy Savings	6,587 kWh	11,504 kWh	n/a
Average Unit Peak Demand Savings	1.24 kW	2.17 kW	n/a
Expected Useful Life	15 years	15 years	n/a
Average Material & Labor Cost	$224	$224	n/a
Average Incremental Cost	n/a	n/a	n/a
Stacking Effect End-Use	HVAC		

2.38.1. Definition of Eligible Equipment

Eligible equipment will be: an ECM replacing PSC or SP motor; an PMSM replacing PSC or SP motor; or a PSC motor replacing a SP motor in an HVAC unit.

[149] See spreadsheet "38-TypicalCalcs_HVAC_ECM_v3.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

2.38.2. Definition of Baseline Equipment

The baseline equipment for this measure only addresses the retrofit option.

Retrofit (Early Replacement)

The baseline equipment for this retrofit measure is a PSC or SP motor in a HVAC unit that provides the primary cooling and ventilation airflow.

New Construction (Includes Major Remodel & Replace on Burn-Out)

New construction is not eligible for this measure since replacing the HVAC fan will improve the HVAC EER value and therefore should apply for the HVAC measure.

2.38.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$kWh = kW * EFLH$$

$$kW = HP * 0.746 * LF / Eff$$

2.38.4. Definitions

kWh	Expected annual energy savings between baseline and installed equipment.
kW	Expected demand reduction between baseline and installed equipment.
EFLH	Effective full load hours.
HP	Motor rated horsepower.
LF	Motor load factor (default is 80%).
Eff	Motor efficiency

2.38.5. Sources

- SCE Workpaper SCE13HC040 Revision 2 Cogged V-Belt Non-Residential HVAC Fans
- ECM Motors: An Energy Saving Opportunity

2.38.6. Stipulated Values

Table 2-180 Typical Occupancy Hours by Building Type

DEER Building Prototype	Occupancy Hours
Assembly	5,110
Education – Community College	3,828
Education – Primary School	2,616
Education – Secondary School	2,840
Education – University*	4,671
Education – Relocatable Classroom	5,012
Health/Medical – Hospital	8,760
Lodging – Hotel*	8,760
Lodging – Motel*	8,760
Manufacturing - Bio/Tech	3,514
Manufacturing – Light Industrial	3,514
Health/Medical – Nursing Home	8,760
Office – Large	3,974
Office – Small	3,371
Restaurant - Fast-Food	6,935
Restaurant - Sit-Down	5,110
Retail - Multistory Large	4,482
Retail - Single-Story Large	5,475
Retail – Small	4,745
Storage – Conditioned	4,707
Grocery	6,570

Table 2-181 Typical Motor Replacement Parameters

Motor Type	HP	LF	EFLH	Eff	kW	Energy Usage
SP	1.00	80%	5310	20%	2.98	15,846
PSC	1.00	80%	5310	29%	2.06	10,928
ECM	1.00	80%	5310	66%	0.90	4,802
PMSM	1.00	80%	5310	73%	0.82	4,341
		SP to PSC Savings			**0.93**	4,918
		SP to ECM Savings			**2.08**	11,044
		PSC to ECM Savings			**1.15**	6,126
		SP to PMSM Savings			**2.17**	11,504
		PSC to PMSM Savings			**1.24**	6,587

2.39. Engine Block Heater

An engine block heater warms an engine which improves the engine start up in cold weather. Typically, an engine block heater will be plugged in during the colder months and the heater will run continuously while connected. The engine block heater controls come in two varieties, engine mounted and wall mounted. A wall mounted heater has a 2 hour delay when plugged in after vehicle use since the engine is already warm enough and equipped with an outside air temperature sensor that will only turn active the heater when the outside air temperature drops below a certain threshold. The engine mounted heater cycles on based on the engine temperature which makes it operate in the same manner as the wall mounted heater.

Table 2-182 and Table 2-183 summarizes the 'typical' expected energy impacts for this measure. Typical values are based on the algorithms and stipulated values described below.

Table 2-182 Typical Saving Estimate for Wall Mounted Engine Block Heater Controls[150]

	Retrofit	New Construction
Deemed Savings Unit	Unit	Unit
Average Unit Energy Savings	2,738 kWh	2,738 kWh
Average Unit Peak Demand Savings	0 kW	0 kW
Expected Useful Life	15 years	15 years
Average Material & Labor Cost	$120	n/a
Average Incremental Cost	n/a	$70
Stacking Effect End-Use	n/a	

Table 2-183 Typical Saving Estimate for Engine Mounted Engine Block Heater Controls[151]

	Retrofit	New Construction
Deemed Savings Unit	Unit	Unit
Average Unit Energy Savings	2,352 kWh	2,352 kWh
Average Unit Peak Demand Savings	0 kW	0 kW
Expected Useful Life	15 years	15 years
Average Material & Labor Cost	$170	n/a
Average Incremental Cost	n/a	$120
Stacking Effect End-Use	n/a	

[150] See spreadsheet "39-TypicalCalcs_BlockHeater_v2.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

[151] See spreadsheet "39-TypicalCalcs_BlockHeater_v2.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

2.39.1. Definition of Eligible Equipment

Eligible equipment will be able to automatically cycle the heater on and off based on need instead of running continuously. Multiple heaters can be connected to the same controller, however, savings are based on a single unit controlled and incentives will only be paid out based on the number of controllers installed.

2.39.2. Definition of Baseline Equipment

The baseline equipment for this measure is the same for retrofit and new construction.

Retrofit (Early Replacement)

The baseline equipment for retrofit is a standard engine block heater with no controls.

New Construction (Includes Major Remodel & Replace on Burn-Out)

The baseline equipment for new construction is a standard engine block heater with no controls.

2.39.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$kWh = kW * (EFLH_{Base} - EFLH_{Prop})$$

2.39.4. Definitions

kWh	Expected annual energy savings between baseline and installed equipment.
kW	Expected heater demand when ON.
$EFLH_{Base}$	Effective full load hours of the baseline unit without automatic controls. Calculated using TMY3 weather data, vehicle operating schedule, deemed heating season and temperature less than 50 degrees Fahrenheit. The temperature requirement is based on studies of when people feel it is cold enough to plug in the heater.
$EFLH_{Prop}$	Effective full load hours of the installed engine block automatic control unit. Calculated using TMY3 weather data, vehicle operating schedule, deemed heating season and temperatures less 24 degrees Fahrenheit. The block heater controls vary the power based on the outdoor air temperature as shown in Table 2-185.

2.39.5. Sources

- RTF: Engine Block Heater Controls Version 1.2
- Illinois TRM Version 8.0 Measure 4.1.1

2.39.6. Stipulated Values

Table 2-184 Typical Vehicle Hours of Operation

Vehicle Type	Typical Daily Schedule
Bus	7 AM to 9 AM and 2 PM to 4 PM
Delivery and Refuse	7 AM to 3 PM
Mass Transit	7 AM to 6 PM
Residential	9 AM to 5 PM

Table 2-185 Typical Engine Block Heater Parameters

Heater Type	Heating Season	Delay	Start Temp	Full Load Temp
Standard	Nov – Mar	0 hours	50 °F	50 °F
Wall Mounted Controlled	Nov – Mar	2 hours	24 °F	-13 °F
Engine Mounted Controlled	Nov – Mar	2 hours	40 °F	-3 °F

Table 2-186 Typical Effective Full Load Hours

	Baseline		Wall-mounted		Engine-mounted	
Vehicle Type	CZ5	CZ6	CZ5	CZ6	CZ5	CZ6
Bus	2,814	2,909	34	168	352	666
Delivery	2,257	2,337	33	157	328	607
Mass Transit	1,903	1,938	30	141	292	518
Residential	2,320	2,374	37	183	370	660

2.40. Dairy Pump VFD

A standard dairy pump will not have controls even though the milk flow is variable. Two pumps are analyzed in this measure: milking vacuum pump and milk transfer pump. The vacuum pump is responsible for keeping a designated negative pressure to milk the cows typically by having a pump oversized and operating at full speed with a bleed valve to maintain the desired pressure. A VFD on this pump will allow the motor to slow down during normal operation and then speed up when necessary. Savings are realized by operating the pump just to meet the vacuum needs without wasting energy through a bleed valve.

The milk transfer pump transports the collected milk into a storage unit (not include milk processing). Since the flow of milk is not consistent this pump will typically cycle off and on throughout the milking process to keep from running without milk present. A VFD on this pump will allow the pump to operate continually at a decreased speed based on the amount of milk being produced. Savings are realized from operating the pump continually at a low speed rather than cycling off and on at full speed.

Table 2-187 and Table 2-188 summarizes the 'typical' expected energy impacts for this measure. Typical values are based on the algorithms and stipulated values described below.

Table 2-187 Typical Saving Estimate for Milking Vacuum Pump VFD[152]

	Retrofit	New Construction
Deemed Savings Unit	HP	HP
Average Unit Energy Savings	3,084 kWh	548 kWh
Average Unit Peak Demand Savings	0.57 kW	0.21 kW
Expected Useful Life	10 years	10 years
Average Material & Labor Cost	$356	n/a
Average Incremental Cost	n/a	$273
Stacking Effect End-Use	n/a	

Table 2-188 Typical Saving Estimate for Milk Transfer Pump VFD[153]

	Retrofit	New Construction
Deemed Savings Unit	Unit	Unit
Average Unit Energy Savings	11,777 kWh	7,687 kWh
Average Unit Peak Demand Savings	2.34 kW	2.73 kW
Expected Useful Life	10 years	10 years
Average Material & Labor Cost	$2,052	n/a
Average Incremental Cost	n/a	$1,469

[152] See spreadsheet "40-TypicalCalcs_DairyVFD_v2.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

[153] See spreadsheet "40-TypicalCalcs_DairyVFD_v2.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

	Retrofit	New Construction
Stacking Effect End-Use	n/a	

2.40.1. Definition of Eligible Equipment

Eligible equipment are pumps that are directly used to create a milking vacuum or transfer milk into storage. Only primary pumps are eligible, secondary, or backup units are not eligible. Full replacement of an existing fixed speed pump with a new VFD driven pump is eligible for this incentive.

2.40.2. Definition of Baseline Equipment

There are two possible project baseline scenarios – retrofit and new construction.

Retrofit (Early Replacement)

The baseline equipment for retrofit are standard vacuum and transfer pumps without a VFD.

New Construction (Includes Major Remodel & Replace on Burn-Out)

Although this measure is considered standard practice when installing a new system, typically, a new construction facility will install equipment from a decommissioned facility instead of buy new equipment. Therefore, this measure is included with new construction.

2.40.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$kWh_{savings,hp} = [(HP - (0.25 * MU)) * 0.746 * DRhr * DY / Eff] / HP$$

$$kWh_{savings} = kWh/unit * N$$

2.40.4. Definitions

$kWh_{savings,hp}$ Expected annual energy savings between baseline and installed equipment normalized per pump motor horsepower.

HP Pump motor nameplate horsepower.

