New Jersey ~~2024 Annual~~Program Year 5 Technical Reference Manual

New Jersey Board of Utilities

New Jersey's Clean Energy Program™

~~2/10/2025~~2/28/2025

Table of Contents

1 INTRODUCTION

This technical reference manual (TRM) has been developed to calculate resource savings, including electricity, natural gas, and other resource savings from technologies and measures, and to calculate electric energy and capacity savings from renewable energy and distributed generation systems. Specific calculation methods for determination of the resource savings or generation are presented.

These calculations use deemed and customer-specific data as input values to industry-accepted energy and peak demand savings algorithms. The data and input values for the algorithms come from the program application forms or from deemed values. The deemed values are based on the recent impact evaluations or best available secondary research applicable to the New Jersey programs when impact evaluations are not available.

1.1 PURPOSE

The TRM was developed for the purpose of calculating energy and peak demand savings for technologies and measures supported by New Jersey's Clean Energy Program (NJCEP). This includes programs administered by the State of New Jersey through the Board of Public Utilities (BPU), the State's electric and natural gas utilities, or other parties who administer clean energy programs under the guidance of the BPU. The TRM will be updated to reflect the addition of new measures, modifications to existing measures, changes to codes and standards, and the results of evaluation studies. The TRM will be used consistently statewide to assess program impacts and calculate energy and peak demand savings consistent with BPU guidance. The TRM may be used to accomplish the following:

- Report to the BPU on program performance;
- Provide inputs for program planning and cost-effectiveness calculations;
- Provide information to the BPU for calculating Quantitative Performance Indicators (QPI) and applying the Performance Incentive Mechanism (PIM);

Resource savings to be measured include electric energy (kWh) and demand (kW) savings, natural gas savings (therms), peak gas savings (therms/day), and savings of other resources (oil, propane, gasoline, and water) where applicable. In turn, these resource savings will be used to determine avoided environmental emissions and other benefits as described in the New Jersey Cost Test. The TRM is also utilized to support preliminary estimates of the electric energy and capacity from renewable energy and distributed generation systems and the associated environmental benefits.

The calculations in this document focus on the determination of the per unit savings for the energy efficiency measures, and the per unit generation for the renewable energy or distributed generation measures. The BPU has adopted net savings for the purposes of evaluating energy efficiency and peak demand reduction program performance, and performing cost-effectiveness testing. For Triennium 1, the BPU adopted a net-to-gross ratio of 1.0, which should be applied to all programs, including low- income programs. For Triennium 2, net to gross ratios used to calculate net savings are shown in **Error! Reference source not found.**~~Appendix H: Net-to-Gross Factors~~ and should be applied to the gross savings calculated from this TRM.

1.2 TRM ORGANIZATION

The TRM is organized by customer sector (Residential and Commercial) and by end-use. Within each end-use section, measures are grouped together by end-use subcategory. Note, sector applicability to measures installed multifamily (MF) buildings depends on whether the building is a low rise (3 stories or less) and whether the measure is located in the individual unit or common area. In-unit measures and all measures in MF low-rise buildings are covered in the Residential section. Measures in common areas of MF high-rise (more than 3 stories) buildings are covered in the Commercial section. Measures used in low-income (LI) or moderate income (MI) programs use the same TRM sections as measures applied to the general population. Any calculations unique to LI or MI programs are identified within each measure section. Measure applied to Agricultural facilities are covered within the Commercial section under the Agricultural end-use.

1.3 TYPES OF CALCULATIONS

The following table summarizes the spectrum of approaches to be used for calculating energy, demand, and resource savings. No one approach will serve all programs and measures. The TRM provides algorithms addressing measure types 1 and 2, and general guidelines for measure type 3.

Table 1-1 Summary of Calculations and Approaches

Type of Measure	Type of Calculation	General Approach	Examples
1. Deemed prescriptive measures	Standard formula and deemed input values	Number of installed units times deemed savings/unit	Residential appliances
2. Measures with important variations in one or more input values (e.g., , efficiency level, capacity, load, etc.)	Standard formula with one or more site-specific input values	Standard formula in the TRM with one or more input values coming from the application form, worksheet, or field tool (e.g., , efficiency levels, unit capacity, site-specific load)	Residential Electric HVAC (change in efficiency level times site-specific capacity times standard operating hours); Field screening tools that use site-specific input values
3. Custom or site-specific measures, or measures in complex comprehensive jobs	Site-specific analysis	Greater degree of site- specific analysis, either in the number of site-specific input values, or in the use of special engineering algorithms, including building simulation programs	Custom Industrial process Complex comprehensive jobs

Several systems work together to ensure accurate data on a given measure:

1. The application form that the customer or customer's agent submits with basic information.
2. Application worksheets and field tools with more detailed site-specific data, input values, and calculations (for some programs).
3. Program tracking systems that compile data and may do some calculations
4. The TRM that contains algorithms and relies on deemed or site-specific input values. Parts or all of the TRM may ultimately be implemented within the tracking system, the application forms and worksheets, and the field tools.

1.4 ALGORITHMS

The TRM presents a set of engineering algorithms to calculate energy and demand savings. Savings are generally driven by a change in efficiency level for the installed measure compared to a baseline level of efficiency. Energy savings are calculated from the change in efficiency and/or the change the annual operating hours of equipment. Operating hours may be expressed as run hours for constant output devices or equivalent full load hours (EFLH) for equipment that operates at varying levels of output throughout the year. Energy and demand savings may be calculated for both electricity and natural gas regardless of the targeted fuel.

1.5 BUILDING ENERGY SIMULATIONS

When building energy simulation software is used to develop savings estimates for several measures in a comprehensive project, the specific algorithms used are inherent in the software and account for interaction among measures by design. Building simulation software used for any program must be compliant with one of the following:

- A software tool addressing residential and/or commercial buildings whose performance has passed testing according to the National Renewable Energy Laboratory's BESTEST software or ASHRAE Standard 140 energy simulation testing protocol,
- Software approved the US Department of Energy's Weatherization Assistance program, or
- RESNET approved home energy rating software (HERS).

1.6 MEASURE INTERACTIVE SAVINGS

Throughout the TRM, the interactive effect of thermostatically-sensitive building components is accounted for in specific measure sections, as appropriate. In instances where there is a measurable amount of interaction between two energy consuming sources, the energy or peak demand savings are accounted for in either the algorithms or in the modeling software used to determine energy savings.

For example, in a measure section where the lighting load has a direct effect on the energy used to condition the space, the TRM provides an interactive effect value to be used in the savings algorithm for certain measures. Other measures rely on the characteristics of the modeling software that account for the effect within a building, such as a new construction protocol software that will apply the effects for a measurable difference in the baseline and efficient buildings.

Measure savings calculation based on simple engineering algorithms are not designed to account for the interactive effects of multiple measures installed in a building. When multiple measures are installed, it is acceptable to sum the individual measure savings. Energy savings calculations based on building energy simulations account for multiple measure interactions by design.

1.7 DATA AND INPUT VALUES

Some input values, including site-specific data, will come directly from the program application forms, worksheets, and field tools. Site-specific data on the application forms are used for measures with important variations in one or more input values (efficiency level, capacity, etc.).

Standard input values are based on the best available measured or industry data, including metered data, measured data from prior evaluations (applied prospectively), field data and program results, nameplate data, in situ values, and/or standards from industry associations.

For the deemed input assumptions where metered or measured data were not available, the input values (e.g., watts, efficiency, equipment capacity, operating hours, coincidence factors) are based on the best available industry data or standards. These input values were based on a review of literature from related evaluation studies and information from various industry organizations, equipment manufacturers, and suppliers. For custom projects, measurement and verification (M&V) options are presented that use pre- and/or post-retrofit measurements of energy consumption or equipment performance to estimate energy savings.

1.8 BASELINE ESTIMATES

For measures in which the existing equipment has failed, is at the end of its useful life, or the program administrator does not have knowledge of the state of the existing equipment, the resource savings values are based difference between the energy use of new products that meet code or represent industry standard practice vs. the high efficiency products promoted through the programs. For early replacement of functioning equipment, energy and demand savings values are based on the difference between high efficiency equipment versus existing equipment. A dual baseline approach must be followed, where the savings relative to the existing equipment baseline are used for the remaining useful life of the existing equipment and a code or standard practice baseline is used for the remaining life of the measure. In lieu of the dual baseline approach, lighting measures may use an adjusted measure life (AML) to account for early replacement of functioning systems and differences in the lifetimes of efficient vs. standard practice equipment. The AML is defined as the lifetime energy savings considering a dual baseline divided by first year savings.

Measures in the TRM are categorized according to the following baseline condition definitions:

Baseline Condition	Attributes
Time of Sale (TOS)	**Definition:** A program in which the customer is incented to purchase or install higher efficiency equipment than if the program had not existed. This may include retail rebate (coupon) programs, upstream buydown programs, online store programs, contractor based programs, or giveaways as examples. May include replacement of existing equipment at the end of its life (i.e., replace on burnout) or purchase of new equipment. In cases where a new construction characterization isn’t explicitly provided, the TOS characterization is typically appropriate. TOS is sometimes referred to as normal replacement (NR). **Baseline:** New standard efficiency, code compliant, or industry standard practice equipment. **Efficient Case:** New, premium efficiency equipment above federal and state codes and standards and industry standard practice. **Example:** Appliance rebate
New Construction (NC)	**Definition:** A program that intervenes during building design, expansion, or gut rehabilitation to support the use of more-efficient equipment and construction practices. **Baseline:** Building code, federal standards, or industry standard practice. **Efficient Case:** The program’s level of building specification **Example:** Building shell and mechanical measures

Baseline Condition	Attributes
Retrofit (RF)	**Definition:** A program that upgrades or enhances existing equipment. **Baseline:** Existing equipment or the existing condition of the building or equipment. A single baseline applies over the measure's life. When a measure is applied to existing operational equipment and the measure benefit will cease upon the end of the underlying equipment's life, the measure life is the smaller of the host equipment remaining life or the full measure life. **Efficient Case:** Post-retrofit efficiency of equipment. **Example:** Air sealing, insulation, controls
Early Replacement (EREP)	**Definition:** A program that replaces existing, operational equipment. **Baseline:** Dual. it begins as the existing equipment and shifts to projected TOS baseline equipment after the remaining life of the existing equipment is over. **Efficient Case:** New, premium efficiency equipment above federal and state codes and industry standard practice. **Example:** Refrigerators and freezers; early replacement of HVAC equipment. *Note: For lighting measures, the adjusted measure life (AML) may be used in lieu of a dual baseline approach.*
Early Retirement (ERET)	**Definition:** A program that retires inefficient, operational duplicative equipment or inefficient equipment that might otherwise be resold. No new equipment is installed in place of the old equipment, and no existing equipment use increases to compensate for the retirement. **Baseline:** The existing equipment, which is retired and not replaced. **Efficient Case:** Assumes zero consumption since the unit is retired. **Example:** Appliance recycling, delamping.
Direct Install (DI)	**Definition:** A program where measures are installed during a site visit and are assumed to replace existing, operational equipment. **Baseline:** Same as EREP. **Efficient Case:** Same as EREP. **Example:** Lighting and low-flow hot water measures *Note: For lighting measures, the adjusted measure life (AML) may be used in lieu of a dual baseline approach.*

1.9 PEAK SAVINGS

1.9.1 ELECTRIC COINCIDENT PEAK DEMAND

System peak demand refers to the highest amount of electricity consumed during a single hour across PJM. Peak coincident demand is the demand of a measure that occurs at the same time as the PJM system peak. PJM system peak is defined as follows in PJM Manual 18b:

"The EE Performance Hours are between the hour ending 15:00 Eastern Prevailing Time (EPT) and the hour ending 18:00 EPT during all days from June 1 through August 31, inclusive, of such Delivery Year, that is not a weekend or federal holiday."

Therefore peak coincident demand savings should be calculated based on the average demand reduction during the hours in that time frame.[1]

Peak demand savings for non-weather sensitive custom measures should be calculated based on the average demand reduction during the hours in that period. For weather sensitive custom measures, peak demand savings should be calculated based on the PJM's Zonal Weighted Temperature Humidity Index ("WTHI") standards for the appropriate zone.[2]

1.9.2 PEAK DAY NATURAL GAS

Calculations have been developed to determine the natural gas energy savings on an annual and peak day basis. Additional calculations done as part of the cost effectiveness calculations allocate the annual savings on a seasonal basis. Peak gas savings are calculated on a therm/day basis, using peak day heating degree-days representing the weather conditions under which the natural gas distribution system reaches peak capacity. Design day conditions from the London Economics study are used to calculate peak gas savings:

Condition	Average Heating Degree days base 65 (°F – day)	Average Daily Temperature (°F)
Winter Design Day	66.4	-1.4

1.10 OTHER RESOURCES

Measures that save electricity or natural gas may also affect the use of other fuels, water or other costs, and will affect emissions. The New Jersey Cost Test accounts for emissions reductions associated with electricity and natural gas and the net direct and indirect economic benefit of these other factors. The NJCT-required outputs from TRM use are natural gas and electric energy and electric summer peak demand gross impact.

1.11 PROSPECTIVE APPLICATION OF THE TRM

The TRM will be updated annually based on evaluation results and available data, and then applied prospectively for future program years in accordance with applicable BPU direction. Prospective application of the TRM will include calculation of gross energy and demand savings from the applicable measure section modified by evaluation-derived in-service rates as presented in Appendix J: In-Service Rates, realization rates as presented in Appendix I: Realization Rates and net to gross ratios as presented in **Error! Reference source not found.**~~Appendix H: Net-to-Gross Factors~~.

1.12 MEASURE COSTS

Measure costs for use in cost-effectiveness calculations are presented in a separate document. Projects will use incremental costs and/or full measure costs depending on the baseline condition. Consult the measure cost document for information on how to calculate measure costs.

1.13 MEASURE LIVES

[1] Coincidence factors and peak demand savings provided in the TRM measure sections are based on best available information. These coincidence factors may not conform to PJM requirements for offers into the forward capacity market.
[2] See PJM Manual 18B, section 10.2.

Measure effective useful life (EUL) is provided in each TRM measure section for the purpose of calculating lifetime energy savings. Projects utilizing a dual baseline approach will rely on a combination of the existing equipment remaining useful life (RUL) and the new equipment EUL. Calculations of lifetime savings for retrofit projects involving add-on equipment such as controls will use the smaller of the measure EUL and the host equipment RUL. Measures where values for adjusted measure life (AML) are provided will use the AML in lieu of a dual baseline approach. Projects consisting of multiple measures that submit a single project wide savings claim should calculate a project level EUL based on the average of the EULs of the individual measures. For such projects where measure-level savings can be calculated, use the savings weighted average of the individual measure EULs. For projects where savings by end-use are available, assign an EUL to each end use based on the measures contributing to the end use savings and estimate the project level EUL as the end-use savings weighted average. For projects were savings by measure or savings by end use are not available, a project-level EUL based on the simple average of the measure EULs is acceptable.

2 RESIDENTIAL

2.1 APPLIANCES

2.1.1 CLOTHES WASHER

Market	Residential/Multifamily
Baseline Condition	TOS
Baseline	Code
End Use Subcategory	Clothes Washer
Measure Last Reviewed	September 2024
Changes Since Last Version	~~Updated default capacity and IMEF values~~ • Updated measure description to provide guidance on calculating total savings for combination washer/dryer units

Description

This measure is for a new or replacement ENERGY STAR or ENERGY STAR Most Efficient residential clothes washer in single family or multifamily homes. Please note that common area laundry rooms in Multifamily buildings should follow the C&I methodology.

ENERGY STAR® clothes washers have a higher Integrated Modified Energy Factor (IMEF) and a lower Integrated Water Factor (IWF), saving energy and water with greater tub capacities and sophisticated wash and rinse systems. Rather than filling the tub with water, efficient wash cycles are achieved by spinning or flipping clothes through a stream of water. Efficient rinse cycles are achieved through high-pressure spraying instead of soaking clothes. Reduced dryer load represents additional energy savings associated with the thorough removal of water from the clothes in the washer.

Note: In the case of a combination washer/dryer unit, total equipment savings will be the sum of savings from this measure in addition to measure 2.1.2 Clothes Dryer.

Baseline Case

The baseline for energy savings calculations is a clothes washer meeting the federal minimum Integrated Modified Energy Factor (IMEF) and not exceeding the federal maximum Integrated Water Factor (IWF), as defined in 10 CFR 430.32(f)(2). The IMEF and IWF are determined by clothes washer configuration (top-load or front-load) and capacity. Energy usage includes the washer and dryer energy consumption and water heating energy usage.

Efficient Case

The energy consumption of the efficient equipment is calculated based on the IMEF and IWF of the ENERGY STAR version 8.1 specification or ENERGY STAR Most Efficient product and other variables as defined in the calculation methodology below.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{washer} + \Delta kWh_{DHW} + \Delta kWh_{dryer}$$

Where,

$$\Delta kWh_{washer} = Cap \times \left(\frac{F_{washer,b}}{IMEF_b} - \frac{F_{washer,q}}{IMEF_q}\right) \times N_{cycles}$$

$$\Delta kWh_{DHW} = Cap \times \left(\frac{F_{DHW,b}}{IMEF_b} - \frac{F_{DHW,q}}{IMEF_q}\right) \times N_{cycles} \times SF_{DHW,electric}$$

$$\Delta kWh_{dryer} = Cap \times \left(\frac{F_{dryer,b}}{IMEF_b} - \frac{F_{dryer,q}}{IMEF_q}\right) \times N_{cycles} \times SF_{dryer,electric}$$

Annual Fuel Savings

$$\Delta Therms = \Delta Therms_{DHW} + \Delta Therms_{dryer}$$

Where,

$$\Delta Therms_{DHW} = Cap \times \left(\frac{F_{DHW,b}}{IMEF_b} - \frac{F_{DHW,q}}{IMEF_q}\right) \times N_{cycles} \times R_q \times SF_{DHW,ff} \times 0.03412$$

$$\Delta Therms_{Dryer} = Cap \times \left(\frac{F_{dryer,b}}{IMEF_b} - \frac{F_{dryer,q}}{IMEF_q}\right) \times N_{cycles} \times SF_{dryer,ff} \times 0.03412$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-1 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkWh_{washer}	Annual electric energy savings attributed to clothes washer operation	Calculated	kWh/yr	
ΔkWh_{DHW}	Annual electric energy savings attributed to water heating	Calculated	kWh/yr	
ΔkWh_{dryer}	Annual electric energy savings attributed to dryer operation	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{DHW}$	Annual fuel savings attributed to water heating	Calculated	Therms/yr	
$\Delta Therms_{dryer}$	Annual fuel savings attributed to dryer operation	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ΔH2O	Annual water savings	Calculated	Gal/yr	
Cap	Capacity of clothes washer	Site-specific. If unknown, use 3.39 or SJG Tier 1 use 5.03, Tier 2 use 4.6. ETG Tier 1 use 5.09, Tier 2 use 4.64	ft^3	[1]
$IMEF_q$	Integrated Modified Energy Factor of efficient unit	Site-specific. If unknown, look up in Table 2-3 or SJG Tier 1 use 2.37, Tier 2 use 2.97. ETG Tier 1 use 2.43, Tier 2 use 2.98	$ft^3/(kWh \cdot cycle)$	[2][3]

Variable	Description	Value	Units	Ref
IWF_q	Integrated water factor for efficient unit	Site-specific. If unknown, look up in Table 2-8	Gal/(cycle·ft^3)	[2][3]
$IMEF_b$	Integrated Modified Energy Factor of baseline unit	Look up in Table 2-2	ft^3/(kWh·cycle)	[2]
N_{cycles}	Number of clothes washer cycles per year	Look up in Table 2-4	cycles	
$F_{washer,b}$	Fraction of total energy consumption attributed to clothes washer operation for the baseline case	Look up in Table 2-5	N/A	[5]
$F_{washer,q}$	Fraction of total energy consumption attributed to clothes washer operation for the efficient case	Look up in Table 2-6	N/A	[6]
$F_{DHW,b}$	Fraction of total energy consumption attributed to water heating for the baseline case	Look up in Table 2-5	N/A	[5]
$F_{DHW,q}$	Fraction of total energy consumption attributed to water heating for the efficient case	Look up in Table 2-6	N/A	[6]
$F_{dryer,b}$	Fraction of total energy consumption attributed to dryer operation for the baseline case	Look up in Table 2-5	N/A	[5]
$F_{dryer,q}$	Fraction of total energy consumption attributed to dryer operation for the efficient case	Look up in Table 2-6	N/A	[6]
$SF_{DHW,electric}$	Electric DHW savings factor	Look up in Table 2-7	N/A	[10]
$SF_{dryer,electric}$	Electric dryer savings factor	Look up in Table 2-7	N/A	[10]
$SF_{DHW,ff}$	Fossil fuel DHW savings factor	Look up in Table 2-7	N/A	[10]
$SF_{dryer,ff}$	Fossil fuel dryer savings factor	Look up in Table 2-7	N/A	[10]
Hrs	Annual operating hours	Look up in Table 2-4	Hrs/yr	
IWF_b	Integrated water factor for baseline unit	Look up in Table 2-2	Gal/(cycle·ft^3)	
CF	Electric coincidence factor	Look up inTable 2-9	N/A	
PDF	Gas peak day factor	Look up in Table 2-9	N/A	
R_q	Recovery efficiency factor	1.26	N/A	[8]
0.03412	Unit conversion, therm/kWh	0.03412	Therm/kWh	
EUL	Effective useful life	See Measure Life Section	Years	

Table 2-2 Federal Standard Minimum IMEF and Maximum IWF

Configuration	Capacity (ft^3)	IMEF	IWF
Top Load	<1.6	1.15	12.0
Top Load	≥1.6	1.57	6.5
Front Load	<1.6	1.13	8.3
Front Load	≥1.6	1.84	4.7

Table 2-3 Efficient Unit Minimum IMEF

<table>
<tr><th>Efficiency Level</th><th>Front Loading</th><th>Top Loading</th></tr>
<tr><td colspan="3">Clothes Washers > 2.5 ft³</td></tr>
<tr><td>ENERGY STAR</td><td>2.76</td><td>2.06</td></tr>
<tr><td>CEE Tier 1</td><td>2.76</td><td>2.76</td></tr>
<tr><td>CEE Tier 2</td><td colspan="2">2.92</td></tr>
<tr><td>CEE Tier 3</td><td colspan="2">3.10</td></tr>
<tr><td colspan="3">Clothes Washers ≤ 2.5 ft³</td></tr>
<tr><td>ENERGY STAR</td><td colspan="2">2.07</td></tr>
<tr><td>CEE Tier 1</td><td colspan="2">2.07</td></tr>
<tr><td>CEE Tier 2</td><td colspan="2">2.20</td></tr>
</table>

Table 2-4 Annual Cycles and Hours

Type	Number of Cycles	Annual Hours	Ref
Single Family	254	295	[4]

Table 2-5 Total Energy Consumption Breakdown for Baseline Case

Efficiency Level	Clothes Washer (F_{washer})	DHW (F_{DHW})	Dryer (F_{dryer})
Federal Standard	0.07	0.65	0.28

Table 2-6 Total Energy Consumption Breakdown for Efficient Case

Efficiency Level	Clothes Washer (F_{washer})	DHW (F_{DHW})	Dryer (F_{dryer})
Clothes Washers (> 2.5 ft^3)			
ENERGY STAR	0.05	0.63	0.32
CEE Tier 1	0.05	0.63	0.32

Efficiency Level	Clothes Washer (F_{washer})	DHW (F_{DHW})	Dryer (F_{dryer})
CEE Tier 2	0.10	0.87	0.03
CEE Tier 3	0.10	0.87	0.03
Clothes Washers (≤ 2.5 ft³)			
CEE Tier 1	0.08	0.72	0.20
CEE Tier 2	0.08	0.72	0.20

Table 2-7 DHW and Dryer Savings Factors

Fuel	$SF_{DHW,electric}$	$SF_{dryer,electric}$	$SF_{DHW,ff}$	$SF_{dryer,ff}$
Electric	1.00	1.00	0	0
Fossil Fuel	0	0	1.00	1.00
Unknown	Look up in **Error! Reference source not found.**~~Appendix K: DHW and Space Heat Fuel Split~~, or default to 0.31	0.68	Look up in **Error! Reference source not found.**~~Appendix K: DHW and Space Heat Fuel Split~~, or default to 0.69	0.32

Table 2-8 Efficient Unit Maximum IWF

Efficiency Level	Front Loading	Top Loading
Standard Sized Clothes Washers (> 2.5 ft³)		
ENERGY STAR	3.2	4.3
CEE Tier 1	3.2	3.2
CEE Tier 2	3.2	3.2
CEE Tier 3	3.0	3.0
Small Sized Clothes Washers (≤ 2.5 ft³)		
ENERGY STAR	4.2	
CEE Tier 1	4.2	
CEE Tier 2	3.7	

Peak Factors

Table 2-9 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.029	[7]
Natural gas peak day factor (PDF)	See **Error! Reference source not**	

Peak Factor	Value	Ref
	found.~~Appendix G: Natural Gas Peak Day Factors~~	

Non-Energy Impacts

$$\Delta H2O = (IWF_b - IWF_q) \times Cap \times N_{cycles}$$

Measure Life

The effective useful life (EUL) is 14 years. [9]

References

[1] Based on the average clothes washer volume of all units that are ENERGY STAR qualified as of 3/17/2020.

[2] 10 CFR Subpart C of Part 430. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32

[3] ENERGY STAR Program Requirements Product Specification for Clothes Washers, Version 8.1. 2021. https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Version%208.1%20Clothes%20Washer%20Final%20Specificaiton%20-%20Partner%20Commitments%20and%20Eligibility%20Criteria.pdf

[4] CEE, Residential Clothes Washer Specification (2022). *https://library.cee1.org/system/files/library/12282/CEE_ClothesWasher_Specification_17May2022.pdf*

[5] 10 CFR Subpart B of Part 430. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-B

[6] The percentage of total energy consumption that is used for the machine, heating the hot water or by the dryer is different depending on the efficiency of the unit. Values are based on a weighted average of top loading and front loading units (based on available product from the ENERGY STAR qualified product list accessed on 3/17/2020) and consumption data from Life-Cycle Cost and Payback Period Excel-based analytical tool, available online at: https://www.regulations.gov/docketBrowser?rpp=25&so=DESC&sb=commentDueDate&po=0&dct=SR&D=EERE2008-BT-STD-0019

[7] Navigant, EmPOWER Maryland DRAFT Final Impact Evaluation Report Evaluation Year 4 (June 1, 2012 – May 31, 2013) Commercial & Industrial Prescriptive & Small Business Programs (2013).

[8] To account for the different efficiency of electric and fossil fuel water heaters (gas water heater: recovery efficiencies ranging from 0.74 to 0.85 (0.78 used), and electric water heater with 0.98 recovery efficiency (http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf). Therefore, a factor of 0.98/0.78 (1.26) is applied.

[9] Regulations.gov, Residential Clothes Washers Life-Cycle Cost Analysis (LCC) Spreadsheets (2021). https://www.regulations.gov/document/EERE-2017-BT-STD-0014-0025

[10] U.S. EIA 2015 Residential Energy Consumption Survey. https://www.eia.gov/consumption/residential/data/2015/

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

2.1.2 CLOTHES DRYER

Market	Residential/Multifamily
Baseline Condition	TOS
Baseline	Code
End Use Subcategory	Clothes Washer
Measure Last Reviewed	December 2022
Changes Since Last Version	• Updated measure description to provide guidance on calculating total savings for combination washer/dryer units

Description

This measure is for a new or replacement ENERGY STAR or ENERGY STAR Most Efficient residential clothes dryer. This measure relates to the installation of a residential clothes dryer meeting the ENERGY STAR V1.1 criteria. ENERGY STAR qualified clothes dryers save energy through a combination of more efficient drying and reduced runtime of the drying cycle. More efficient drying is achieved through increased insulation, modifying operating conditions such as air flow and/or heat input rate, improving air circulation through better drum design or booster fans, and improving efficiency of motors. Reducing the runtime of dryers through automatic termination by temperature and moisture sensors is believed to have the greatest potential for reducing energy use in clothes dryers. ENERGY STAR provides criteria for both gas and electric clothes dryers.

Note: In the case of a combination washer/dryer unit, total equipment savings will be the sum of savings from this measure in addition to measure 2.1.1 Clothes Washer.

This measure can also be used for small commercial and industrial applications.

Baseline Case

The baseline for energy savings calculations is a clothes dryer meeting the federal minimum combined energy factor for machines manufactured after January 2015. The minimum combined energy factor varies by clothes dryer type.

Efficient Case

The energy consumption of the efficient equipment is calculated based on the combined energy factor of the ENERGY STAR or ENERGY STAR Most Efficient product and other variables defined in the calculation methodology.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = Cycles_{annual} \times Load \times \left(\frac{F_{elec,b}}{CEF_b} - \frac{F_{elec,q}}{CEF_q}\right)$$

Annual Fuel Savings

$$\Delta Therms = Cycles_{annual} \times Load \times \left(\frac{F_{fuel,b}}{CEF_b} - \frac{F_{fuel,q}}{CEF_q}\right) \times \frac{3{,}412}{100{,}000}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-10 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$Cycles_{Annual}$	Number of dryer cycles per year	Site-specific. If unknown, use 283	Cycles	[14]
Hrs	Annual run hours of clothes dryer	Site-specific. If unknown, use 290[3]	Hrs/yr	[14][16]
Load	Average total weight of clothes per drying cycle	Look up in Table 2-11	lbs	[14]
$F_{elec,b}$	Percentage of energy consumed that is derived from electricity for baseline condition	Look up in Table 2-11	N/A	[15][16]

[3] Assumes average of 56 minutes per cycle based on Ecova, 'Dryer Field Study', Northwest Energy Efficiency Alliance (NEEA) 2014.

Variable	Description	Value	Units	Ref
CEF_b	Combined energy factor for baseline condition	Look up in Table 2-11	lb/kWh	[13]
$F_{elec,q}$	Percentage of energy consumed that is derived from electricity for efficient condition	Look up in Table 2-11	N/A	[15][16]
CEF_q	Combined energy factor for efficient case	Site-specific. If unknown, look up in Table 2-11	lb/kWh	[12]
$F_{fuel,b}$	Percentage of energy consumed that is derived from fossil fuel for baseline condition	Look up in Table 2-11	N/A	[15][16]
$F_{fuel,q}$	Percentage of energy consumed that is derived from fossil fuel for efficient case	Look up in Table 2-11	N/A	[15][16]
CF	Electric coincidence factor	Look up in Table 2-12	N/A	[15]
PDF	Gas peak demand factor	Look up in Table 2-12	N/A	
3,412	Conversion factor from kWh to Btu	3,412	Btu/kWh	
100,000	Conversion factor from Btu to therms	100,000	Btu/Therm	
EUL	Effective useful life	See Measure Life Section	Years	

Table 2-11 Default Values for Various Dryer Types

Dryer Type	Load	$F_{elec,b}$	$F_{elec,q}$	$F_{fuel,b}$	$F_{fuel,q}$	CEF_b	CEF_q (Energy Star)	CEF_q (Energy Star Most Efficient)
Vented Gas Dryer	8.45	0.16[4]	0.16	0.84[5]	0.84	3.30	3.48	
Ventless or Vented Electric, Standard ≥ 4.4 ft^3	8.45	1.00	1.00	0.00	0.00	3.73	3.93	4.3
Ventless or Vented Electric, Compact (120V) < 4.4 ft^3	3.00	1.00	1.00	0.00	0.00	3.61	3.80	4.3
Vented Electric, Compact (240V) < 4.4 ft^3	3.00	1.00	1.00	0.00	0.00	3.27	3.45	4.3
Ventless Electric, Compact (240V) < 4.4 ft^3	3.00	1.00	1.00	0.00	0.00	2.55	2.68	3.7

[4] %Electric accounts for the fact that some of the savings on gas dryers comes from electricity (motors, controls, etc). 16% was determined using a ratio of the electric to total savings from gas dryers given by ENERGY STAR Draft 2 Version 1.0 Clothes Dryers Data and Analysis.

[5] %Gas accounts for the fact that some of the savings on gas dryers comes from electricity (motors, controls, etc). 84% was determined using a ratio of the gas to total savings from gas dryers given by ENERGY STAR Draft 2 Version 1.0 Clothes Dryers Data and Analysis.

Peak Factors

Table 2-12 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.029	[17]
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The effective useful life (EUL) is 12 years [11].

References

[11] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020.

[12] ENERGY STAR Program Requirements for Clothes Dryers. n.d. Accessed December 27, 2022. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Final%20Version%201.1%20Clothes%20Dryers%20Specification%20-%20Program%20Commitment%20Criteria%20and%20Eligibility%20Criteria_0.pdf

[13] PART 430 - ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS n.d. https://federalregister.gov. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430#430.32

[14] *Savings Calculator for ENERGY STAR Qualified Appliances*, ENERGY STAR, 2012. https://www.sfwmd.gov/sites/default/files/documents/calculator_energy_star_res_appliance_savings.xlsx

[15] *Mid-Atlantic Technical Reference Manual (TRM) V10*. (2020). https://neep.org/sites/default/files/media-files/trmv10.pdf

[16] ENERGY STAR Draft 2 Version 1.0 Clothes Dryers Data and Analysis, August 2013. https://www.energystar.gov/sites/default/files/specs/ENERGY%20STAR%20Draft%202%20Version%201.0%20Clothes%20Dryers%20Data%20and%20Analysis.xlsx

[17] Northwest Energy Efficiency Alliance (NEEA), *Dryer Field Study*, November 2014. https://ecotope-publications-database.ecotope.com/2014_005_1_DryerStudy.pdf

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

2.1.3 DISHWASHER

Market	Residential/Multifamily
Baseline Condition	NC/TOS
Baseline	Code
End Use Subcategory	Kitchen
Measure Last Reviewed	December 2022

Description

This measure covers the installation of ENERGY STAR® V6.0 qualified residential dishwashers. A dishwasher is a cabinet-like appliance that, with the aid of water and detergent, washes, rinses, and dries (when a drying process is included) dishware, glassware, eating utensils, and most cooking utensils by chemical, plumbing, and/or electrical means and discharges to the plumbing drainage system. ENERGY STAR® rated machines run more efficiently while washing dishes through improved technology such as soil sensors, improved water filtration, more efficient jets, and innovative dish rack designs. Qualified dishwashers are atleast 8.6% more efficient than non-certified models.

Baseline Case

The baseline condition is a residential dishwasher as defined in the Measure Description section above with type equivalent to the efficient case meeting the minimum effective federal performance standards. The baseline water heating system is a standard efficiency storage type electric or fossil fuel system (fuel type equivalent to the actual existing condition). Current federal annual energy consumption performance standards for dishwashers are provided in the table below.

Efficient Case

The compliance condition is an ENERGY STAR® V6.0 qualified residential dishwasher as defined in the Measure Description section above. Qualifying equipment must have rated annual energy consumption at or below the ENERGY STAR® qualified specifications as indicated the table below, based on dishwasher type. The energy consumption rating of the qualified dishwasher is to be taken from the application.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \left(kWh_b - kWh_q\right) \times (F_{machine} + F_{wh} \times ElecSF_{wh})$$

Annual Fuel Savings

$$\Delta Therms = \left(kWh_b - kWh_q\right) \times F_{wh} \times FuelSF_{wh} \times 1.307 \times \frac{3{,}412}{100{,}000}$$

Summer Peak Coincident Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-13 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
kWh_q	Annual rated electric energy use for energy efficient condition	Site-specific. If unknown, look up in Table 2-14	kWh	[24]
kWh_b	Annual rated electric energy use for baseline condition	Look up in Table 2-14	kWh	[18]
$F_{machine}$	Fraction of energy used for the dishwasher machine	0.44	N/A	[19]
F_{wh}	Fraction of energy used for the water heater	0.56	N/A	[19]
Hrs	Annual operating hours	301	Hours	[18]
$ElecSF_{wh}$	Electric Savings Factor for water heaters	Look up in Table 2-15	N/A	[21]
$FuelSF_{wh}$	Fuel Savings Factor of water heaters	Look up in Table 2-15	N/A	[21]
1.307	Ratio of recovery efficiency of electric water heater to the recovery efficiency of fossil fuel water heater	1.307	N/A	[22][18]

Variable	Description	Value	Units	Ref
3,412	Conversion factor from kWh to Btu	3,412	Btu/kWh	
100,000	Conversion factor from Btu to therms	100,000	Btu/therm	
CF	Electric coincidence factor	Look up in Table 2-16	N/A	
PDF	Gas peak day factor	Look up in Table 2-16	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 2-14 Baseline and Efficient kWh

Dishwasher Type	kWh_b	kWh_e
Compact	222	203
Standard	307	270

Table 2-15 Savings Factors

Type	Electric	Fuel
Electric WH	1.00	0
Fossil Fuel WH	0	1.00
Other	0	0
Unknown	Look up in **Error! Reference source not found.**~~Appendix K: DHW and Space Heat Fuel Split~~, or default to 0.20	Look up in **Error! Reference source not found.**~~Appendix K: DHW and Space Heat Fuel Split~~, or default to 0.54

Peak Factors

Table 2-16 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.029	[20]
Natural gas peak day factor (PDF)	**Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The effective useful life (EUL) is 11 years [23].

References

[18] 10 CFR 430.32 (f)(1). https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430#p-430.32(f)(1) An average of 215 annual 1.4-hour dishwasher cycles is assumed in order to estimate conventional and qualifying energy ratings, for a total of 301 hours of active use per year.

[19] ENERGY STAR Residential Appliance Savings Calculator, 2012.

[20] From NY TRM v10: "Based on 8,760 end use data for Missouri, provided to VEIC by Ameren for use in the Illinois TRM. The average dishwasher load during peak hours is divided by the peak load. In the absence of a New York specific load shape, this is deemed a reasonable proxy because load shapes are not expected to vary significantly by region. Data from Ameren was adjusted to account for the difference in assumed annual operating hours (252 hours were used in the referenced study whereas 301 hours are cited in this document) and peak range was adjusted to reflect New York peak time (the hour ending in 5PM) from Illinois peak time (1PM to the hour ending 5PM)."

[21] Based on NYSERDA Residential Statewide Baseline Study of New York State – July 2015.[6] "Unknown" shall only be applied when the collection of information on water heating fuel is not feasible due to program configuration of delivery mechanism. ElecSF and FuelSF "unknown" factors may not sum to 100% due to the presence of other water heating fuels.

[22] Per 10 CFR 430 Subpart B Appendix E – Uniform Test Method for Measuring the Energy Consumption of Water Heaters: *6.3.2 Recovery Efficiency*.

[23] California Public Utilities Commission EUL Table, version 027 (updated November 12, 2022). Accessed December 30, 2022. https://www.caetrm.com/shared-data/value-table/EUL/

[24] *ENERGY STAR® Program Requirements for Residential Dishwashers Eligibility Criteria Version 6.0* (2016), Table 1. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Residential%20Dishwasher%20Version%206.0%20Final%20Program%20Requirements.pdf

Field Code Changed

Field Code Changed

Field Code Changed

[6] NYSERDA Residential statewide Baseline Study. Volume 1: Single Family Report, Table 38: Water Heating Fuel Type by Climate Zone. Overall statewide averages applied. ElecSF and FuelSF "unknown" factors may not sum to 100% due to the presence of other water heating fuels. In the condition of other water heating fuels in home, the designation "Other" shall be applied.

2.1.4 INDUCTION RANGE/COOKTOP

Market	Residential/Multifamily
Baseline Condition	RF/TOS
Baseline	Existing
End Use Subcategory	Kitchen
Measure Last Reviewed	January 2023

Description

This measure is applicable to the replacement of electric resistance and fossil fuel cooktops with electric induction cooktops in single family and multifamily in-unit kitchens. Induction cooktops heat food faster, are easier to clean, are less likely to burn those using them, and have a higher cooking efficiency than electrical resistance stoves. Conventional residential cooktops typically employ fossil fuel or resistance heating elements to transfer energy, with efficiencies of approximately 32% and 75%-80% respectively. Residential induction cooking tops instead consist of an electromagnetic coil that creates a magnetic field when supplied with an electric current. When brought into this field, compatible cookware is warmed internally, transferring energy with approximately 85% efficiency. If the replacement equipment is a range or induction cooktop, the cooktop must have either 4 or 5 burners.

Baseline Case

The baseline condition is a standalone electric resistance or fossil fuel-fired cooktop.

Efficient Case

The compliance condition is an induction cooktop with compatible cookware.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = kWh_b \times F_{elec,b} - kWh_q$$

Where,

$$kWh_b = 1.135 \times kWh_q$$

Annual Fuel Savings

$$\Delta Therms = Therms_b \times F_{fuel,b}$$

Where,

$$Therms_b = 2.1 \times kWh_q \times \frac{3,412}{100,000}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-17 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
kWh_b	Energy consumption by electric baseline cooktop	Site-specific, if unknown use abovementioned formulae	kWh	[25]
kWh_q	Energy consumption by induction cooktop	Site-specific, if unknown use 125 kWh	kWh	[26]
hrs	Annual operating hours	Site-specific, if unknown use 365 hours	Hours	[27]
$F_{elec,b}$	Electric factor; used to account for the presence or absence of an electric cooktop in the baseline condition	Use a value of 1.0 if the baseline cooktop is electric. Otherwise, use 0.0. If unknown, use 0.61.	N/A	[30]
$F_{fuel,b}$	Fossil fuel factor; used to account for the presence or absence of a fossil fuel-fired cooktop in the baseline condition	Use a value of 1.0 is the baseline cooktop is fossil fuel. Otherwise, use 0.0. If unknown, use 0.39.	N/A	[30]
$Therms_b$	Energy consumption by fossil fuel baseline cooktop	Site-specific, if unknown use abovementioned formulae.	Therms	[28]

Variable	Description	Value	Units	Ref
1.135	Relative efficiency of induction to resistance cooktops	1.135	N/A	[25]
2.1	Relative efficiency of induction to gas cooktops	2.1	N/A	[28]
3,412	Conversion from Btu to kWh	3,412	Btu/kWh	
100,000	Conversion from Btu to therms	100,000	Btu/therm	
CF	Electric coincidence factor	See Table 2-18	N/A	
EUL	Effective useful life	See Measure Life Section	Years	[29]

Peak Factors

Table 2-18 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.8	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 16 years [29].

References

[25] SWAP015-01, Induction Cooking with or without Electric Range, pg 7, May 2020. Available online at http://deeresources.net/workpapers. Based on relative efficiency of induction to resistance cooktops, 0.84/0.74 = 1.135

[26] ENERGY STAR®, Emerging Technology, 2021-2022 Residential Induction Cooking Tops, January 2023 https://www.energystar.gov/about/2021_residential_induction_cooking_tops

[27] Frontier Energy, Residential Cooktop Performance and Energy Comparison Study, Frontier Energy Report # 501318071-R0, Table 9, July 2019. https://cao-94612.s3.amazonaws.com/documents/Induction-Range-Final-Report-July-2019.pdf

[28] SWAP013-01, Residential Cooking Appliances – Fuel Substitution, pg 10; based on relative efficiency of induction to gas cooktops,0.84/0.399 = 2.1, May 2020

[29] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (TRM), Version 10, January 2023.https://dps.ny.gov/system/files/documents/2023/03/c1e1783c-c3d3-48a4-8647-a5923c39553c.pdf.

[30] Residential Energy Consumption Survey 2015, table HC3.1

Field Code Changed

Field Code Changed

2.1.5 REFRIGERATORS

Market	Residential/Multifamily
Baseline Condition	NC/TOS/EREP/DI
Baseline	Code/Existing/Dual
End Use Subcategory	Kitchen
Measure Last Reviewed	September 2024
Changes Since Last Version	• ~~Clarified language in parameter look ups~~ • ~~Added baseline values per JCPL PY2 evaluation~~

Description

This measure relates to the purchase and installation of a new refrigerator or refrigerator/freezer meeting either ENERGY STAR® 5.1 or Consortium for Energy Efficiency (CEE) TIER 2 or TIER 3 specifications (defined as requiring ≥10%, ≥15% or ≥ 20% less energy consumption than an equivalent unit meeting federal standard requirements respectively).

Baseline Case

Early Replacement (EREP): Early replacement uses a dual baseline. The baseline is the existing unit for the remaining life of the existing unit and the baseline is a code-compliant/standard efficiency unit for the remaining life of the installed equipment. Savings are calculated between the existing unit and the new efficient unit consumption during the assumed remaining life of the existing unit, and between a hypothetical new baseline unit and the efficient unit consumption for the remainder of the measure life.

Time of Sale (TOS) and new construction (NC): The baseline condition is a new refrigerator meeting the minimum federal efficiency standard for refrigerator efficiency as presented below.

Efficient Case

The efficient condition is a high-efficiency refrigerator meeting ENERGY STAR® 5.1 or Consortium for Energy Efficiency (CEE) TIER 2 or TIER 3 specifications requirements.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = \left(kWh_b - kWh_q\right) \times (1 + HVAC_c) \times F_{occ}$$

Annual Fuel Savings

$$\Delta Therms = \left(kWh_b - kWh_q\right) \times HVAC_{ff} \times F_{occ} \times 10$$

Peak Demand Savings

$$\Delta kW_{Peak} = \left(\frac{kWh_b - kWh_q}{8{,}760}\right) \times (1 + HVAC_d) \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 2-19 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings for	Calculated	kWh/yr	
ΔTherms	Annual fuel savings for Time of Sale	Calculated	Therms/yr	
$\Delta kW_{Peak,}$	Peak Demand Savings for Time of Sale	Calculated	kWr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
AV	Adjusted volume of refrigerator	Site-specific	ft^3	

Variable	Description	Value	Units	Ref
kWh_q	Annual energy consumption of qualifying efficiency unit	Site-specific, if unknown look up in Table 2-20 for ENERGY STAR specifications and Table 2-22 for CEE specifcationsTable 2-20	kWh/yr	[32][35]
kWh_b	Annual energy consumption of code-compliant baseline unit	NC/TOS: look up code efficiency in Table 2-20. EREP/DI: use existing unit, if unknown, look up in Table 2-21.	kWh/yr	[31]
F_{occ}	Adjustment factor to account for number of occupants	Look up in Table 2-29 ~~Table 2-29~~, if unknown use 1.0	N/A	[33]
CF	Electric coincidence factor	Look up in Table 2-24	N/A	
PDF	Gas peak day factor	Look up in Table 2-24	N/A	
$HVAC_c$	HVAC interaction factor for annual electric energy consumption	If unconditioned space, use 0, otherwise look up in **Error! Reference source not found.**~~Appendix F: HVAC Interactivity Factors~~	N/A	
$HVAC_d$	HVAC interaction factor for peak demand at utility summer peak hour	If unconditioned space, use 0, otherwise look up in **Error! Reference source not found.**~~Appendix F: HVAC Interactivity Factors~~	N/A	
$HVAC_{ff}$	HVAC interaction factor for annual fossil fuel energy consumption	If unconditioned space, use 0, otherwise look up in **Error! Reference source not found.**~~Appendix F: HVAC Interactivity Factors~~	MMBtu/kWh	
8,760	Hours per year	8,760	Hrs/yr	
10	Unit conversion, Therm/MMBtu	10	Therms/MMBtu	
EUL	Effective useful life of new unit	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 2-20 Federal Standard and ENERGY STAR Refrigerator Maximum Annual Energy Consumption

Product Category	Federal Baseline Maximum Energy Usage, kWh_b[7]	ENERGY STAR Maximum Energy Usage, kWh_q[8]
Standard Size Models: 7.75 cubic feet or greater		
1. Refrigerator-freezers and refrigerators other than all-refrigerators with manual defrost.	$7.99 \times AV + 225.0$	$7.19 \times AV + 202.5$
1A. All-refrigerators—manual defrost.	$6.79 \times AV + 193.6$	$6.11 \times AV + 174.2$
2. Refrigerator-freezers—partial automatic defrost	$7.99 \times AV + 225.0$	$7.19 \times AV + 202.5$
3. Refrigerator-freezers—automatic defrost with top-mounted freezer without an automatic icemaker.	$8.07 \times AV + 233.7$	$7.26 \times AV + 210.3$
3-BI. Built-in refrigerator-freezer—automatic defrost with top-mounted freezer without an automatic icemaker.	$9.15 \times AV + 264.9$	$8.24 \times AV + 238.4$
3I. Refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker without through-the-door ice service.	$8.07 \times AV + 317.7$	$7.26 \times AV + 294.3$
3I-BI. Built-in refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker without through-the-door ice service.	$9.15 \times AV + 348.9$	$8.24 \times AV + 322.4$
3A. All-refrigerators—automatic defrost.	$7.07 \times AV + 201.6$	$6.36 \times AV + 181.4$
3A-BI. Built-in All-refrigerators—automatic defrost.	$8.02 \times AV + 228.5$	$7.22 \times AV + 205.7$
4. Refrigerator-freezers—automatic defrost with side-mounted freezer without an automatic icemaker.	$8.51 \times AV + 297.8$	$7.66 \times AV + 268.0$
4-BI. Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer without an automatic icemaker.	$10.22 \times AV + 357.4$	$9.20 \times AV + 321.7$
4I. Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without through-the-door ice service.	$8.51 \times AV + 381.8$	$7.66 \times AV + 352.0$
4I-BI. Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without through-the-door ice service.	$10.22 \times AV + 441.4$	$9.20 \times AV + 405.7$
5. Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker.	$8.85 \times AV + 317.0$	$7.97 \times AV + 285.3$
5-BI. Built-In Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker.	$9.40 \times AV + 336.9$	$8.46 \times AV + 303.2$
5I. Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker without through-the-door ice service.	$8.85 \times AV + 401.0$	$7.97 \times AV + 369.3$

[7] 10 CFR Subpart C of Part 430, https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32

[8] ENERGY STAR Program Requirements Product Specifications for Residential Refrigerators and Freezers Version 5.1. Effective 9/15/2014. https://www.energystar.gov/sites/default/files/asset/document/Refrigerators_and_Freezers_Program_Requirements_V5.1.pdf

Field Code Changed

Field Code Changed

Product Category	Federal Baseline Maximum Energy Usage, kWh_b[7]	ENERGY STAR Maximum Energy Usage, kWh_q[8]
5I-BI. Built-In Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker without through-the-door ice service.	$9.40 \times AV + 420.9$	$8.46 \times AV + 387.2$
5A. Refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service.	$9.25 \times AV + 475.4$	$8.33 \times AV + 436.3$
5A-BI. Built-in refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service.	$9.83 \times AV + 499.9$	$8.85 \times AV + 458.3$
6. Refrigerator-freezers—automatic defrost with top-mounted freezer with through-the-door ice service.	$8.40 \times AV + 385.4$	$7.56 \times AV + 355.3$
7. Refrigerator-freezers—automatic defrost with side-mounted freezer with through-the-door ice service.	$8.54 \times AV + 432.8$	$7.69 \times AV + 397.9$
7-BI. Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer with through-the-door ice service.	$10.25 \times AV + 502.6$	$9.23 \times AV + 460.7$
Compact Size Models: Less than 7.75 cubic feet		
11. Compact refrigerator-freezers and refrigerators other than all-refrigerators with manual defrost.	$9.03 \times AV + 252.3$	$8.13 \times AV + 227.1$
11A.Compact all-refrigerators—manual defrost.	$7.84 \times AV + 219.1$	$7.06 \times AV + 197.2$
12. Compact refrigerator-freezers—partial automatic defrost	$5.91 \times AV + 335.8$	$5.32 \times AV + 302.2$
13. Compact refrigerator-freezers—automatic defrost with top-mounted freezer.	$11.80 \times AV + 339.2$	$10.62 \times AV + 305.3$
13I. Compact refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker.	$11.80 \times AV + 423.2$	$10.62 \times AV + 389.3$
13A. Compact all-refrigerators—automatic defrost.	$9.17 \times AV + 259.3$	$8.25 \times AV + 233.4$
14. Compact refrigerator-freezers—automatic defrost with side-mounted freezer.	$6.82 \times AV + 456.9$	$6.14 \times AV + 411.2$
14I. Compact refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker.	$6.82 \times AV + 540.9$	$6.14 \times AV + 495.2$
15. Compact refrigerator-freezers—automatic defrost with bottom-mounted freezer.	$11.80 \times AV + 339.2$	$10.62 \times AV + 305.3$
15I. Compact refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker.	$11.80 \times AV + 423.2$	$10.62 \times AV + 389.3$

Where $AV = fresh\ volume + (1.63 \times freezer\ volume)$

Table 2-21 Existing Refrigerator Baseline Consumption

	Primary Refrigerator	Secondary Refrigerator	Freezer
kWh_b	1120 JCPL[9] 958 All others	581	770 JCPL 593 All others

Table 2-22 CEE Residential Refrigerator Efficiency Specification

Efficiency Level	Percent Improvement Over Measured[10] Federal Minimum Efficiency Standard
CEE Tier 1[11]	10
CEE Tier 2	15
CEE Tier 3	30

Table 2-23 Occupant Adjustment Factor

Number of Occupants	F_{occ}
0	1.00
1	1.05
2	1.10
3	1.13
4	1.15
5 or more	1.16
Unknown	1.00

Peak Factors

Table 2-24 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1.0	
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

[9] Values from the JCPL PY2 Evaluation of the Refrigeator and Freezer Recycling Program applied to the UMP refrigerator and freezer UEC regression models.
[10] Measure Minimum Efficiency Standard is defined as the measured energy consumption of the refrigerator according to the DOE test method, prior to the application of any adder (84 kWh/yr) for automatic icemakers. For refrigerators with automatic icemakers, the percentage improvement is calculated by dividing the difference in annual energy use by the minimum efficiency standard, less the 84 kWh/yr adder.
[11] CEE Tier 1 is aligned with the ENERGY STAR Version 5.1 specifcation for resendential refrigerators.

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 2-25 Measure Life

Equipment	EUL	RUL	Ref
Refrigerator	12	4	[34]

References

[31] 10 CFR Subpart C of Part 430, https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32

[32] ENERGY STAR Program Requirements Product Specifications for Residential Refrigerators and Freezers Version 5.1. Effective 9/15/2014. https://www.energystar.gov/sites/default/files/asset/document/Refrigerators_and_Freezers_Program_Requirements_V5.1.pdf

[33] The Occupant Adjustment Factor is developed from simulating audits within the Oak Ridge National Laboratory, National Energy Audit Tool (NEAT), 2012. https://weatherization.ornl.gov/obtain/

[34] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx. Accessed December 2022.

[35] CEE, 2022 CEE Home Appliances Initiative and Residential Refrigerator Specification, May 2022 https://library.cee1.org/content/cee-residential-refrigerator-specification

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

2.1.6 FREEZER

Market	Residential/Multifamily
Baseline Condition	NC/TOS/RF/EREP
Baseline	Code/Existing/Dual
End Use Subcategory	Kitchen
Measure Last Reviewed	December 2022
Changes Since Last Version	• ~~Clarified language in parameter look ups~~ • ~~Added baseline values per JCPL PY2 evaluation~~

Description

This measure relates to the promotion of residential freezers meeting the ENERGY STAR 5.1 criteria through retail channels and through upstream efforts such as the ENERGY STAR Retail Products Program. In the measure, a freezer meeting the efficiency specifications of ENERGY STAR is installed in place of a model meeting the federal standard (NAECA). Energy usage specifications are defined in the tables below. Freezer adjusted volume used in the specifications is calculated as follows:

$$AV = 1.76 \times (total\ freezer\ volume)$$

Baseline Case

Early Replacement (EREP): Early replacement uses a dual baseline. The baseline is the existing unit for the remaining life of the existing unit and the baseline is a code-compliant/standard efficiency unit for the remaining life of the installed equipment. Savings are calculated between the existing unit and the new efficient unit consumption during the assumed remaining life of the existing unit, and between a hypothetical new baseline unit and the efficient unit consumption for the remainder of the measure life.

Time of Sale (TOS) and new construction (NC): The baseline condition is a new freezer meeting the minimum federal efficiency standard for refrigerator efficiency as presented below.

Efficient Case

The efficient equipment is defined as a freezer meeting the freezer efficiency specifications of ENERGY STAR v 5.1, as calculated below.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \left(kWh_b - kWh_q\right) \times (1 + HVAC_c) \times F_{occ}$$

Annual Fuel Savings

$$\Delta Therms = \left(kWh_b - kWh_q\right) \times HVAC_{ff} \times F_{occ} \times 10$$

Peak Demand Savings

$$\Delta kW_{Peak} = \left(\frac{kWh_b - kWh_q}{8{,}760}\right) \times (1 + HVAC_d) \times TAF \times LSAF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 2-26 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
kWh_b	kWh consumption for basline case	TOS/NC: Look up code efficiency in Table 2-27, if volume unknown use Table 2-28 EREP/DI: Use existing unit, if unknown use Table 2-28	kWh/yr	[36][44]
kWh_q	kWh consumption for energy efficient case	Site-specific, if unknown look up in Table 2-27. If volume unknown use Table 2-28.	kWh/yr	[37]
F_{occ}	Adjustment factor to account for number of occupants	Look up in **Table 2-29** ~~Table 2-29~~. If unknown use 1.0	N/A	[42]
$HVAC_c$	HVAC interaction factor for annual electric energy consumption	0.080. If unconditioned space use 0	N/A	[43]
$HVAC_d$	HVAC interaction factor for peak demand at utility summer peak hour	0.175. If unconditioned space use 0	N/A	[43]
$HVAC_{ff}$	HVAC interaction factor for annual fossil fuel energy consumption	-0.002. If unconditioned space use 0	MMBtu/kWh	
TAF	Temperature Adjustment Factor	1.23	N/A	[39]
LSAF	Load Shape Adjustment Factor	1.15	N/A	[40]
CF	Electric coincidence factor	Look up in Table 2-30	N/A	
PDF	Gas peak day factor	Look up in Table 2-30	N/A	
EUL	Effective useful life	See Measure Life Section	Years	
RUL	Remaining useful life	See Measure Life Section	Years	

Table 2-27 Freezer Baseline and Efficient Annual kWh Consumption

Product Class	Baseline Annual kWh Consumption (kWh_b) [36]	Energy Efficient Annual kWh Consumption (kWh_q) [37]
Full-Size Freezers, where AV is adjusted volume		
8. Upright freezers with manual defrost	$5.57 \times AV + 193.7$	$5.01 \times AV + 174.3$
9. Upright freezers with automatic defrost without an automatic icemaker	$8.62 \times AV + 228.3$	$7.76 \times AV + 205.5$
9I. Upright freezers with automatic defrost with an automatic icemaker	$8.62 \times AV + 312.3$	$7.76 \times AV + 289.5$
9-BI. Built-In upright freezers with automatic defrost without an automatic icemaker	$9.86 \times AV + 260.9$	$8.87 \times AV + 234.8$
9I-BI. Built-in upright freezers with automatic defrost with an automatic icemaker	$9.86 \times AV + 344.9$	$8.87 \times AV + 318.8$
10. Chest freezers and all other freezers except compact freezers	$7.29 \times AV + 107.8$	$6.56 \times AV + 97.0$
10A. Chest freezers with automatic defrost	$10.24 \times AV + 148.1$	$9.22 \times AV + 133.3$
Compact Freezers, where AV is adjusted volume		
16. Compact upright freezers with manual defrost	$8.65 \times AV + 225.7$	$7.79 \times AV + 203.1$
17. Compact upright freezers with automatic defrost	$10.17 \times AV + 351.9$	$9.15 \times AV + 316.7$
18. Compact chest freezers	$9.25 \times AV + 136.8$	$8.33 \times AV + 123.1$

If freezer volume is unknown, use the default consumption values in Table 2-28.

Table 2-28 Default Values

Product Category	AV (assumed)	kWh_b	kWh_q	Market Share Weighting [38]
Upright Freezer	24.4	770 JCPL 593 All others	395	36.74%
Chest Freezer	18.0	770 JCPL 593 All others	215	63.26%
Weighted Average		770 JCPL 593 All others	281	100%

Table 2-29 Occupant Adjustment Factor

Number of Occupants	F_{occ}
Unknown	1.00
1	1.05

Number of Occupants	F_{occ}
2	1.10
3	1.13
4	1.15
5 or more	1.16

Peak Factors

Table 2-30 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1.0	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 2-31 Measure Life

Equipment	EUL	RUL	Ref
Freezer	11	3.66	[41]

References

[36] "Electronic Code of Federal Regulations (ECFR)." 2020. https://www.ecfr.gov/cgi-bin/

[37] "ENERGY STAR Program Requirements for Residential Refrigerators and Freezers Partner Commitments." https://www.energystar.gov/ia/partners/product_specs/program_reqs/Refrigerators_and_Freezers_Program_Requirements_V5.0.pdf.

[38] The weighted average unit energy savings is calculated using the market share of upright and chest freezers. The assumed market share, as presented in the table above, comes from 2011 NIA-Frz-2008 Shipments data.

[39] Temperature adjustment factor based on Blasnik, Michael, "Measurement and Verification of Residential Refrigerator Energy Use, Final Report 2003-2004 Metering Study", July 29, 2004 (p.47) and assuming 78% of refrigerators are in cooled space (based on BGE Energy Use Survey, Report of Findings, December 2005; Mathew Greenwalk & Associates) and 22% in un-cooled space. Although this evaluation is based upon refrigerators only it is considered a reasonable estimate of the impact of cycling on freezers and gave exactly the same result as an alternative methodology based on Freezer eShape data.

[40] Daily load shape adjustment factor also based on Blasnik, Michael, "Measurement and Verification of Residential Refrigerator Energy Use, Final Report, 2003-2004 Metering Study", July 29, 2004 (p. 48), (extrapolated by taking the ratio of existing summer to existing annual profile for hours ending 15 through 18, and multiplying by new annual profile).

[41] ENERGY STAR assumes 11 years based on Appliance Magazine U.S. Appliance Industry: Market Value, Life Expectancy & Replacement Picture for 2005-2012, 2011.

[42] The Occupant Adjustment Factor is developed from simulating audits within the ORNL weatherization tool, National Energy Audit Tool (NEAT), Oak Ridge National Laboratory, 2012.
[43] From NY TRM V10, Pg 1162
[44] JCPL PY2 Evaluation

2.1.7 WATER COOLER

Market	Residential/Multifamily
Baseline Condition	NC/TOS
Baseline	Code
End Use Subcategory	Kitchen
Measure Last Reviewed	December 2022

Description

This measure estimates savings for installing ENERGY STAR Water Coolers compared to standard efficiency equipment in residential applications. The measurement of energy and demand savings is based on a deemed savings value multiplied by the quantity of the measure.

Baseline Case

Residential water cooler meeting Energy Star v. 2.0 Water Cooler requirements as directed by N.J. PL 2021, c. 464.

Efficient Case

ENERGY STAR v. 3.0 compliant residential water cooler.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \left(kWh_b - kWh_q\right) \times 365$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hr} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 2-32 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Hr	Annual hours of operation	Site-specific. If unknown, assume 8,760	Hrs	
kWh_b	Energy use of baseline water cooler	Look up in Table 2-33	kWh/day	[45]
kWh_q	Energy use of energy efficient water cooler	Site-specific. If unknown, look up in Table 2-33	kWh/day	[46]
CF	Electric coincidence factor	Look up in Table 2-34	N/A	
PDF	Gas peak day factor	Look up in Table 2-34	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 2-33 Water Cooler Energy Use

Energy Star Water Cooler Type Product Capacity Class, and Conditioning Method	Baseline kWh_b (kWh/day)	Default Efficient kWh_q (kWh/day)
Cold Only	0.16	0.16
Hot & Cold – Low Capacity[12]	0.87	0.68
Hot & Cold – High Capacity[13]	0.87	0.80
Hot & Cold On-Demand	0.18	0.18

[12] A water cooler with a cold-water dispenser capacity of 0.50 gallons per hour or less, as measured per ANSI/ASHRAE Standard 18. For units that also provide hot water, the unit must have a hot-water dispenser capacity that is equal to or less than 41 exact 6 oz. cups per hour, as rated per ANSI/ASHRAE Standard 18.