0.25 Constant, HP required per milking unit.

MU Number of milking units connected to the vacuum pump.

0.746 Constant, conversion factor kW / HP.

DRhr	Daily runtime in hours required for milking.
DY	Amount of milking days per year.
Eff	Pump motor nameplate efficiency.
$kWh_{savings}$	Expected annual energy savings between baseline and installed equipment.
kWh/unit	Deemed savings associated with each milk transfer pump VFD
N	Number of milk transfer pump VFDs being installed on primary pump motors.

2.40.5. Sources

- DEER 2014 EUL Table 2/4/2014
- Vermont TRM 1/1/2018
- RTF: Dairy Milking Machines Vacuum Pump VFD Version 1.2
- Work Paper: PGE3PAGR116 Revision 0: Milk Vacuum Pump VSD (Dairy Farm Equipment)
- Work Paper SCE13PR004 Revision 2: Agricultural Milk Transfer Pump VSD
- Work Paper PGE3PAGR118 Revision 0: Milk Transfer Pump VSD

2.40.6. Stipulated Values

Table 2-189 Deemed Savings for Dairy Pump VFDs

Pump Type	Savings kWh/unit	Demand Savings kW/unit
Transfer pump VFD	11,777	2.34
Vacuum pump VFD	43,691	0.57

2.41. Compressed Air Measures

Compressed air in a facility can have many uses and many ways to save energy. This measure applies to savings associated with: adding a VFD on the air compressor, installing a low pressure drop filter, installing a no-loss condensate drain, installing an efficient spray nozzle, and installing an efficient refrigerated compressed air dryer.

Table 2-190 through Table 2-194 summarizes the 'typical' expected energy impacts for each measure, along with a description for each measure. Typical values are based on the algorithms and stipulated values described below[154].

VFD Compressor: The baseline compressor for this measure is a load/unload controller the operates at a fixed speed to meet the desired PSI setpoint. Installing a VFD on the air compressor allows the compressor to modulate the speed based on actual demand and save energy by operating at a more efficient part load setting. This measure only applies to motors <200 horsepower.

Table 2-190 Typical Saving Estimate for Air Compressor VFD

	Retrofit	New Construction
Deemed Savings Unit	HP	HP
Average Unit Energy Savings	949 kWh	949 kWh
Average Unit Peak Demand Savings	0.15 kW	0.15 kW
Expected Useful Life	13 years	13 years
Average Material & Labor Cost	$223	n/a
Average Incremental Cost	n/a	$223
Stacking Effect End-Use	Compressed air	

Low Pressure Filter: The typical compressed air filter has a pressure drop that starts at 3 psi and ends at 5 psi. The low pressure filter has a pressure drop that starts at 1 psi and ends at 3 psi. Savings are realized by reducing the compressor setpoint by 2 psi to account for the lower filter pressure drop.

[154] See spreadsheet "41-TypicalCalcs_CompressedAir_v2.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

Table 2-191 Typical Savings Estimate for a Low Pressure Filter

	Retrofit	**New Construction**
Deemed Savings Unit	HP	HP
Average Unit Energy Savings	44 kWh	44 kWh
Average Unit Peak Demand Savings	0.007 kW	0.007 kW
Expected Useful Life	10 years	10 years
Average Material & Labor Cost	$10	n/a
Average Incremental Cost	n/a	$10
Stacking Effect End-Use	Compressed air	

No-loss condensate drain: Compressed air causes the system to build up condensate that needs to be drained occasionally. The typical drain uses the high pressure to exhaust the condensate out but also exhaust some compressed air. A no-loss condensate drain monitors the amount of condensate present and then exhaust only the condensate without wasting any compressed air.

Table 2-192 Typical Savings Estimate for a No-Loss Condensate Drain[155]

	Retrofit	**New Construction**
Deemed Savings Unit	Unit	Unit
Average Unit Energy Savings	1,970 kWh	1,970 kWh
Average Unit Peak Demand Savings	0.29 kW	0.29 kW
Expected Useful Life	10 years	10 years
Average Material & Labor Cost	$244	n/a
Average Incremental Cost	n/a	$194
Stacking Effect End-Use	n/a	

Efficient Air Nozzle: A compressed air nozzle is used to blow off parts or drying. A high-efficiency air nozzle reduces the amount of air required, compared to a standard nozzle, to adequately accomplish the nozzle purpose. High-efficiency air nozzles must meet a SCFM rating at 80 psig less than or equal to: 1/8” 11 SCFM, 1/4” 29 SCFM, 5/16” 56 SCFM, and 1/2” 140 SCFM.

155 Savings are calculated using an average unit efficiency. See spreadsheet “41_TypicalCalcs_CompressedAir_v2.xlsx” for assumptions and calculation used to estimate the typical unit savings and incremental costs.

Table 2-193 Typical Savings Estimate for an Efficient Compressed Air Nozzle

	Retrofit	New Construction
Deemed Savings Unit	Unit	Unit
Average Unit Energy Savings	2,223 kWh	2,223 kWh
Average Unit Peak Demand Savings	0.35 kW	0.35 kW
Expected Useful Life	15 years	15 years
Average Material & Labor Cost	$85	n/a
Average Incremental Cost	n/a	$85
Stacking Effect End-Use	n/a	

Efficient Refrigerated Compressed Air Dryer: The air dryer in the compressed air cycle prevents excess condensate from forming in the compressed air supply lines, which can damage the system if not controlled. The baseline air dryer is a non-cycling refrigerated dryer. The efficient refrigerated air dryer can either be: thermal mass, variable speed or digital scroll controlled. Savings are realized during periods where the efficient dryer can turn off or operate at a lower part load operation rather than running the whole time.

Table 2-194 Typical Saving Estimate for an Efficient Refrigerated Compressed Air Dryer

	Retrofit	New Construction
Deemed Savings Unit	CFM	CFM
Average Unit Energy Savings	10.62 kWh	10.62 kWh
Average Unit Peak Demand Savings	1.66 W	1.66 W
Expected Useful Life	13 years	13 years
Average Material & Labor Cost	$6	n/a
Average Incremental Cost	n/a	$6
Stacking Effect End-Use	Compressed air	

2.41.1. Definition of Eligible Equipment

Eligible equipment for this measure will be installed as the primary unit in the compressed air system. The compressor VFD can be new construction or a retrofit and will be installed on the air compressor and programmed to allow the compressor to vary in speed based on load demand. The low pressure filter should decrease the pressure drop across the filter and then the compressor should be adjusted to provide the same source air pressure. The no-loss condensate drain should expel enough condensate so that none gets into the system but does not waste any compressed air. The efficient nozzle needs to be able to deliver the same performance while using less airflow. The efficient air dryer will be able to cycle on and off based on the part load demand.

2.41.2. Definition of Baseline Equipment

There are two possible project baseline scenarios – retrofit and new construction. This measure currently only addresses the retrofit scenario.

Retrofit (Early Replacement)

The baseline equipment for this measure is: an air compressor without VFD controls, a standard filter, an open tube with ball valve to limit the amount of air waste, a standard air nozzle, and a standard air dryer.

New Construction (Includes Major Remodel & Replace on Burn-Out)

n/a

2.41.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

VFD Air Compress: $kWh = 0.9 * HP * EFLH * (CF_b – CF_e)$

$kW = kWh / EFLH * CF$

Low Pressure Filter: $kWh = (kW_{typ} * deltaP * SF * EFLH / HP_{typ}) * HP$

$kW = kWh / EFLH * CF$

No-Loss Condensate Drain: $kWh = CFM_{loss} * kW_{cfm} * EFLH$

$kW = kWh / EFLH * CF$

Efficient Nozzle: $kWh = SCFM * \%reduction * kW_{cfm} * \%use * EFLH$

$kW = kWh / EFLH * CF$

Efficient Dryer: $kWh = Ps * (EC_{50,base} – EC_{50,eff}) * EFLH * CFM_{50,cap}$

$kW = kWh / EFLH * CF$

2.41.4. Definitions

kWh	Expected annual energy savings between baseline and installed equipment.
kW	Expected peak demand savings.

EFLH	Effective full load hours of the facility in which the air compressor system will be engaged.
HP	Air compressor motor nameplate horsepower.
CF_b	Baseline compressor efficiency factor.
CF_e	Efficient compressor with VFD control efficiency factor.
kW_{typ}	Typical industrial motor power consumption.
deltaP	Change in pressure drop across the filter between baseline and installed unit.
SF	Savings factor associated with decrease in filter pressure drop.
HP_{typ}	Typical industrial motor horsepower.
CFM_{loss}	Rate of exhaust airflow through open condensate drain.
SCFM	Standard nozzle airflow at 80 psi.
%reduction	Percent reduction in airflow comparing the efficient nozzle to a standard nozzle.
%use	Percentage of time the nozzle will be in use during operating hours.
Ps	Full flow specific power usage.
EC_{50}	Energy consumption ratio of the dryer at 50% capacity.
$CFM_{50,cap}$	System rated airflow when running at 50% capacity.
CF	Peak coincidence factor. Represents the % of the connected load reduction which occurs during Idaho Power's peak period.

2.41.5. Sources

- Workpaper SCE17PR005 revision 0 Air Compressor VSD
- Illinois TRM Version 8.0 Measure 4.7.1 – 4.7.5

2.41.6. Stipulated Values

Table 2-195 Typical Hours of Operation and Coincidence Factor Based on Shift Schedules

Shift Type	Hours/Days	EFLH	CF	Weight
Single Shift	8/5	1976	0.59	16%
2-Shift	16/5	3952	0.95	23%
3-Shift	24/5	5928	0.95	25%
4-Shift	24/7	8320	0.95	36%
Weighted Average		5702	0.89	100%

Table 2-196 Typical Parameters Based on Compressor Type

Compressor Type	kW_{Typ}	kW_{cfm}
Reciprocating - On/off control	70.2	0.184
Reciprocating - Load/Unload	74.8	0.136
Screw 0 load/Unload	82.3	0.152
Screw - inlet modulation	82.5	0.055
Screw - inlet modulation w/ unloading	82.5	0.055
Screw - variable displacement	73.2	0.153
Screw - VSD	70.8	0.178
typical	77.56	0.107

Table 2-197 Typical Energy Consumption Ratio by Dryer Type

Dryer Type	CZ5
thermal-mass	0.729
VSD	0.501
Digital Scroll	0.501
Average	0.577

2.42. Smart Power Strip

A standard power strip provides continuous power to all devices that are plugged into the power strip. A smart power strip will cycle off all devices that are plugged into the controlled outlets based on expected time of non-use. There are three different methods for a power strip to cycle off controlled equipment: Motion Sensor, Load Sensor, and Timer. The motion sensor detects movement in the room and then will turn equipment after a set amount of inactivity in the detected space. The load sensor has a master load outlet that will control the other plugs. When the master load power drops below a set threshold, such as when a computer is shutdown or goes into sleep mode, then all other controlled equipment is shutdown. The load sensing circuit must be sensitive enough to detect small changes in power consumption to correctly control the whole power strip. A timer controls the equipment with a user defined programmed schedule. Savings are realized by powering down all nonessential equipment during unoccupied hours. This will eliminate wasted energy from equipment being left on as well as reducing loads produced by the small energy draw from equipment even when they are powered off.