[13] A water cooler with a cold-water dispenser capacity that is greater than 0.50 gallons per hour, as measured per ANSI/ASHRAE Standard 18. For units that also provide hot water, the unit must have a hot-water dispenser capacity greater than 41 exact 6 oz. cups per hour, as rated per ANSI/ASHRAE Standard 18.

Peak Factors

Table 2-34 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1.0	[47]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 10 years. [45]

References

[45] ENERGY STAR Product Specification for Water Coolers Version 2.0. https://www.energystar.gov/sites/default/files/specs//ES%20WC%20V2%200%20Spec.pdf

[46] ENERGY STAR Product Specifications for Water Coolers Version 3.0. https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Verison%203.0%20Water%20Coolers%20Final%20Specification_0.pdf

[47] Assumes 24/7 operation. Site-specific load shape information should be used if known.

Field Code Changed

Field Code Changed

2.1.8 AIR PURIFIER

Market	Residential/Multifamily
Baseline Condition	TOS
Baseline	ISP
End Use Subcategory	Indoor Environment
Measure Last Reviewed	September 2024
Changes Since Last Version	~~Clarified baseline CADR definition, use same cfm in baseline and efficient cases~~

Description

An air purifier (cleaner) meeting the efficiency specifications of ENERGY STAR is purchased and installed in place of a model meeting the New Jersey P.L. 2021, c. 464 minimum standards. Compliance with this standard will start on January 1, 2023. The Coincidence factor (CF) assumes that the purifier usage is evenly spread throughout the year and the annual active operating hours assume that the air purifier operates 16 hours a day for 365 days[51].

Baseline Case

The baseline equipment is assumed to be a conventional non-ENERGY STAR unit, meeting the New Jersey P.L. 2021, c. 464 minimum standards.

Efficient Case

The efficient equipment is defined as an air purifier meeting the efficiency specifications of ENERGY STAR Version 2.0. Certified air cleaner models shall produce a minimum 30 CADR for Smoke to be considered under this specification.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = kWh_b - kWh_q$$

Where,

$$kWh_b = Hrs \times \left(\frac{CADR_b}{CADR\_per\_watt_b \times 1{,}000}\right) + (8{,}760 - Hrs) \times \frac{PartialPower_b}{1{,}000}$$

$$kWh_q = Hrs \times \left(\frac{CADR_q}{CADR\_per\_watt_q \times 1{,}000}\right) + (8{,}760 - Hrs) \times \frac{PartialPower_q}{1{,}000}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 2-35 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
kWh_b	Annual electric consumption of the baseline case	Calculated	kWh/yr	
kWh_q	Annual electric consumption of the efficient case	Calculated	kWh/yr	
$CADR_b$	Clean Air Delivery Rate (CADR) for baseline air purifier	Use same value as $CARD_q$	cfm	[48]
CADR_per_watt$_b$	Clean Air Delivery Rate (CADR) per watt for baseline air purifier	Look up in Table 2-36	cfm/Watt	[48]
$PartialPower_b$	Partial On Mode Power for baseline air purifier by category	Look up in Table 2-36	Watts	[48]
$CADR_q$	Clean Air Delivery Rate (CADR) for efficient air purifier	Site-specific. If unknown, look up in Table 2-37	cfm	[49]
CADR_per_watt$_q$	Clean Air Delivery Rate (CADR) per watt for efficient air purifier	Site-specific. If unknown, look up in Table 2-37	cfm/watt	[49]
$PartialPower_q$	Partial On Mode Power for efficient air purifier by category	Site-specific. If unknown, look up in Table 2-37	Watts	[49]

Variable	Description	Value	Units	Ref
Hrs	Annual active operating hours	5,840	Hrs	[51]
CF	Electric coincidence factor	Look up in Table 2-40	N/A	
EUL	Effective useful life	See Measure Life Section	Years	
1,000	Conversion from Watts to kW	1,000	Watts/kW	
8,760	Hours per year	8,760	Hours	

Table 2-36 Baseline Air Purifier Specifications

Clean Air Delivery Rate (CADR) Range	CADR used indeemed savings calculation	CADR per Watt	Partial On Mode Power with WiFi connection (Watts)	Partial On Mode Power without WiFi connection (Watts)
30 ≤ CADR < 100	75	1.7	2	1
100 ≤ CADR < 150	125	1.9	2	1
150 ≤ CADR < 200	175	2.0	2	1
200 ≤ CADR < 250	225	2.0	2	1
CADR ≥ 250	275	2.0	2	1

Table 2-37 Efficient Air Purifier Specifications

Clean Air Delivery Rate (CADR) Range	CADR used in deemed savings calculation	Minimum Smoke CADR per Watt	Maximum Partial On Mode Power with WiFi connection (watts)	Maximum Partial On Mode Power without WiFi connection (watts)
51 ≤ CADR < 100	75	1.9	2	1
101 ≤ CADR < 150	125	2.4	2	1
151 ≤ CADR < 200	175	2.9	2	1
201 ≤ CADR < 250	225	2.9	2	1
CADR ≥ 250	275	2.9	2	1

Table 2-38 Deemed kWh Savings

Clean Air Delivery Rate (CADR) Range	CADR used in deemed savings calculation	kWh Savings	
		Maximum Partial On Mode Power with WiFi connection	Maximum Partial On Mode Power without WiFi connection
51 ≤ CADR < 100	75	27	27
101 ≤ CADR < 150	125	80	80
151 ≤ CADR < 200	175	159	159
201 ≤ CADR < 250	225	204	204
CADR ≥ 250	275	249	249

Table 2-39 Deemed kW Savings

Clean Air Delivery Rate (CADR) Range	CADR used in deemed savings calculation	kW Savings	
		Maximum Partial On Mode Power with WiFi connection	Maximum Partial On Mode Power without WiFi connection
51 ≤ CADR < 100	75	0.0031	0.0031
101 ≤ CADR < 150	125	0.0091	0.0091
151 ≤ CADR < 200	175	0.0181	0.0181
201 ≤ CADR < 250	225	0.0233	0.0233
CADR ≥ 250	275	0.0285	0.0285

Peak Factors

Table 2-40 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.667[14]	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 9 years [50].

[14] Assumes equal likelihood of usage at any time of day (16/24 hours)

References

[48] "New Jersey A5160 | 2020-2021 | Regular Session." n.d. LegiScan. Accessed December 21, 2022. https://legiscan.com/NJ/text/A5160/2020

[49] "ENERGY STAR Program Requirements for Room Air Cleaners -Partner Commitments ENERGY STAR ® Program Requirements for Room Air Cleaners Partner Commitments, Version 2.0 Rev. May 2002." n.d. Accessed December 21, 2022. https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Version%202.0%20Room%20Air%20Cleaners%20Specification%20%28Rev.%20May%202022%29.pdf

[50] EPA, Consumer Messaging Guide for Energy Star Certified Appliances. August 2018. https://www.energystar.gov/sites/default/files/asset/document/ES_Consumer_Messaging_Guide_2018_508-c.pdf

[51] "ENERGY STAR Appliance Calculator". https://www.energy.gov/energysaver/maps/appliance-energy-calculator. n.d. Accessed December 21, 2022.

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

2.1.9 DEHUMIDIFIER

Market	Residential/Multifamily
Baseline Condition	TOS/NC
Baseline	Code /ISP
End Use Subcategory	Indoor Environment
Measure Last Reviewed	January 2023

Description

This measure covers the installation of residential stand-alone or whole-house dehumidifiers meeting the minimum qualifying efficiency standards established under the ENERGY STAR® Program, Version 5.0, effective October 31, 2019. This measure is restricted to dehumidifiers with a product moisture removal capacity of less than or equal to 185 pints/day.

Baseline Case

The baseline condition is a stand-alone or whole-house dehumidifier meeting the minimum effective federal standard for performance.

Dehumidifiers manufactured and distributed in commerce on or after June 13, 2019, must meet the energy conservation standards, rated in Integrated Energy Factor as specified in the Code of Federal Regulations.

Efficient Case

The compliance condition is an ENERGY STAR® v. 5 qualified stand-alone or whole-house dehumidifier.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{pints/day \times 0.473 \times hrs}{24} \times \left(\frac{1}{IEF_b} - \frac{1}{IEF_q}\right)$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 2-41 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Pints/day	Product capacity to remove moisture	Site-specific	(pints/day)	
hrs	Annual run hours of dehumidifier	2,160	Hrs	[52]
IEF_b	Baseline Integrated Energy Factor	Look up in Table 2-42, Table 2-43	liters/kWh	[53]
IEF_q	Energy Efficient Integrated Energy Factor	Site-specific. If unknown, look up in Table 2-44, Table 2-45	liters/kWh	[54]
0.473	Conversion factor from liters to pint	0.473	liters/pint	
24	Hours in one day	24	N/A	
CF	Electric coincidence factor	Look up in Table 2-46	N/A	[55]
EUL	Effective useful life	See Measure Life Section	Years	

Table 2-42 Stand-Alone Dehumidifiers Baseline Integrated Energy Factor

Product Capacity (pints/day)	Integrated Energy Factor (liters/kWh)
≤ 25.00	1.30
25.01 to 50.00	1.60
≥50.01	2.80

Table 2-43 Whole-House Dehumidifiers Baseline Integrated Energy Factor

Product Case Volume (ft^3)	Integrated Energy Factor (liters/kWh)
≤ 8.0	≥1.77
> 8.0	≥2.41

Table 2-44 Stand-Alone Dehumidifiers Energy Efficient Integrated Energy Factor

Product Capacity (pints/day)	Integrated Energy Factor (liters/kWh)
≤ 25.00	≥1.57
25.01 to 50.00	≥1.80
≥50.01	≥3.30

Table 2-45 Whole-House Dehumidifiers Energy Efficient Integrated Energy Factor

Product Case Volume (ft^3)	Integrated Energy Factor (liters/kWh)
≤ 8.0	≥2.09
> 8.0	≥3.30

Peak Factors

Table 2-46 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.405	[55]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 12 years[56].

References

[52] ACEEE, Lauren Mattison and Dave Korn, The Cadmus Group, Inc.,"Dehumidifiers: A Major Consumer of Residential Electricity", 2012, https://www.aceee.org/files/proceedings/2012/data/papers/0193-000291.pdf

[53] 10 CFR 430.32(v)(2), January 2023 https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32#p-430.32(v)(2)

[54] ENERGY STAR® Program Requirements Product Specification for Dehumidifiers, Eligibility Criteria Version 5.0, October 2019

Field Code Changed

[55] Dehumidifier Metering in PA and Ohio by ADM from 7/17/2013 to 9/22/2013. 31 Units metered. Assumes all non-coincident peaks occur within window and that the average load during this window is representative of the June PJM days as well.
[56] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (TRM), Version 10, January 2023.

2.1.10 ROOM AIR CONDITIONER

Market	Residential/Multifamily
Baseline Condition	TOS
Baseline	Code
End Use Subcategory	Indoor Environment
Measure Last Reviewed	December 2022

Description

This measure relates to the purchase and installation of a room air conditioner that meets or exceeds the current ENERGY STAR 4.2 efficiency standards. A room air conditioner is powered by a single phase electric current and is an encased assembly designed as a unit for mounting in a window or through the wall. Qualifying units may be cooling only (non-reverse cycle) or provide cooling, heating, and ventilation. Only cooling energy savings are calculated in this measure.

Note that if the AC unit is connected to a network in a way so as to enable it to respond to energy related commands, there is a 5% extra CEER allowance. In these instances, the default baseline CEER would be 0.95 multiplied by the appropriate CEER from Table 2-48.

Baseline Case

The baseline condition is a room AC unit that meets the minimum federal efficiency standards [57] of the combined energy efficiency ratio based on the installed unit size and type.

Efficient Case

The efficient condition is a room air conditioner that meets or exceeds current ENERGY STAR specifications (version 4.2) [58]. The CEER for the efficient case should use site-specific information. If site-specific information is unknown, then default values may be used.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{Cap}{1{,}000} \times \left(\frac{1}{CEER_b} - \frac{1}{CEER_q}\right) \times EFLH_c$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{Cap}{1{,}000} \times \left(\frac{1}{CEER_b} - \frac{1}{CEER_q}\right) \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 2-47 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Cap	Capacity of energy efficient equipment	Site-specific	Btu/hr	
$CEER_q$	Combined Energy Efficiency Ratio of ENERGY STAR unit in Btus per Watt-hour	Site-specific. If unknown, look up in Table 2-48	Btu/Wh	[61]
$CEER_b$	Combined Energy Efficiency Ratio of baseline unit in Btus per Watt-hour	Look up in Table 2-48, if unknown use 11.0[15]	Btu/Wh	[57]
$EFLH_c$	Cooling equivalent full-load hours	600	Hours	[63]
1,000	Conversion from W to kW	1,000	W/kW	
CF	Electric coincidence factor	Look up in Table 2-49	N/A	[62]
EUL	Effective useful life	See Measure Life Section	Years	

[15] Default value (11.0) is the CEER value from minimum Federal Standard for the most common room AC type – <8000 capacity range with louvered sides [60]

Table 2-48 Standard and ENERGY STAR CEER Values for Room Air Conditioner

Product Type and Class (Btu/hour)		Federal standard with louvered sides ($CEER_b$)	Federal standard without louvered sides ($CEER_b$)	ENERGY STAR with louvered sides ($CEER_q$)	ENERGY STAR without louvered sides ($CEER_q$)
Without reverse cycle	<6,000	11.0	10.0	12.1	11.0
	6,000 to 7,999	11.0	10.0	12.1	11.0
	8,000 to 10,999	10.9	9.6	12.0	10.6
	11,000 to 13,999	10.9	9.5	12.0	10.5
	14,000 to 19,999	10.7	9.3	11.8	10.2
	20,000 to 27,999	9.4	9.4	10.3	10.3
	≥28,000	9.0	9.4	9.9	10.3
With reverse cycle	<14,000		9.3		10.2
	≥14,000		8.7		9.6
	<20,000	9.8		10.8	
	≥20,000	9.3		10.2	
Casement-only		9.5		10.5	
Casement slider		10.4		11.4	

Peak Factors

Table 2-49 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.31	[62]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 12 years. [59]

References

[57] Code of Federal Regulations. 2022. Review of Title 10, Chapter II, Subchapter D, Part 430, Subpart C, section 430.32 b) Room Air Conditioners. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32

Field Code Changed

[58] "ENERGY STAR Program Requirements for Room Air Conditioners -Eligibility Criteria ENERGY STAR ® Program Requirements Product Specification for Room Air Conditioners Eligibility Criteria Draft Version 4.2." n.d. Accessed January 9, 2023. https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Draft%20Version%204.2%20Room%20Air%20Conditioners%20Specification_0_0.pdf
[59] GDS Associates, Inc. 2007. *Review of Energy Efficiency Measures/Programs Reference Document for the ISO Forward Capacity Market (FCM)*. Https://Library.cee1.org. June 2007. https://library.cee1.org/system/files/library/8842/CEE_Eval_MeasureLifeStudyLights%2526HVACGDS_1Jun2007.pdf
[60] NEEP, Mid-Atlantic Technical Reference Manual, V10. pp 70-71., April 2020, https://neep.org/sites/default/files/media-files/trmv10.pdf
[61] "Room Air Conditioners Key Product Criteria." n.d. www.energystar.gov. Accessed January 10, 2023. https://www.energystar.gov/products/heating_cooling/air_conditioning_room/key_product_criteria.
[62] RLW Analytics. 2008. *Review of Coincidence Factor Study Residential Room Air Conditioners*. Puc.nh.gov. June 2008. https://www.puc.nh.gov/electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/124_SPWG%20Room%20%20AC%20Evaluation%20FINALReport%20June%2023%20ver7.pdf.
[63] VEIC Estimate. Consistent with analysis of PEPCo and LIPA, and conservative relative to ARI.

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

2.2 APPLIANCE RECYCLING

2.2.1 REFRIGERATOR & FREEZER RECYCLING

Market	Residential
Baseline Condition	ERET
Baseline	Existing
End Use Subcategory	N/A
Measure Last Reviewed	September 2024
Changes Since Last Version	• • Added ~~JCPL default values from PY2 evaluation~~compact refrigerators

Description

In many cases, when a refrigerator or freezer is replaced by a homeowner, the existing unit is retained, sold, or donated for use elsewhere, representing additional load on the grid. This measure covers recycling of the existing, functional equipment, thereby eliminating the consumption associated with that equipment. Refrigerator and freezer recycling programs (also called "bounty" programs) receive energy savings credit for permanently removing inefficient, functional refrigerators and freezers from the electric grid.

This measure covers the recycling of primary (i.e., installed in a kitchen) and secondary[16] (i.e., installed elsewhere) refrigerators, refrigerator-freezers and freezers. To account for the fact that secondary equipment is occasionally installed and operating for only part of the year, a part-time use adjustment factor has been developed and embedded within the gross savings estimate for secondary units to establish average annual per unit deemed electric savings.

This measure ~~does not cover~~also includes the recycling of equipment classified by the Code of Federal Regulations as "Compact refrigerator/refrigerator-freezer/freezer". This refers to any refrigerator, refrigerator-freezer or freezer with a total refrigerated volume of less than 7.75 ft3 (220 liters), where the total refrigerated volume has been determined in accordance with the procedure prescribed in Appendix A (refrigerators and refrigerator-freezers) or B (freezers) of 10 CFR 430 Subpart B.112.

[16] Secondary refrigerators are spare or backup refrigerators not installed in the kitchen.

Baseline Case

The savings calculations below apply to recycling of a functioning primary or secondary refrigerator, refrigerator-freezer, or freezer with total refrigerated volume of 7.75 ft3 (220 liters) or more.

Efficient Case

The compliance condition is the recycling of an existing room refrigerator or freezer as defined in the Measure Description section above.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \left(\frac{\Delta kWh}{unit}\right)$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \left(\frac{\Delta kW}{unit}\right)$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \mathrm{N/A}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 2-50 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	

Variable	Description	Value	Units	Ref
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
ΔkWh/unit	Energy Savings per unit	Look up in Table 2-51	kWh	[65]
ΔkW/unit	Demand Savings per unit	Look up in Table 2-51	kWh	[65]
CF	Electric coincidence factor	Look up in Table 2-52	N/A	
PDF	Gas peak demand factor	Look up in Table 2-52	N/A	
EUL	Effective useful life	See Measure Life Section	Years	[64]

Table 2-51 Default Values for Annual Energy and Peak Demand Savings

	Primary Refrigerator	Secondary Refrigerator	Freezer	Compact Refrigerator[17]
ΔkWh/unit	~~1120~~1,120 JCPL[18] 958 All others	581	770 JCPL 593 All others	295
ΔkW/unit	0.15	0.10	0.10	0.03

Inserted Cells

Peak Factors

Table 2-52 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 5 years for a refrigerator and 4 years for a freezer [64].

References

[64] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

[65] DNV, Appliance Recycling Program Impact Evaluation Study, June 2021 https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7BE846898E-5EAE-4F42-9F97-385982740AC6%7D

Field Code Changed

[17] Annual savings for compact refrigerators based on average annual consumption of compact refrigerators compliant with US Federal Standards. Data available here: https://www.energystar.gov/productfinder/download/certified-residential-refrigerators/

[18] Values from the JCPL PY2 Evaluation of the Refrigeator and Freezer Recyling Program applied to the UMP refrigerator and freezer UEC regression models.

[66] JCPL PY2 Evaluation

Keeling, J.; Bruchs, D. (2017). Chapter 7: Refrigerator Recycling Evaluation Protocol. The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68563. http://www.nrel.gov/docs/fy17osti/68563.pdf

2.2.2 ROOM AC UNIT RECYCLING

Market	Residential
Baseline Condition	ERET
Baseline	Existing
End Use Subcategory	Recycling
Measure Last Reviewed	January 2023

Description

This measure describes the savings resulting from implementing a drop off service taking existing working inefficient Room Air Conditioner units from service, prior to their natural end of life. Like the Refrigerator Early Retirement / Recycling measure, this measure quantifies savings associated with the removal of room air conditioner units from service (rather than transferred to another location in the home or another household) and thus does not decrement savings due to retired units that are replaced in participants' homes. A room air conditioner is an appliance, other than a "packaged terminal air conditioner," which is powered by a single-phase electric current and that is an encased assembly designed as a unit for mounting in a window or through the wall for the purpose of providing delivery of conditioned air to an enclosed space.

Baseline Case

The baseline condition is the existing inefficient room air conditioning unit.

Efficient Case

The existing room air conditioning unit is removed from service and dismantled/recycled.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{Hrs \times Btuh \times (1/EER_{exist})}{1{,}000} \times Part\ Use\ Factor$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \mathrm{N/A}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 2-53 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Hrs	Run hours of window AC unit	600	Hours	[63]
Btuh	Capacity of replaced unit	Site-specific, if unknown assume 7,829	Btu/hr	[69]
EER_{exist}	Efficiency of existing unit	Site-specific, if unknown assume 9.8	Btu/W/hr	[70]
Part Use Factor	Fraction of those units that are not in daily use throughout the entire cooling season as reported by the participant	Site-specific, if unknown use 0.34	N/A	[72]
CF	Electric coincidence factor	Look up in Table 2-54	N/A	
PDF	Gas peak day factor	Look up in Table 2-54	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Peak Factors

Table 2-54 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.3	[71]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 3 years. [67]

References

[67] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx .

[68] VEIC Estimate. Consistent with analysis of PEPCo and LIPA, and conservative relative to ARI.

[69] RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners (June 23, 2008 p. 22), based on population average. https://www.puc.nh.gov/electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/124_SPWG%20Room%20%20AC%20Evaluation%20FINALReport%20June%2023%20ver7.pdf

[70] Minimum Federal Standard for most common room AC type (8000-14,999 capacity range with louvered sides) per federal standards from 10/1/2000 to 5/31/2014.

[71] RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners (June 23, 2008 p. 32), CF value for Hartford, CT. https://www.puc.nh.gov/electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/124_SPWG%20Room%20%20AC%20Evaluation%20FINALReport%20June%2023%20ver7.pdf

[72] Source: Cadmus analysis, EmPOWER 2018 P1 & P2 ARP participant survey

Field Code Changed

Field Code Changed

2.2.3 DEHUMIDIFIER RECYCLING

Market	Residential
Baseline Condition	ERET
Baseline	Existing
End Use Subcategory	Dehumidifier
Measure Last Reviewed	January 2023
Changes Since Last Version	• ~~Updated coincidence factor and source~~

Description

In many cases, when homeowner replaces a dehumidifier, the existing unit is retained, sold, or donated for use elsewhere, representing additional load on the grid. This measure covers recycling of existing, functional, portable dehumidifiers, thereby eliminating the consumption associated with that equipment. This measure should target, but not be limited to, dehumidifiers put into service prior to June 2019. If provided data indicate the unit is replaced rather than retired, savings shall be based on the Residential Dehumidifier measure in this TRM.

Baseline Case

The baseline condition is the existing dehumidifier in working condition.

Efficient Case

The existing dehumidifier is removed from service and not replaced.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = capacity \times \frac{0.473}{24} \times hrs \times \frac{1}{L/kWh}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times RUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 2-55 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Capacity	Capacity of the unit	Site-specific. If unknown, use 56 pints/day	pints/day	
L/kWh	Dehumidifier Efficiency in liters (L) of water removed per kWh	Lookup in Table 2-56 based on manufacture date. If unknown, assume manufactuer date later than October 2012.[19]	L/kWh	[75][76][77]
0.473	Conversion factor	0.473	L/pint	
24	Conversion factor	24	Hr/day	
Hrs	Hours of use[20]	Site-specific. If unknown use 1,632	Hours/yr	[74]
CF	Electric coincidence factor	Lookup in Table 2-56	N/A	
PDF	Gas peak day factor	Lookup in Table 2-56	N/A	
RUL	Remaining useful life	See Measure Life Section	Years	[73]

Table 2-56 Dehumidifier Capacity and Efficiency

Capacity Range (pints/day)	ENERGY STAR Labeled (L/kWh)	Non-ENERGY STAR Labeled	
		Manufacture date before Oct. 2012 (≥L/kWh)	Manufacture date of Oct. 2012 or later (≥L/kWh)
≤ 25	1.57	1.00	1.35
>25 to ≤ 35	1.80	1.20	1.35

[19] Default manufacture date assumes that 2/3 of dehumidifier EUL (12 years) have elapsed [73]
(2/3) x (12 years) = 8 year vintage
2023 – (8 years) = 2015 manufacture date
[20] Default run hour assumption based on 68 days per year, 24 hours of use [74].

Capacity Range (pints/day)	ENERGY STAR Labeled (L/kWh)	Non-ENERGY STAR Labeled	
		Manufacture date before Oct. 2012 (≥L/kWh)	Manufacture date of Oct. 2012 or later (≥L/kWh)
>35 to ≤ 45	1.80	1.30	1.50
>45 to ≤ 50	1.80	1.30	1.60
>50 to ≤ 55	3.30	1.30	1.60
>54 to ≤ 75	3.30	1.50	1.70
>75 to ≤ 185	3.30	2.25	2.50

Peak Factors

Table 2-57 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.405	[78]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The remaining useful life (RUL) is 4 years [73].

References

[73] CA DEER gives the following rule-of-thumb for remaining useful life: RUL = (1/3) X EUL. As the Energy Star Dehumidifier [replacement] uses an EUL of 12 years, we have a suggested RUL of (1/3) X 12 years = 4 years.

[74] Savings Calculator for ENERGY STAR® Qualified Appliances Version 3.0 Last Updated October 1, 2012.

[75] ENERGY STAR® Program Requirements for Dehumidifiers, Version 5.0, February 2019.

[76] 42 U.S.C, Title 42 Chapter 77, Subchapter III, Part A, (cc)(1) and (cc)(2). https://uscode.house.gov/view.xhtml?path=/prelim@title42/chapter77/subchapter3&edition=prelim

[77] Code of Federal Regulations Title 10, Chapter 2, Subchapter D, Part 430, Subpart C (v)(1). https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C

[78] Dehumidifier Metering in PA and Ohio by ADM from 7/17/2013 to 9/22/2013. 31 Units metered. Assumes all non-coincident peaks occur within window and that the average load during this window is representative of the June PJM days as well.

Field Code Changed

Field Code Changed

2.3 HVAC

2.3.1 AIR SOURCE HEAT PUMPS AND MINI-SPLIT HEAT PUMPS

Market	Residential/Multifamily
Baseline Condition	TOS/NC/EREP/DI
Baseline	Code/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	March 2024
Changes Since Last Version	• ~~Moved cooling-only equipment (central A/C, PTAC)~~Clarified guidance on baselines assumptions for midstream applications: when to ~~separate measure~~ • ~~Added~~assume partial vs. whole displacement ~~algorithm, updated description,~~ and ~~parameters~~fuel-switching vs. non-fuel switching

Description

This measure targets the use of air source heat pumps (ASHP) and mini split heat pumps in residential and low-rise multifamily applications. This measure may apply to early replacement of an existing system, replacement on failure, or installation of a new unit in a new or existing residential or multifamily low-rise building for HVAC applications.

In certain instances, air source heat pumps and mini-split heat pumps may only partially meet the heating load, requiring a supplementary heating system to satisfy the full heating load of the dwelling. As such, this measure addresses two displacement scenarios: partial and whole.

- **Partial displacement:** the heat pump fulfils a portion of the dwelling's heating load. Partial displacements occur in either of two scenarios: 1) the installation of a heat pump that shares the dwelling's heating load with a separate supplemental heating system or 2) the installation of a "dual fuel" heat pump that incorporates a backup fossil fuel furnace to supplement the heat pump output. Partial displacements are addressed in the equations below by a load factor parameter (F_{load}), which represents the actual heating output of the heat pump as compared to the total theoretical heating output.[21] The partial displacement scenario only applies to heating displacement; this measure assumes that the installed heat pump will serve the entire cooling load of the zone(s) affected by the installation. If

[21] For ductless heat pumps, F_{load} is calculated as the actual heating output of the heat pump divided by the total theoretical heating output. Total theoretical heating output is represented by the heat pump rated heating capacity multiplied by annual full load heating hours. See Table 2-64~~Table 2-642-64~~ for more information.
For ducted heat pumps, where the system is more likely to function with a temperature-based switchover from one central system to another, F_{load} is represented by the fraction of annual heating degree hours that are above the switchover temperature. See Table 2-65~~Table 2-652-65~~ for more information.

the installed heat pump is not a cold-climate heat pump, assume a partial displacement scenario unless there is evidence for a whole displacement installation (such as proof that any pre-existing heating systems were removed).

- **Whole displacement:** the heat pump and any integrated supplemental resistance heat meets the dwelling's entire heating load. May assume whole displacement scenario if the installed heat pump is a cold-climate heat pump.

This measure does not accommodate the interactive effects of concurrent weatherization upgrades.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow the residential protocol presented in this measure.

Baseline Case

For whole building new construction, the baseline equipment is an air source, dual fuel or mini-split heat pump meeting the compliance requirements of IECC 2021 for single family and multifamily low-rise residential buildings (see Appendix E). Per Table R405.4.2(1) of IECC 2021, the standard reference design for residential buildings with a proposed air-source heat pump is the same heating and cooling system as proposed. For multifamily high-rise buildings, refer to the commercial heat pump measure (Section 3.5.1).

For replacement of failed equipment, or equipment reaching end of useful life, the baseline is a minimally code compliant version of the replaced system type and fuel. If the baseline system fuel is unknown, such as in a midstream delivery method, calculate savings using a gas baseline (fuel switching project, assume 14% boilers and 86% furnaces as baseline equipment) and electric baseline (non fuel switching project, assume ASHP as baseline equipment) and calculate the weighted average using the weights in the table below.[22]

	Fuel switch	Non fuel switch
ACE	0.130	0.870
JCPL	0.216	0.784
RECO	0.013	0.987
PSEG	0.412	0.588
Average	**0.193**	**0.807**

For early replacement projects, use dual baselines:

- For the remaining useful life (RUL) of the existing equipment, the baseline efficiency is the efficiency of the existing equipment. If the site-specific efficiency of the existing equipment is unknown, use the equipment efficiency from the IECC version in force when the equipment was new (if equipment vintage is unknown, use IECC 2012 efficiency requirements in Appendix E).
- For the duration of the measure life after the end of the RUL, the baseline is a minimally code-compliant version of the replaced equipment type and fuel.

[22] Weights calculated by quantity of heat pump projects designated as fuel switching by measure name in the Tri 2 utility filings workbooks.

For spaces with no existing heating: For previously unheated spaces in an existing home that has an existing central heating system, the customer may have planned to install a heat pump regardless of program intervention, or the customer may have planned to extend the existing central HVAC system to heat the new space. The baseline can therefore vary between a new equipment scenario and a retrofit scenario. For such installations, the baseline energy consumption algorithm is designed to blend the baseline energy consumptions of the new equipment scenario and retrofit scenario using a baseline factor, $F_{baseline,h}$.[23]

$$\begin{pmatrix} Baseline\ heating \\ consumption \end{pmatrix} = F_{baseline,h} \times \begin{pmatrix} New\ equipment \\ scenario\ consumption \end{pmatrix} + (1 - F_{baseline,h}) \times \begin{pmatrix} Existing\ equipment \\ scneario\ consumption \end{pmatrix}$$

- New equipment scenario: absent the program, the customer would have purchased new heating equipment instead of extending the existing central heating system. The new equipment scenario baseline is a code-compliant air-source heat pump of the same size as the installed heat pump.
- Retrofit scenario: absent the program, the customer would have extended the existing central heating system instead of purchasing new heating equipment. The retrofit scenario baseline is the existing central heating equipment.

For spaces with no existing cooling: For homes without existing cooling, or spaces without cooling in an existing home that has an existing central cooling system, the customer may have planned to install a cooling regardless of program intervention, or the customer may have planned to leave the space without any cooling. The baseline can therefore vary between a new load scenario and a non-new load scenario. For such installations, the baseline energy consumption algorithm is designed to blend the baseline energy consumptions of the new equipment scenario and retrofit scenario using a baseline factor, $F_{baseline,c}$.[24]

$$\begin{pmatrix} Baseline\ cooling \\ consumption \end{pmatrix} = F_{baseline,c} \times \begin{pmatrix} New\ load \\ scenario\ consumption \end{pmatrix} + (1 - F_{baseline,c}) \times \begin{pmatrix} Non-new\ load \\ consumption \end{pmatrix}$$

- New load scenario: absent the program, the customer would not install any cooling. The new load scenario baseline is no existing cooling.
- Non-new load scenario: absent the program, the customer would have added cooling to the space. The non-new load scenario cooling baseline is the existing central cooling system if one exists, or a code-compliant air conditioner of the same cooling capacity as the installed heat pump.

Efficient Case

An air source heat pump or mini split heat pump that exceeds the program qualifying efficiency requirements.

[23] The baseline heating factors presented in Table 2-63~~Table 2-632-63~~ are based on reference [93]. $F_{baseline,h}$ is calculated as the total percent of respondents who would install new baseline equipment, averaged across heating fuel types in table 2-17 of the report.

[24] The baseline cooling factors presented in Table 2-63~~Table 2-632-63~~ are based on reference [93]. $F_{baseline,c}$ is calculated as the percent of respondents without existing cooling who would not have installed an alternative cooling system without the heat pump. The percent of respondents who installed a central heat pump with no existing cooling was assumed to be 46%, based on the known proportion of respondents who installed a minisplit with no existing cooling.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = kWh_b - kWh_q$$

Where,

$$kWh_b = kWh_{c,b} + kWh_{h,b}$$

For partial displacement applications,

$$kWh_q = kWh_{c,q} + F_{load} \times kWh_{h,q} + (1 - F_{load}) \times kWh_{supplement}$$

If supplemental heat is an existing electric resistance heating system:

$$kWh_{supplement} = \frac{Cap_h}{3.412 \times 1{,}000} \times EFLH_h$$

If supplemental heat is an existing fossil fuel system:

$$kWh_{supplement} = 0$$

For whole displacement applications,

$$kWh_q = kWh_{c,q} + kWh_{h,q}$$

Calculate $kWh_{c,b}$, $kWh_{h,b}$, and $kWh_{supplement}$ using the algorithms in Table 2-58 for the appropriate baseline and supplemental equipment type, if applicable.

Calculate $kWh_{c,q}$ and $kWh_{h,q}$ using the algorithms in Table 2-59 for the appropriate efficient equipment type.

Note:

- Conversions from SEER to SEER2, EER to EER2, and HSPF to HSPF2 can be found in Appendix E.
- The oversize derating factor (OSF) in the equations below is applicable for heat pump applications where the heat pump is sized based on heating capacity but is oversized for cooling. The appropriate OSF should be determined from site-specific conditions if possible; otherwise use the default values provided in Table 2-63.

Table 2-58 Baseline or Supplemental Electric Energy Consumption Equations

Baseline Equipment	Cooling kWh ($kWh_{c,b}$)	Heating kWh ($kWh_{h,b}$ or $kWh_{supplement}$)
No existing cooling	$(1 - F_{baseline,c}) \times \frac{Cap_c}{SEER2_b \times 1{,}000} \times EFLH_c$	N/A
No existing heating, central fossil fuel system	N/A	$F_{baseline,h} \times \frac{Cap_h}{HSPF2_b \times 1{,}000} \times EFLH_h$

Baseline Equipment	Cooling kWh ($kWh_{c,b}$)	Heating kWh ($kWh_{h,b}$ or $kWh_{supplement}$)
No existing heating, central electric resistance/electric furnace	N/A	$F_{baseline,h} \times \frac{Cap_h}{HSPF2_b \times 1{,}000} \times EFLH_h + (1 - F_{baseline,h}) \times \frac{Cap_h}{3.412 \times 1{,}000} \times EFLH_h$
Mini-split heat pump, ASHP (Cooling Capacity < 65 kBtu/h) or whole building new construction	$OSF \times \frac{Cap_c}{SEER2_b \times 1{,}000} \times EFLH_c$	$\frac{Cap_h}{HSPF2_b \times 1{,}000} \times EFLH_h$
Mini-split AC, Air Conditioner (Cooling Capacity < 65 kBtu/h)	$\frac{Cap_c}{SEER2_b \times 1{,}000} \times EFLH_c$	N/A
PTAC with electric resistance heat	$\frac{Cap_c}{EER2_b \times 1{,}000} \times EFLH_c$	$\frac{Cap_h}{3.412 \times 1{,}000} \times EFLH_h$
PTAC with fossil fuel heat	$\frac{Cap_c}{EER2_b \times 1{,}000} \times EFLH_c$	N/A
PTHP	$OSF \times \frac{Cap_c}{EER2_b \times 1{,}000} \times EFLH_c$	$\frac{Cap_h}{COP_b \times 3.412 \times 1{,}000} \times EFLH_h$
Electric resistance/electric furnace heating	N/A	$\frac{Cap_h}{3.412 \times 1{,}000} \times EFLH_h$
Room Air Conditioner	$\frac{Cap_c}{CEER_b \times 1{,}000} \times EFLH_c$	N/A

Table 2-59 Energy Efficient Electric Energy Consumption Equations

Qualifying Equipment	Efficient Cooling kWh ($kWh_{c,q}$)	Efficient Heating kWh ($kWh_{h,q}$)
Mini-split heat pump, ASHP (Cooling Capacity < 65 kBtu/h)	$OSF \times \frac{Cap_c}{SEER2_q \times 1{,}000} \times EFLH_c$	$\frac{Cap_h}{HSPF2_q \times 1{,}000} \times EFLH_h$
PTHP	$OSF \times \frac{Cap_c}{EER2_q \times 1{,}000} \times EFLH_c$	$\frac{Cap_h}{COP_q \times 3.412 \times 1{,}000} \times EFLH_h$

Annual Fuel Savings

$$\Delta Therms = Therms_b - Therms_q$$

Where,

$$Therms_b = see\ \text{Table 2-60}\ \cancel{\text{Table 2-60}}\ for\ appropriate\ baseline\ equipment\ type$$

For partial displacement applications in which the heat pump supplements an existing fossil fuel system,

$$Therms_q = (1 - F_{load}) \times Therms_b$$

For partial displacement applications in which a new supplemental fossil fuel heating system is installed,

$$Therms_q = (1 - F_{load}) \times Therms_{q,ff}$$

$$Therms_{q,ff} = see\ 2\text{-}61\cancel{2\text{-}61}\ for\ appropriate\ qualifying\ equipment\ type$$

For whole displacement applications,

$$Therms_q = 0$$

Table 2-60 Baseline Fossil Fuel Consumption

Baseline Equipment	Baseline fuel consumption ($Therms_b$)
Fossil Fuel (Gas, Oil, Propane) Furnace/Boiler	$\frac{Cap_h}{Eff_{b,fuel} \times 100{,}000} \times EFLH_h$
No existing heating, central fossil fuel system	$(1 - F_{baseline,h}) \times \frac{Cap_h}{Eff_{b,fuel} \times 100{,}000} \times EFLH_h$

2-61 Energy Efficient Fossil Fuel Consumption

Qualifying Equipment	Efficient fuel consumption ($Therms_{q,ff}$)
New Supplemental Fossil Fuel (Gas, Oil, Propane) Furnace/Boiler	$\frac{Cap_h}{Eff_{q,fuel} \times 100{,}000} \times EFLH_h$

To calculate savings in gallons of delivered fuel, use Table 3-200.

Table 2-62 Fuel Savings in Gallons

Delivered Fuel	Fuel savings (gallons)
Oil	$\Delta Gal_{Oil} = \frac{\Delta Therms}{1.4}$
Propane	$\Delta Gal_{Propane} = \frac{\Delta Therms}{0.916}$

Peak Demand Savings

$$\Delta kW_{Peak} = OSF \times Cap_c \times \frac{1}{1{,}000} \times \left(\frac{1}{EER2_b} - \frac{1}{EER2_q}\right) \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Use single baseline for whole displacement new construction and replace on failure.

Use dual baseline for early replacement addition to existing equipment. In both cases, the RUL is defined by the smaller of the pre-existing heating or cooling system RUL.

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline: $\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 2-63 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ΔGal_{Oil}	Oil savings	Calculated	Gallons	
$\Delta Gal_{Propane}$	Propane savings	Calculated	Gallons	
kWh_b	Baseline electrical consumption	Calculated	kWh/yr	
kWh_q	Energy efficient electrical consumption	Calculated	kWh/yr	
Cap_c	Cooling capacity of installed unit	Site-specific	Btu/hr	
Cap_h	Heating capacity of installed heat pump heating equipment	Site-specific	Btu/hr	

Variable	Description	Value	Units	Ref
$SEER2_q$	SEER2 of installed unit	Site-specific	Btu/W-h	
$EER2_q$	EER2 of qualifying unit	Site-specific	Btu/W-h	
COP_q	Coefficient of performance of the qualifying unit at 47F	Site-specific	N/A	
$HSPF2_q$	HSPF2 of the installed unit	Site-specific	Btu/W-h	
$SEER2_b$	SEER2 of baseline unit	Site-specific or lookup in Appendix E	Btu/W-h	[79][80][85][86]
$EER2_b$	EER2 of baseline unit	Site-specific or lookup in Appendix E	Btu/W-h	[79][80][85][86]
$HSPF2_b$	HSPF2 of the baseline unit	Site-specific or lookup in Appendix E.	Btu/W-h	[79][80][85][86]
$CEER_b$	Combined Energy Efficiency Ratio of baseline room air conditioner[25]	Use federal standard values in Appendix E, if unknown, use 11.0	Btu/W-h	
$Eff_{b,fuel}$	Efficiency of baseline boiler/furnace	Site-specific or lookup in Appendix E	N/A	[79][80][84]
$Eff_{q,fuel}$	Efficiency of newly installed supplemental boiler/furnace	Site-specific	N/A	
OSF	Oversize derating factor[26]	Site-specific, if unknown, use 0.8	N/A	
F_{load}	Partial Displacement Factor to account for the portion of heating load met by the heat pump	Lookup in Table 2-64	N/A	[88][90]
$F_{baseline,h}$	Fraction of projects where, absent the program, the customer would have purchased new heating equipment for a previously unheated space instead of extending existing central system	If installed heat pump is a ductless minisplit: 0.18 If installed heat pump is a ducted ASHP: 0.27	N/A	[93]
$F_{baseline,c}$	Fraction of projects where, absent the program, the customer would not have installed cooling in previously uncooled space, so the added cooling represented added electrical load	If installed heat pump is a ductless minisplit: 0.74 If installed heat pump is a ducted ASHP: 0.34	N/A	[93]

[25] Default value (11.0) is the CEER value from minimum Federal Standard for the most common room AC type – <8000 capacity range with louvered sides
[26] Heat pump systems may be sized to meet the peak heating load and will be oversized for cooling. The cooling EFLH assumes a nominal 20% oversizing. This derating factor has been added to account for the oversizing of heat pump cooling capacity when the unit is sized based on heating capacity. A user with a more accurate estimation of the oversizing can use a different factor than the one mentioned above to account for oversizing.

Variable	Description	Value	Units	Ref
$kWh_{c,b}$	Baseline cooling electrical consumption, whole displacement	Calculated from Table 2-58	kWh/yr	
$kWh_{h,b}$	Baseline heating electrical consumption, whole displacement	Calculated from Table 2-58	kWh/yr	
$kWh_{c,q}$	Energy efficient cooling electrical consumption, whole displacement	Calculated from Table 2-59	kWh/yr	
$kWh_{h,q}$	Energy efficient heating electrical consumption, whole displacement	Calculated from Table 2-59	kWh/yr	
$kWh_{h,supplement}$	Energy efficient heating electrical consumption of supplemental heating system	Calculated	kWh/yr	
$Therms_b$	Baseline fuel consumption	Calculated from Table 2-58	Therms/yr	
$Therms_q$	Energy efficient fuel consumption	Calculated	Therms/yr	
$Therms_{q,ff}$	Fuel consumption of new efficient fuel equipment for partial displacement applications where a new supplemental fossil fuel heating system is installed	Calculated	Therms/yr	
$EFLH_c$	Equivalent Full Load Hours of operation for the average unit during the cooling season	Lookup in Appendix C	Hours	
$EFLH_h$	Equivalent Full Load Hours of operation for the average unit during the heating season	Lookup in Appendix C	Hours	
COP_b	Coefficient of performance of the baseline PTHP at 47F	Lookup in Appendix C	N/A	[79][80][85][86]
1,000	Conversion from W to kW	1,000	W/kW	
3.412	Conversion factor from kWh to kBtu	3.412	kBtu/kWh	
1.4	Conversion from therms to gallons	1.4	Therms/gal	0
0.916	Conversion from therms to gallons	0.916	Therms/gal	0
CF	Cooling coincidence factor	Lookup in Table 2-66	N/A	[83]
PDF	Gas peak day factor	Lookup in Table 2-66	N/A	
EUL	Effective useful life	See Measure Life Section	Years	[81]
RUL	Remaining useful life	See Measure Life Section	Years	

Table 2-64 Partial Displacement Factors for Ductless Heat Pumps[27]

NJ Climate Region	Supplemental Fuel Type			
	Delivered (Oil/Propane)	Electric	Natural Gas	Unknown
Northern	0.61	0.45	0.41	0.43
Southern	0.46	0.23	0.26	0.27
Coastal	0.46	0.23	0.26	0.27
Central	0.46	0.23	0.26	0.27
Pine Barrens	0.46	0.23	0.26	0.27
Statewide Average	**0.48**	**0.26**	**0.27**	**0.29**

Table 2-65 Partial Displacement Factors for Ducted Heat Pumps[28]

NJ Climate Region	Switchover Point					
	15°F	25°F	30°F	35°F (default)	40°F	45°F
Northern	0.95	0.78	0.68	0.43	0.29	0.17
Southern	0.99	0.82	0.71	0.43	0.29	0.19
Coastal	0.98	0.91	0.85	0.64	0.46	0.30
Central	0.99	0.83	0.74	0.47	0.31	0.19
Pine Barrens	1.00	0.86	0.76	0.46	0.31	0.19
Statewide Average	**0.98**	**0.84**	**0.75**	**0.48**	**0.33**	**0.20**

Note: For ducted heat pumps, assume a default switchover point of 35°F unless a site-specific switchover point is known and supported with documentation such as a photo of programmed controls.

[27] Partial displacement factors represent the fraction of the heating load provided by the heat pump. For ductless heat pumps, the partial displacement factors are calculated using data from a 2022 Heat Pump Impact Evaluation, prepared for NYSERDA by DNV (https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications/PPSER/Program-Evaluation/Heat-Pump-Impact-Evaluation-Report-August-2022.pdf). The load fractions for ductless heat pumps are calculated as the measured annual heat output of the ductless heat pump divided by the total predicted annual heat output using rated heating capacity:

F_{load}=(($Actual\ heat\ output\ per\ metered\ data,\ Btu/yr$))/(($Total\ heat\ pump\ capacity, Btu/h$)×$EFLH_{Heating}$)

The New York load fractions for ductless heat pumps were mapped to New Jersey climate zones based on the corresponding ASHRAE climate zone. Default to statewide average if site-specific climate zone is unknown.

[28] Partial displacement factors represent the fraction of the heating load provided by the heat pump. For ducted heat pumps, the partial displacement factors are based on the percentage of heating degree hours above the "switchover point," or the point at which heating is assumed to switch from the heat pump to the supplemental system. Assume a default switchover point of 35°F unless a site-specific switchover point is known and supported with documentation such as a photo of programmed controls.

Field Code Changed

Peak Factors

Table 2-66 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.69	[83]
Natural gas peak day factor (PDF)	See Appendix G	

Measure Life

The remaining useful life (RUL) for existing equipment is 1/3 of the effective useful life (EUL) of the equipment.

Table 2-67 Measure Life

Equipment	EUL	RUL	Ref
Central A/C	15	5	[81]
Air source heat pump	15	5	[81]
Mini split heat pump	15	5	[81]
PTAC/PTHP	15	5	[81]
Room air conditioner	12	4	[91]
Fossil fuel furnace/boiler	20	6.7	[81]
Electric resistance/electric furnace	20	6.7	[81][550]~~[549550]~~

References

[79] ASHRAE Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-5, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

[80] ASHRAE Standard 90.1-2013, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-5, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

[81] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

[82] *ENERGY STAR® HVAC QUALITY INSTALLATION PROGRAM A new approach to residential HVAC efficiency and performance*. Pg 2, https://www.energystar.gov/ia/home_improvement/downloads/ESQI_factsheet.pdf?07d7-31fc

[83] NEEP, *Mid-Atlantic Technical Reference Manual*, V9. (October 2019). Pg 95 https://neep.org/sites/default/files/resources/Mid_Atlantic_TRM_V9_Final_clean_wUpdateSummary%20-%20CT%20FORMAT.pdf

[84] Code of Federal Regulations. 2022. Review of Title 10, Chapter II, Subchapter D, Part 430 eCFR. December 1, 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430

Field Code Changed

Field Code Changed

Field Code Changed

[85] "2021 INTERNATIONAL ENERGY CONSERVATION CODE (IECC) | ICC DIGITAL CODES." n.d. Codes.iccsafe.org. Accessed November 16, 2022. https://codes.iccsafe.org/content/IECC2021P2/chapter-4-ce-commercial-energy-efficiency.

[86] "2012 INTERNATIONAL ENERGY CONSERVATION CODE (IECC) | ICC DIGITAL CODES." n.d. Codes.iccsafe.org. Accessed January 23, 2023 https://codes.iccsafe.org/content/IECC2012P5/chapter-4-ce-commercial-energy-efficiency

[87] Code of Federal Regulations. 2022. Review of Title 10, Chapter II, Subchapter D, Part 430, Subpart C, section 430.32 b) Room Air Conditioners

[88] TMY3 data for NJ climate zone representative cities: Northern – Allentown, PA; Central – Trenton, NJ; Pine Barrens – McGuire AFB NJ; Southwest – Philadelphia, PA International Airport; Coastal – Atlantic City, NJ.

[89] Oak Ridge National Laboratory, *Fuel Conversions Needed in the Weatherization Assistant*, https://weatherization.ornl.gov/wp-content/uploads/2018/05/FuelConversions.pdf

[90] Adjusted the overall New York load fraction using the fraction of HDD above 32°F for each New Jersey climate zone. New York load fraction per 2022 *Heat Pump Impact Evaluation*, prepared for NYSERDA by DNV: https://pseg1com.sharepoint.com/sites/JointUtilityEnergyEfficiencyPrograms/EMVSERAJoint

[91] GDS Associates, Inc. 2007. *Review of Energy Efficiency Measures/Programs Reference Document for the ISO Forward Capacity Market (FCM)*. Https://Library.cee1.org. June 2007. https://library.cee1.org/system/files/library/8842/CEE_Eval_MeasureLifeStudyLights%2526HVACGDS_1Jun2007.pdf

[92] *Energy Saver 101: Everything you need to know about Home Heating* https://www.energy.gov/sites/prod/files/2014/01/f6/homeHeating.pdf

[93] Guidehouse, *[R2246] Residential Heat Pump Metering Study*, May 2024. https://app.box.com/s/6u94k3zij1ocwmqlh7oxl5vnie1fmn7c

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

2.3.2 CENTRAL AIR CONDITIONER, MINI-SPLIT AC AND PTAC

Market	Residential/Multifamily
Baseline Condition	TOS/NC/EREP/DI
Baseline	Code/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	March 2024
Changes Since Last Version	• ~~Created new measure with cooling equipment only (central AC, PTAC)~~ • ~~Included Mini-split Air Conditioner and Room Air Conditioner~~

Description

This measure targets the use of central air conditioners (AC) , mini-split air conditioners (MSAC) and packaged terminal air conditioners (PTAC) in residential and low-rise multifamily applications as further described below. This measure may apply to early replacement of an existing system, replacement on burnout, or installation of a new unit in a new or existing residential or multifamily low-rise building for HVAC applications.

The algorithms also include the calculation of additional energy and demand savings due to the proper sizing of high efficiency units.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol in Section 4.5.1. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow the residential protocol presented in this measure as outlined in Table 2-58, Table 2-69 and Table 2-70 below.

Baseline Case

For time of sale or new construction projects, the baseline equipment is a central air conditioner, mini-split air conditioners or packaged terminal system minimally compliant with IECC 2021 (see Appendix E).

For early replacement projects or direct install projects, use dual baselines:

- For the remaining useful life (RUL) of the existing equipment, the baseline is the actual existing equipment. If the site specific efficiency of the existing equipment is unknown, use the equipment efficiency from the IECC version in force when the equipment was new (if equipment vintage is unknown, use IECC 2013 efficiency requirements from Appendix E).
- For the duration of the measure life after the end of the RUL, the baseline is a current code-compliant version of the replaced equipment.

Efficient Case

A central air conditioner, mini-split air conditioners or packaged terminal air conditioner (PTAC) that meets or exceeds program ~~eligibility~~ requirements.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = kWh_b - kWh_q$$

Calculate kWh_b using the algorithms in Table 2-58 for the appropriate baseline equipment type.

Calculate kWh_q using the algorithms in Table 2-59 for the appropriate efficient equipment type.

Note: Conversions from SEER to SEER and EER to EER2 can be found in Appendix E.

Table 2-68 Baseline Energy Consumption Equations

Baseline Equipment	Baseline Cooling kWh (kWh_b)
Air Conditioner (Cooling Capacity < 65 kBtu/h)	$\frac{Cap_c}{SEER2_b \times 1{,}000} \times EFLH_c$
Room Air Conditioner	$\frac{Cap_c}{CEER_b \times 1{,}000} \times EFLH_c$
PTAC	$\frac{Cap_c}{EER_b \times 1{,}000} \times EFLH_c$

Table 2-69 Energy Efficient Energy Consumption Equations

Qualifying Equipment	Efficient Cooling kWh (kWh_q)
Air Conditioner (Cooling Capacity < 65 kBtu/h)	$\frac{Cap_c}{SEER2_q \times 1{,}000} \times EFLH_c$
Room Air Conditioner	$\frac{Cap_c}{CEER_q \times 1{,}000} \times EFLH_c$
PTAC	$\frac{Cap_c}{EER_q \times 1{,}000} \times EFLH_c$

Peak Demand Savings

Table 2-70 Peak Demand Savings Equations

Qualifying Equipment	Peak Demand Savings (ΔkW_{Peak})
Air Conditioner (Cooling Capacity < 65 kBtu/h)	$\Delta kW_{Peak} = Cap_c \times \frac{1}{1{,}000} \times \left(\frac{1}{EER2_b} - \frac{1}{EER2_q}\right) \times CF$
Room Air Conditioner	$\Delta kW_{Peak} = Cap_c \times \frac{1}{1{,}000} \times \left(\frac{1}{CEER_b} - \frac{1}{CEER_q}\right) \times CF$
PTAC	$\Delta kW_{Peak} = Cap_c \times \frac{1}{1{,}000} \times \left(\frac{1}{EER_b} - \frac{1}{EER_q}\right) \times CF$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 2-71 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
kWh_b	Baseline electrical consumption	Calculated	kWh/yr	
kWh_q	Energy efficient electrical consumption	Calculated	kWh/yr	
Cap_c	Cooling capacity of installed unit	Site-specific	Btu/hr	
$SEER2_q$	SEER2 of installed unit[29]	Site-specific	Btu/W-h	
$CEER_q$	CEER of installed unit	Site-specific	Btu/W-h	
$EER2_q$	EER2 of qualifying unit	Site-specific	Btu/W-h	
$SEER2_b$	SEER2 of baseline unit[1]	TOS/NC: Look up in Appendix E for current code-compliant efficiency EREP/DI: Site-specific, if unknown use code efficiency in force when equipment was new or use 2013 if vintage is unknown	Btu/W-h	[94][95]
$CEER_b$	CEER of baseline unit	TOS/NC: Look up in Appendix E for current code-compliant efficiency EREP/DI: Site-specific, if unknown use code efficiency in force when equipment was new or use 2013 if vintage is unknown	Btu/W-h	[94][95]
$EER2_b$	EER2 of baseline unit	TOS/NC: Look up in Appendix E for current code-compliant efficiency	Btu/W-h	[94][95]

[29] SEER to SEER2 conversion found in Appendix E.

Variable	Description	Value	Units	Ref
		EREP/DI: Site-specific, if unknown use code efficiency in force when equipment was new or use 2013 if vintage is unknown		
$EFLH_c$	Equivalent Full Load Hours of operation for the average unit during the cooling season	Look up in Appendix C	Hours	
1,000	Conversion from W to kW	1,000	W/kW	
CF	Electric coincidence factor	0.69	N/A	[97]
EUL	Effective useful life	See Measure Life section	Years	[96]

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 2-72 Measure Life

Equipment	EUL	RUL	Ref
Central AC, MSAC and PTAC	15	5	[96]
Room AC	9	3	[96]

References

[94] ASHRAE Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-5, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

[95] ASHRAE Standard 90.1-2013, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-5, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

[96] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

[97] NEEP, *Mid-Atlantic Technical Reference Manual*, V9. (October 2019). Pg 95 https://neep.org/sites/default/files/resources/Mid_Atlantic_TRM_V9_Final_clean_wUpdateSummary%20-%20CT%20FORMAT.pdf

[98] See Appendix

Field Code Changed

Field Code Changed

2.3.3 WATER SOURCE HEAT PUMP (GROUNDWATER AND GROUND LOOP)

Market	Residential/Multifamily
Baseline Condition	TOS/NC/EREP
Baseline	Code/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	May 2024
Changes Since Last Version	• ~~Algorithms revisions~~

Description

This prescriptive measure targets the use of water source heat pumps (sometimes called geothermal heat pumps) in residential and multifamily low-rise applications as further described below. This measure may apply to early replacement of an existing system, replacement on burnout, or installation of a new unit in a new or existing residential or low-rise residential building for HVAC applications. The following heat pump types are included in this measure.

- Water-to-air groundwater
- Water-to-air ground loop
- Brine-to-air groundwater loop
- Brine-to-air ground loop

This measure is limited to single-zone equipment; complex built-up systems should follow custom analysis. This measure requires that:

- The heat pump system will be installed in lost opportunity projects *or* in retrofit/early retirement projects in buildings with viable existing ductwork.
- The heat pump system will be the sole source of heating and cooling in the space; it will not be installed in association with another non-electric source of auxiliary heat.

Baseline Case

For whole building new construction and time of sale applications, the baseline equipment is an air source, dual fuel or mini-split heat pump meeting the compliance requirements of IECC 2021. However, if the preexisting failed system was a ground-source heat pump, the baseline should reflect the type and efficiency of the previous system in accordance with IECC 2021 standards. For multi-family high-rise residential buildings, refer to the algorithms in Commercial and Industrial Section.

For replacement of failed equipment, or end of useful life, the baseline would be a minimally code compliant version of the replaced system type and fuel.

For early replacement projects, use dual baselines:

- For the remaining useful life (RUL) of the existing equipment, the baseline is the actual existing equipment. If the site-specific efficiency of the existing equipment is unknown, use the equipment efficiency from the IECC version in force when the equipment was new (if equipment vintage is unknown, use IECC 2012).
- For the duration of the measure life after the end of the RUL, the baseline is a code-compliant version of the replaced equipment.

Efficient Case

A water-to-air groundwater loop water-to-air ground loop, brine-to-air groundwater loop, or brine-to-air ground loop heat pump that meets or exceeds ~~code~~program requirements.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = kWh_b - kWh_q$$

Where,

$$kWh_b = kWh_{c,b} + kWh_{h,b} + kWh_{au,b}$$

$$kWh_q = kWh_{c,q} + kWh_{h,q} + kWh_{p,q}$$

Calculate $kWh_{c,b}$, $kWh_{h,b}$, and $kWh_{p,b}$ using the algorithms in **Table 2-73**~~Table 2-73~~ for the appropriate baseline equipment type.

Calculate $kWh_{c,q}$, $kWh_{h,q}$, and $kWh_{p,q}$ using the algorithms in **Table 2-74**~~Table 2-74~~ for the appropriate efficient equipment type.

Note:

Conversions from SEER to SEER2, EER to EER2, and HSPF to HSPF2 can be found in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~.

The cooling output of the installed unit (Q_c) and the heating output of the installed unit (Q_h) are calculated as follows.

$$Q_c = Cap_c \times EFLH_c \times OSF$$

$$Q_h = Cap_h \times EFLH_h$$

The oversize derating factor (OSF) is applicable for heat pump applications where the heat pump is sized based on heating capacity but is oversized for cooling. The appropriate OSF should be determined from site-specific conditions if possible, otherwise use a default value of 0.8.

Table 2-73 Baseline Energy Consumption Equations

Baseline Equipment	Baseline Cooling kWh ($kWh_{c,b}$)	Baseline Heating kWh ($kWh_{h,b}$)	Auxiliary Energy Use kWh ($kWh_{au,b}$)[30]
Air Source Heat Pump (< 65 kBtu/h)	$\frac{Q_c}{SEER2_b \times 1{,}000}$	$\frac{Q_h}{HSPF2_b \times 1{,}000}$	N/A
Air Source Air Conditioner (< 65 kBtu/h)	$\frac{Q_c}{SEER2_b \times 1{,}000}$	N/A	N/A
PTAC with electric resistance heat	$\frac{Q_c}{EER2_b \times 1{,}000}$	N/A	N/A
PTHP	$\frac{Q_c}{EER2_b \times 1{,}000}$	$\frac{Q_h}{COP_b \times 3.412 \times 1{,}000}$	N/A
GSHP (< 65 kBtu/h)	$\frac{Q_c}{EER2_b \times 1{,}000}$	$\frac{Q_h}{COP_b \times 3.412 \times 1{,}000}$	$\frac{0.746 \times HP_b \times FLH_{pump}}{Eff_{motor,b}}$
Electric Resistance/electric furnace heating	N/A	$\frac{Q_h}{3.412 \times 1{,}000}$	N/A
Room Air Conditioner	$\frac{Q_c}{CEER_b \times 1{,}000}$	N/A	N/A
Furnace[31]	N/A	N/A	$4.908 \times Cap_{furnace} + 128.1$

Table 2-74 Qualifying Equipment Energy Consumption Equations

Efficient Cooling kWh ($kWh_{c,q}$)	Efficient Heating kWh ($kWh_{h,q}$)	Efficient Ground/Groundwater Loop Circulating Pump kWh ($kWh_{p,q}$)
$\frac{Q_c}{EER_{season,q} \times 1{,}000}$	$\frac{Q_h}{COP_{season,q} \times 3.412 \times 1{,}000}$	$\frac{0.746 \times HP_q \times FLH_{pump}}{Eff_{motor,q}}$

Calculate seasonal efficiencies as follows:

If heat pump is part-load capable:

$$EER_{season,q} = F_{full} \times EER_{full,q} \times 1.09 \times F_{pump,full} + F_{part} \times EER_{part,q} \times F_{pump,part}$$

$$COP_{season,q} = F_{full} \times COP_{full,q} \times 1.08 \times F_{pump,full} + F_{part} \times COP_{part,q} \times F_{pump,part}$$

If heat pump is not part-load capable:

$$EER_{season,q} = rated\ EER$$

$$COP_{season,q} = rated\ COP$$

[30] This parameter represents the additional energy consumption unrelated to cooling or heating. For ground source heat pumps, it represents the pump energy to circulate the heat exchange fluid through the ground loop. For furnaces, it represents the fan energy to distribute the heated air.

[31] This equation was derived by constructing a simple linear regression model that relates the output furnace heating capacity to the fan auxiliary usage using data downloaded from the AHRI website for all active residential furnaces.

Annual Fuel Savings

$$\Delta Therms = Therms_b - Therms_q$$

Where,

$$Therms_b = see\ \textbf{Table 2-75}\cancel{\text{Table 2-75}}\ for\ appropriate\ baseline\ equipment\ type$$

$$Therms_q = 0\ \textit{(If the unit uses a furnace backup, use equation from Table 1-3)}$$

Table 2-75 Energy Efficient Fuel Consumption

Baseline Equipment	Baseline fuel consumption ($Therms_b$)
Electric heating (heat pump, electric resistance)	0
Fossil fuel furnace	$\frac{Q_h}{Eff_{b,fuel} \times 100{,}000}$

To calculate savings in gallons of delivered fuel, use Table 3-200.