Table 2-198 summarizes the 'typical' expected energy impacts for this measure. Typical values are based on the algorithms and stipulated values described below.

Table 2-198 Typical Saving Estimate for Smart Power Strip Devices[156]

	Retrofit	New Construction
Deemed Savings Unit	Unit	Unit
Average Unit Energy Savings	65 kWh	65 kWh
Average Unit Peak Demand Savings	0 kW	0 kW
Expected Useful Life	4 years	4 years
Average Material & Labor Cost	$44	n/a
Average Incremental Cost	n/a	$39
Stacking Effect End-Use	n/a	

2.42.1. Definition of Eligible Equipment

Eligible equipment are power strips that are capable of automatically cutting power to all equipment plugged into the controllable slots. Strips can be controlled with a motion sensor, load sensor, or timer.

2.42.2. Definition of Baseline Equipment

There are two possible project baseline scenarios – retrofit and new construction.

Retrofit (Early Replacement)

[156] See spreadsheet "42-TypicalCalcs_SmartStrip_v2.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

The baseline equipment for retrofit are standard power strips that do not have automatic shutoff controls.

New Construction (Includes Major Remodel & Replace on Burn-Out)

The baseline equipment for new construction are standard power strips that do not have automatic shutoff controls.

2.42.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$kWh_{savings} = kWh_{savings/unit} * N$$

2.42.4. Definitions

$kWh_{savings}$	Expected annual energy savings between baseline and installed equipment.
$kWh_{savings/unit}$	Expected annual energy savings per smart strip unit installed.
N	Number of units installed.

2.42.5. Sources

- RTF Commercial Smart Plug Power Strips version 4.1

2.42.6. Stipulated Values

Table 2-199 Deemed Savings by Control Device

Control Device	Installation Location	Savings kWh/unit	Cost $/unit
Motion Sensor	Office Workstation	67	$49
Load Sensor	Office Workstation	133	$35
Timer	Office Workstation	42	$34
Timer	Office Workstation + Common Areas	110	$34

2.43. Potato and Onion Ventilation Variable Frequency Drive

When potatoes and onions are harvested, they are stored in large storage sheds that need to have adequate ventilation to properly preserve the produce during storage. Potatoes and onions need to be well ventilated to maintain proper temperature, provide oxygen and remove carbon dioxide. Installing a variable frequency drive (VFD) on the ventilation fans help keep uniform temperatures in the whole storage shed compared to cycling the ventilation fan on and off. Savings are realized by allowing the ventilation fans to operate at lower speeds based on actual system demands.

Table 2-200 summarizes the ‘typical’ expected energy impacts for this measure. Typical values are based on the algorithms and stipulated values described below.

Table 2-200 Typical Savings Estimate for Potato and Onion Ventilation VFDs[157]

	Retrofit	New Construction
Deemed Savings Unit	HP	HP
Average Unit Energy Savings	1,193 kWh	1,193 kWh
Average Unit Peak Demand Savings	0.144 kW	0.144 kW
Expected Useful Life	10 years	10 years
Average Material & Labor Cost	$264	n/a
Average Incremental Cost	n/a	$264
Stacking Effect End-Use	n/a	

2.43.1. Definition of Eligible Equipment

Eligible equipment is a variable frequency drive installed on the primary ventilation fan used to directly control the environment in a potato or onion storage shed structure. The VFD should be able to reduce the fan speed down to preset minimum value based on system demands.

2.43.2. Definition of Baseline Equipment

There are two possible project baseline scenarios – retrofit and new construction.

Retrofit (Early Replacement)

The baseline equipment for retrofit are single speed ventilation fans with only on and off cycle ability.

New Construction (Includes Major Remodel & Replace on Burn-Out)

[157] See spreadsheet “43-TypicalCalcs_PotatoOnionShedVFD_v1.xlsx” for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

The baseline equipment for new construction are single speed ventilation fans with only on and off cycle ability.

2.43.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$kWh_{savings} = kWh_{savings/hp} * HP * N$$

$$kW_{savings} = kW_{savings/hp} * HP * N$$

2.43.4. Definitions

$kWh_{savings}$	Expected annual energy savings between baseline and installed equipment.
$kWh_{savings/unit}$	Deemed annual energy savings per motor horsepower.
$kW_{savings}$	Expected peak demand savings between baseline and installed equipment.
$kW_{savings/unit}$	Deemed peak demand energy savings per motor horsepower.
HP	Ventilation fan nameplate rated horsepower.
N	Number of units installed.

2.43.5. Sources

- RTF Potato/Onion Shed Variable Frequency Drives Version 3.3

2.43.6. Stipulated Values

Table 2-201 Deemed Savings Normalized by Horsepower

	Energy Savings (kWh/hp)	Demand Savings (kW/hp)
Ventilation VFD	1193	0.144

2.44. Kitchen Ventilation Hood

Commercial kitchens need to have ventilation fans to exhaust heat and effluent created while cooking. These fans typically are operated manually on/off and are on the whole time during operating hours. Installing temperature and optic sensors on the exhaust hoods or a smoke/VOC sensor in the exhaust hood to control the ventilation fans so they only operate when necessary and can decrease speed based on the ventilation demand. The temperature sensor detects when a cooking surface is in use and the optic sensor detects the amount of effluent in the air and adjusts the fan speed accordingly. Savings are realized by decreasing the fan operating speed during normal hours of operation.

Table 2-202 summarizes the 'typical' expected energy impacts for this measure. Typical values are based on the algorithms and stipulated values described below.

Table 2-202 Typical Savings Estimate for Kitchen Ventilation Hood Controls[158]

	Retrofit	New Construction
Deemed Savings Unit	HP	HP
Average Unit Energy Savings	4,590 kWh	4,590 kWh
Average Unit Peak Demand Savings	0.39 kW	0.39 kW
Expected Useful Life	15 years	15 years
Average Material & Labor Cost	$469	n/a
Average Incremental Cost	n/a	$248
Stacking Effect End-Use	HVAC	

2.44.1. Definition of Eligible Equipment

Eligible equipment is a variable frequency drive installed on the kitchen ventilation fans that is controlled by a temperature and optic sensor. The VFD should be able to reduce the fan speed down to a preset minimum value based on system demands. Kitchen HVAC system must be able to accommodate the variable exhaust airflow caused by the hood VFD.

2.44.2. Definition of Baseline Equipment

There are two possible project baseline scenarios – retrofit and new construction.

Retrofit (Early Replacement)

The baseline equipment for retrofit are single speed ventilation fans with only on and off cycle ability.

New Construction (Includes Major Remodel & Replace on Burn-Out)

[158] See spreadsheet "44-TypicalCalcs_KitchenVentHood_v2.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

The baseline equipment for new construction are single speed ventilation fans with only on and off cycle ability.

2.44.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$kWh_{savings} = (HP * 0.7457 / Eff / LF) * (1 - (1 - \%reduction) ^{2.7}) * Hours * Days$$

$$kW_{savings} = kWh_{savings} / Hours / Days * CF$$

2.44.4. Definitions

$kWh_{savings}$	Expected annual energy savings between baseline and installed equipment.
HP	Fan motor nameplate horsepower.
Eff	Fan motor nameplate efficiency.
LF	Load factor, default 75%.
%reduction	Estimated average percent reduction from the installed unit.
Hours	Daily operating hours.
Days	Annual day kitchen is in operation.
CF	Peak coincidence factor. Represents the % of the connected load reduction which occurs during Idaho Power's peak period.

2.44.5. Sources

- Workpaper: SCE17CC008 Commercial Kitchen Exhaust Hood Demand Controlled Ventilation Revision 2
- Workpaper: SWFS012-01 Exhaust Hood Demand Controlled Ventilation, Commercial

2.44.6. Stipulated Values

Table 2-203 Deemed Savings Normalized by Horsepower

	Energy Savings (kWh/hp)	Demand Savings (kW/hp)
Kitchen Hood VFD	4,590	0.391

Table 2-204 Average Kitchen Exhaust Hood Demand Controlled Ventilation Parameters

Exhaust HP	Baseline kW	Measure kW	kW Reduction	Fan Speed Percent Reduction	Baseline annual kWh	Measure Annual kWh	Annual Savings kWh
4.42	6.12	2.68	3.43	25%	35,784	15,498	20,286

2.45. Dedicated Outdoor Air System (DOAS)

A Dedicated Outdoor Air System (DOAS) takes in 100% outside air and delivers it to all spaces. This outside air is usually conditioned to either room temperature or slightly chilled and satisfies all the ventilation required for each space. A parallel system in each space then operates on 0% outside air to properly condition the space. This system setup allows for the DOAS and secondary systems to be independently sized to only maintain the latent and sensible loads. This system setup allows for several high efficiency measures to be implemented including a total energy recovery unit and variable refrigerant flow units. Savings are realized by: allowing the two parallel systems to be properly sized to each space: running the units at optimal efficiency and installing an energy recovery device between outdoor air and the exhaust air.

Table 2-205 summarizes the 'typical' expected energy impacts for this measure. Typical values are based on the algorithms and stipulated values described below.

Table 2-205 Typical Savings Estimate for a Dedicated Outdoor Air System[159]

	Retrofit	New Construction
Deemed Savings Unit	Tons	Tons
Average Unit Energy Savings	1,731 kWh	1,063 kWh
Average Unit Peak Demand Savings	0.31 kW	0.14 kW
Expected Useful Life	15 years	15 years
Average Material & Labor Cost	$5,760	n/a
Average Incremental Cost	n/a	-$2,608
Stacking Effect End-Use	HVAC	

2.45.1. Definition of Eligible Equipment

Eligible equipment is a Dedicated Outdoor Air System with a parallel space conditioning unit and a total energy recovery device on the exhaust air. For nontransient dwelling units, energy recovery systems shall result in an energy enthalpy recovery ratio of at least 50% at cooling design condition and at least 60% at heating design condition. The energy recovery system shall provide the required enthalpy recovery ratio at both heating and cooling design conditions, unless one mode is not required for the climate zone by the exceptions below.[160]

Exceptions to Nontransient Dwelling Units:

1. Nontransient dwelling units in Climate Zone 3C.
2. Nontransient dwelling units with no more than 500 ft^2 of conditioned floor area in Climate Zone 0, 1, 2, 3, 4C, and 5C.

[159] See spreadsheet "45-TypicalCalcs_DOAS_v1.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

[160] See ASHRAE Standard, 90.1, 2019 Section 6.5.6.1 Exhaust Air Energy Recovery, 6.5.6.1.1 Nontransient Dwelling Units.

3. Enthalpy recovery ratio requirements at heating design condition in Climate Zones 0, 1, and 2.
4. Enthalpy recovery ratio requirements at cooling design condition in Climate Zones 4, 5, 6, 7, 8.