Table 2-76 Fuel Savings in Gallons of Delivered Fuel

Delivered Fuel	Fuel savings (gallons)
Oil	$\Delta Gal_{Oil} = \frac{\Delta Therms}{1.4}$
Propane	$\Delta Gal_{Propane} = \frac{\Delta Therms}{0.916}$

Peak Demand Savings

$$\Delta kW_{Peak} = kW_{peak,cool} + kW_{peak,pump}$$

Where,

$$\Delta kW_{peak,cool} = Cap_c \times \frac{1}{1{,}000} \times \left(\frac{1}{EER2_b} - \frac{1}{EER_{full,q}}\right) \times CF_c$$

$$\Delta kW_{peak,pump} = 0.746 \times \left\{\left(HP_b \times LF \times \frac{1}{Eff_{motor,b}}\right) - \left(HP_q \times LF \times \frac{1}{Eff_{motor,q}} \times DSF_{VFD}\right)\right\} \times CF_{pump}$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 2-77 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ΔGal_{Oil}	Oil savings	Calculated	Gallons	
$\Delta Gal_{Propane}$	Propane savings	Calculated	Gallons	
kWh_b	Baseline electrical consumption	Calculated	kWh/yr	

Variable	Description	Value	Units	Ref
kWh_q	Energy efficient electrical consumption	Calculated	kWh/yr	
Q_c	Cooling output of qualifying unit	Calculated	Btu	
Q_h	Heating output of qualifying unit	Calculated	Btu	
Cap_c	Cooling capacity of qualifying unit	Site-specific	Btu/hr	
Cap_h	Heating capacity of qualifying unit	Site-specific	Btu/hr	
$Cap_{furnace}$	Heating capacity of pre-existing furnace (MBH)	Site-specific	MBH	
$EFLH_c$	Equivalent Full Load Hours of operation for the average unit during the cooling season	Lookup in Appendix C	Hours	
$EFLH_h$	Equivalent Full Load Hours of operation for the average unit during the heating season	Lookup in Appendix C	Hours	
F_{full}	Seasonal weighting factor for full load efficiency	0.25	N/A	[101]
$EER_{season,q}$	Adjusted EER of qualifying unit	Calculated	Btu/W-h	
$EER_{full,q}$	Full load EER of qualifying unit	Site-specific	Btu/W-h	
$F_{pump,full}$	Factor to adjust the full load efficiency to account for additional pumping power used by the system	0.90	N/A	[101]
F_{part}	Seasonal weighting factor for part load efficiency	0.75	N/A	[101]
$EER_{part,q}$	Part load EER of qualifying unit (if part load capable), per manufacturer literature or AHRI certification	Site-specific	Btu/W-h	
$F_{pump,part}$	Factor to adjust the part load efficiency to account for additional pumping power used by the system	0.84	N/A	[101]
$COP_{season,q}$	Adjusted coefficient of performance of the qualifying unit	Calculated	N/A	
$COP_{full,q}$	Full load coefficient of performance of the qualifying unit, per manufacturer literature or AHRI certification	Site-specific	N/A	
$COP_{part,q}$	Part load coefficient of performance of the qualifying unit (if part-load capable), per manufacturer literature or AHRI certification	Site-specific	N/A	

Variable	Description	Value	Units	Ref
HP_q	Horsepower of qualifying ground/groundwater loop circulating pump motor	Site-specific	HP	
HP_b	Horsepower of base case ground/groundwater loop circulating pump motor	Site-specific, if unknown use HP_q	HP	
$SEER2_b$	SEER of baseline unit	Site-specific or look up in Appendix	Btu/W-h	[105][106][108][109]
$IEER_b$	IEER of baseline unit	Site-specific or look up in Appendix EError! Reference source not found.~~Appendix E: Code-Compliant Efficiencies~~	Btu/W-h	[105][106][108][109]
$EER2_b$	EER of baseline unit	Site-specific or look up in Appendix E	Btu/W-h	[105][106][108][109]
$HSPF2_b$	Heating seasonal performance factor of the baseline unit	Site-specific, if unknown look up in Appendix E	Btu/W-h	[105][106][108][109]
$CEER_b$	Combined Energy Efficiency Ratio of baseline room air conditioner[32]	Use federal standard values in Appendix E, if unknown, use 11.0	Btu/W-h	[101]
$Eff_{motor,b}$	Efficiency of base case ground/groundwater loop circulating pump motor	Site-specific, if unknown look up in Table 2-78~~Table 2-78~~	N/A	[107]
$Eff_{motor,q}$	Efficiency of qualifying ground/groundwater loop circulating pump motor	Site-specific	N/A	[107]
$Eff_{b,fuel}$	Efficiency of baseline furnace	Site-specific or look up in Appendix E	N/A	[105][106]
OSF	Oversize derating factor	Site-specific, if unknown use 0.8	N/A	
$kWh_{c,b}$	Baseline cooling electrical consumption	Calculated from Table 2-73~~Table 2-73~~	kWh/yr	
$kWh_{h,b}$	Baseline heating electrical consumption	Calculated from Table 2-73~~Table 2-73~~	kWh/yr	
$kWh_{au,b}$	Baseline auxiliary electrical consumption	Calculated from Table 2-73~~Table 2-73~~	kWh/yr	
$kWh_{c,q}$	Energy efficient cooling electrical consumption	Calculated from Table 2-74~~Table 2-74~~	kWh/yr	

[32] Default value (11.0) is the CEER value from minimum Federal Standard for the most common room AC type – <8000 capacity range with louvered sides

Variable	Description	Value	Units	Ref
$kWh_{h,q}$	Energy efficient heating electrical consumption	Calculated from Table 2-74~~Table 2-74~~	kWh/yr	
$kWh_{p,q}$	Energy efficient ground/groundwater loop circulating pump electrical consumption	Calculated from Table 2-74~~Table 2-74~~	kWh/yr	
$Therms_b$	Baseline fuel consumption	Lookup in Table 2-75~~Table 2-75~~	Therms/yr	
$Therms_q$	Energy efficient fuel consumption	0	Therms/yr	
COP_b	Coefficient of performance of the baseline unit	Site-specific or look up in Appendix E	N/A	[105][106][108][109]
1.09	Correction for 9% increase in EER as the entering fluid temperature decreases from 77°F to 68°F	1.09	N/A	[101]
1.08	Correction for 8% increase in COP as entering fluid temperature increases from 32°F to 40°F	1.08	N/A	[101]
1,000	Conversion from W to kW	1,000	W/kW	
3.412	Conversion factor from kWh to kBtu	3.412	kBtu/kWh	
0.746	Conversion from HP to kW	0.746	kW/hp	
1.4	Conversion from therms to gallons	1.4	Therms/gal	
0.916	Conversion from therms to gallons	0.916	Therms/gal	
LF	Load factor of pump motor	0.75	N/A	[102]
DSF_{VFD}	Demand savings factor to account for variable speed pumping in qualifying unit	If variable speed pump: 0.210 If constant speed: 1.0		See section 2.3.6
FLH_{pump}	Annual full-load hours of ground/groundwater loop circulating pump motor, approximated as $EFLH_c$ + $EFLH_h$	Look up in Error! Reference source not found.~~Appendix D: HVAC Fan and Pump Operating Hours~~	Hours	
CF_c	Cooling coincidence factor	Lookup in Table 2-79~~Table 2-79~~	N/A	
CF_{pump}	Pump coincidence factor	Lookup in Table 2-79~~Table 2-79~~	N/A	
PDF	Gas peak day factor	Lookup in Table 2-79~~Table 2-79~~	N/A	
EUL	Effective useful life	See Measure Life section	Years	
RUL	Remaining useful life	See Measure Life section	Years	

Table 2-78 Federal Baseline Motor Efficiencies

Motor HP	Motor Nominal Full-Load Efficiencies (percent)							
	2 Poles		4 Poles		6 Poles		8 Poles	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
1	77.0	77.0	85.5	85.5	82.5	82.5	75.5	75.5
1.5	84.0	84.0	86.5	86.5	87.5	86.5	78.5	77.0
2	85.5	85.5	86.5	86.5	88.5	87.5	84.0	86.5
3	86.5	85.5	89.5	89.5	89.5	88.5	85.5	87.5
5	88.5	86.5	89.5	89.5	89.5	89.5	86.5	88.5
7.5	89.5	88.5	91.7	91.0	91.0	90.2	86.5	89.5
10	90.2	89.5	91.7	91.7	91.0	91.7	89.5	90.2
15	91.0	90.2	92.4	93.0	91.7	91.7	89.5	90.2
20	91.0	91.0	93.0	93.0	91.7	92.4	90.2	91.0

Peak Factors

Table 2-79 Peak Factors

Peak Factor	Value	Ref
Cooling coincidence factor (CFc)	0.69	[110]
Pump coincidence factor (CF_{pump})	If unit runs continuously all year, CF=1.0, else use 0.5	[112]
Natural gas peak day factor (PDF)	See Appendix G	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 2-80 Measure Life

Equipment	EUL	RUL	Ref
Water source Pump	15	5	[104]
Ground source heat pump	25	8.33	[103]
Central A/C	15	5	[104]
Air source heat pump	15	5	[104]
PTAC/PTHP	15	5	[104]
Room air conditioner	12	4	[91]
Fossil fuel furnace	20	6.7	[104]
Electric resistance/electric furnace	20	6.7	[104][552]~~[5512]~~

References

[99] VEIC Estimate. Consistent with analysis of PEPCo and LIPA, and conservative relative to ARI.

[100] VEIC estimate. Extrapolation of manufacturer data.

[101] From NY TRM V11, pg 278-288

[102] *Determining Electric Motor Load and Efficiency*. (DOE, 2014), pg 1, https://www.energy.gov/sites/prod/files/2014/04/f15/10097517.pdf

[103] ASHRAE: Owning and Operating Cost Database, Equipment Life/Maintenance Cost Survey: https://xp20.ashrae.org/publicdatabase/system_service_life.asp?selected_system_type=1

[104] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

[105] ASHRAE Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-5, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

[106] ASHRAE Standard 90.1-2013, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-5, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

[107] *§ CFR431.25 Energy conservation standards and effective dates*, (2023) Table 1, https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-431/subpart-B/subject-group-ECFR03b7039d87b7cc6/section-431.25

[108] "2021 INTERNATIONAL ENERGY CONSERVATION CODE (IECC) | ICC DIGITAL CODES." n.d. Codes.iccsafe.org. Accessed November 16, 2022. https://codes.iccsafe.org/content/IECC2021P2/chapter-4-ce-commercial-energy-efficiency.

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

[109] "2012 INTERNATIONAL ENERGY CONSERVATION CODE (IECC) | ICC DIGITAL CODES." n.d. Codes.iccsafe.org. Accessed January 23, 2023 https://codes.iccsafe.org/content/IECC2012P5/chapter-4-ce-commercial-energy-efficiency

[110] NEEP, *Mid-Atlantic Technical Reference Manual*, V9. (October 2019). Pg 95

[111] ENERGY STAR® HVAC QUALITY INSTALLATION PROGRAM A new approach to residential HVAC efficiency and performance. Pg 2, https://www.energystar.gov/ia/home_improvement/downloads/ESQI_factsheet.pdf?07d7-31fc

[112] Determining Electric Motor Load and Efficiency. (DOE, 2014), pg 1, https://www.energy.gov/sites/prod/files/2014/04/f15/10097517.pdf

Field Code Changed

Field Code Changed

2.3.4 GAS FORCED AIR AND HYDRONIC HEATING

Market	Residential/Multifamily
Baseline Condition	TOS/NC/EREP
Baseline	Code/Dual
End Use Subcategory	HVAC Equipment
Measure Last Reviewed	March 2024
Changes Since Last Version	• ~~Renamed~~ • Revised equation to ~~"Gas Forced Air/Hydronic Heating"~~ • ~~Added footnote to explain accommodate claiming energy savings~~account for ~~early replacement installations with non-EC motor baseline~~oversizing

Description

This section provides energy savings algorithms for qualifying furnaces and boilers installed in single family detached and low-rise multifamily buildings. The input values are based on the specifications of the actual equipment being installed and IECC 2021 standards which require an efficiency rating equal to or greater than the minimum required by federal law for residential units.

Baseline Case

New construction, time of sale: In the case of new construction, replacement of failed equipment, or end of useful life, the baseline furnace or boiler is a minimally code compliant unit with an efficiency as required by IECC 2021, which is the current residential code adopted by the state of New Jersey [113].

Early Replacement: In the case of early replacement of a working unit where the unit would have otherwise continued to function, use dual baselines as described below. This measure assumes the existing equipment is the same fuel type as the installed equipment.

- For the remaining useful life of existing unit: Baseline is the existing equipment of the same fuel type as the installed equipment. If unknown, use the code in force when the equipment was new. If the equipment vintage is unknown, look up the 2013 minimum efficiency from Appendix E.
- For the duration of the measure life after the RUL of the existing equipment: Baseline is a minimally code complient unit as required by IECC 2021.

Efficient Case

Furnace or boiler with an efficiency ~~higher than code or standard practice~~that meets or exceeds program requireme.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = N/A$$ [33]

Annual Fuel Savings

$$\Delta Therms = Cap_{in} \times EFLH_h \times \cancel{\frac{Eff_q/Eff_b - 1}{100}} \frac{Eff_q/(Eff_b \times F_{os}) - 1}{100}$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$ [1]

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

[33] If the baseline system has a single-speed, shaded-pole (SP) or permanent-split capacitor (PSC) supply fan motor, electric energy savings should be claimed for this measure by referring to Measure 4.5.14 EC Motors. Electric energy savings cannot be claimed for new construction or time of sale baseline, or if the early replacement baseline has EC motors.

Calculation Parameters

Table 2-81 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
Cap_{in}	Input capacity of qualifying unit	Site-specific	kBtu/hr	
Eff_q	Furnace or Boiler Proposed Efficiency	Site-specific	N/A	
Eff_b	Furnace or Boiler Baseline Efficiency	Site-specific or unknown lookup in Table 2-82 and Table 2-83 for single family detached/multifamily low-rise units	N/A	[113]
$EFLH_h$	Equivalent Full Load Hours of operation for the average unit during the heating season	Look up in Appendix E	Hrs/yr	
F_{os}	Oversizing factor to account for baseline efficiency degradation when equipment is oversized more than the standard assumption	0.9	N/A	[116]
100	Conversion factor	100	kBtu/Therms	
EUL	Effective useful life of furnace or boiler	See Measure Life section	years	[114]
RUL	Remaining useful life	See Measure Life section	years	[114]
PDF	Gas peak day factor	Lookup in Table 2-84	N/A	

Table 2-82 Baseline AFUE of Single Family and Low-Rise Multifamily Furnaces

Product Class	AFUE	Compliance Date	AFUE (Manufactured before compliance Date)
Weatherized gas furnaces	0.81	January 1, 2015.	0.78
Non-weatherized gas furnaces (not including mobile home furnaces)	0.80	November 19, 2015.	0.78
Weatherized oil-fired furnaces	0.78	January 1, 1992.	0.78
Non-weatherized oil-fired furnaces (not including mobile home furnaces)	0.83	May 1, 2013.	0.78
Mobile Home gas furnaces	0.80	November 19, 2015.	0.75
Mobile Home oil-fired furnaces	0.75	September 1, 1990.	0.75

Table 2-83 Baseline AFUE of Single Family and Low-Rise Multifamily Boilers

Product Class	AFUE Manufactured before Sep 1, 2012	AFUE (Manufactured on and after Sep 1, 2012 and before Jan 15, 2021)	AFUE (Manufactured on and after January 15, 2021)
Gas-fired hot water boiler	0.80	0.82	0.84
Gas-fired steam boiler	0.75	0.80	0.82
Oil-fired hot water boiler	0.80	0.84	0.86
Oil-fired steam boiler	0.80	0.82	0.85

Peak Factors

Table 2-84 Peak Factors

Peak Factor	Value	Ref
Natural gas peak day factor (PDF)	Look up in Appendix G	

Measure Life

The remaining useful life (RUL) for retrofit projects is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 2-85 Measure Life

Equipment	New construction EUL	Retrofit RUL	Ref
Furnace	20	6.7	[115]
Boiler	20	6.7	[115]

References

[113] Code of Federal Regulations. 2022. Review of Title 10, Chapter II, Subchapter D, Part 430, Subpart C §430.32(e). December 1, 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32#p-430.32(e)

[114] Simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

[115] California eTRM, CPUC Support Tables: Effective Useful Life and Remaining Useful Life https://www.caetrm.com/cpuc/table/effusefullife/

[116] Placeholder assumption based on NREL simulation model relationships between efficiency and part load ratio

Field Code Changed

Field Code Changed

2.3.5 HIGH EFFICIENCY BATHROOM EXHAUST FAN

Market	Residential/Multifamily
Baseline Condition	TOS/DI/EREP
Baseline	Existing
End Use	Ventilation Fan
Measure Last Reviewed	September 2024
Changes Since Last Version	~~Updated HDD/CDD values and recalculated annual energy savings~~

Description

This market opportunity is defined by the need for continuous mechanical ventilation due to reduced air-infiltration from a tighter building shell. In retrofit projects, existing fans may be too loud, or insufficient in other ways, to be operated as required for proper ventilation.This measure assumes a fan capacity of 20 CFM at 0.1 inches of water column (w.c.) static pressure and a decibel level below 2 sones. Installations should be sized to meet the minimum ventilation rate as required by ASHRAE 62.2.

Baseline Case

Standard efficiency quiet bathroom ventilation fan, operating at a ventilation rate compliant with ASHRAE 62.2, with an average efficiency of 3.1 CFM/watt

Efficient Case

Energy efficient quiet bathroom ventilation fan, operating at a ventilation rate compliant with ASHRAE 62.2, with an average efficiency of 8.3 CFM/watt

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = CFM \times \left(\frac{1}{Eff_b} - \frac{1}{Eff_q}\right)/1{,}000 \times Hrs$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = CFM \times \left(\frac{1}{Eff_b} - \frac{1}{Eff_q}\right)/1{,}000 \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 2-86 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
CFM	Nominal Capacity of the exhaust fan	Site-specific, if unknown use 20 CFM	CFM	[117]~~[1167]~~
Eff_b	Average efficacy for baseline fan	Site-specific, if unknown use 3.1 CFM/watt	CFM/watt	[118]~~[1178]~~
Eff_q	Average efficacy for efficient fan	Site-specific, if unknown use 8.3 CFM/watt	CFM/watt	[119]~~[1189]~~
Hrs	Annual hours of operation	8,760	Hrs/yr	
CF	Electric coincidence factor	Lookup in Table 3-152	N/A	
EUL	Effective useful life	See Measure Life section	Years	

Peak Factors

Table 2-87 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1	

Measure Life

The effective useful life (EUL) is 19 years [120]~~[119120]~~.

References

~~[116]~~[117] 20 CFM is used with continuous bathroom ventilation in ASHRAE 62.2. Note that 50CFM is the closest available fan size to ASHRAE 62.2 Section 4.1 Whole House Ventilation rates based upon typical square footage and bedrooms

~~[117]~~[118] VEIC analysis looking at average baseline fan (i.e. non-Brushless Permanent Magnet) efficacies at static pressures of 0.1 and 0.25 inches of water column for quiet fans rated for 50 CFM

~~[118]~~[119] VEIC analysis looking at average efficient fan (i.e. Brushless Permanent Magnet) efficacies at static pressures of 0.1 and 0.25 inches of water column for quiet fans rated for 50 CFM

~~[119]~~[120] GDS Associates, *Measure Life Report: Residential and C&I Lighting and HVAC measures* (SPWG 2007), https://library.cee1.org/sites/default/files/library/8842/CEE_Eval_MeasureLifeStudyLights&HVACGDS_1Jun2007.pdf

Field Code Changed

2.3.6 EC MOTOR

Market	Residential/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Motor
Measure Last Reviewed	December 2022

Description

This measure covers the retrofit installation of an Electronically Commuted (EC) Motor to replace an HVAC supply fan motor or hydronic circulator pump motor in residential heating and cooling systems.

The deemed annual electric energy savings for fans are determined for each New Jersey location by scaling the energy savings derived from the evaluation of a 2014 Wisconsin ECM metering study using heating degree days and cooling degree days for each location.

Electric energy savings for pumps are calculated by multiplying the difference in the reciprocal of motor efficiencies with the efficient circulator motor horsepower.

Baseline Case

An existing HVAC fan or pump with a single-speed, shaded-pole (SP) or permanent-split capacitor (PSC) motor.

Efficient Case

HVAC fan or pump with an Electronically Commuted (EC) Motor.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

Pumps:

$$\Delta kWh = \Delta kWh_h + \Delta kWh_c$$

Where,

$$\Delta kWh_h = hp \times \left(\frac{1}{Eff_b} - \frac{1}{Eff_q}\right) \times LF \times 0.746 \times hrs_h$$

$$\Delta kWh_c = hp \times \left(\frac{1}{Eff_b} - \frac{1}{Eff_q}\right) \times LF \times 0.746 \times hrs_c$$

Fans:

$$\Delta kWh = \Delta kWh_{fan}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

Pumps:

$$\Delta kW_{Peak} = \frac{\Delta kWh}{hrs} \times CF_{pump}$$

Fans:

$$\Delta kW_{Peak} = \Delta kW_{fan} \times CF_{fan}$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL = N/A$$

Calculation Parameters

Table 2-88 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Annual peak electric demand savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{fan}	Annual energy savings per fan motor	Look up in Table 2-90	kWh/unit	[121]~~[1201]~~ [122]~~[1212]~~
ΔkW_{fan}	Electric demand savings per fan motor	Central A/C: 0.116 No Central A/C: 0	kW/unit	[122]~~[1212]~~

Variable	Description	Value	Units	Ref
		Unknown: 0.05[34]		
hp	Efficient circulator motor horsepower	Site-specific	HP	
Eff_b	Baseline motor efficiency	Site-specific, if unknown look up in Table 2-89	N/A	[124]~~[1234]~~
Eff_q	Efficient motor efficiency	Site-specific, if unknown look up in Table 2-89	N/A	[124]~~[1234]~~
LF	Motor load Factor	0.9	N/A	[123]~~[1223]~~ [125]~~[1245]~~
hrs_h	Operating hours during the heating season	3,504	hrs/yr	[125]~~[1245]~~
hrs_c	Operating hours during the cooling season[35]	2,208	hrs/yr	[125]~~[1245]~~
hrs	Total operating hours	5,712	hrs/yr	
0.746	Conversion factor for HP to kWh	0.746	kW/HP	
CF_{fan}	Electric coincidence factor fan	Look up in Table 2-91	N/A	
CF_{pump}	Electric coincidence factor pump	Look up in Table 2-91	N/A	
EUL	Effective Useful Life	See Measure Life ~~Measure Life~~ Section	Years	
RUL	Remaining Useful Life	See Measure Life ~~Measure Life~~ Section	Years	

Table 2-89 Default Motor Efficiency by Motor Type

Motor Type	Assumed Efficiency
Shaded Pole (SP)	0.40
Permanent Split Capacitor (PSC)	0.50
ECM	0.70

[34] Weighted average calculated using RECS 2020 Data -https://www.eia.gov/consumption/residential/data/2020/hc/pdf/HC%207.7.pdf
[35] Cooling assumes three months (92 days) of 24 hour operation

Table 2-90 Annual Fan Energy Savings

Climate Region	Annual Energy Saved (ΔkWh_{fan})					HDD	CDD
	Total with Central AC	Total without Central AC	Circulation Mode	Heating Mode	Cooling Mode		
North	435	323	211	112	112	6,136	934
Coastal	404	298	211	87	106	4,795	886
Central	434	313	211	102	121	5,588	1,008
Pine barrens	425	312	211	101	113	5,529	945
Southwest	440	314	211	103	126	5,658	1,048
Statewide Average	429	312	211	101	117	5,553	973

*The percent difference in HDD is applied to the Heating Mode column kWh savings and the percent difference in the CDD is applied to the Cooling Mode column kWh savings.

Peak Factors

Table 2-91 Peak Factors

Peak Factor	Value	Ref
Fan coincidence factor (CF_{fan})	0.68	[122]~~[1212]~~
Pump coincidence factor (CF_{pump})	0.8	[126]~~[1256]~~
Natural gas peak day factor (PDF)	N/A	

Measure Life

The remaining useful life (RUL) for retrofit projects is limited to the RUL of the host equipment. If unknown, assume 1/3 of the host equipment EUL.

References

~~[120]~~[121] ONJSC: Monthly/Annual Temperature Normals (1991-2020). http://climate.rutgers.edu/stateclim_v1/norms/monthly/index.html

~~[121]~~[122] Annual energy savings per fan motor were calculated for each New Jersey location by scaling the energy savings derived from the evaluation of a 2014 Wisconsin ECM metering study using heating degree days and cooling degree days for each location. Cadmus Group. *Focus on Energy Evaluated Deemed Savings Changes*. November 2014.

~~[122]~~[123] US DOE, *Evaluation of Retrofit Variable-Speed Furnace Fan Motors*, January 2014. https://www.nrel.gov/docs/fy14osti/60760.pdf

~~[123]~~[124] DOE Building Technologies Office. Energy Savings Potential and Opportunities for High-Efficiency Electric Motors in Residential and Commercial Equipment.

Field Code Changed

Field Code Changed

https://www.energy.gov/sites/prod/files/2014/02/f8/Motor%20Energy%20Savings%20Potential%20Report%202013-12-4.pdf. Accessed December 2022

~~[124]~~[125] M Samotyj, *Assessment of New Energy Efficient Circulator Pump Technology*. (EPRI, 2010), Pg 4-3, https://www.epri.com/research/products/1020132

~~[125]~~[126] *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs V9*. (New York State Joint Utilities, 2021), Pg 211, technitechnical-resource-manual-version-9-filed-october-27-2021-effective-january-1-2022.pdf (ny.gov)cal-resource-manual-version-9-filed-october-27-2021-effective-january-1-2022.pdf (ny.gov)

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

2.3.7 DUCT SEALING AND DUCT INSULATION

Market	Residential/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Category	HVAC
Measure Last Reviewed	September 2024
Changes Since Last Version	• ~~Removed non-ducted equipment from look-up tables~~ • ~~Clarified notes before algorithms~~ • ~~Removed references to DI Baseline Condition and dual baseline~~

Description

This measure describes evaluating the savings associated with performing duct sealing using mastic sealant or metal tape to the distribution system of homes with either central air conditioning or a ducted heating system. The measure also applies to insulating ductwork in unconditioned and semi-conditioned spaces of residential buildings.

If duct insulation is involved with the improvement, the first method, "Evaluation of Distribution Efficiency," must be used to estimate energy savings.

1) "Evaluation of Distribution Efficiency" – this methodology requires the evaluation of three duct characteristics below, and use of the Building Performance Institute's (BPI) "Guidance on Estimating Distribution Efficiency" [127]~~[1267]~~, which are summarized in

Table 2-93

~~Table 2-93~~ and Table 2-94 for convenience.

- Duct location, including percentage of duct work found within the conditioned space
- Duct leakage evaluation. The duct leakage assessment values are based on an assumption of 6.5% of assumed air handler flow (tight); 21% (average); or 35% (leaky).
- Duct insulation evaluation

Determine Distribution Efficiency by evaluating duct system before and after duct sealing using Building Performance Institute "Guidance on Estimating Distribution Efficiency" or the values reproduced from that document in Table 2-94 that match the duct system, and if the majority of the duct system is in conditioned space add the matching value fromTable 2-95, not to exceed 100%.

2) RESNET Test 380 4.4.2 – this method involves the pressurization of the house to 25 Pascals with reference to outside and a simultaneous pressurization of the duct system to reach equilibrium with the envelope or inside pressure of zero Pascals. A blower door is used to pressurize the building to 25 Pascals with reference to outside, when that is achieved the

duct blaster is used to equalize the pressure difference between the duct system and the house. The amount of air required to bring the duct system to zero Pascals with reference to the building is the amount of air leaking through the ductwork to the outside. This technique is described in detail in section 4.4.2 of the ANSI/RESNET/ICC 380 - 2016 Standards: http://www.resnet.us/professional/standards

Field Code Changed

Baseline Case

The baseline condition is existing leaky duct work within the unconditioned space in the home.

Efficient Case

The efficient condition is sealed duct work throughout the unconditioned space in the home.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

Calculate electric savings for cooling equipment and/or electric heating equipment, if applicable.

Methodology 1: Evaluation of distribution efficiency

$$\Delta kWh = \Delta kWh_{cooling} + \Delta kWh_{heating}$$

Where,

$$\Delta kWh_{cooling} = \frac{DE_{post,cool} - DE_{pre,cool}}{DE_{post,cool}} \times EFLH_{cool} \times \frac{Cap_{cool}}{SEER}$$

$$\Delta kWh_{heating} = \frac{DE_{post,heat} - DE_{pre,heat}}{DE_{post,heat}} \times EFLH_{heat} \times \frac{Cap_{heat}}{HSPF}$$

Methodology 2: RESNET Test 803.7

$$\Delta kWh = \Delta kWh_{cooling} + \Delta kWh_{heating}$$

Where,

$$\Delta kWh_{cooling} = \frac{CFM_{25B} - CFM_{25Q}}{400} \times EFLH_{cool} \times \frac{12}{SEER}$$

$$\Delta kWh_{heating} = \frac{CFM_{25B} - CFM_{25Q}}{400} \times EFLH_{heat} \times \frac{12}{HSPF}$$

Annual Fuel Savings

Calculate fuel savings for fuel heating equipment, if applicable.

$$\Delta Therms = \frac{\frac{DE_{post,heat} - DE_{pre,heat}}{DE_{post,heat}} \times EFLH_{heat} \times Cap_{heat}}{AFUE \times 100}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh_{cooling}}{EFLH_{cool}} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-92 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
$\Delta kWh_{cooling}$	Annual electric energy savings, cooling	Calculated	kWh/yr	
$\Delta kWh_{heating}$	Annual electric energy savings, heating	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
Cap_{cool}	Capacity of air cooling system	Site-specific	kBtu/hr	
Cap_{heat}	Capacity of air heating system	Site-specific	kBtu/hr	
CFM_{25B}	Standard duct leakage test result at 25 Pascal pressure differential of the duct system prior to sealing	Site-specific	CFM	
CFM_{25Q}	Standard duct leakage test result at 25 Pascal pressure differential of the duct system after sealing	Site-specific	CFM	
SEER	Seasonal energy efficiency ratio	Site-specific, if unknown look up in Table 2-95	Btu/W·hr	[127]~~[1267]~~
HSPF	Heating seasonal performance factor	Site-specific, if unknown look up in Table 2-95	Btu/W·hr	[127]~~[1267]~~
DE_{post}	Distribution efficiency after duct sealing and insulation	Look up in Table 2-93	N/A	[128]~~[1278]~~

Variable	Description	Value	Units	Ref
		~~Table 2-93~~. For conditioned area, look up adder in Table 2-94		
DE_{pre}	Distribution efficiency before duct sealing and insulation	Look up in Table 2-93 ~~Table 2-93~~. For conditioned area, look up adder in Table 2-94	N/A	[128]~~[1278]~~
AFUE	Annual fuel utilization efficiency	Look up in Table 2-96 ~~Table 2-96~~	N/A	[127]~~[1267]~~
$EFLH_{cool}$	Cooling equivalent full load hours	Lookup in **Error! Reference source not found.**~~Appendix C:~~ Heating and Cooling EFLH	Hrs	
$EFLH_{heat}$	Heating equivalent full load hours	Lookup in **Error! Reference source not found.**~~Appendix C:~~ Heating and Cooling EFLH	Hrs	
400	Rule of Thumb, CFM/ton	Site-specific, if unknown use 400	CFM/ton	
12	Unit conversion, kBtu/hr·ton	12	kBtu/ hr·ton	
100	Unit conversion, kBtu/therm	100	kBtu/therm	
CF	Electric coincidence factor	Look up in Table 2-97	N/A	
PDF	Gas peak day factor	Look up in Table 2-97	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 2-93 Distribution Efficiencies

Duct Insulation	Location	Attic		Basement		Vented Crawl	
	Leakage Assessment / HVAC Type	Heat	Cool	Heat	Cool	Heat	Cool
R-0	Leaky	0.69	0.61	0.93	0.81	0.74	0.76
	Average	0.73	0.64	0.94	0.87	0.78	0.83
	Tight	0.77	0.73	0.95	0.94	0.82	0.91
R-2	Leaky	0.76	0.65	0.94	0.83	0.80	0.78
	Average	0.82	0.74	0.96	0.88	0.85	0.85
	Tight	0.87	0.84	0.97	0.95	0.90	0.93
R-4+	Leaky	0.79	0.67	0.95	0.83	0.82	0.79
	Average	0.84	0.77	0.96	0.89	0.87	0.86

Duct Insulation	Location	Attic		Basement		Vented Crawl	
	Leakage Assessment / HVAC Type	Heat	Cool	Heat	Cool	Heat	Cool
	Tight	0.90	0.87	0.98	0.95	0.92	0.94
R-8+	Leaky	0.80	0.69	0.95	0.83	0.84	0.79
	Average	0.86	0.79	0.97	0.89	0.89	0.87
	Tight	0.92	0.90	0.98	0.95	0.94	0.94

For duct systems partly in unconditioned and conditioned space, add the values from Table 2-94 below to DE_{pre} and DE_{post} determined from

Table 2-93

~~Table 2-93~~, with a max DE of 100%. Use the 50% adder values if 50% or more of the duct system is inside a conditioned space. Use the 80% adder values if 80% of more of the duct system is inside a conditioned space.

Table 2-94 Distribution Efficiencies Adders for Conditioned Space

Location	Attic				Basement				Vented Crawl			
HVAC Type	Heat		Cool		Heat		Cool		Heat		Cool	
Insulation/ Conditioned	50%	80%	50%	80%	50%	80%	50%	80%	50%	80%	50%	80%
R-0	0.06	0.11	0.04	0.09	0.02	0.03	0.02	0.03	0.06	0.11	0.03	0.05
R-2	0.04	0.06	0.04	0.07	0.01	0.01	0.01	0.02	0.03	0.05	0.02	0.03
R-4+	0.03	0.04	0.03	0.05	0.01	0.01	0.01	0.01	0.02	0.04	0.01	0.03
R-8+	0.02	0.03	0.02	0.03	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.02

Table 2-95 SEER and HSPF Values

Product Class	SEER	HSPF
Split systems – air conditioners	13	-
Split systems – heat pumps	14	8.2
Single package units – air conditioners	14	-
Single package units – heat pumps	14	8.0

Table 2-96 AFUE Values

Product Class	Efficiency Value	Efficiency Unit
Non-weatherized gas furnaces	0.80	AFUE
Mobile home gas furnaces	0.80	AFUE
Non-weatherized oil-fired furnaces	0.83	AFUE
Mobile home oil-fired furnaces	0.75	AFUE
Weatherized gas furnaces	0.81	AFUE

Product Class	Efficiency Value	Efficiency Unit
Weatherized oil-fired furnaces	0.78	AFUE
Electric furnaces	3.412	HSPF

Peak Factors

Table 2-97 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.69	[129]~~[1289]~~
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 2-98 Measure Life

Equipment	EUL	RUL	Ref
Duct Sealing & Duct Insulation	15	5	[131]~~[1301]~~

References

~~[126]~~[127] 10 CFR Subpart C of Part 430, https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32

~~[127]~~[128] Building Performance Institute, Duct Efficiency Tables, http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf

~~[128]~~[129] BG&E, Development of Residential Load Profile for Central Air Conditioners and Heat Pumps.

~~[129]~~[130] Residential Energy Services Network, ANSI/RESNET/ICC 380-2019. http://www.resnet.us/blog/wp-content/uploads/2016/01/ANSI-RESNET-ICC_380-2016-posted-on-website-6-15-16.pdf

~~[130]~~[131] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

2.3.8 HEAT OR ENERGY RECOVERY VENTILATOR

Market	Residential/Multifamily
Baseline Condition	NC/TOS
Baseline	Code
End Use Subcategory	Heat Recovery
Measure Last Reviewed	December 2022

Description

This measure covers the installation of Energy Recovery Ventilators (ERV) and Heat Recovery Ventilators (HRV). ERVs and HRVs reduce heating and cooling loads while maintaining required ventilation rates by facilitating heat transfer between outgoing conditioned air and incoming outdoor air. ERVs and HRVs employ air-to-air heat exchangers to recover energy from exhaust air for the purpose of pre-conditioning outdoor air prior to supplying the conditioned air to the space, either directly or as part of an air-conditioning system. This measure only applies in cases where ERV/HRV functionality is not required by federal, state, local, or municipal codes or standards. For the purposes of this measure, ERVs and HRVs are distinguished as follows:

- Energy Recovery Ventilator (ERV): Transfers both sensible (heat content) and latent (moisture content) heat between supply and exhaust airstreams.
- Heat Recovery Ventilator (HRV): Transfers sensible heat only between supply and exhaust airstreams.

Baseline Case

The baseline condition for this measure is a single- or multifamily dwelling with an IECC 2021-compliant exhaust fan system with no heat or energy recovery.

Efficient Case

The compliance condition for this measure is a single- or multifamily dwelling with an ASHRAE 62.2-compliant exhaust fan system equipped with AHRI certified ERV or HRV components.

Annual Energy Savings Algorithm

Note: Conversions from SEER to SEER2, EER to EER2, and HSPF to HSPF2 can be found in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~.

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_c + \Delta kWh_h + \Delta kWh_{fan}$$

Cooling energy savings:

For ERVs:

$$\Delta kWh_c = \frac{4.5 \times CFM \times Eff_{hx,total} \times \left(H_{outdoor,c} - H_{indoor}\right)}{1{,}000 \times SEER2} \times hrs_c$$

For HRVs:

$$\Delta kWh_c = \frac{1.08 \times CFM \times Eff_{hx,sens} \times \left(T_{outdoor,c} - T_{indoor}\right)}{1{,}000 \times SEER2} \times hrs_c$$

Heating energy savings (both ERVs and HRVs):

$$\Delta kWh_h = \frac{1.08 \times CFM \times Eff_{hx,sens} \times \left(T_{indoor} - T_{outdoor,h}\right)}{1{,}000 \times HSPF2} \times F_{ElecHeat} \times hrs_h$$

Fan energy savings:

$$\Delta kWh_{fan} = \Delta kW_{fan} \times (hrs_h + hrs_c)$$

$$\Delta kW_{fan} = CFM \times \left(\frac{1}{(cfm/watt)_b} - \frac{1}{(cfm/watt)_q}\right) \times \frac{1}{1{,}000}$$

Annual Fuel Savings

$$\Delta Therms = \frac{1.08 \times CFM \times Eff_{hx,sens} \times \left(T_{indoor,h} - T_{oudoor,h}\right)}{100{,}000 \times AFUE} \times F_{FuelHeat} \times hrs_h$$

Summer Peak Demand Savings

$$\Delta kW_{Peak} = \left(\frac{1.08 \times CFM \times Eff_{hx,sense} \times (T_{outdoor,c,peak} - T_{indoor,c})}{1{,}000 \times EER} + \Delta kW_{fan}\right) \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-99 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ΔkWh_{c}	Annual electric energy savings during cooling season	Calculated	kWh	
ΔkWh_{h}	Annual electric energy savings during heating season	Calculated	kWh	
ΔkWh_{fan}	Annual electric energy savings due to fan operation	Calculated	kWh	
CFM	Flow rate of supply air passing through ERV/HRV	Site-specific	Ft^3/min	
$(cfm/watt)_b$	Baseline ERV/HRV fan efficacy	Look up in Table 2-103	cfm/watt	[138]~~[1378]~~
$(cfm/watt)_q$	Efficient ERV/HRV fan efficacy	Site-specific	cfm/watt	
$Eff_{hx,total}$	Total effectiveness of heat exchanger per rating in accordance with AHRI Standard 1060	Site-specific	N/A	[132]~~[1312]~~
Effhx,sens	Sensible effectiveness of heat exchanger per rating in accordance with AHRI Standard	Site-specific, if unknown use 0.65	N/A	[138]~~[1378]~~
SEER2	Seasonal average energy efficiency of electric cooling equipment	Site-specific, if unknown lookup in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~ for equipment type and size	Btu/watt-hour	
EER2	Energy efficiency ratio of electric cooling equipment[36]	Site-specific, if unknown lookup in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~ for equipment type and size	Btu/watt-hour	

[36] If needed, calculate EER as follows:
$EER = (1.12 \times SEER) - (0.02 \times SEER^2)$

Variable	Description	Value	Units	Ref
HSPF2	Heating seasonal performance factor of electric heating equipment[37]	Site-specific, if unknown lookup in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~ for equipment type and size	Btu/watt-hour	
AFUE	Efficiency of fossil fuel heating equipment (AFUE, Et or Ec)	Site-specific, if unknown lookup in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~ for equipment type and size	N/A	
$T_{indoor,h}$	Indoor heating setpoint temperature	Site-specific, if unknown use 70	°F	
$T_{indoor,c}$	Indoor cooling setpoint temperature	Site-specific, if unknown use 70	°F	
H_{indoor}	Enthalphy of indoor air	Lookup in Table 2-100 based on T_{indoor}	Btu/lb	
HP	Total fan horsepower	Site-specific	HP	
LF	Load factor	Site-specific, if unknown use 0.92	N/A	[137]~~[1367]~~
hrs_c	Operating hours in the cooling season	Look up in Table 2-100	hrs	[135]~~[1345]~~
hrs_h	Operating hours in the heating season	Look up in Table 2-100	hrs	[135]~~[1345]~~
$T_{outdoor,c}$	Temperature of outside air during cooling	Look up in Table 2-101	Btu/lb	[136]~~[1356]~~
$T_{outdoor,h}$	Temperature of outside air during heating	Look up in Table 2-101	Btu/lb	[136]~~[1356]~~
$T_{outdoor,c,peak}$	Peak outdoor temperature during cooling season	Look up in Table 2-104	°F	[139]~~[1389]~~
$H_{outdoor,c,peak}$	Peak Enthalpy of outdoor air during cooling season	Look up in Table 2-104	°F	[139]~~[1389]~~
$H_{outdoor,c}$	Enthalpy of outside air during cooling	Lookup in Table 2-101	Btu/lb	[136]~~[1356]~~
$F_{ElecHeat}$	Electric heating factor, to account for presence of electric heat	Use 1 if electric heat, otherwise use 0	N/A	
$F_{FuelHeat}$	Fuel heating factor, to account for presence of fuel heat	Use 1 if fuel heat, otherwise use 0	N/A	
1.08	Specific heat of air × density of inlet air @ 70°F × 60 min/hr	1.08	BTU/h.°F.CFM	

[37] If needed, convert COP to HSPF as follows:
$HSPF = COP \times 3.412$. COP for electric resistance heat is 1.0

Variable	Description	Value	Units	Ref
4.5	Density of inlet air at 70 °F x 60 min/hr	4.5	Lb.min/ft^3.hr	
60	Minutes per hour	60	Min/hr	
1,000	Conversion factor, one kW equals 1,000 Watts	1,000	W/kW	
100,000	Conversion from Btu to therms	100,000	Btu/therm	
0.746	Conversion from horsepower to kW	0.746	kW/hp	
CF	Electric coincidence factor	Look up in Table 2-105	N/A	[133]~~[1323]~~
PDF	Gas peak day factor	Look up in Table 2-105	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 2-100 Indoor Enthalpy

Temperature, T_{indoor} (°F)	Enthalpy, H_{indoor} at 50% Relative Humidity (Btu/lb)	Temperature, T_{indoor} (°F)	Enthalpy, H_{indoor} at 50% Relative Humidity (Btu/lb)
65	22.7	72	26.4
66	23.2	73	27.0
67	23.7	74	27.5
68	24.2	75	28.1
69	24.8	76	28.7
70	25.3	77	29.3
71	25.8	78	29.9

Table 2-101 Heating and Cooling Hours[38]

NJ Climate Region	Heating Hours, hrs_h	Cooling Hours, hrs_c
Northern	4,970	1,670
Southwest	4,896	1,783
Coastal	4,981	1,954
Central	4,969	1,810

[38] Calculated from TMY3 data for representative weather stations for each NJ climate zone. Cooling hours are defined as any hour when outdoor air temperature is above 65°F for the months of June through August and heating hours are defined as any hour when outdoor air temperature is below 65°F for the months of October through April. The heating and cooling hours above represent the count of each in a typical meteorological year.

NJ Climate Region	Heating Hours, hrs_h	Cooling Hours, hrs_c
Pine Barrens	4,899	1,828
Statewide Average	4,955	1,808

Table 2-102 Outdoor Air Temperature and Enthalpy

NJ Climate Region	Avg. outdoor temperature during cooling season, $T_{outdoor,c}$ (°F)	Avg. outdoor temperature during heating season, $T_{outdoor,h}$ (°F)	Avg. enthalpy[39] of outdoor air at during cooling season, $H_{outdoor,c}$ (Btu/lb)
Northern	74.6	42.1	13.1
Southwest	74.5	42.7	27.8
Coastal	73.0	46.2	27.0
Central	74.3	43.2	27.7
Pine Barrens	73.7	43.4	27.4
Statewide Average	74.1	43.5	25.1

Table 2-103 Baseline Fan Efficacy

Fan Location	Airflow Rate Minimum (CFM)	Minimum Efficacy (CFM/Watt)
HRV,ERV	Any	1.2
In-line supply or exhaust fan	Any	3.8
Other exhaust fan	<90	2.8
Other exhaust fan	>= 90	3.5
Unknown	Any	2.8

Table 2-104 Peak Outdoor Air Temperature and Enthalpy

NJ Climate Region	Peak outdoor temperature during cooling season, $T_{outdoor,c,peak}$ (°F)	Peak Enthalpy of outdoor air at duing cooling season, $H_{outdoor,c,peak}$ (Btu/lb)
Northern	89	40.24
Southwest	93	42.28
Coastal	90	41.26
Central	93	42.28
Pine Barrens	94	41.22

[39] Assuming 50% relative humidity

NJ Climate Region	Peak outdoor temperature during cooling season, $T_{outdoor,c,peak}$ (°F)	Peak Enthalpy of outdoor air at duing cooling season, $H_{outdoor,c,peak}$ (Btu/lb)
Statewide Average	92	41.65

Peak Factors

Table 2-105 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.69	[133]~~[1323]~~
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The effective useful life (EUL) is 14 years [134]~~[1334]~~.

References

~~[131]~~[132] Performance Rating of air-to-air exchanges for Energy Recovery Ventilation Equipment, AHRI, December 2022. http://www.ahrinet.org/ERVcertification

~~[132]~~[133] Based on BG&E 'Development of Residential Load Profile for Central Air Conditioners and Heat Pumps' research, the Maryland Peak Definition coincidence factor is 0.69. This study is not publicly available, but is referenced by M. M. Straub, Using Available Information for Efficient Evaluation of Demand-Side Management Programs, Electricity Journal, and supported by research conducted by Cadmus on behalf of the RM Management Committee, September 2011.

~~[133]~~[134] PA Consulting Group Inc., Focus on Energy Evaluation Business Programs: Measure Life Study, final report, August 2009 https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf

~~[134]~~[135] ONJSC: Monthly/Annual Temperature Normals (1991-2020), December 2022 http://climate.rutgers.edu/stateclim_v1/norms/monthly/index.html.

~~[135]~~[136] NSRDB, TMY3 data, December 2022. https://nsrdb.nrel.gov/data-sets/tmy

~~[136]~~[137] *Proposed Standard Savings Estimation Protocol for Ultra-Premium Efficiency Motors*, Cascade Energy, November 5, 2012. Table 6: Load Factor by Nameplate hp and End Use. November 5, 2012

~~[137]~~[138] "2021 INTERNATIONAL ENERGY CONSERVATION CODE (IECC) | ICC DIGITAL CODES." n.d. Table C403.8.5. Codes.iccsafe.org. Accessed November 16, 2022. https://codes.iccsafe.org/content/IECC2021P2/chapter-4-ce-commercial-energy-efficiency.

~~[138]~~[139] ASHRAE Fundamentals 2021 - Chapter 14 Climactic Design Conditions - https://handbook.ashrae.org/Handbook.aspx#. Peak temperature and enthalpy taken from data from representative weather stations for each NJ climate zone.

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

2.3.9 MAINTENANCE

Market	Residential /Multifamily
Baseline Type	RF
Baseline	Existing
End Use Subcategory	Maintenance
Measure Last Reviewed	December 2022

Description

This section provides energy savings algorithms for existing HVAC maintenance in residential applications.

For gas applications, a tune-up of residential fossil fuel space heating boilers or furnaces results in improved seasonal heating efficiency. A tune-up typically involves inspection, cleaning the heating unit of dust and dirt, checking safety components, and/or adjustment of boiler and appurtenances per manufacturer's recommendations.

A gas savings calculation requires measurement of steady state furnace or boiler efficiency before and after maintenance using an electronic combustion analyzer. Alternatively, before and after maintenance efficiencies may be measured following the method described in ANSI/ASHRAE Standard 103-2007, Method of Testing for Annual Fuel Utilization Efficiency of Residential Central Furnaces and Boilers. Maximum post-maintenance efficiency must not exceed equipment nameplate efficiency. Technicians performing maintenance must provide documentation of before- and after-combustion analysis results.

Electric Units such as Central A/C and heat pumps also benefit greatly from tune ups. A tune up typically includes cleaning filters, inspecting bearings, verification of refrigerant charge and correct, if necessary, clean condenser, and if accessible, evaporator coil.

Note that gas savings calculations (therms) are only applicable for gas units, whereas electric saving calculations are only applicable for electric units.

Baseline Case

Gas: Residential fossil fuel space heating boiler or furnace in a single family or low-rise *Multifamily* building that has not received a tune-up in 5 years or more.

Electric: An existing central A/C, air source heat pump, ground source heat pump, ductless mini-split heat pump, mini-split AC, PTAC, or PTHP unit that has not received a tune-up in 5 years or more.

Efficient Case

Gas: Residential fossil fuel space heating boiler or furnace that has undergone a tune-up in accordance with the manufacturer's recommendations.

Electric: Electric unit after receiving tune-up.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_c + \Delta kWh_h$$

Where,

$$\Delta kWh_c = \frac{Cap_c}{SEER} \times SF \times EFLH_c$$

$$\Delta kWh_h = \frac{Cap_h}{HSPF} \times SF \times EFLH_h$$

For geothermal heat pumps:

$$SEER = EER_g \times GSHPDF \times GSER$$

$$HSPF = COP_g \times GSHPDF \times 3.412$$

For PTAC and PTHP:

$$SEER = EER$$

Annual Fuel Savings

$$\Delta Therms = Cap_{in} \times ELFH_h \times \frac{\left(\frac{1}{SSE_b} - \frac{1}{SSE_q}\right)}{100}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{Cap_c}{EER} \times SF \times CF$$

For geothermal heat pumps:

$$EER = EER_g \times GSPK$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-106 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ΔkWh_c	Annual electric cooling energy savings	Calculated	kWh/yr	
ΔkWh_h	Annual electric heating energy savings	Calculated	kWh/yr	
SSE_b	Steady state efficiency of baseline gas HVAC equipment	Site-specific	N/A	
SSE_q	Steady state efficiency of repaired gas HVAC equipment	Site-specific	N/A	
Cap_c	Cooling Capacity of electrical unit receiving tune-up	Site-specific	kBtu/hr	
Cap_h	Heating Capacity of electrical unit receiving tune-up	Site-specific	kBtu/hr	
Cap_{in}	Input capacity of unit receiving tune-up	Site-specific	kBtu/hr	
EER	Energy Efficiency Ratio of unit receiving tune-up	Site-specific. If unknown, see **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~	Btu/W-h	[143]~~[1423]~~
EER_g	Full Load Energy Efficiency Ratio of ground source heat pump receiving tune up (this is measured differently than EER of an ASHP and must be converted)	Site-specific	Btu/W-h	

Variable	Description	Value	Units	Ref
SEER/EER/HSPF/SEER2, EER2, HSPF2	Efficiency of unit receiving tune-up	Site-specific. If unknown, see Error! Reference source not found.~~Appendix E: Code-Compliant Efficiencies~~	Btu/W-h	[143]~~[1423]~~
COP_g	Full Load coefficient of Performance of ground source heat pump receiving tune-up	Site-specific	N/A	
HSPF	Heating Seasonal Performance Factor of unit receiving tune-up	Site-specific. If unknown, see Error! Reference source not found.~~Appendix E: Code-Compliant Efficiencies~~	Btu/W-h	[143]~~[1423]~~
SF	Savings factor, assumed savings due completion of tune up[40]	0.05	N/A	[149]~~[1489]~~
$EFLH_h$	Equivalent Full Load Hours of operation for the average unit during the heating season	Lookup in Error! Reference source not found.~~Appendix C:~~ Heating and Cooling EFLH	Hours	[140]~~[139140]~~
$EFLH_c$	Equivalent Full Load Hours of operation for the average unit during the cooling season[41]	Lookup in Error! Reference source not found.~~Appendix C:~~ Heating and Cooling EFLH	Hours	[142]~~[1412]~~
GSER	Factor used to determine the SEER of a GSHP based on its EER_g	1.02	Btu/W-h	

[40] VEIC estimate. Extrapolation of manufacturer data.
[41] VEIC Estimate. Consistent with analysis of PEPCo and LIPA, and conservative relative to ARI.

Variable	Description	Value	Units	Ref
GSPK	Factor to convert EER_g to the equivalent EER of an air conditioner to enable comparisons to the baseline unit	0.8416	N/A	
GSHPDF	Ground Source Heat Pump De-rate Factor	0.885	N/A	
3.412	Conversion from Btu to W-h	3.412	Btu/W-h	
CF	Electric coincidence factor	Look up in Table 2-107	N/A	
PDF	Gas peak day factor	Look up in Table 2-107	N/A	
EUL	Estimated useful life	Look up in Table 2-108	Years	
100	Conversion from kBtu to therms	100	kBtu/Therms	

Peak Factors

Table 2-107 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.69	[141]~~[1401]~~
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

Measure life is dependent on the gas/electric equipment receiving a tune-up.

Table 2-108 Measure Life

Equipment	EUL	Ref
Air Conditioner – Room (RAC)	12	[144]~~[1434]~~
Air Conditioner – Central (CAC)	15	[145]~~[1445]~~
Air Conditioner – PTAC	15	[145]~~[1445]~~
Boiler, Hot Water – Steel Water Tube	24	[146]~~[1456]~~
Boiler, Hot Water – Steel Fire Tube	25	[146]~~[1456]~~
Boiler, Hot Water – Cast Iron	35	[146]~~[1456]~~
Boiler, Steam – Steel Water Tube	30	[146]~~[1456]~~
Boiler, Steam – Steel Fire Tube	25	[146]~~[1456]~~

Equipment	EUL	Ref
Boiler, Steam – Cast Iron	30	[146]~~[1456]~~
Furnace, Gas Fired	22	[147]~~[1467]~~
Gas Heat Pump	15	[145]~~[1445]~~
Heat Pump - Air Source (ASHP)	15	[145]~~[1445]~~
Heat Pump – Ground Source (GSHP)	25	[148]~~[1478]~~
Heat Pump – PTHP	15	[145]~~[1445]~~
Ductless Mini-Split	15	[150]~~[149150]~~

References

~~[139]~~[140] NJ utility analysis of heating customers, annual gas usage.
~~[140]~~[141] NEEP, *Mid-Atlantic Technical Reference Manual*, *V10* (May 2020).
~~[141]~~[142] VEIC estimate.
~~[142]~~[143] NMR Group, Inc., *2018 Pennsylvania Statewide Act 129 Residential Baseline Study* (Feb 2018). https://www.puc.pa.gov/Electric/pdf/Act129/SWE-Phase3_Res_Baseline_Study_Rpt021219.pdf
~~[143]~~[144] GDS Associates, Inc., *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures* (June 2007) Table 1 – Residential Measures.
~~[144]~~[145] DEER 2014 EUL. http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx
~~[145]~~[146] ASHRAE Handbook, 2015.
~~[146]~~[147] U.S. DOE. *Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Furnaces* and *Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Commercial Warm Air Furnaces* (2016). https://www.regulations.gov/document?D=EERE-2014-BT-STD-0031-0217
~~[147]~~[148] ASHRAE: Owning and Operating Cost Database, Equipment Life/Maintenance Cost Survey. https://xp20.ashrae.org/publicdatabase/system_service_life.asp?selected_system_type=1
~~[148]~~[149] *Residential HVAC Installation Practices: A Review of Research Findings* (US DOE, 2018), Pg 5. https://www.energy.gov/eere/buildings/articles/residential-hvac-installation-practices-review-research-findings
~~[149]~~[150] Based on 2016 DOE Rulemaking Technical Support Document, as recommended in Navigant 'ComEd Effective Useful Life Research Report', May 2018. https://www.icc.illinois.gov/docket/P2017-0312/documents/287811/files/501915.pdf

Field Code Changed
Field Code Changed
Field Code Changed
Field Code Changed
Field Code Changed
Field Code Changed

2.3.10 BOILER CONTROLS

Market	Residential/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use	HVAC
Measure Last Reviewed	September 2024
Changes Since Last Version	• ~~Added default boiler capacity per PY2 evaluation results~~

Description

This measure applies to the installation of reset controls to a residential heating boiler to adjust the boiler water temperature based on the outdoor air temperature. A boiler reset control has two temperature sensors - one outside the house and one in the boiler water. As the outdoor temperature rises and falls, the control adjusts the water temperature to the lowest setting required to meet heating demand.

The input values are based on data supplied by the utilities and customer information on the application form, confirmed with manufacturer data. Unit savings are based on study results.

Baseline Case

Existing boiler without reset controls.

Efficient Case

Installation of boiler reset controls. The system's minimum temperature setpoint must be set no more than 10 degrees above manufacturer's recommended minimum return temperature.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Annual Fuel Savings

$$\Delta Therms = SF \times \frac{EFLH_h \times Cap_{in}}{100}$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = N/A$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-109 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
Cap_{in}	Input capacity of boiler	Site specific. If unknown, use 117	kBtu/hr	[156]
SF	Savings factor, estimated percent reduction in heating load due to controls being installed.	0.05	N/A	[151]~~[1501]~~
$EFLH_h$	Estimated full load hours for heating	Lookup in **Error! Reference source not found.**~~Appendix C:~~ Heating and Cooling EFLH	hrs	[152]~~[1512]~~
EUL	Effective useful life	Lookup in Table 2-111	Years	
PDF	Peak day factor	Lookup in Table 2-110		
100	Conversion from kBtu to therm	100	kBtu	

Peak Factors

Table 2-110 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The effective useful life (EUL) of boiler controls is the smaller of to the remaining useful life (RUL) of the boiler or 7.33 years. If boiler RUL is unknown, assume 1/3 of the boiler EUL.

Table 2-111 Measure Life

Equipment	EUL	RUL	Ref
Boiler, Hot Water – Steel Water Tube	24	8	[153]~~[1523]~~
Boiler, Hot Water – Steel Fire Tube	25	8.33	[557]~~[5557]~~
Boiler, Hot Water – Cast Iron	35	11.67	[557]~~[5557]~~
Boiler, Steam – Steel Water Tube	30	10	[557]~~[5557]~~
Boiler, Steam – Steel Fire Tube	25	8.33	[557]~~[5557]~~
Boiler, Steam – Cast Iron	30	10	[557]~~[5557]~~

References

~~[150]~~[151] GDS Associates, Inc. Natural Gas Energy Efficiency Potential in Massachusetts, 2009, p. 38 Table 6-4. https://ma-eeac.org/wp-content/uploads/5_Natural-Gas-EE-Potenial-in-MA.pdf
~~[151]~~[152] Simulations of prototypical buildings from the NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022.
~~[152]~~[153] ASHRAE Handbook, 2015.
~~[153]~~[154] ETG PY2 Impact Evaluation

Field Code Changed

2.3.11 FILTER WHISTLE

Market	Residential/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Filter Whistle
Measure Last Reviewed	December 2022
Changes Since Last Version	• ~~Removed references to DI Baseline Condition and dual baseline~~

Description

This section provides energy savings algorithms for filter whistles on air handlers installed in residential settings. Dirty air handler filters result in increases energy consumption for the circulation fan and decreases system heating and cooling efficiency. These whistles attach to the filter of the air handler and make a sound when it is time to replace the filter.

Savings estimates are based on reduced blower fan motor power requirements for winter and summer use of the blower fan motor. This air handler filter whistle measure applies to central forced-air furnaces, central AC and heat pump systems. Where homes do not have central cooling, only the annual heating savings will apply.

Baseline Case

Air Handler Filter without Filter Whistle

Efficient Case

Air Handler Filter with Filter Whistle to promote regular replacement of filter

Annual Energy Savings Algorithm

Annual Electric Energy Savings

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

Where,

$$kW_{motor} = HP \times 0.746$$

$$\Delta kWh_{heat} = kW_{motor} \times EFLH_h \times EI \times ISR$$

$$\Delta kWh_{cool} = kW_{motor} \times EFLH_c \times EI \times ISR$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh_{cool}}{EFLH_c} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-112 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
ΔkWh_h	Annual heating electric energy savings	Calculated	kWh/yr	
ΔkWh_c	Annual cooling electric energy savings	Calculated	kWh/yr	
kW_{motor}	Motor full load electric demand	Calculated, if HP is unknown use 0.377	kW	
HP	Horsepower of blower motor	Site specific, if unknown use 0.5[42]	HP	
$EFLH_h$	Equivalent Full Load Hours of operation for the average unit during the heating season	Lookup in **Error! Reference source not found.**~~Appendix C:~~ Heating and Cooling EFLH	Hours	[155]~~[1545]~~
$EFLH_c$	Equivalent Full Load Hours of operation for the average unit during the cooling season	Lookup in **Error! Reference source not found.**~~Appendix C:~~ Heating and Cooling EFLH	Hours	[156]~~[1556]~~
EI	Efficiency Improvement	15%	N/A	[157]~~[1567]~~
ISR	In-service rate	Look up by program in **Error! Reference source not found.**~~Appendix J: In-Service Rates~~, or use default values: Default for Kits = 15%, Default for Direct Install = 100%	N/A	[158]~~[1578]~~

[42] Typical blower motor capacity for gas furnace is ¼ to ¾ HP, Avg of ½ HP =0.377kW.

Variable	Description	Value	Units	Ref
CF	Electric coincidence factor	Look up in Table 2-113	N/A	
PDF	Gas peak demand factor	Look up in Table 2-113	N/A	
EUL	Effective useful life	See Measure Life Section	Years	[160]~~[159~~160]
0.746	Conversion factor for HP to kWh	0.746	kW/HP	

Peak Factors

Table 2-113 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.69	[159]~~[158~~9]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 2-114 Measure Life

Equipment	EUL	RUL	Ref
Filter Whistle	5	1.67	[160]~~[159~~160]

References

~~[154]~~[155] NJ utility analysis of heating customers, annual gas usage

~~[155]~~[156] VEIC Estimate. Consistent with analysis of PEPCo and LIPA, and conservative relative to ARI.

~~[156]~~[157] Energy.gov *Maintaining Your Air Conditioner* (Accessed 12/16/2022), Says that replacing a dirty air filter with a clean one can lower total air conditioner energy consumption by 5-15%. Since the algorithms in this measure only take into account the blower fan energy use, a 15% savings seems reasonable. https://www.energy.gov/energysaver/maintaining-your-air-conditioner

~~[157]~~[158] The In Service Rate is the average of values reported by FirstEnergy EDCs for kits including an air handler furnace whistle for PY9. http://www.puc.pa.gov/filing_resources/issues_laws_regulations/act_129_information/electric_distribution_company_act_129_reporting_requirements.aspx

~~[158]~~[159] Per NY TRM: "Based on BG&E 'Development of Residential Load Profile for Central Air Conditioners and Heat Pumps' research, the Maryland Peak Definition coincidence factor is 0.69. This study is not publicly available, but is referenced by M. M. Straub, Using Available Information for Efficient Evaluation of Demand-Side Management Programs, Electricity Journal, September 2011 and supported by research conducted by Cadmus on behalf of the RM Management Committee."