For spaces other than nontransient dwelling units, energy recovery systems shall result in an enthalpy recovery ratio of at least 50%. The energy recovery system shall provide the required enthalpy recovery ratio at both heating and cooling design conditions, unless one mode is not required for the climate zone by the exception below.[161]

1. Laboratory systems meeting ASHRAE 90.1 Section 6.5.7.3.
2. Systems serving spaces that are not cooled and that are heated to less than 60 degree.
3. Heating energy recovery where more than 60% of the outdoor air heating energy is provided from site-recovered energy or site-solar energy in Climate Zones 5 through 8.
4. Enthalpy recovery ratio requirements at heating design condition in Climate Zone 0, 1, and 2.
5. Enthalpy recovery ratio requirement at cooling design condition in Climate Zone 3C, 4C, 5B, 5C, 6B. 7, and 8.
6. Where the sum of the airflow rates exhausted and relieved within 20 ft of each other is less than 75% of the design outdoor airflow rate.
7. Heating energy recovery for systems in Climate Zones 0 through 4 requiring dehumidification during heating mode that employ energy recovery and have a minimum SEER of 0.40.
8. Systems expected to operate less than 20 hours per week at the outdoor percentage covered by ASHRAE 90.1 Section 6.5.6.1.

2.45.2. Definition of Baseline Equipment

Baseline equipment for this measure is determined by the nature of the project. There are two possible scenarios: retrofit (early replacement) or new construction.

Retrofit (Early Replacement)

The baseline equipment for retrofit projects is an existing mechanical HVAC system that does not currently use a 100% outdoor air ventilation unit.

New Construction (Includes Major Renovations)

The baseline equipment for new construction projects is an HVAC system that meets the local building energy codes and standards.

[161] See ASHRAE Standard, 90.1, 2019 Section 6.5.6.1 Exhaust Air Energy Recovery, 6.5.6.1.2 Spaces Other than Nontransient Dwelling Units.

2.45.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta kWh = \Delta kWh/ton * Cap$$

$$\Delta kW = \Delta kW/ton * Cap$$

2.45.4. Definitions

ΔkWh	Expected energy savings between baseline and installed equipment.
ΔkW	Expected demand reduction between baseline and installed equipment.
ΔkWh/ton	Energy savings on a per unit basis as stipulated in Table 2-206 and Table 2-207.
ΔkW/ton	Demand reduction on a per unit basis as stipulated in Table 2-206 and Table 2-207.
Cap	Capacity (in Tons) of the HVAC system on which DOAS will be replacing.

2.45.5. Sources

- ASHRAE, Standard 90.1-2019.
- University of Nebraska: Energy Benefits of Different Dedicated Outdoor Air Systems Configurations in Various Climates
- Desert Aire: AHRI 920 Performance Rating and Comparisons of DX-DOAS Unit Efficiency
- Engineered Systems: September 2013: Cost of DOAS/Radiant
- Business Energy Advisor: Dedicated Outdoor Air Systems: https://fpl.bizenergyadvisor.com/BEA1/PA/PA_Ventilation/PA-54

2.45.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Table 2-206 Energy Savings for New Construction DOAS

	Climate Zone 5		Climate Zone 6		Weighted Average	
	kWh/ton	**kW/ton**	**kWh/Ton**	**kW/ton**	**kWh/Ton**	**kW/ton**
Heat Pump	1887	0.19	2225	0.12	1,954	0.17
Package RTU	809	0.19	680	0.12	783	0.17
Package VAV	1513	0.35	1395	0.329	1,489	0.34
Package VAV and Temperature	717	0.22	566	0.12	686	0.20
GSHP	602	-0.15	662	-0.18	614	(0.15)
WSHP	852	0.09	842	0.02	849	0.07

Table 2-207 Energy Savings for Retrofit DOAS

	Climate Zone 5		Climate Zone 6		Weighted Average	
Baseline HVAC Type	**kWh/ton**	**kW/ton**	**kWh/Ton**	**kW/ton**	**kWh/Ton**	**kW/ton**
Heat Pump	2,646	0.37	3,021	0.29	2,721	0.35
Package RTU	1,448	0.37	1,305	0.29	1,420	0.35
Package VAV	2,231	0.55	2,099	0.48	2,205	0.54
Package VAV and Temperature	1,346	0.41	1,178	0.29	1,313	0.38
GSHP	1,219	0	1,285	-0.04	1,232	(0.01)
WSHP	1,496	0.26	1,485	0.18	1,494	0.24

Table 2-208 Energy Savings and Cost Estimates for New Construction based on Baseline HVAC type

	VAV to DOAS	**RTU to DOAS**
kWh/ton	1,489	783
kW/ton	0.34	0.17
Cost	$(2,608)	$(2,608)

2.46. Generator: Circulating Block Heater

This measure applies to replacing an existing thermo siphon heater on a backup generator with a circulating block heater and a smaller electric resistance heater. It is important to keep a backup generator warm when not in operation to allow for a quick startup and therefore provide the shortest break in electricity. The typical thermos siphon heater relies on the change in density to circulate the heated coolant within the generator which is slow and causes non-uniform temperatures throughout the generator requiring the heater to stay on longer to sufficiently warm up the whole system. A circulating block heater uses a small pump to circulate the heated coolant providing better uniform temperatures throughout the system. Energy savings are realized by being able to run the system less often and by not wasting energy by overheating some parts of the system.

Table 2-209 through Table 2-211 summarizes the 'typical' expected energy impacts for this measure. Typical values are based on the algorithms and stipulated values described below.

Table 2-209 Typical Savings Estimate for a Circulating Block Heater on a Backup Generator < 200 kW[162]

	Retrofit	New Construction
Deemed Savings Unit	Unit	Unit
Average Unit Energy Savings	1,106 kWh	1,106 kWh
Average Unit Peak Demand Savings	0.14 kW	0.14 kW
Expected Useful Life	15 years	15 years
Average Material & Labor Cost	$1,268	n/a
Average Incremental Cost	n/a	$239
Stacking Effect End-Use	n/a	

Table 2-210 Typical Savings Estimate for a Circulating Block Heater on a Backup Generator 201-500 kW[163]

	Retrofit	New Construction
Deemed Savings Unit	Unit	Unit
Average Unit Energy Savings	2,493 kWh	2,493 kWh
Average Unit Peak Demand Savings	0.31 kW	0.31 kW
Expected Useful Life	15 years	15 years
Average Material & Labor Cost	$2,152	n/a
Average Incremental Cost	n/a	$573
Stacking Effect End-Use	n/a	

[162] See spreadsheet "46-TypicalCalcs_GenBlockHeater_v2.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

[163] See previous footnote.

Table 2-211 Typical Savings Estimate for a Circulating Block Heater on a Backup Generator 501-1000 kW[164]

	Retrofit	New Construction
Deemed Savings Unit	Unit	Unit
Average Unit Energy Savings	4385 kWh	4385 kWh
Average Unit Peak Demand Savings	0.55 kW	0.55 kW
Expected Useful Life	15 years	15 years
Average Material & Labor Cost	$2,645	n/a
Average Incremental Cost	n/a	$573
Stacking Effect End-Use	n/a	

2.46.1. Definition of Eligible Equipment

Eligible equipment is a recirculation pump with a small electric resistance heater directly installed onto a backup generator.

2.46.2. Definition of Baseline Equipment

Baseline equipment for this measure is determined by the nature of the project. There are two possible scenarios: retrofit (early replacement) or new construction.

Retrofit (Early Replacement)

The baseline equipment for retrofit projects is the existing thermo siphon engine heater without a circulation device.

New Construction (Includes Major Renovations)

The baseline equipment for new construction projects is a pre-heating device other than a circulating block heater or similar device.

2.46.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta kWh = \Delta kWh/unit * N$$

$$\Delta kW = \Delta kW/unit * N$$

2.46.4. Definitions

ΔkWh	Expected energy savings between baseline and installed equipment.

[164] See previous footnote.

ΔkW	Expected demand reduction between baseline and installed equipment.
ΔkWh/unit	Energy savings on a per unit basis.
ΔkW/unit	Demand reduction on a per unit basis.
N	Quantity of generator block heaters being replaced.

2.46.5. Sources

- Workpaper SCE17HC055 Circulating Block Heater Revision 0
- RTF Commercial Standby Generator Block Heaters v1.1

2.46.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Table 2-212 Stipulated Energy Savings Based on Generator Size

Backup Generator Size (kW)	Heater Size (kW)	Savings kWh/yr	Demand Savings (kW)
37-199	1	3,472	0.43
200-799	2	11,466	1.43
800-1099	4	13,616	1.70
100-2500	8	21,650	2.70

2.47. Air Conditioning Tune Up

The following algorithms and assumptions are applicable to implementing an air conditioning unit tune up measure. This measure only applies to retrofit projects where the refrigerant needs to be added. Savings are based on the expansion component having a fixed orifice or a thermal expansion valve. Table 2-213 through Table 2-214 summarizes the 'typical' expected (per ton) unit energy impacts for this measure.[165] Typical values are based on algorithms and stipulated values described below.

Table 2-213 Typical Savings Estimates for Air Conditioning Tune Up – Fixed Orifice

	Retrofit	**New Construction**
Deemed Savings Unit	ton	ton
Average Unit Energy Savings	146 kWh	n/a
Average Unit Peak Demand Savings	0.09 kW	n/a
Expected Useful Life	10 Years	n/a
Average Material & Labor Cost	$35	n/a
Average Incremental Cost	n/a	n/a
Stacking Effect End-Use	HVAC	

Table 2-214 Typical Savings Estimates for Air Conditioning Tune Up –TXV

	Retrofit	**New Construction**
Deemed Savings Unit	ton	ton
Average Unit Energy Savings	53 kWh	n/a
Average Unit Peak Demand Savings	0.03 kW	n/a
Expected Useful Life	10 Years	n/a
Average Material & Labor Cost	$35	n/a
Average Incremental Cost	n/a	n/a
Stacking Effect End-Use	HVAC	

2.47.1. Definition of Eligible Equipment

All commercial unitary and split air conditioning system are eligible for this measure provided the tune up process included the following items:

- Check refrigerant charge
- Identify and repay leaks if refrigerant charge is low
- Measure and record refrigerant pressure
- Measure and record temperature drop at indoor coil
- Clean condensate drain line

[165] See spreadsheet "47-TypicalCalcs_ACtuneup_v1.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

- Clean outdoor coils and straighten fins.
- Clean indoor and outdoor fan blades
- Repair damaged insulation at the suction line.
- Change Air filter
- Measure and record blower amp draw

2.47.2. Definition of Baseline Equipment

Baseline equipment for this measure is determined by the nature of the project. The baseline is a system with demonstrated imbalances of refrigerant charger or does not have a standing maintenance contract or a tune-up within in the last 36 months.[166] There are two possible scenarios: retrofit (early replacement) or new construction.

Retrofit (Early Replacement)

All existing air conditioning units that are operating as designed and provides cooling and comfort to the conditioned space are eligible for this measure.

New Construction (Includes Major Remodel & Replace on Burn-Out)

New Construction is not eligible for this measure since a new unit should already be operating at design specifications when installed.

2.47.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta kWh = Cap * (1/EER_{pre} - 1/EER_{post}) / 1000 * EFLH$$

$$EER_{pre} = (1 - EL) * EER_{post}$$

$$\Delta kW = Cap * (1/EER_{pre} - 1/EER_{Post}) / 1000 * CF$$

2.47.4. Definitions

ΔkWh Expected energy savings for air conditioning tune up

ΔkW_{peak} Expected peak demand savings.

EFLH Equivalent full load cooling hours. Idaho specific EFLH are by weather zone and building in Table 2-215.

[166] Illinois TRM 4.4.1 Air Conditioner Tune-up.

CF Peak coincidence factor. Represents the % of the connected load reduction which occurs during Idaho Power's peak period in Table 2-216.

EER Energy Efficiency Ratio for existing systems before and after the tune up. This is defined as the ratio of the cooling capacity of the air conditioner in British Thermal Units per hour, to the total electrical input in watts. Since ASHRAE does not provide EER requirements for air-cooled air conditioners < 65,000 Btu/h, assume the following conversion:

$$EER \approx -0.02 * SEER^2 + 1.12 * SEER$$

EL Efficiency Loss determined by the percentage of refrigerant charge left in the system. Deemed values by expansion component in Table 2-217.

Cap Nominal cooling capaity in kBTU/Hr (1 ton = 12,000BTU/Hr)

2.47.5. Sources

- Illinois Technical Reference Manual v8.0
- Arkansas Technical Reference Manual v8.0

2.47.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Table 2-215 Stipulated Equivalent Full Load Cooling and Heating Hours (EFLH) by Building Type[167]

	Zone 5		Zone 6		Weighted values	
Building Type	EFLH Cooling	EFLH Heating	EFLH Cooling	EFLH Heating	EFLH Cooling	EFLH Heating
Assembly	879	966	758	1059	855	985
Education - Primary School	203	299	173	408	197	321
Education - Secondary School	230	406	196	514	223	428
Education - Community College	556	326	530	456	551	352
Education - University	697	341	721	449	702	363
Grocery	564	1825	460	2011	544	1862
Health/Medical - Hospital	1616	612	1409	679	1575	625
Health/Medical - Nursing Home	1049	1399	884	1653	1016	1450
Lodging - Hotel	1121	621	1075	780	1112	653
Lodging - Motel	978	682	937	796	970	705
Manufacturing - Light Industrial	530	699	415	1088	507	777
Office - Large	746	204	680	221	733	207
Office - Small	607	256	567	360	599	277
Restaurant - Sit-Down	811	624	716	709	792	641
Restaurant - Fast-Food	850	722	734	796	827	737
Retail - 3-Story Large	765	770	644	998	741	816
Retail - Single-Story Large	724	855	576	998	694	884
Retail - Small	726	886	619	1138	705	936
Storage - Conditioned	335	688	242	989	316	748

[167] Prototypical building energy simulations were used to generate Idaho specific heating and cooling equivalent full load hours for various buildings.

Table 2-216 HVAC Coincidence Factors by Building Type

Building Type	Coincidence Factor
Assembly	0.47
Education - Community College	0.54
Education - Primary School	0.1
Education - Secondary School	0.1
Education - University	0.53
Grocery	0.54
Health/Medical - Hospital	0.82
Health/Medical - Nursing Home	0.49
Lodging - Hotel	0.67
Lodging - Motel	0.63
Manufacturing - Light Industrial	0.46
Office - Large	0.58
Office - Small	0.51
Restaurant - Fast-Food	0.48
Restaurant - Sit-Down	0.46
Retail - 3-Story Large	0.66
Retail - Single-Story Large	0.56
Retail - Small	0.49
Storage - Conditioned	0.41

Table 2-217 Efficiency Loss Factor by Refrigerant Charge Level[168]

Percentage Charged	Fixed Orifice	TXV
70	0.37	0.12
75	0.29	0.09
80	0.20	0.07
85	0.15	0.06
90	0.10	0.05
95	0.05	0.03
100	0.00	0.00
120	0.03	0.04

[168] Arkansas Technical Reference Manual v8.0 table 47 and table 48.

2.48. High Efficiency Battery Chargers

The following algorithms and assumptions are applicable to replacing a traditional battery charger with a single high frequency battery charger that converts AC to DC power more efficiently. The battery charger system can be used for industrial material handling vehicles or forklifts. Table 2-218 through Table 2-219 summarizes the 'typical' expected unit energy impacts for this measure.[169] Typical values are based on algorithms and stipulated values described below.

Table 2-218 Typical Savings Estimates for High Efficiency Battery Chargers – Single Phase

	Retrofit	New Construction
Deemed Savings Unit	Unit	Unit
Average Unit Energy Savings	1,111 kWh	1,111 kWh
Average Unit Peak Demand Savings	0.02 kW	0.02 kW
Expected Useful Life	15 Years	15 Years
Average Material & Labor Cost	$400	n/a
Average Incremental Cost	n/a	$400
Stacking Effect End-Use	HVAC	

Table 2-219 Typical Savings Estimates for High Efficiency Battery Chargers – Three Phase

	Retrofit	New Construction
Deemed Savings Unit	Unit	Unit
Average Unit Energy Savings	5,563 kWh	5,563 kWh
Average Unit Peak Demand Savings	0.63 kW	0.63 kW
Expected Useful Life	15 Years	15 Years
Average Material & Labor Cost	$400	n/a
Average Incremental Cost	n/a	$400
Stacking Effect End-Use	HVAC	

2.48.1. Definition of Eligible Equipment

All commercial battery charging system are eligible for this measure if meet efficiency requirements below:

- Power conversion efficiency is greater than 89%
- Maintenance Power is less than 10 W

[169] See spreadsheet "48-TypicalCalcs_HighEffBatteryCharger_v1.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

2.48.2. Definition of Baseline Equipment

Baseline equipment for this measure is determined by the nature of the project. There are two possible scenarios: retrofit (early replacement) or new construction.

Retrofit (Early Replacement)

The baseline equipment for retrofit projects is a traditional Ferro resonant (FR) or silicon-controlled rectifier (SCR) existing battery charger that operates in an industrial or warehouse setting to power forklifts.

New Construction (Includes Major Renovations)

The baseline equipment for new construction projects is typical Ferro resonant (FR) or silicon-controlled rectifier (SCR) charging equipment, operating with minimum 8-hour shift operation five days per week.

2.48.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta kWh = Hours_{charge} * (W_{charge\_pre} - W_{charge\_post}) + Hours_{idle} * (W_{cidle\_pre} - W_{idle\_post})/1000$$

$$\Delta kW = \Delta kWh/(Hours_{charge} + Hours_{idle}) * CF$$

2.48.4. Definitions

ΔkWh	Expected energy savings for high efficiency battery chargers
ΔkW_{peak}	Expected peak demand savings.
$Hours_{charge}$	Annual number of hours the charging system is actively charging.
W_{charge}	Wattage draw of the charging system in active charging mode.
$Hours_{idle}$	Annual number of hours the charging system is operating with no load or in maintenance mode on a fully charged battery.
W_{idle}	Wattage draw of the charging system is operating with no load or in maintenance mode.
CF	Peak coincidence factor.

2.48.5. Sources

- AR TRM v8.0.
- IL TRM v8.0.

2.48.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Table 2-220 Battery Charging System - Hours and Wattages

Equipment	Charging hours (hrs/yr)	Idle hours (hrs/yr)	W_{charge_pre}	W_{idle_pre}	W_{charge_post}	W_{idle_post}	CF
Single Phase	3,942	4,818	2,000	50	1767	10	0.19
Three Phase	8,234	536	5,785	34	5111	10	1

2.49. Defrost Coil Control

The following algorithms and assumptions are applicable to install electric defrost control on small commercial walk-in freezer and reach-in cooler systems. A refrigeration system with electric defrost is set to run the defrost cycle periodically throughout the day. A defrost control uses temperature and pressure sensors to monitor system processes and statistical modeling to learn the operations and requirements of the system. When the system calls for a defrost cycle, the controller determines if it is necessary and starts the cycle. Table 2-221 through Table 2-222 summarizes the 'typical' expected unit energy impacts for this measure.[170] Typical values are based on algorithms and stipulated values described below.

Table 2-221 Typical Savings Estimates for Defrost Coil Control - Cooler

Cooler	Retrofit	New Construction
Deemed Savings Unit	per fan	n/a
Average Unit Energy Savings	220 kWh	n/a
Average Unit Peak Demand Savings	0.45 kW	n/a
Expected Useful Life	10 Years	n/a
Average Material & Labor Cost	$500	n/a
Average Incremental Cost	n/a	n/a
Stacking Effect End-Use	Refrigeration	

Table 2-222 Typical Savings Estimates for Defrost Coil Control - Freezer

Freezer	Retrofit	New Construction
Deemed Savings Unit	per fan	n/a
Average Unit Energy Savings	171 kWh	n/a
Average Unit Peak Demand Savings	0.35 kW	n/a
Expected Useful Life	10 Years	n/a
Average Material & Labor Cost	$500	n/a
Average Incremental Cost	n/a	n/a
Stacking Effect End-Use	Refrigeration	

2.49.1. Definition of Eligible Equipment

All commercial defrost coil control system are eligible for this measure.

2.49.2. Definition of Baseline Equipment

Baseline equipment for this measure is determined by the nature of the project. There are two possible scenarios: retrofit (early replacement) or new construction.

[170] See spreadsheet "49-TypicalCalcs_DefrostCoilControl_v1.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

Retrofit (Early Replacement)

The baseline equipment for retrofit projects is a small commercial walk-in freezer or reach-in cooler refrigeration system without evaporator coil defrost control.

New Construction (Includes Major Renovations)

New Construction is not eligible for this measure since a new unit should already be equipped with automatic defrost coil control when installed.

2.49.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta kWh = \#fans * kW_{DE} * SVG * BF$$

$$\Delta kWh = \Delta kW * FLH$$

2.49.4. Definitions

ΔkWh	Expected energy savings for defrost coil control
ΔkW_{peak}	Expected peak demand savings.
#fans	Number of evaporator fans
kW_{DE}	kW of defrost element per evaporator fan.
SVG	% of defrost cycles saved by control.
BF	Bonus factor for reduced cooling load from eliminating heat generated by defrost element from entering the cooler or freezer.
FLH	Average full load defrost hours.