~~[159]~~[160] DEER 2020 http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

Field Code Changed

Field Code Changed

Field Code Changed

2.3.12 CEILING FAN

Market	Residential/Multifamily
Baseline Condition	TOS/DI
Baseline	Existing/Dual
End Use Subcategory	Ceiling Fan
Measure Last Reviewed	September 2024
Changes Since Last Version	• ~~Clarified TOS and DI baseline definitions~~ • ~~Clarified when to calculate heating penalty~~ • ~~Moved HVAC interactivity factor look-ups to appendix~~

Description

This section provides energy savings algorithms for the installation of an ENERGY STAR v4.0 ceiling fan/light unit in residential settings. These units are known to be 60% more efficient than conventional units due to improved motors and blade design [161]~~[1601]~~.

Since the savings from this measure are derived from more efficient ventilation and lighting, which have very different load shapes and measure life, the savings are split by component and claimed together.

Baseline Case

TOS: Code compliant ceiling fan/light unit with EISA qualified incandescent or halogen light bulbs.

DI: Use dual baseline. The baseline equipment for the first baseline period is the site-specific existing fan . The baseline equipment for the second baseline period is a code-compliant fan/light weith EISA qualified incandescent or halogen light bulbs.

Efficient Case

An ENERGY STAR v4.0 certified ceiling fan/lighting unit with LED bulbs.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{fan} + \Delta kWh_{light}$$

Where,

$$\Delta kWh_{fan} = \frac{\text{Days} \times Hrs_{fan} \times \left[\left(F_{low,b} \times W_{low,b}\right) + \left(F_{med,b} \times W_{med,b}\right) + \left(F_{high,b} \times W_{high,b}\right)\right]}{1{,}000} - \frac{\text{Days} \times Hrs_{fan} \times \left[\left(F_{low,q} \times W_{low,q}\right) + \left(F_{med,q} \times W_{med,q}\right) + \left(F_{high,q} \times W_{high,q}\right)\right]}{1{,}000}$$

$$\Delta kWh_{light} = \frac{W_{b,light} - W_{q,light}}{1{,}000} \times Hrs_{light} \times (1 + HVAC_e)$$

Annual Fuel Savings

If fan is located in unconditioned/exterior space:

$$\Delta Therms = 0$$

Heating penalty from improved lighting, if fan is located in heated space:

$$\Delta Therms = -\frac{W_{b,light} - W_{q,light}}{1{,}000} \times Hrs_{light} \times HF \times \frac{0.03412}{Eff_{heat}} \times F_{FH}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \Delta kW_{fan} + \Delta kW_{light}$$

Where,

$$\Delta kW_{fan} = \frac{W_{high,b} - W_{high,q}}{1{,}000} \times CF_{fan}$$

$$\Delta kW_{light} = \frac{W_{b,light} - W_{q,light}}{1{,}000} \times CF_{light} \times (1 + HVAC_d)$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms:

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 2-115 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{fan}	Annual ceiling fan savings	Calculated	kWh/yr	
ΔkWh_{light}	Annual light savings	Calculated	kWh/yr	
ΔkW_{fan}	Annual fan peak demand savings	Calculated	kW	
ΔkW_{light}	Annual light peak demand savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
Days	Days used per year	Site-specific, if unknown use 365	Days/yr	[164]~~[1634]~~
Hrs_{fan}	Daily Fan "On Hours"	Site-specific, if unknown use 3	Hrs/day	[164]~~[1634]~~
$W_{low,b}$	Fan wattage at Low speed of baseline	TOS: 15 DI: Site-specific, if unknown use 15	Watts	[164]~~[1634]~~
$W_{med,b}$	Fan wattage at Medium speed of baseline	TOS: 34 DI: Site-specific, if unknown use 34	Watts	[164]~~[1634]~~
$W_{high,b}$	Fan wattage at High speed of baseline	TOS: 67 DI: Site-specific, if unknown use 67	Watts	[164]~~[1634]~~
$W_{low,q}$	Fan wattage at Low speed of ENERGY STAR	TOS: 6 DI: Site-specific, if unknown use 6	Watts	[164]~~[1634]~~
$W_{med,q}$	Fan wattage at Medium speed of ENERGY STAR	TOS: 23 DI: Site-specific, if unknown use 23	Watts	[164]~~[1634]~~

Variable	Description	Value	Units	Ref
$W_{high,q}$	Fan wattage at High speed of ENERGY STAR	TOS: 56 DI: Site-specific, if unknown use 56	Watts	[164]~~[1634]~~
$W_{b,light}$	Total lighting wattage of baseline fixture	TOS: 129 DI: Site-specific, if unknown use 129	Watts	[164]~~[1634]~~
$W_{q,light}$	Total lighting wattage of energy efficient fixture	TOS: 42 DI: Site-specific, if unknown use 42	Watts	[164]~~[1634]~~
F_{FH}	Fraction of homes using fossil fuel heat	Look up in **Error! Reference source not found.**~~Appendix K: DHW and Space Heat Fuel Split~~	N/A	
$F_{low,b}$	Fraction of time spent at Low speed of baseline	0.4	N/A	[164]~~[1634]~~
$F_{med,b}$	Fraction of time spent at Medium speed of baseline	0.4	N/A	[164]~~[1634]~~
$F_{high,b}$	Fraction of time spent at High speed of baseline	0.2	N/A	[164]~~[1634]~~
$F_{low,q}$	Fraction of time spent at Low speed of ENERGY STAR	0.4	N/A	[164]~~[1634]~~
$F_{med,q}$	Fraction of time spent at Medium speed of ENERGY STAR	0.4	N/A	[164]~~[1634]~~
$F_{high,q}$	Fraction of time spent at High speed of ENERGY STAR	0.2	N/A	[164]~~[1634]~~
1,000	Conversion from W to kW	1,000	W/kW	
Hrs_{light}	Lighting hours of operation	Look up in Table 2-116	Hrs/yr	[162]~~[1612]~~[163]~~[1623]~~
$HVAC_e$	HVAC Interactive Factor for Annual Energy Savings	Look up in **Error! Reference source not found.**~~Appendix F: HVAC Interactivity Factors~~	N/A	[162]~~[1612]~~
$HVAC_d$	HVAC Interactive Factor for Peak Demand Savings	Look up in **Error! Reference source not found.**~~Appendix F: HVAC Interactivity Factors~~	N/A	[162]~~[1612]~~
HF	Heating Factor	0.47	N/A	

Variable	Description	Value	Units	Ref
Eff_{heat}	Efficiency of heating system	0.8	N/A	
CF	Electric coincidence factor	Look up in Table 2-117	N/A	
PDF	Gas peak demand factor	Look up in Table 2-117	N/A	
EUL	Effective useful life of new unit	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 2-116 Lighting Hours

Installation Location	Hrs
Interior	679
Exterior	1643
Unknown	808

Peak Factors

Table 2-117 Peak Factors

Peak Factor	Value	Ref
Fan coincidence factor (CF_{fan})	0.3	[165]~~[1645]~~
Light coincidence factor (CF_{light})	0.06	[162]~~[1612]~~
Natural gas peak day factor (PDF)	N/A	N/A

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 2-118 Measure Life

Equipment	EUL	RUL	Ref
Ceiling Fan	15	5	[162]~~[1612]~~

References

~~[160]~~[161] “Ceiling Fans.” n.d. Www.energystar.gov. https://www.energystar.gov/products/ceiling_fans.

~~[161]~~[162] "MID-ATLANTIC TECHNICAL REFERENCE MANUAL VERSION 9." n.d. Accessed November 23, 2022. https://neep.org/sites/default/files/resources/Mid_Atlantic_TRM_V9_Final_clean_wUpdateSummary%20-%20CT%20FORMAT.pdf .

~~[162]~~[163] DNV KEMA Energy and Sustainability, Pacific Northwest National Laboratory, *Residential Lighting End-Use Consumption Study: Estimation Framework and Initial Estimates*. (US DOE, 2012), Table 4.4, https://www1.eere.energy.gov/buildings/publications/pdfs/ssl/2012_residential-lighting-study.pdf

~~[163]~~[164] https://www.energystar.gov/sites/default/files/asset/document/light_fixture_ceiling_fan_calculator.xlsx

~~[164]~~[165] Assuming that the CF for a ceiling fan is the same as Room AC; Consistent with coincidence factors found in: *RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners*, (June 23, 2008) http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf

Field Code Changed

Field Code Changed

Field Code Changed

2.3.13 SMART THERMOSTAT

Market	Residential/Multifamily
Baseline Condition	RF/TOS
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	February 2024
Changes Since Last Version	• ~~Removed references to DI Baseline Condition and dual baseline~~ • ~~Corrected capacity units in parameters table~~ • ~~Added ISR parameter to algorithms~~ • ~~Added deemed savings for Midstream delivery method~~

Description

This measure covers the installation of Smart or Connected ENERGY STAR® V1.0[43] thermostats applied to single-family and multifamily residential HVAC systems. A "smart" thermostat that is ENERGY STAR® certified has the following properties [168]~~[1678]~~.

- Automatic scheduling
- Occupancy sensing (set "on" as a default)
- For homes with a heat pump, smart thermostats must be capable of controlling heat pumps to optimize energy use and minimize the use of backup electric resistance heat.
- Ability to adjust settings remotely via a smart phone or online. In the absence of connectivity to the connected thermostat (CT) service provider, retain the ability for residents to locally:
    - View the room temperature,
    - View and adjust the set temperature, and
    - Switch between off, heating and cooling
- Have a static temperature accuracy ≤ ± 2.0 °F
- Have network standby average power consumption of ≤ 3.0 W average (Includes all equipment necessary to establish connectivity to the CT service provider's cloud, except those that can reasonably be expected to be present in the home, such as Wi-Fi routers and smart phones.)

[43] ENERGY STAR® V2.0 Connected Thermostats is under development.

- Enter network standby after ≤ 5.0 minutes from user interaction (on device, remote or occupancy detection)
- The following capabilities may be enabled through the CT device, CT service or any combination of the two. The CT product shall maintain these capabilities through subsequent firmware and software changes.
  - Ability for consumers to set and modify a schedule.
  - Provision of feedback to occupants about the energy impact of their choice of settings.
  - Ability for consumers to access information relevant to their HVAC energy consumption, e.g. HVAC run time.

Baseline Case

Mix of standard non-programmable and programmable thermostats for central heating and cooling systems

Efficient Case

Smart Thermostat meeting the measure description above.

Annual Energy Savings Algorithms

Note: Conversions from SEER to SEER2, EER to EER2, and HSPF to HSPF2 can be found in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~.

Annual Electric Energy Savings

$$\Delta kWh = ISR \times (\Delta kWh_{cool} + \Delta kWh_{heat})$$

Where,

$$\Delta kWh_{cool} = \left(Cap_c \times EFLH_{cool} \times \frac{1}{SEER2} \times SF_{elec,c} \times F_{elecCool}\right)$$

$$\Delta kWh_{heat} = \left(Cap_{h,out} \times EFLH_{heat} \times \frac{1}{HSPF2} \times SF_{elec,h} \times F_{elecHeat}\right)$$

Annual Fuel Savings

$$\Delta Therms = ISR \times Cap_{h,fuel} \times EFLH_{heat} \times \frac{1}{AFUE} \times SF_{fuel} \times F_{fuelHeat} \times \frac{1}{100}$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-119 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated For Online Marketplace or Midstream delivery, look up in Table 2-119	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ΔkWh_{cool}	Cooling electric savings	Calculated	kWh/yr	
ΔkWh_{heat}	Heating electric savings	Calculated	kWh/yr	
Cap_c	Cooling capacity per residence	Site-specific, if unknown use 36 kBTU/hr[44]	kBtu/hr	[173]~~[1723]~~
SEER2	Seasonal energy efficiency ratio of cooling unit	Site-specific, if unknown, look up in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~	Btu/W-h	[166]~~[1656]~~
$EFLH_{cool}$	Equivalent full load hours of operation during cooling season	Look up in **Error! Reference source not found.**~~Appendix C: Heating and Cooling EFLH~~	Hours	[167]~~[1667]~~
$SF_{elec,c}$	Cooling energy savings factor	0.07	N/A	[171]~~[1701]~~
$F_{elecCool}$	Electric cooling factor; used to account for the presence or absence of an electric cooling system	Electric Cooling: 1 No Electric Cooling: 0	N/A	[169]~~[1689]~~

[44] Assumes a 1,800 ft² home with 20 BTU/h-ft2 cooling load: 1,800 ft2 x 20 BTU/h-ft2 x 1/(1,000 kBTU/h)/(BTU/h) = 36 kBTU/h

Variable	Description	Value	Units	Ref
		Unknown: 0.39		
$Cap_{h,out}$	Output heating capacity in kBTU/h per residence	Site-specific, if unknown use 72 kBtu/hr[45]	kBtu/hr	[173]~~[1723]~~
$Cap_{h,fuel}$	Heating capacity in of existing fossil heat unit	Site-specific, if unknown use 90 kBtu/hr[46]	kBtu/hr	[173]~~[1723]~~
HSPF2	Heating seasonal performance factor of heating unit. If rated in COP, convert using HSPF = COP x 3.412	Site-specific, if unknown look up in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~	Btu/W-h	[166]~~[1656]~~
$EFLH_{heat}$	Equivalent full load hours of operation during heating season	Look up in **Error! Reference source not found.**~~Appendix C: Heating and Cooling EFLH~~	Hours	[167]~~[1667]~~
AFUE	Annual fuel utilization efficiency	Site-specific, if unknown look up in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~	N/A	[166]~~[1656]~~
SF_{fuel}	Fuel heating energy savings factor	0.06	N/A	[171]~~[1701]~~
$SF_{elec,h}$	Electric heating energy savings factor	0.06	N/A	[171]~~[1701]~~
$F_{elecHeat}$	Electric heating factor; used to account for the presence or absence of an electric heating system	Electric Heating: 1 No Electric Heating: 0 Unknown: look up by program in **Error! Reference source not found.**~~Appendix K: DHW and Space Heat Fuel Split~~, or default = 0.15	N/A	[170]~~[169170]~~
$F_{FuelHeat}$	Fossil fuel heating factor; used to account for the presence or absence of a fossil fuel heating system	Fossil Fuel Heating: 1 No Fossil Fuel Heating: 0 Unknown: look up by program in **Error! Reference source not found.**~~Appendix K: DHW and Space Heat Fuel Split~~, or default = 0.95	N/A	[170]~~[169170]~~

[45] Assumes a 1,800 ft² home with 40 Btu/h-ft² heating load: 1,800 ft² x 40 Btu/h-ft² x 1/(1,000 kBtu/h)/(Btu/h) = 72 kBtu/h
[46] Assumes a 1,800 ft² home with 40 Btu/h-ft² heating load and 80% AFUE: 1,800 ft² x 40 Btu/h-ft² x 1/0.80 x 1/(1,000 kBtu/h)/(Btu/h) = 90 kBtu/h

Variable	Description	Value	Units	Ref
100	Conversion factor, kBTU to therms	100	kBTU/therms	
CF	Electric coincidence factor	Look up in Table 2-121	N/A	
PDF	Gas peak day factor	Look up in Table 2-121	N/A	
EUL	Effective useful life	See Measure Life Section	Years	
ISR	In-service rate	Lookup in Appendix J. Default is 1.0	N/A	

Table 2-120 Deemed Savings for Online Marketplace Smart Thermostats

CEF-II Equipment Combinations	ΔkWh	ΔkW	ΔTherms
Boiler and No Cooling	0	-	62.0357
Furnace (Non-Weatherized) and No Cooling	0	-	65.1375
Electric Resistance	1,221.805	-	0
CAC, No Heating	160.603	-	0
CAC, Boiler	160.603	-	62.0357
CAC, Furnace (Non-Weatherized)	160.603	-	65.1375
CAC, Electric Resistance	1,382.408	-	0
ASHP - Split	706.3351	-	0
ASHP - Package	782.8119	-	0

Peak Factors

Table 2-121 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The effective useful life (EUL) is 5 years [172]~~[1712]~~.

References

~~[165]~~[166] "2012 INTERNATIONAL ENERGY CONSERVATION CODE (IECC) | ICC DIGITAL CODES." n.d. Codes.iccsafe.org. Accessed January 23, 2023 https://codes.iccsafe.org/content/IECC2012P5/chapter-4-ce-commercial-energy-efficiency

~~[166]~~[167] Simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

~~[167]~~[168] *ENERGY STAR® Program Requirements Product Specification for Connected Thermostat Products, Eligibility Criteria Version 1.0*, (January 2017), pg. 10 https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Program%20Requirements%20for%20Connected%20Thermostats%20Version%201.0.pdf

~~[168]~~[169] EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States, Table HC7.7 https://www.eia.gov/consumption/residential/data/2015/hc/php/hc7.7.php ("Unknown" calculated as the number of homes with central AC divided by the total number of homes).

~~[169]~~[170] EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States, Table HC6.7 https://www.eia.gov/consumption/residential/data/2015/hc/php/hc6.7.php ("Unknown" calculated as the number of homes with electric heat divided by the total number of homes).

~~[170]~~[171] *TRM Mid-Atlantic Technical Reference Manual:Version 10* (NEEP, 2020), Pg 104, https://neep.org/mid-atlantic-technical-reference-manual-trm-v10

~~[171]~~[172] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

~~[172]~~[173] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs, Version 10, Pg 308

2.4 LIGHTING

2.4.1 LAMPS AND FIXTURES

Market	Residential/Multifamily
Baseline Condition	TOS/NC/RF/EREP/ERET/DI
Baseline	Existing/Code
End Use Subcategory	Lighting
Measure Last Reviewed	September 2024
Changes Since Last Version	• ~~Moved HVAC interactivity factor look-ups to appendix~~ • ~~Corrected AML and RUL labels in measure life table~~ • ~~Corrected hours value in parameters table~~

Description

This section provides energy saving algorithms for the installation of screw-in ENERGY STAR LED general service lamps, ENERGY STAR LED fixtures, ENERGY STAR specialty LED lamps, Nightlights, and Holiday Lights.

Savings from lamps and fixtures are based on the difference between the baseline lamp/fixture wattage and new lamp/fixture wattage, and the average daily hours of usage for the lighting unit being replaced.

For ENERGY STAR Lamps, baseline lamp/fixture wattage is based on the lumen output of the ENERGY STAR lamp/fixture and a minimum lamp/fixture lumen per watt efficacy. Using the relationship in this section, the baseline lamp wattage for General Service Lamps is installed lumens divided by 45 lumens per watt, compliant with Federal regulations issued on May 8, 2022 and New Jersey P.L. 2021, c. 464 minimum standards[181]~~[1801]~~. Full compliance with this standard by retailers shall commence on August 1, 2023[180]~~[179180]~~.

Baseline Case

ENERGY STAR Lamps and Fixtures: Baseline wattage assumed to equal to the installed lumens divided by 45 lumens per watt for general service bulbs in kits and retail distribution. For direct install lights exempt from or installed prior to enforcement of the EISA requirement, if the site-specific baseline wattage is unknown, use the baseline wattage assumptions in Table 2-123, Table 2-124, and Table 2-125.

Nightlights: Non LED Nightlights, assumed 6.75 watts.

Holiday Lights: Traditional incandescent holiday lights with a wattage higher than the LED wattage. For incandescent mini-bulbs, incandescent C7 bulbs, and incandescent C9 bulbs, assume baselines of 0.48, 6, and 7 watts per bulb respectively.

Efficient Case

ENERGY STAR Lamps and Fixtures: Qualifying Lamp/Fixture ENERGY STAR wattage

Nightlights: Qualifying LED Nightlight wattage.

Holiday Lights: Qualifying LED Holiday Lights wattage.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

ENERGY STAR Lamps and Fixtures:

$$\Delta kWh = N_q \times \frac{W_{b,ES} - W_{q,ES}}{1{,}000} \times Hrs_{ES} \times (1 + HVAC_c) \times ISR$$

Where,

$$W_{b,ES} = \frac{Lumen_q}{45}$$

Nightlights:

$$\Delta kWh = \frac{W_{NL} \times H_{NL,daily} \times 365}{1{,}000}$$

Holiday Lights:

$$\Delta kWh = [F_{C9} \times \Delta kWh_{C9}] + [F_{C7} \times \Delta kWh_{C7}] + [F_{mini} \times \Delta kWh_{mini}]$$

Where,

$$\Delta kWh_{C9} = \frac{\left[\left(W_{b,C9} - W_{q,C9}\right) \times N_{bulbs} \times N_{strands} \times Hrs_{HL}\right]}{1{,}000}$$

$$\Delta\, kWh_{C7} = \frac{\left[\left(W_{b,C7} - W_{q,C7}\right) \times N_{bulbs} \times N_{strands} \times Hrs_{HL}\right]}{1{,}000}$$

$$\Delta\, kWh_{mini} = \frac{\left[\left(W_{b,mini} - W_{q,mini}\right) \times N_{bulbs} \times N_{strands} \times Hrs_{HL}\right]}{1{,}000}$$

Annual Fuel Savings

ENERGY STAR Lamps and Fixtures:

$$\Delta Therms = -N_q \times \frac{W_{b,ES} - W_{q,ES}}{1{,}000} \times Hrs \times HVAC_{ff} \times \frac{0.03412}{Eff_{heat}} \times F_{FH}$$

No fuel savings associated with Nightlights and Holiday Lights.

Peak Demand Savings

ENERGY STAR Lamps and Fixtures:

$$\Delta kW_{Peak} = N_q \times \frac{W_{b,ES} - W_{q,ES}}{1,000} \times CF \times (1 + HVAC_d)$$

No Peak Demand Savings associated with Nightlights and Holiday Lights.

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-122 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
N_q	Quantity of energy efficient fixtures	Site-specifc	N/A	
$W_{b,ES}$	Wattage of baseline fixture	EISA Compliant: Calculated based on algorithm above Exempt from EISA Compliance: Site-specific, if unkown look up in Table 2-123, Table 2-124, Table 2-125	kW	[184]~~[1834]~~
$W_{q,ES}$	Wattage of energy efficient fixture	Site-specifc	kW	
$Lumens_q$	Lumens of energy efficient fixture	Site-specific	Lumens	
F_{mini}	Percentage of holiday lights that are “mini”	Site-specific, if unknown use 0.5	%	[178]~~[1778]~~

Variable	Description	Value	Units	Ref
F_{C7}	Percentage of holiday lights that are "C7"	Site-specific, if unknown use 0.25	%	[178]~~[1778]~~
F_{C9}	Percentage of holiday lights that are "C9"	Site-specific, if unknown use 0.25	%	[178]~~[1778]~~
N_{bulbs}	Number of bulbs per strand	Site-specific, if unknown use 50	Bulbs/Strand	[179]~~[1789]~~
$N_{strands}$	Number of strands of lights per package	Site-specific, if unknown use 1	Strands/package	[179]~~[1789]~~
Hrs_{ES}	Annual Hours of Operation	Site-specific, if unknown use 679	Hrs/yr	[174]~~[1734]~~
$HVAC_c$	HVAC Interactive Factor for Annual Energy Savings	Look up in **Error! Reference source not found.**~~Appendix F: HVAC Interactivity Factors~~	N/A	[174]~~[1734]~~
$HVAC_d$	HVAC Interactive Factor for Peak Demand Savings	Look up in **Error! Reference source not found.**~~Appendix F: HVAC Interactivity Factors~~	N/A	[174]~~[1734]~~
$HVAC_{ff}$	Heating factor, or percentage of lighting savings that must be heated	Look up in **Error! Reference source not found.**~~Appendix F: HVAC Interactivity Factors~~	N/A	[174]~~[1734]~~
ISR	In-service rate	Look up by program in **Error! Reference source not found.**~~Appendix J: In-Service Rates~~, or use default value = 0.92	N/A	[187]~~[1867]~~
Eff_{heat}	Efficiency of heating system	0.8	N/A	[183]~~[1823]~~
F_{FH}	Fraction of homes using fossil fuel heat	0.8	N/A	[182]~~[1812]~~
W_{NL}	Average watts replaced for an LED nightlight installation	6.75	W	[176]~~[1756]~~
$Hrs_{NL,daily}$	Average daily burn time for LED nightlight replacements	12	hrs	[177]~~[1767]~~
365	Days per year	365	Day/yr	
1,000	Conversion from watts to kW	1,000	W/kW	
0.03412	Conversion factor	0.03412	Therms/kWh	
$W_{q,mini}$	Wattage of LED mini bulbs	0.08	W/Bulb	[178]~~[1778]~~
$W_{b,mini}$	Wattage of incandescent mini bulbs	0.48	W/Bulb	[178]~~[1778]~~
$W_{q,C7}$	Wattage of LED C7 bulbs	0.48	W/Bulb	[178]~~[1778]~~
$W_{b,C7}$	Wattage of incandescent C7 bulbs	6	W/Bulb	[178]~~[1778]~~
$W_{q,C9}$	Wattage of LED C9 bulbs	2	W/Bulb	[178]~~[1778]~~
$W_{b,C9}$	Wattage of incandescent C9 bulbs	7	W/Bulb	[178]~~[1778]~~

Variable	Description	Value	Units	Ref
45	Conversion from lumens of energy efficient fixture to wattage of baseline fixture	45	Lumens/watt	
Hrs_{HL}	Annual hours of operation for Holiday Lights	150	Hrs/yr	[178]~~[1778]~~
CF	Electric coincidence factor	Look up in Table 2-126	N/A	
PDF	Gas peak day factor	Look up in Table 2-126	N/A	
EUL	Effective useful life (use AML for EREP/DI, use EUL for TOS/NC per Measure Life Section)	See Measure Life Section	Years	

Table 2-123 Exempt Standard Lamp Baselines

Bulb Type	Lumen Range	$W_{b,ES}$
A-Lamp (A15, A17, A19, A21)	< 310	Use ENERGY STAR Watts Equivalent
	310 – 749	40
	750 – 1,049	60
	1,050 – 1,489	75
	1,490 – 2,600	100
	> 2,600	Use ENERGY STAR Watts Equivalent

Table 2-124 Exempt Specialty Lamps Baseline

Bulb Type	Base Type	Lumen Range	$W_{b,ES}$
Globe All G (G30, G25, G16.5)	E26 and E17	< 90	Use ENERGY STAR Watts Equivalent
		90 – 179	10
		180 – 249	20
		250 – 349	25
		350 – 749	40
		750 – 1,049	43
		1,050 – 1,489	53
		1,490 – 2,600	72
		> 2,600	Use ENERGY STAR Watts Equivalent
	E12 (Candelabra)	< 90	Use ENERGY STAR Watts Equivalent
		90 – 179	10
		180 – 249	20
		250 – 349	25
		350 – 499	40
		500 – 1,049	60
		> 1,049	Use ENERGY STAR Watts Equivalent
Globe (G40)		< 90	Use ENERGY STAR Watts Equivalent

Bulb Type	Base Type	Lumen Range	$W_{b,ES}$
	E26 (Medium), E17, and E12	90 – 179	10
		180 – 249	20
		250 – 349	25
		350 – 499	40
		500 – 1,049	60
		> 1,049	Use ENERGY STAR Watts Equivalent

Bulb Type	Base Type	Lumen Range	$W_{b,ES}$
Decorative (Shapes B10, B11, B13, BA10, BA11, CA10, C7, C9, F10, F15, ST, S14)	E26 (Medium) and E17	< 70	Use ENERGY STAR Watts Equivalent
		70 – 89	10
		90 – 149	15
		150 – 299	25
		300 – 749	40
		750 – 1,049	43
		1050 – 1,489	53
		1,490 – 2,600	72
		> 2,600	Use ENERGY STAR Watts Equivalent
	Candelabra base E12	< 70	Use ENERGY STAR Watts Equivalent
		70 – 89	10
		90 – 149	15
		150 – 299	25
		300 – 449	40
		450 – 1,049	60
		> 1,049	Use ENERGY STAR Watts Equivalent

Table 2-125 Exempt Reflector/Flood Lamps Baseline

Bulb Type	Lumen Range	$W_{b,ES}$
R20	200 - 299	30
	300 – 718	45
	719 – 810	50
	811 – 1,002	55
	1,003 – 1,202	65
	1,203 – 1,516	75
	1,517 – 1,733	90
	1,734 – 2,184	100
	> 2,184	120
PAR20	200 - 299	30
	300 – 718	40
	719 – 810	50
	811 – 1,002	55
	1,003 – 1,202	65
	1,203 – 1,516	75
	1,517 – 1,733	90
	1,734 – 2,184	100

Bulb Type	Lumen Range	$W_{b,ES}$
	> 2,184	120
BR30, BR40, ER40	200 – 299	30
	300 – 399	40
	400 – 649	50
	650 – 1,419	65
	1,420 – 1,789	75
	1,790 – 2,045	90
	2,046 – 2,578	100
	> 2,578	120
ER30	200 – 299	30
	300 – 399	40
	400 – 956	50
	957 – 1183	55
	1184 – 1419	65
	1420 – 1789	75
	1790 – 2045	90
	2046 – 2578	100
	> 2578	120
PAR30, PAR38, R40	639 – 847	40
	848 – 956	50
	957 – 1,183	55
	1,184 – 1,419	65
	1,420 – 1,789	75
	1,790 – 2,045	90
	2,046 – 2,578	100
	> 2,578	120
R14, PAR16, R16	200 – 299	30
	300 – 399	40
	400 – 499	50
	500 – 599	60
	600 – 1,000	65
MR16	< 450	35

Bulb Type	Lumen Range	$W_{b,ES}$
	450 – 600	50
	> 600	75
For any lamps/bulb types for reflector lamps not captured in the criteria above	All	Use ENERGY STAR Watts Equivalent

Peak Factors

Table 2-126 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.06	[174]~~[1734]~~
Natural gas peak day factor (PDF)	N/A	

Measure Life

Table 2-127 Measure Life

Equipment	AML (for EREP/DI)	EUL (for NC/TOS)	Ref
Lamps and Fixtures	4	15	[185]~~[1845]~~[186]~~[1856]~~[188]~~[1878]~~

References

~~[173]~~[174] "MID-ATLANTIC TECHNICAL REFERENCE MANUAL VERSION 9." n.d. Accessed November 23, 2022. https://neep.org/sites/default/files/resources/Mid_Atlantic_TRM_V9_Final_clean_wUpdateSummary%20-%20CT%20FORMAT.pdf .

~~[174]~~[175] DNV KEMA Energy and Sustainability, Pacific Northwest National Laboratory, *Residential Lighting End-Use Consumption Study: Estimation Framework and Initial Estimates*. (US DOE, 2012), Table 4.4, https://www1.eere.energy.gov/buildings/publications/pdfs/ssl/2012_residential-lighting-study.pdf

~~[175]~~[176] Jackie Berger, *NJ Comfort Partners Energy Saving Protocols and Engineering Estimates*. (Applied Public Policy Research Institute for Study and Evaluation (APPRISE), 2014), Pg 21, https://www.njcleanenergy.com/files/file/Protocol%20and%20Engineering%20Estimate%20Summary.pdf .

~~[176]~~[177] *Southern California Edison Company, LED, Electroluminescent & Fluorescent Night Lights: Work Paper WPSCRELG0029 Rev.1,* (February 2009), pp. 2–3

~~[177]~~[178] The DSMore Michigan Database of Energy Efficiency Measures: Based on spreadsheet calculations using collected data

~~[178]~~[179] Typical values of lights per strand and strands per package at Home Depot and other stores

~~[179]~~[180] "Regulations.gov." n.d. Www.regulations.gov. Accessed December 1, 2022. https://www.regulations.gov/document/EERE-2021-BT-STD-0012-0022.

~~[180]~~[181] "New Jersey A5160 | 2020-2021 | Regular Session." n.d. LegiScan. Accessed December 1, 2022. https://legiscan.com/NJ/bill/A5160/2020.

~~[181]~~[182] https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430#430.32

~~[182]~~[183] Based on RECS 2015 data for Middle Atlantic Region (Table HC6.7).