2.49.5. Sources

- Vermont TRM v8.0.
- PPL Calculator for Commercial Refrigeration Measures

2.49.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Table 2-223 Battery Charging System - Hours and Wattages

Space	kW DE	SVG	BF	FLH	kW Savings	kWh Savings
Cooler	0.9	0.3	1.67	487	220	0.45
Freezer	0.9	0.3	1.3	487	171	0.35

2.50. Networked Lighting Controls

The following algorithms and assumptions are applicable to the installation of networked lighting controls in commercial and industrial spaces which are more efficient than required by prevailing codes and standards. Table 2-224 summarize the typical expected energy impacts for efficient lighting control system.[171] Typical values are based on algorithms and stipulated values described below. The typical savings value is calculated assuming a 21% improved efficiency.

Table 2-224 Typical Savings Estimates for Network Lighting Controls[172]

	New Construction
Deemed Savings Unit	Sensor
Average Unit Energy Savings	147 kWh
Average Unit Peak Demand Savings	27 W
Expected Useful Life	12 Years
Average Material & Labor Cost	n/a
Average Incremental Cost	$49[173]
Stacking Effect End-Use	HVAC, Lighting

* Retrofit scenario is still eligible, please check Idaho Power's website for details.

2.50.1. Definition of Eligible Equipment

Eligible controls must be installed on a new LED fixture or LED Level 2 retrofit kit. Choose luminaire Level Lighting Controls (LLLC) for interior applications and exterior applications. LLLC requires that luminaries must be individually addressable, and each fixture must have a minimum of 2 control strategies. One of the two strategies must be a senser-based strategy.

- Sensor-based occupancy sensing (on/off and/or dimming)
- Sensor-based daylight harvesting with continuous dimming.
- Tuning
  - High-end trim (not applicable for exterior applications or interior applications with daylight harvesting)
  - Advanced scheduling/zone
  - Personal tuning with continuous dimming (interior only)

[171] See spreadsheet "50-TypicalCalcs_Networked Lighting Controls_v1.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

[172] Estimated savings are based on a single sensor controlling an average of 128 watts.

[173] $49 is estimated by Northwest Energy Efficiency Alliance (NEEA)'s 2020 Luminaire Level Lighting Controls Incremental Cost Study

2.50.2. Definition of Baseline Equipment

There are two possible project baseline scenarios – retrofit and new construction. When using actual lighting load installed, stacking effects with measure 2.1 are not required and can be ignored.

Retrofit (Early Replacement)

The baseline standard for this measure is commercial and industrial space equipped with manual switch control system.

New Construction (Includes Major Remodel & Replace on Burn-Out)

The baseline standard for this measure is commercial and industrial space equipped with occupancy sensor control system.

2.50.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$kWh_{savings} = sysWatt_{baseline} * HOU * \Delta CSF$$

$$kW_{savings} = sysWatt_{baseline} * \Delta CSF$$

2.50.4. Definitions

$kWh_{savings}$	Expected energy savings for networked lighting control
$kW_{savings}$	Expected peak demand savings
$sysWatt_{baseline}$	Full-load input power per base system, in watts.
HOU	Hours of Use
CSF	Control savings fraction resulting from controls-induced changes in run time or power consumption.

2.50.5. Sources

- Regional Technical Forum, Standard Protocol Calculator for Non-Residential Lighting improvements, https://rtf.nwcouncil.org/standard-protocol/non-residential-lighting-retrofits
- Northwest Energy Efficiency Alliance, Energy Savings from Networked lighting control (NLC) systems with and without LLLC

2.50.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Table 2-225 Stipulated Control Savings Fraction by Space Type

SPACE TYPE	Occupancy Sensor Control	Luminaire Level Lighting Control than Occupancy Sensor Control
Assembly	25%	8%
Break Room	25%	25%
Classroom	15%	10%
Computer Room	25%	25%
Conference	25%	25%
Dining	15%	35%
Gymnasium	25%	25%
Hallway	60%	4%
Hospital Room	25%	25%
Industrial	25%	25%
Kitchen	25%	25%
Library	25%	25%
Lobby	25%	25%
Lodging (Guest Rooms)	25%	25%
Open Office	15%	35%
Parking Garage	25%	25%
Private Office	15%	35%
Process	25%	25%
Public Assembly	25%	25%
Restroom	50%	5%
Retail	25%	25%
Stairs	64%	4%
Storage	50%	5%
Technical Area	25%	8%
Warehouse Aisle	50%	25%
Other	25%	25%

Table 2-226 Stipulated Lighting Hours of Use (HOU) by Building Type

Building Type	Hours of Use
Assembly	2,700
Automotive Repair	3,100
College	2,100
University	2,100
Exterior 24 Hour Operation	8,766
Hospital	4,200
Industrial Plant with One Shift	5,500
Industrial Plant with Three Shifts	7,000
Industrial Plant with Two Shifts	5,500
Library	3,000
Lodging, Hotel	3,500
Lodging, Motel	3,500
Manufacturing	5,500
Office <20,000 sf	2,600
Office >100,000 sf	3,300
Office 20,000 to 100,000 sf	3,300
Other Health, Nursing, Medical Clinic	4,300
Parking Garage	6,300
Restaurant, Sit-Down	4,900
Restaurant, Fast-Food	4,900
Retail 5,000 to 50,000 sf	3,900
Retail Anchor Store >50,000 sf Multistory	4,400
Retail Big Box >50,000 sf One-Story	6,000
Retail Boutique <5,000 sf	2,500
Retail Mini Mart	7,200
Retail Supermarket	6,800
School, Primary	2,500
School, Secondary	2,500
Street & Area Lighting (Photo Sensor Controlled)	4,383
Warehouse	2,600
Other	3,800

2.51. Evaporative Fan Controls

The following algorithms and assumptions are applicable to the installation of a new evaporator fan motor with temperature controls in a refrigerator or freezer space. The controller reduces airflow of the evaporator fans when there is no refrigerant flow reducing the energy usage. Table 2-227 through Table 2-228 summarizes the 'typical' expected (per unit) energy impacts for this measure.[174] Typical values are based on algorithms and stipulated values described below.

Table 2-227 Typical Savings Estimates for Evaporative Fan Motor and Controls in Freezers

	Retrofit	New Construction
Deemed Savings Unit	Unit	Unit
Average Unit Energy Savings	483 kWh	n/a
Average Unit Peak Demand Savings	0.06 kW	n/a
Expected Useful Life	16 Years	n/a
Average Material & Labor Cost	$ 291	n/a
Average Incremental Cost	n/a	n/a
Stacking Effect End-Use	Refrigeration	

Table 2-228 Typical Savings Estimates for Evaporative Fan Motor and Controls in Coolers

	Retrofit	New Construction
Deemed Savings Unit	Unit	Unit
Average Unit Energy Savings	514 kWh	n/a
Average Unit Peak Demand Savings	0.06 kW	n/a
Expected Useful Life	16 Years	n/a
Average Material & Labor Cost	$ 291	n/a
Average Incremental Cost	n/a	n/a
Stacking Effect End-Use	Refrigeration	

2.51.1. Definition of Eligible Equipment

The eligible equipment is equipment that has an energy management system (EMS) or other electronic controls to modulate evaporator fan operation based on temperature of the refrigerated space.

2.51.2. Definition of Baseline Equipment

Baseline equipment for this measure is determined by the nature of the project. There are two possible scenarios: retrofit (early replacement) or new construction.

[174] See spreadsheet "51-TypicalCalcs_Evaporative Fan Contorls_v1.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

Retrofit (Early Replacement)

The baseline standard for this measure is an existing shaded pole evaporator fan motor with no temperature controls with 8,760 annual operating hours.

New Construction (Includes Major Remodel & Replace on Burn-Out)

New construction is not eligible for this measure as this measure is assumed to be standard practice.

2.51.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$kWh_{savings} = kW_{savings} * 8760$$

$$kW_{savings} = [(kW_{evap} * n_{fans}) - kW_{circ}] * (1 - DC_{comp}) * DC_{evap} * BF$$

2.51.4. Definitions

$kWh_{savings}$	Expected energy savings for evaporative fan controls
$kW_{savings}$	Expected peak demand savings
kW_{evap}	Nameplate connected load kW of each evaporator fan = 0.123kW (default)
n_{fans}	Number of evaporator fans
kW_{circ}	Nameplate connected load kW of the circulating fan = 0.035kW
DC_{comp}	Duty cycle of the compressor = 50% (default)
DC_{evap}	Duty cycle of the evaporator fan = Coolers: 100%; Freezers: 94% (default)
BF	Bonus factor for reducing cooling load from replacing the evaporator fan with a lower wattage circulating fan when the compressor is not running = Low Temp:1.5, Medium Temp: 1.3, High Temp: 1.2

2.51.5. Sources

- Arkansas TRM v8.0
- Illinois TRM v8.0

2.51.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Type	Temp	Bonus factor	Duty cycle of the evaporator fan	kWh	kW
Freezer	Low	1.5	0.94	543	0.062
Freezer	Medium	1.3	0.94	471	0.054
Freezer	High	1.2	0.94	435	0.050
Cooler	Low	1.5	1	578	0.066
Cooler	Medium	1.3	1	501	0.057
Cooler	High	1.2	1	463	0.053

2.52. Circulation Pump

The following algorithms and assumptions are applicable to the installation of Electronically Commutated Motor (ECM) on Hydronic Heating and Domestic Hot Water recirculation pumps and additional savings associated with implementing pump speed controls. Savings are broken down based on the pump horsepower and if pump speed controls are present. Pump controls must be able to automatically adjust the motor speed based on pressure and/or temperature sensors. Table 2-229 through Table 2-232 summarizes the 'typical' expected (per unit) energy impacts for this measure.[175] Typical values are based on algorithms and stipulated values described below.

Table 2-229 Typical Savings Estimates for ECM without Speed Controls and <=1 HP

	Retrofit	**New Construction**
Deemed Savings Unit	Unit	Unit
Average Unit Energy Savings	225 kWh	225 kWh
Average Unit Peak Demand Savings	0.08 kW	0.08 kW
Expected Useful Life	12 years	12 years
Average Material & Labor Cost	$1,497	n/a
Average Incremental Cost	n/a	$304
Stacking Effect End-Use	HVAC	

Table 2-230 Typical Savings Estimates for ECM without Speed Controls and >1 HP

	Retrofit	**New Construction**
Deemed Savings Unit	Unit	Unit
Average Unit Energy Savings	1,039 kWh	1,039 kWh
Average Unit Peak Demand Savings	0.36 kW	0.36 kW
Expected Useful Life	12 years	12 years
Average Material & Labor Cost	$3,460	n/a
Average Incremental Cost	n/a	$598
Stacking Effect End-Use	HVAC	

[175] See spreadsheet "52-TypicalCalcs_Circulation Pump_v1.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

Table 2-231 Typical Savings Estimates for ECM with Speed Controls and <=1 HP

	Retrofit	New Construction
Deemed Savings Unit	Unit	Unit
Average Unit Energy Savings	462 kWh	462 kWh
Average Unit Peak Demand Savings	0.15 kW	0.15 kW
Expected Useful Life	12 years	12 years
Average Material & Labor Cost	$1,602	n/a
Average Incremental Cost	n/a	$409
Stacking Effect End-Use	HVAC	

Table 2-232 Typical Savings Estimates for ECM with Speed Controls and >1 HP

	Retrofit	New Construction
Deemed Savings Unit	Unit	Unit
Average Unit Energy Savings	2,187 kWh	2,187 kWh
Average Unit Peak Demand Savings	0.69 kW	0.69 kW
Expected Useful Life	12 years	12 years
Average Material & Labor Cost	$6,167	n/a
Average Incremental Cost	n/a	$1,034
Stacking Effect End-Use	HVAC	

2.52.1. Definition of Eligible Equipment

The eligible equipment are electronically commutated motors installed on circulation pumps on the hydronic heating or domestic hot water systems. Additional savings are achieved by installing automatic speed controls that adjust the pump motor speed using temperature and/or pressure sensors.

2.52.2. Definition of Baseline Equipment

Baseline equipment for this measure is determined by the nature of the project. There are two possible scenarios: retrofit (early replacement) or new construction.

Retrofit (Early Replacement)

The baseline standard for this measure is an existing low efficiency pump motor with no speed controls.

New Construction (Includes Major Remodel & Replace on Burn-Out)

The new construction baseline for this measure is a code compliant pump motor with no speed controls.

2.52.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$\Delta kWh = \Delta kWh/unit * N$$

$$\Delta kW = \Delta kW/unit * N$$

2.52.4. Definitions

ΔkWh	Expected energy savings between baseline and installed equipment.
ΔkW	Expected demand reduction between baseline and installed equipment.
ΔkWh/unit	Energy savings on a per unit basis.
ΔkW/unit	Demand reduction on a per unit basis.
N	Quantity of circulation pump motors installed

2.52.5. Sources

- RTF Commercial Circulator Pumps Version 2.1

2.52.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Table 2-233 Deemed Savings for ECMs without Speed Controls on Circulation Pump

Nominal HP Size	ECM w/ no speed controls	Energy Savings (kWh)	Peak Demand Savings (kW)	Efficient Measure Cost ($)	Incremen t Cost ($)
1/12	>1/16 - ≤1/8 horsepower (>100 - ≤200 Max watts)	98	0.03	$872	$165
1/6	>1/8 - ≤1/6 horsepower (>200 - ≤300 Max watts)	125	0.04	$1,046	$353
1/4	>1/6 - ≤1/4 horsepower (>300 - ≤400 Max watts)	157	0.05	$1,177	$354
1/2	>1/4 - ≤1/2 horsepower (>400 - ≤550 Max watts)	237	0.08	$1,570	$335
3/4	>1/2 - ≤3/4 horsepower (>550 - ≤750 Max watts)	317	0.11	$1,963	$316
1	>3/4 - ≤1.25 horsepower (>750 - ≤1000 Max watts)	416	0.14	$2,357	$303
1 1/2	>1.25 - ≤1.75 horsepower (>1000 - ≤1300 Max watts)	624	0.21	$3,535	$455
2	>1.75 - ≤2.5 horsepower (>1300 - ≤1750 Max watts)	831	0.29	$4,713	$607
3	>2.5 - ≤3.5 horsepower (>1750 - ≤2350 Max watts)	1,039	0.36	$5,891	$758
4	>3.5 - ≤4.5 horsepower (>2350 - ≤3100 Max watts)	1,247	0.43	$7,070	$910
5	>4.5 - ≤5 horsepower (>3100 - ≤3700 Max watts)	1,455	0.50	$8,248	$1,062

Table 2-234 Deemed Savings for ECMs with Speed Controls on Circulation Pump

Nominal HP Size	ECM w/ speed controls	Energy Savings (kWh)	Peak Demand Savings (kW)	Efficient Measure Cost ($)	Incremen t Cost ($)
1/12	>1/16 - ≤1/8 horsepower (>100 - ≤200 Max watts)	168	0.05	$989	$283
1/6	>1/8 - ≤1/6 horsepower (>200 - ≤300 Max watts)	247	0.08	$1,142	$449
1/4	>1/6 - ≤1/4 horsepower (>300 - ≤400 Max watts)	313	0.10	$1,274	$451
1/2	>1/4 - ≤1/2 horsepower (>400 - ≤550 Max watts)	494	0.16	$1,672	$436
3/4	>1/2 - ≤3/4 horsepower (>550 - ≤750 Max watts)	675	0.21	$2,069	$422
1	>3/4 - ≤1.25 horsepower (>750 - ≤1000 Max watts)	875	0.28	$2,467	$414
1 1/2	>1.25 - ≤1.75 horsepower (>1000 - ≤1300 Max watts)	1,312	0.42	$3,700	$620
2	>1.75 - ≤2.5 horsepower (>1300 - ≤1750 Max watts)	1,749	0.55	$4,934	$827
3	>2.5 - ≤3.5 horsepower (>1750 - ≤2350 Max watts)	2,187	0.69	$6,167	$1,034
4	>3.5 - ≤4.5 horsepower (>2350 - ≤3100 Max watts)	2,624	0.83	$7,401	$1,241
5	>4.5 - ≤5 horsepower (>3100 - ≤3700 Max watts)	3,061	0.97	$8,634	$1,448

2.53. Pump Optimization

The following algorithms and assumptions are applicable to pump optimization. This measure can be done to optimize the design and control of centrifugal water pumping systems, including water solutions with freeze protection up to 15% concentration by volume. Other fluid and gas pumps cannot this this measure calculation. The measurement of energy and demand savings for commercial and industrial applications will vary with the type of pumping technology, operating hours, efficiency, and existing and proposed controls. Depending on the specific application slowing the pump, trimming or replacing the impeller may be suitable option for improving pumping efficiency. Pumps up to 40 HP are allowed to use this energy savings calculation. Larger motors should use a custom calculation. Table 2-235 summarizes the 'typical' expected (per unit) energy impacts for this measure.[176] Typical values are based on algorithms and stipulated values described below.

Table 2-235 Typical Savings Estimates for Pump Optimization

	Retrofit	New Construction
Deemed Savings Unit	HP	n/a
Average Unit Energy Savings	46 kWh	n/a
Average Unit Peak Demand Savings	0.03 kW	n/a
Expected Useful Life	8 years[177]	n/a
Average Material & Labor Cost	$245	n/a
Average Incremental Cost	n/a	n/a
Stacking Effect End-Use	Miscellaneous End Use	

2.53.1. Definition of Eligible Equipment

The eligible equipment is equipment that has optimized centrifugal pumping system meeting the applicable program efficiency requirements:

- Pump balancing values no more than 15% throttled.
- Balancing values on at least one load 100% open.

2.53.2. Definition of Baseline Equipment

Baseline equipment for this measure is assumed to be the existing pumping system including existing controls and sequence of operations. The baseline equipment 's HP range is up to 40 HP. Only equipment with a centrifugal water pumping system is applicable.

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[176] See spreadsheet "53-TypicalCalcs_PumpOptimization_v1.xlsx" for assumptions and calculations used to estimate the typical unit energy savings and incremental costs.

[177] SCE Pump Test Final Report (2009), Summit Blue Consulting, LLC. This value is a weighted average of estimates provided by program participants.

2.53.3. Algorithms

The following energy and demand savings algorithms are applicable for this measure:

$$kWh_{savings} = HP_{motor} * 0.746 * LF/\eta_{motor} * Hours * ESF$$

$$kW_{savings} = HP_{motor} * 0.746 * LF/\eta_{motor} * Hours * ESF * CF$$

2.53.4. Definitions

***kWh**savings* — Expected energy savings for pump optimization

***kW**savings* — Expected peak demand savings

***HP**motor* — Installed nameplate motor horsepower

0.746 — Conversion factor from horsepower to kW (kW/hp)

LF/η_{motor} — Combined as a single factor since efficiency is a function of load = 0.65

Hours — Annual operating hours of the pump

ESF — Energy savings factor; assume a value of 15%

CF — Summer coincident peak factor for measure

2.53.5. Sources

- Ameren Missouri TRM v2.0
- Illinois TRM v9.0
- SCE Pump Test Final Report (2009), Summit Blue Consulting, LLC.

2.53.6. Stipulated Values

The following tables stipulate allowable values for each of the variables in the energy and demand savings algorithms for this measure.

Table 2-236 Stipulated Equivalent Full Load Hours (EFLH) by Building Type

	Zone 5		Zone 6		Weighted values	
Building Type	EFLH Cooling	EFLH Heating	EFLH Cooling	EFLH Heating	EFLH Cooling	EFLH Heating
Assembly	879	966	758	1059	855	985
Education - Primary School	203	299	173	408	197	321
Education - Secondary School	230	406	196	514	223	428
Education - Community College	556	326	530	456	551	352
Education - University	697	341	721	449	702	363
Grocery	564	1825	460	2011	544	1862
Health/Medical - Hospital	1616	612	1409	679	1575	625
Health/Medical - Nursing Home	1049	1399	884	1653	1016	1450
Lodging - Hotel	1121	621	1075	780	1112	653
Lodging - Motel	978	682	937	796	970	705
Manufacturing - Light Industrial	530	699	415	1088	507	777
Office - Large	746	204	680	221	733	207
Office - Small	607	256	567	360	599	277
Restaurant - Sit-Down	811	624	716	709	792	641
Restaurant - Fast-Food	850	722	734	796	827	737
Retail - 3-Story Large	765	770	644	998	741	816
Retail - Single-Story Large	724	855	576	998	694	884
Retail - Small	726	886	619	1138	705	936
Storage - Conditioned	335	688	242	989	316	748

3. Appendix A: Document Revision History

Table 3-1 Document Revision History

Date	Modified Version	Revised Version	Description of Changes
4/01/14	-	1.0	Initial Adoption of TRM.
11/04/14	1.0	1.1	Added *PVVT* and *GSHP* system types to HVAC Controls measure chapter. Updates were made to values in the summary tables which provide a unit savings estimate based on an assumed average of system types. System type specific values were added to the remaining applicable tables in this section. Updated tables include Table 2-59 through Table 2-77.
04/16/15	1.1	1.2	Added *WSHP* system type to HVAC Controls measure chapter. Updates were made to values in the summary tables which provide a unit savings estimate based on an assumed average of system types. System type specific values were added to the remaining applicable tables in this section. Updated tables include Table 2-59 through Table 2-77.
05/19/15	1.2	1.3	Found typo in several tables (Table 2-59 through Table 2-77). Table values updated to reflect corresponding calculator spreadsheets.
05/27/15	1.3	1.4	Found typo in several tables (Table 2-59 through Table 2-61). Table values updated to reflect corresponding calculator spreadsheets.
06/26/15	1.4	1.5	Updated savings values for Evaporative Pre-Cooler measure (Chapter 17) to incorporate data from new source. Accounts for the fact that the studies used to determine savings are biased towards R-22 and that R-410A has higher savings potential. New numbers assume a mix of both refrigerants, but a predominance of R-410A.
08/06/15	1.5	1.6	Made small revisions to three chapters: 1) Sections 2.12 and 2.13: Expanded description of eligible equipment to include changing from A/C only to Heat-Pump and visa versa. 2) Section 2.10: Added references for the reader which provide full descriptions of the listed HVAC system types. 3) Section 2.16: Updated numbers in Table 2-124 to reflect those in summary table and consistent with the previous update.

Date	Modified Version	Revised Version	Description of Changes
10/30/2015	1.6	1.7	Updated (4) measures to include energy savings under IECC 2012. Note that only a handful of measures were affected by the IECC 2012 code update: 1) High Efficiency A/C 2) High Efficiency Heat Pumps 3) Guest Room Occupancy Sensors 4) Direct/Indirect Evaporative Coolers Updated eligibility language for new construction baseline in measures affected by changes in IECC 2012. This included the addition of Appendix B which describes cases in which individual HVAC controls measures are eligible due to exceptions in IECC 2012 requirements.
12/1/2017	1.7	2.0	Updated (7) measures to include energy savings under IECC 2015. Note that only a handful of measures were affected by the IECC 2015 code update: 1) Efficient Interior Lighting and Controls (New Construction) 2) Efficient Windows 3) HVAC Controls 4) Hotel/Motel Guestroom Energy Management Systems 5) High Efficiency Air Conditioning 6) High Efficiency Heat Pumps 7) Evaporative Coolers (Direct and Indirect) Added (12) measures to the TRM: 1) Refrigeration: Automatic High Speed Doors 2) High Volume Low Speed Fans 3) HVAC Fan Motor Belts 4) Refrigeration Strip Curtains 5) Electronically Commutated Motors in HVAC units 6) Engine Block Heater Controls 7) Dairy Pump VFD 8) Compressed Air Measures 9) Smart Power Strips 10) Potato/Onion Ventilation VFD 11) Kitchen Ventilation Hood VFD 12) Dedicated Outdoor Air System

Date	Modified Version	Revised Version	Description of Changes
8/21/18	2.0	2.1	Rewrote section 1.6 Application of Stacking Effect in the TRM for clarity and ease of use. Changed may “Stacking Effect End-Use” values for simplicity and to match the revised stacking effect section. Updated savings and cost values for section 2.14 High Efficiency Chiller based on data from new sources and changing the expected installed unit efficiency. Changed the measure life for the Compressed Air Dryer from 10 to 13 years based on information from new sources. Changed the retrofit cost for cogged HVAC fan motor belts based on revised cost data.
10/15/18	2.1	2.2	Updated Section 2.38 to include Shaded Pole motors as a potential baseline equipment. Updated Table 2-222 and 2-224 to include Shaded Pole motors and savings from Shaded Pole motors to ECMs and PSC motors.

<table>
<tr><th>Date</th><th>Modified Version</th><th>Revised Version</th><th>Description of Changes</th></tr>
<tr><td>9/9/2020</td><td>2.2</td><td>3.0</td><td>Reviewed all measures for the most up to date information regarding energy savings and incremental costs.

Adjusted the cost and/or savings estimates to most measures based on current measure studies.

Updated all measures to comply with the new IECC 2018 building code requirements.

The following (7) measures were removed as Idaho TRM measures:
1. 2.3 Efficient Vending Machines
2. 2.4 Vending Machine Controls
3. 2.21 Kitchen: Efficient Dishwashers
4. 2.22 Refrigeration: Efficient Refrigerated Cases
5. 2.27 Door Gaskets
6. 2.32 PC Management Software
7. 2.33 Variable Frequency Drives (Process Application)

The following (6) measures have been added as Idaho TRM measures:
1. 2.47 Air Conditioning Tune Up
2. 2.48 High Efficiency Battery Chargers
3. 2.49 Refrigeration Defrost Control
4. 2.50 Networked lighting Control
5. 2.51 Evaporative Fan Control
6. 2.52 Circulation Pump</td></tr>
<tr><td>4/9/2021</td><td>3.0</td><td>3.1</td><td>Clarified Language 2.35

Added new measure 2.53 Pump Optimization

Adjusted savings and cost values for measure 2.34 Refrigeration: Automatic High Speed Doors to better reflect actual baseline conditions and installation costs per square foot.</td></tr>
</table>

Date	Modified Version	Revised Version	Description of Changes
11/14/2021	3.1	3.2	Updated tables to reflect changes and fixes in the following measures: 1. 2.5 Efficient Washing Machines 2. 2.6 Wall Insulation 3. 2.10 HVAC Controls 4. 2.12 High Efficiency Air Conditioning 5. 2.13 High Efficiency Heat Pumps 6. 2.20 Kitchen: Ice Machine 7. 2.39 Engine Block Heaters 8. 2.41 Compressed Air Measures 9. 2.44 Kitchen Ventilation Hood

4. Appendix B

Several of the controls measures listed in Chapter 2.10 are required by IECC 2015 and 2018 for certain new construction buildings. This appendix reproduces the exceptions listed in IECC and identifies the cases for which these controls measures are still eligible under the New Construction Program. Note that while the listed controls are not eligible as energy efficiency measures under the New Construction Program (except as presented in this Appendix), they remain eligible under the Retrofit Program as retrofit measures for which the energy code considerations presented here can be ignored.

The HVAC controls measures covered in Chapter 2.10 are listed in Table 4-1. The remainder of this section is organized in sub-sections which outline the conditions in which these controls measures are eligible under the New Construction Program.

Table 4-1 List of Eligible HVAC Control Measures

Item	Measure
1	Optimum Start/Stop
2	Economizer Controls
3	Demand Controlled Ventilation (DCV)
4	Supply Air Reset
5	Chilled Water Reset
6	Condenser Water Reset

4.1. Optimum Start Stop

Sections C403.2.4.2.2 and C4.3.2.4.2.3 of IECC 2018[178] indicates that automatic startup controls are required for all HVAC systems and be capable of automatically adjusting the daily start time of the HVAC system in order to bring each space to the desired occupied temperature immediately prior to scheduled occupancy. While automatic shut-down controls are required, they can be time-clock based or programmable.

This measure is only eligible when the system(s) install both optimum start and optimum stop simultaneously on the same system(s) or for zones with a full HVAC load demand not exceeding 6,800 Btu/h and having a readily accessible manual shutoff switch.

4.2. Economizer Controls

Section C403.3 of IECC 2018[179] indicates that economizer controls are required on all *Simple HVAC Systems* except when stated in the exceptions listed below. Simple HVAC Systems are defined as unitary or packaged HVAC equipment,[180] each serving one zone and controlled by a single thermostat in the zone served. This also includes two-pipe heating systems serving one or

[178] IECC 2018 Sections C403.2.4.3.2 and C403.2.4.3.3

[179] IECC 2018 Section C403.3.1

[180] As listed in Tables C403.2.3(1) through C403.2.3(8) IECC 2015 and 2018

more zones, where no cooling system is installed. Economizers are required for all *Complex HVAC Systems*.[181] Several exceptions are listed in Section C403.3 of IECC 2018[182] and represent the only cases in which this measure is eligible. Note that these exceptions apply only to *Simple HVAC systems.*

Exceptions (2018):

- Individual fan cooling units with supply capacity less than 54,000 Btu/h and have the following:
  - Have direct expansion cooling coils.
  - The total chilled water system capacity minus the capacity of fan units with air economizers is less than 1,320,000 Btu/h for local water-cooled chilled-water systems or 1,720,000 Btu/h for air-cooled chilled-water systems.
  - The total supply capacity of all fan-cooling units without economizers shall not exceed 20% or 300,000 Btu/h, whichever is greater.
- Where more than 25 of the air designed to be supplied by the system is to spaces that are designed to be humidified above 35 ^{o}F dew-point temperature to satisfy process needs.
- Systems that serve residential spaces where the system capacity is less than 8,600,000 Btu/h.
- Systems expected to operate less than 20 hours per week.
- Where the use of outdoor air for cooling will affect supermarket open refrigerated casework systems.
- Chilled-water cooling systems that are passive or use induction where the total chilled water system capacity minus the capacity of fan units with air economizers is less than 1,320,000 Btu/h for local water-cooled chilled-water systems or 1,720,000 Btu/h for air-cooled chilled-water systems.
- Systems that include a heat recover system in accordance with Section C403.4.5 of IECC 2018.

4.3. Demand Control Ventilation (DCV)

Section C403.2.6.1 of IECC 2018[183] states that Demand Control Ventilation (DCV) is required for spaces greater than 500 ft^2, **and** an average occupant load of 25 people per 1000 ft^2, **and** served by systems with one or more of the following:

1) An air-side economizer.
2) Automatic modulating control of the outdoor air damper.
3) A design outdoor airflow greater than 3,000 cfm.

[181] Complex HVAC systems are defined as all systems listed in Tables C403.2.3(1) through C403.2.3(8) which cannot be categorized as either unitary or packaged.

[182] Section C403.3.1 of IECC 2018

[183] Section C403.2.5.1 of IECC 2018

This measure is only eligible when the above conditions are not met or when the system meets one of the following exceptions.

- Systems with energy recovery (ERV) complying with Section C403.2.7 of IECC 2018[184].
- Multiple-zone systems without direct digital control (DDC) of individual zones communicating with a central control panel.
- System with a design outdoor airflow less than 1,200 cfm.
- Spaces where the supply airflow rate minus any makeup or outgoing transfer air requirement is less than 1,200 cfm.
- Ventilation provided for process loads only.

4.4. Supply Air Temperature Reset Controls

Section C403.4.4.5 of IECC 2018[185] states that multiple-zone systems shall include an automatic supply-air temperature reset in response to building loads or outdoor air temperature. The control reset shall be capable of adjusting the supply air temperature not less than 25% of the difference between the design supply air temperature and the design room air temperature. This measure is only eligible when the system meets one of the following exceptions:

- Systems that prevent reheating, recooling or mixing of heated and cooled supply air.
- 75% of the energy for reheating is from site-recovered or site-solar energy sources.
- Zones with peak supply air quantities less than 300 cfm.

4.5. Chilled Water Reset Controls

Section C403.4.2.4 item 1 of IECC 2018[186] Chilled water reset controls are required for all hydronic systems greater than or equal to 500,000 Btu/h (300,000 Btu/h for IECC 2012) in design output capacity supplying heated or chilled water to comfort conditioning systems.

This measure is only eligible on hydronic systems less than 500,000 Btu/h (300,000 Btu/h for IECC 2012) in design output capacity.

4.6. Condenser Water Reset Controls

Section C403.5.1 of IECC 2018 states that the refrigeration system condenser shall have control logic to reset the condensing temperature setpoint according to the ambient dry-bulb temperature for air-cooled condensers, and the ambient wet-bulb temperature for evaporatively cooled condensers. Note, this measure is not required by IECC 2012.

[184] Section C403.2.5.1 of IECC 2018

[185] Section C403.4.5.4 of IECC 2018

[186] Section C403.4.3.4 item 1 of IECC 2018

This measure is only eligible for projects that are not required to meet the standards of IECC 2018.