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

~~[183]~~[184] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – Version 10. (New York State Joint Utilities, 2022), Pg 341-344, https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V10.pdf

~~[184]~~[185] ENERGY STAR® Program Requirements Product Specification for Lamps (Light Bulbs) V2.1, June 2017, pg. 19 (Capped at 20 years). https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Lamps%20V2.1%20Final%20Specification.pdf

~~[185]~~[186] ENERGY STAR® Program Requirements Product Specification for Luminaires (Light Fixtures) V2.2, August 2019, pg. 18 (Capped at 20 years). https://www.energystar.gov/sites/default/files/Luminaires%20V2.2%20Final%20Specification.pdf

~~[186]~~[187] 2021 Pennsylvania TRM, Volume 2, Residential Measures, http://www.puc.pa.gov/pcdocs

~~[187]~~[188] Residential AML value based on analysis conducted in Maryland. Reference: Recommended Estimated Useful Life Assumptions for the EmPOWER Upstream Lighting Programs, Joint Recommendation, PSC Staff, PSC Independent Evaluator, Office of Peoples Counsel, Maryland Energy Administration and EmPOWER Electric Utilities, Case No. 9648.

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

2.4.2 OCCUPANCY SENSOR

Market	Residential/Multifamily
Baseline Condition	RF/TOS
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	February 2024
Changes Since Last Version	• ~~Removed references to DI Baseline Condition and dual baseline~~

Description

This measure defines the savings associated with installing a wall-mounted occupancy sensor that switches lights off after a brief delay when it does not detect occupancy.

Baseline Case

The baseline case is lighting controlled by a manual switch.

Efficient Case

The efficient condition is lighting that is controlled with an occupancy sensor. It is assumed that the controlled load is a mix of efficient and inefficient lighting.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = (W_q/1{,}000) \times hrs \times SVG_e \times ISR \times (1 + HVAC_c)$$

Annual Fuel Savings

$$\Delta Therms = (W_q/1{,}000) \times hrs \times SVG_e \times ISR \times HVAC_{ff}$$

Peak Demand Savings

$$\Delta kW_{Peak} = (W_q/1{,}000) \times SVG_e \times ISR \times CF \times (1 + HVAC_d)$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-128 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
W_q	Total wattage of the fixture(s) being controlled by the occupancy sensor	Site specific, if unknown assume 105.5	W	[200]~~[199~~200]
SVG_e	Percentage of annual lighting energy saved by lighting control	Site-specific, if unknown assume 49%	%	[193]~~[192~~3]
ISR	In service rate or percentage of units rebated that get installed	Site-specific, if unknown use default = 0.98	N/A	[194]~~[193~~4]
Hrs	Average hours of use per year	Look up in	Hours	[189]~~[188~~9][190]~~[189~~0][191]~~[190~~1][192]~~[191~~2]
$HVAC_c$	HVAC Interactive Factor for Annual Energy Savings	Look up in **Error! Reference source not found.**~~Appendix F: HVAC~~	N/A	[192]~~[191~~2]

Variable	Description	Value	Units	Ref
		~~Interactivity Factors~~		
$HVAC_{ff}$	HVAC Interactive Factor for Annual Fuel Savings	Look up in Error! Reference source not found.~~Appendix F: HVAC Interactivity Factors~~	N/A	[192]~~[1912]~~
$HVAC_d$	HVAC Interactive Factor for Peak Demand Savings	Look up in Error! Reference source not found.~~Appendix F: HVAC Interactivity Factors~~	N/A	[192]~~[1912]~~
1000	Unit Conversion, kW/Watts	1,000	kW/W	
CF	Electric coincidence factor	Look up in Table 2-130 Peak Factors ~~Table 2-130 Peak Factors~~	N/A	
PDF	Gas peak day factor	Look up in Table 2-130 Peak Factors ~~Table 2-130 Peak Factors~~	N/A	
EUL	Effective useful life (use AML for EREP/DI, use EUL for TOS/NC per Measure Life Section)	See Measure Life Section	Years	

Table 2-129 Hours

Installation Location	Annual Hours
Residential interior & in-unit Multi Family	679
Multi Family Common Areas	5,950
Unknown	679

Peak Factors

Table 2-130 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	Lookup in Table 2-131	[196]~~[1956]~~[197]~~[1967]~~[198]~~[1978]~~
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Table 2-131 Summer Electric Peak Coincidence Factors

Installation Location	Type	Coincidence Factor (CF)
Residential interior and in-unit Multi Family	Utility Peak CF	0.059
	PJM CF	0.058
Multi Family Common Areas	PJM CF	0.86
Exterior	PJM CF	0.018
Unknown	Utility Peak CF	0.059
	PJM CF	0.058

Measure Life

Table 2-132 Measure Life

Equipment	AML (for EREP/DI)	EUL (for NC/TOS)	Ref
Lamps and Fixtures	4	15	[201]~~[2001]~~[202]~~[2012]~~[203]~~[2023]~~

References

~~[188]~~[189] Based on Navigant Consulting, "EmPOWER Residential Lighting Program: 2016 Residential Lighting Inventory and Hours of Use Study" August 31, 2017, page 13. The HOU value is for an efficient lamp.

~~[189]~~[190] Multi family common area lighting assumption is 16.3 hours per day (5950 hours per year) based on Focus on Energy Evaluation, ACES Deemed Savings Desk Review, November 2010. This estimate is consistent with the Common Area "Non-Area Specific) assumption (16.2 hours per day or 5913 annually) from the Cadmus Group In., "Massachusetts Multifamily Program Impact Analysis", July 2012, p 2-4.

~~[190]~~[191] Unknown" assumes a residential interior or in-unit multifamily application.

~~[191]~~[192] "MID-ATLANTIC TECHNICAL REFERENCE MANUAL VERSION 9." n.d. Accessed November 23, 2022. https://neep.org/sites/default/files/resources/Mid_Atlantic_TRM_V9_Final_clean_wUpdateSummary%20-%20CT%20FORMAT.pdf. https://neep.org/sites/default/files/resources/NEEP_CI_Lighting_LS_FINAL_Report_ver_5_7-19-11_0.pdf

~~[192]~~[193] Average of two studies. Navigant Consulting. Department of Energy Solid-State Lighting Program. Energy Savings Estimates of Solid-State Lighting in General Illumination Lighting Applications. September 2016. This study

Field Code Changed

Field Code Changed

estimates a 71% energy savings from connected lighting in residential applications. (Table F.4). Efficiency Vermont. Smart Lighting & Smart Hub. DIY Install: Does it Yield. August 2016. This study estimates reductions in hours of use of up to 27%. Additionally, the metering study saw significant amounts of dimming of lamps that were on non-dimming circuits, but did not quantify the savings associated with this consumer action.

~~[193]~~[194] First year ISR of 0.9 (EMPOWER MD Lighting Study, EY5). Assume lifetime ISR of 0.99 (2006-2008 California Residential Lighting Evaluations, and used in the Uniform Methods Project). Assume half of bulbs not installed in year one are installed in year two, and the other half in year three. Using a discount rate of 5%, this gives 0.90 + 0.045 * 0.95 + 0.045 * 0.95^2 = 0.98

~~[194]~~[195] The criteria that are used to determine whether equipment is "operational" vary among jurisdictions and there is no related industry standard practice. This TRM provides assumptions for estimating savings and costs for early replacement measures, but does not address this threshold question of whether a measure should be considered early replacement.

~~[195]~~[196] Based on Navigant Consulting "EmPOWER Residential Lighting Program: 2016 Residential Lighting Inventory and Hours of Use Study" August 31, 2017, page 15

~~[196]~~[197] Consistent with value currently used for EmPOWER Maryland Programs as of October 1, 2017. Derived from C&I common area lighting coincidence.

~~[197]~~[198] Calculated from Itron eShapes, which is 8760 hourly data by end use for Upstate New York.

~~[198]~~[199] Navigant, *ComEd Luminaire Level Lighting Control IPA Program Impact Evaluation Report* Table 8.1 Page 10 https://icc.illinois.gov/docket/P2020-0486/documents/299941/files/523013.pdf.

~~[199]~~[200] Statewide Evaluation Team (GDS Associates Inc, Nexant, Research Into Action, Apex Analytics LLC), *Energy Efficiency Potential Study for Pennsylvania* (2015), Appendix D, Pg D-1, https://www.puc.pa.gov/pcdocs/1345079.pdf

~~[200]~~[201] ENERGY STAR® Program Requirements Product Specification for Lamps (Light Bulbs) V2.1, June 2017, pg. 19 (Capped at 20 years). https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Lamps%20V2.1%20Final%20Specification.pdf

~~[201]~~[202] ENERGY STAR® Program Requirements Product Specification for Luminaires (Light Fixtures) V2.2, August 2019, pg. 18 (Capped at 20 years). https://www.energystar.gov/sites/default/files/Luminaires%20V2.2%20Final%20Specification.pdf

~~[202]~~[203] Residential AML value based on analysis conducted in Maryland. Reference: Recommended Estimated Useful Life Assumptions for the EmPOWER Upstream Lighting Programs, Joint Recommendation, PSC Staff, PSC Independent Evaluator, Office of Peoples Counsel, Maryland Energy Administration and EmPOWER Electric Utilities, Case No. 9648.

Field Code Changed

Field Code Changed

Field Code Changed

2.5 PLUG LOAD

2.5.1 OFFICE EQUIPMENT

Market	Residential/Multifamily
Baseline Condition	TOS
Baseline	Code
End Use	Plug Load
Measure Last Reviewed	December 2022

Description

This section provides deemed savings for installing ENERGY STAR office equipment compared to standard efficiency equipment in residential and multifamily applications.

Per unit savings are primarily derived from the ENERGY STAR calculator for office equipment [204]~~[2034]~~.

Baseline Case

The baseline condition is assumed to be standard equipment of similar type used in a residential setting.

Efficient Case

The efficient condition is ENERGY STAR equipment meeting ENERGY STAR v8 Eligibility Criteria [205]~~[2045]~~ and used in a residential setting.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = Lookup\ in\ \text{Table 2-134}\cancel{\text{Table 2-134}}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = Lookup\ in\ \text{Table 2-134}\cancel{\text{Table 2-134}}$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \mathrm{N/A}$$

Calculation Parameters

Table 2-133 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Lookup in Table 2-134	kWh/yr	[204]~~[2034]~~
ΔkW_{Peak}	Peak Demand Savings	Lookup in Table 2-134	kW	[204]~~[2034]~~
ΔkW_{Life}	Lifetime electric energy savings	Calculated	kWh	

Table 2-134 Office Equipment Energy and Demand Savings Values per Unit

Measure		Energy Savings (kWh)	Demand Savings (kW)	Source
Computer (Desktop)		119	0.0161	[204]~~[2034]~~
Computer (Laptop)		22	0.0030	[204]~~[2034]~~
Printer (laser, monochrome)	≤ 5 images/min	37	0.0050	[204]~~[2034]~~
	5 < images/min ≤ 15	26	0.0035	
	15 < images/min ≤ 20	24	0.0031	
	20 < images/min ≤ 30	42	0.0057	
	30 < images/min ≤ 40	50	0.0068	
	40 < images/min ≤ 65	181	0.0244	
	65 < images/min ≤ 82	372	0.0502	
	82 < images/min ≤ 90	542	0.0732	
	> 90 images/min	686	0.0926	
Printer (Ink Jet)		6	0.0008	[204]~~[2034]~~
Multifunction Device (laser, monochrome)	≤ 5 images/min	57	0.0077	[204]~~[2034]~~
	5 < images/min ≤ 10	48	0.0065	
	10 < images/min ≤ 26	52	0.0070	
	26 < images/min ≤ 30	93	0.0126	
	30 < images/min ≤ 50	248	0.0335	

Measure		Energy Savings (kWh)	Demand Savings (kW)	Source
	50 < images/min ≤ 68	420	0.0567	
	68 < images/min ≤ 80	597	0.0806	
	> 80 images/min	764	0.1031	
Multifunction Device (Ink Jet)		6	0.0008	[204]~~[2034]~~
Monitor		8	0.0032	[204]~~[2034]~~

Peak Factors

Peak savings are incorporated in the demand savings values above.

Measure Life

The measure life for residential office equipment is 5 years [206]~~[2056]~~.

References

~~[203]~~[204] ENERGY STAR Office Equipment Calculator https://dnr.mo.gov/sites/dnr/files/media/file/2021/01/office-equipment-calculator.xlsx. Per PA TRM: "Using a commercial office equipment load shape, the percentage of total savings that occur during the PJM peak demand period was calculated and multiplied by the energy savings. As of December 1, 2018, the published ENERGY STAR Office Equipment Calculator does not reflect the current specification for computers (ENERGY STAR® Program Requirements Product Specification for Computers Eligibility Criteria Version 8.0). As a result, the savings values for computers presented in this measure entry reflect savings for V6-compliant models. This characterization should be updated when an updated ENERGY STAR Office Equipment Calculator becomes available."

~~[204]~~[205] ENERGY STAR Computers Final Version 8.0 Specification Rev. July 2022

~~[205]~~[206] Residential desktop measure life. California Public Utilities Commission EUL Table, version 027 (updated November 12, 2022). Accessed December 30, 2022. https://www.caetrm.com/shared-data/value-table/EUL/027/

Field Code Changed

Field Code Changed

Field Code Changed

2.5.2 TELEVISIONS

Market	Residential/multifamily
Baseline Type	TOS
Baseline	Code
End Use Subcategory	Electronics
Measure Last Reviewed	December 2022

s

Description

This measure relates to the upstream promotion of televisions meeting the ENERGY STAR "Most Efficient Television" Eligibility Criteria.

Baseline Case

The baseline condition is assumed to be a television meeting the Energy Star 8.0 efficiency standard and used in a residential setting.

Efficient Case

The efficient condition is an ENERGY STAR television meeting the EPA Most Efficient TV criteria and used in a residential setting.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = kWh_b - kWh_q$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = (kW_b - kW_q) \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \mathrm{N/A}$$

Calculation Parameters

Table 2-135 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
kWh_b	Annual electric energy savings for baseline case	Look up in Table 2-136	kWh/yr	[207]~~[2067]~~[208]~~[2078]~~
kWh_q	Peak Demand Savings for efficient case	Look up in Table 2-136	kWh/yr	[207]~~[2067]~~[209]~~[2089]~~
kW_b	Peak Demand Savings for baseline case	Look up in Table 2-137	kW	[207]~~[2067]~~[208]~~[2078]~~
kW_q	Annual electric energy savings for efficient case	Look up in Table 2-137	kW	[207]~~[2067]~~[209]~~[2089]~~
CF	Coincidence factor	Look up in Table 2-138	N/A	
PDF	Gas peak demand factor	Look up in Table 2-138	N/A	
EUL	Effective useful life of new unit	See Measure Life Section	Years	

Table 2-136 Conventional and ENERGY STAR kWh

Diagonal screen size	Conventional kWhb	ENERGY STAR kWhq
20	35.3	30.9
22	37.8	32.6
26	44.5	37.2
32	54.1	44.0
37	64.1	51.1

Diagonal screen size	Conventional kWhb	ENERGY STAR kWhq
42	75.2	59.0
47	86.9	67.6
52	98.9	76.7
57	110.7	85.9
62	121.9	95.1
65	128.2	100.4

Table 2-137 Conventional and ENERGY STAR kW

Diagonal screen size	Conventional kWb	ENERGY STAR kWq
20	0.018	0.016
22	0.020	0.017
26	0.024	0.020
32	0.029	0.023
37	0.034	0.027
42	0.040	0.032
47	0.047	0.036
52	0.053	0.041
57	0.060	0.046
62	0.066	0.051
65	0.069	0.054

Peak Factors

Table 2-138 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)[47]	0.21	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The estimated useful life (EUL) is 6 years. [207]~~[2067]~~

[47] The coincidence value is an estimate based on the on-mode hours per day (5 hours/day) as a percentage of all hours.

References

~~[206]~~[207] "Consumer_Electronics_Calculator". October 2016. Energystar.gov. Accessed December 9, 2022. https://www.energystar.gov/sites/default/uploads/buildings/old/files/Consumer_Electronics_Calculator.xlsx.

~~[207]~~[208] ENERGY STAR® Program Requirements for Televisions Eligibility Criteria Version 8.0 https://www.energystar.gov/sites/default/files/Final%20V8.0%20TVs%20Program%20Requirements.pdf

~~[208]~~[209] ENERGY STAR® Most Efficient 2020 Recognition Criteria Televsions https://www.energystar.gov/sites/default/files/Televisions%20ENERGY%20STAR%20Most%20Efficient%202020%20Final%20Criteria.pdf

Field Code Changed

Field Code Changed

2.5.3 SMART STRIP

Market	Residential/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	January 2024
Changes Since Last Version	~~Removed references to DI Baseline Condition and dual baseline~~

Description

Advanced Power Strips (APS) are surge protectors that contain a number of power-saver sockets. There are two types of APS: Tier 1 and Tier 2.

Tier 1 APS have a master control socket arrangement and will shut off the items plugged into the controlled power-saver sockets when they sense that the appliance plugged into the master socket has been turned off. Conversely, the appliance plugged into the master control socket has to be turned on and left on for the devices plugged into the power-saver sockets to function.

Tier 2 APS deliver additional functionality beyond that of a Tier 1 unit, as Tier 2 units manage both standby and active power consumption. The Tier 2 APS manage standby power consumption by turning off devices from a control event; this could be a TV or other item powering off, which then powers off the controlled outlets to save energy. Active power consumption is managed by the Tier 2 unit by monitoring a user's engagement or presence in a room by either or both infrared remote signals sensing or motion sensing. After a period of user absence or inactivity, The Tier 2 unit will shut off all items plugged into the controlled outlets, thus saving energy. There are two types of Tier 2 APS available on the market. Tier 2 Infrared (IR) detect signals sent by remote controls to identify activity, while Tier 2 Infrared-Occupancy Sensing (IR-OS) use remote signals as well as an occupancy sensing component to detect activity and sense for times to shut down. Due to uncertainty surrounding the differences in savings for each technology, the Tier 2 savings are blended into a single number.

Baseline Case

The assumed baseline is a standard power strip that does not control any of the connected loads.

Efficient Case

The efficient case is the use of a Tier 1 or Tier 2 Advanced Power Strip.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = Usage \times ERP \times ISR$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = Load \times ERP_{Peak} \times ISR$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \text{N/A}$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-139 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	N/A	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	N/A	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Usage	Annual usage of system connected to power strip	Lookup in Table 2-140	kWh	[210]~~[2109]~~
ERP	Energy reduction percentage	Lookup in Table 2-140	N/A	[210]~~[2109]~~
ISR	In-service rate	Look up by program in Appendix, or use default values in Table 2-140	N/A	[210]~~[2109]~~
Load	Demand of system connected to power strip	Lookup in Table 2-140	kW	[210]~~[2109]~~
ERP_{Peak}	Energy reduction percentage during peak period	Lookup in Table 2-140	N/A	[210]~~[2109]~~
CF	Electric coincidence factor	Look up in Table 2-141	N/A	
PDF	Gas peak demand factor	Look up in Table 2-141	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 2-140 Impact Factors for Advanced Power Strip Types

Strip Type	End-Use	ERP	ERP_{Peak}	ISR	Usage (kWh)	Load (kW)
Tier 1	Home Entertainment Center	0.27	0.20	0.86	471	0.057
Tier 1	Home Office	0.21	0.18	0.86	399	0.043
Tier 1	Unspecified	0.25	0.19	0.81	449	0.051
Tier 2	Unspecified	0.44	0.41	0.76	471	0.058

Peak Factors

Peak demand savings are accounted for in the percent reduction factors presented above.

Table 2-141 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	N/A	

Measure Life

Table 2-142 Measure Life

Equipment	EUL	Ref
Smart Strip	5	[211]~~[2101]~~

References

~~[209]~~[210] RLPNC 17-3: Advanced Power Strip Metering Study," Massachusetts Programs Administrators and EEAC, (Mar. 2019), https://ma-eeac.org/wp-content/uploads/RLPNC_173_APSMeteringReport_Revised_18March2019.pdf

~~[210]~~[211] California eTRM, CPUC Support Tables: Effective Useful Life and Remaining Useful Life, https://www.caetrm.com/cpuc/table/effusefullife/

Field Code Changed

2.5.4 SOUNDBAR

Market	Residential/Multifamily
Baseline Type	TOS
Baseline	Code
End Use Subcategory	Soundbar
Measure Last Reviewed	December 2022

Description

This measure covers soundbars in residential applications meeting the minimum qualifying efficiency standards established under the ENERGY STAR® program, Program Requirements for Audio/Video Version 3.0, effective December 2014. A soundbar is a mains-connected product that offers audio amplification housed in a wide horizontal enclosure. ENERGY STAR® rated soundbars have a lower power draw when in sleep and idle modes and a higher amplifier efficiency than conventional models. Qualified soundbars use about 70% less energy than unqualified equipment.

Baseline Case

The baseline condition is a non-ENERGY STAR® qualified soundbar in a residential application.

Efficient Case

The compliance condition is an ENERGY STAR® qualified soundbar in a residential application with power performance specifications meeting or exceeding the requirements of ENERGY STAR® Program Requirements for Audio/Video Version 3.0, effective December 2014.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = units \times (kWh_b - kWh_q)$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{8{,}760} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \text{N/A}$$

Calculation Parameters

Table 2-143 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Units	Number of measures installed during program	Site-specific	N/A	
kWh_b	Energy consumption for baseline case	77	kWh/yr	[212]~~[2112]~~
kWh_q	Efficient unit energy consumption	29	kWh/yr	[212]~~[2112]~~
8,760	Hours in 1 year	8,760	Hours/yr	
CF	Electric coincidence factor	Look up in Table 2-144	N/A	[214]~~[2134]~~
PDF	Gas peak demand factor	Look up in Table 2-144	N/A	
EUL	Effective useful life	See Measure Life Section	Years	[215]~~[2145]~~

Peak Factors

Table 2-144 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.8	[214]~~[2134]~~
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 7 years. [215]~~[2145]~~

References

~~[211]~~[212] Pacific Gas and Electric Work Paper PGECOAPP128 Retail Products Platform Revision #2, October 2015, pg 74 http://deeresources.net/workpapers

~~[212]~~[213] Retail Products Platform: Product Analysis, Last updated May 25, 2016 – ENERGY STAR® + 15% annual consumption increased by 15% to reflect minimum compliance with ENERGY STAR® Specification V3.0
~~[213]~~[214] Per NY TRM: "No source specified – update pending availability and review of applicable references."
~~[214]~~[215] EPA, Consumer Messaging Guide for Energy Star Certified Consumer Electronics. December 2016. https://www.energystar.gov/sites/default/files/asset/document/CE_Consumer_Messaging.pdf

Field Code Changed

2.5.5 ELECTRIC VEHICLE CHARGERS

Market	Residential/Multifamily
Baseline Condition	TOS
Baseline	ISP
End Use Subcategory	N/A
Measure Last Reviewed	January 2023

Description

The measure is for the purchase of a Level 2 electric vehicle charger consistent with the ENERGY STAR V1.1 specification for Electric Vehicle Supply Equipment (EVSE) installed for residential household use. Networked chargers enable access to online energy management tools through an EVSE network. Non-networked chargers are standalone units that are not connected to other units through an EVSE network.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

Baseline Case

A non-ENERGY STAR V1.1 networked or non-networked Level 2 electric vehicle charger.

Efficient Case

An ENERGY STAR qualified networked or non-networked Level 2 electric vehicle charger [216]~~[2156]~~.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = ((Hrs_{PS} + Hrs_{US}) \times W_b - \left(Hrs_{PS} \times W_{q,p} + Hrs_{US} \times W_{q,u}\right))/1{,}000$$

Where,

$$Hrs_{ps} = Hours_p - Hours_c$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = Avg_{kW} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 2-145 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Hrs_{ps}	Annual standby hours plugged in	Calculated	Hours	
Hrs_{c}	Annual active charging hours	Site-specific, if unknown assume 278	Hours	[220]~~[219220]~~
Hrs_{p}	Total annual hours plugged in	Site-specific, if unknown assume 3,511	Hours	[220]~~[219220]~~
Hrs_{us}	Annual standby hours unplugged	Site-specific, if unknown assume 5,249	Hours	[220]~~[219220]~~
W_{b}	Baslines average standby power	Lookup in Table 2-146	W	[217]~~[2167]~~[218]~~[2178]~~
$W_{q,p}$	Efficient average standby power with vehicle plugged in	Lookup in Table 2-146	W	[219]~~[2189]~~
$W_{q,u}$	Efficient average standby power in no vehicle mode	Lookup in Table 2-146	W	[219]~~[2189]~~
Avg_{kW}	Average electric demand during standby	Lookup in Table 2-146	kW	
CF	Electric coincidence factor	Lookup in Table 2-147	N/A	
PDF	Gas peak day factor	Lookup in Table 2-147	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 2-146 Standby Power

Network Type	W_b	$W_{q,p}$	$W_{q,u}$	kW
Non-Networked[48]	3.7	3.5	2.1	0.00107
Networked~~[48]~~[47][48]	9.9	3.2	2.5	0.00713

Peak Factors

Table 2-147 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 10 years [216]~~[2156]~~.

References

~~[215]~~[216] Energy Star Spec v1.1 effective from 3/31/2021. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20V1.1%20DC%20EVSE%20Final%20Specification_0.pdf

~~[216]~~[217] Based on Northwest Power and Conservation Council, Regional Technical Forum updated workbook for Level 2 Electric Vehicle Charger version 3.0 https://nwcouncil.app.box.com/v/Lvl2EVChrgrsv3-0

~~[217]~~[218] INL charger testing https://avt.inl.gov/evse-type/ac-level-2.html

~~[218]~~[219] "ENERGY STAR Market and Industry Scoping Report: Electric Vehicle Supply Equipment ENERGY STAR Market and Industry Scoping Report Electric Vehicle Supply Equipment (EVSE)" 2013 (source data is from INL). https://www.energystar.gov/sites/default/files/asset/document/electric_vehicle_scoping_report.pdf

~~[219]~~[220] 2021 ENERGY STAR QPL of Residential EVSE. Averaged Partial On Mode Input Power (W) and Idle Mode Input Power (W). See Northwest Power and Conservation Council, Regional Technical Forum updated workbook for Level 2 Electric Vehicle Charger version 3.0 https://nwcouncil.app.box.com/v/Lvl2EVChrgrsv3-0

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

[48] kW for non-networked and networked type = $(((W_b - W_{q,p})*Hrs_{PS}/8482) + ((W_b - W_{q,u})*Hrs_{US}/8482))/1000$

2.5.6 HEDGE TRIMMERS, LEAF BLOWER, PUSH LAWNMOWERS, CHAINSAWS AND SNOW BLOWER

Market	Residential
Baseline Condition	TOS
Baseline	Existing
End Use Subcategory	Landscaping Equipment
Measure Last Reviewed	March 2024
Changes Since Last Version	~~New Measure~~

Description

This is a time of sale measure that applies to the purchase of new residential lawn equipment, which include trimmers, leaf blower, push lawnmowers (not self propelled or ride-on, but contains an electric motor driving the blade), chainsaws, and snow blowers. This measure assumes the offset of converting use of gas lawn equipment to electrical lawn equipment, which in turn saves fossil fuels and increases electric use.

Baseline Case

The baseline equipment is an existing residential gas lawn equipment, which includes trimmers, leaf blower, push lawnmowers, chainsaws, and snow blower.

Efficient Case

The energy efficient equipment must be new residential electric lawn equipment, which includes trimmers, leaf blower, push lawnmowers, chainsaws, and snow blower.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = Look\ up\ in\ \textbf{Table 2-150}\cancel{\text{Table 2-150}}$$

Deemed annual energy savings in Table 2-150 calculated as follows:

$$\Delta kWh = \frac{Hrs}{t_{charge}} \times E_{battery} \times \frac{D}{Eff_{charger}} \times \frac{1}{1{,}000}$$

Annual Fuel Savings (Alternate Fuel)

$$\Delta Gal_{Gasoline} = Look\ up\ in\ \textbf{Table 2-150}\cancel{\text{Table 2-150}}$$

Annual Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hrs} \times CF$$

Daily Peak Fuel Savings

$$N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings (Alternate Fuel)

$$\Delta Gal_{Life} = \Delta Gal \times EUL$$

Calculation Parameters

Table 2-148 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Look up in Table 2-150	kWh/yr	[221]~~[2201]~~
$\Delta Gal_{gasoline}$	Annual gallons gasoline savings	Look up in Table 2-150	Gallons	[221]~~[2201]~~
ΔkW_{Peak}	Annual peak electric demand savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
ΔGal_{Life}	Lifetime fuel savings	Calculated	Gallons	
Hrs	Annual operating hours	Look up in Table 2-149	Hrs	[221]~~[2201]~~
t_{charge}	Run time per charge	Look up in Table 2-149	Hrs	[223]~~[2223]~~
$E_{battery}$	Rated energy of the battery	Look up in Table 2-149	Wh	[223]~~[2223]~~
D	Discharge rate	0.90	%	[223]~~[2223]~~
$Eff_{charger}$	Efficiency of the charger	0.92	%	[223]~~[2223]~~
1,000	Unit conversion, Wh/kWh	1,000	Wh/kWh	
EUL	Effective useful life	See Measure Life ~~Measure Life~~	Years	[221]~~[2201]~~

Table 2-149 Parameters Values

Type of Electric Equipment	Hrs	t_{charge}	$E_{battery}$
Trimmer	8.21	0.5	1HP Replacement: 100 2HP Replacement: 240
Leaf Blower	9.4	0.25	1HP Replacement: 100 2HP Replacement: 240
Push Lawnmower	15	1	300
Chainsaw	9.12	0.09	150
Snow Blower	8	0.75	280

When calculated using the assumptions above, the energy impacts are equal to the values below. These deemed impacts may be used instead of calculating site-specific savings if reliable input parameters are not available.

Table 2-150 Deemed Energy Impacts

Type of Electric Equipment	ΔkWh_{equip}	$\Delta Gal_{gasoline}$
Trimmer	1HP Replacement: -1.61 2HP Replacement: -3.86	1HP Replacement: 1.41 2HP Replacement: 2.35
Leaf Blower	1HP Replacement: -3.68 2HP Replacement: -8.83	1HP Replacement: 1.41 2HP Replacement: 2.35
Push Lawnmower	-4.4	3.75
Chainsaw	-14.87	1.64
Snow Blower	-2.92	8

Peak Factors

Table 2-151 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.5	[224]~~[2234]~~
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is given in Table 2-152 [221]~~[2201]~~.

Table 2-152 Measure Life

Type of Electric Equipment	Measure Life (yrs)
Trimmer	8

Type of Electric Equipment	Measure Life (yrs)
Leaf Blower	8
Push Lawnmower	10
Chainsaw	8
Snow Blower	10

References

~~[220]~~[221] PSEG CEF-EE II Filing 12.1.23
~~[221]~~[222] Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling, EPA 2002
~~[222]~~[223] PSEG-LI TRM
~~[223]~~[224] Placeholder assumption until further research conducted.

2.5.7 ELECTRIC RIDING LAWN MOWER

Market	Residential
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Landscaping Equipment
Measure Last Reviewed	February 2024
Changes Since Last Version	~~New measure~~

Description

This measure claims savings for the replacement of a gasoline powered ride-on lawnmower with a new all-electric ride-on lawnmower. This measure is characterized for residential applications.

Baseline Case

The baseline condition is assumed to be a gasoline powered ride-on lawnmower.

Efficient Case

The efficient condition is an all-electric ride-on lawnmower.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = -Q \times Q_{time} \times kW_{Draw} \times N_{battery}$$

Annual Fuel Savings (Another Fuel)

$$\Delta Gal_{Gasoline} = U$$

Annual Peak Demand Savings

$$\Delta kW = -kW_{Draw} \times N_{battery} \times CF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings (Another Fuel)

$$\Delta Gal_{Gasoline,\,lifetime} = Gal_{Gasoline} \times EUL$$

Calculation Parameters

Table 2-153 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings, calculated using the default values below	Calculated (From default value: -72.9)	kWh/yr	[221]~~[2201]~~
$\Delta Gal_{gasoline}$	Annual gasoline savings	Calculated (From default value: 36)	gal/yr	[221]~~[2201]~~
ΔkW_{Peak}	Annual peak demand savings	Calculated (From default value: -0.56)	kW/yr	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Gal_{iGasoline,\ life}$	Lifetime gasoline savings	Calculated	gal	
Q	Number of full charges in a year[49]	32	N/A	[221]~~[2201]~~
Q_{time}	Time required to fully charge battery[50]	4	Hrs	[221]~~[2201]~~
kW_{draw}	Demand draw of battery while charging	0.56	kW	[221]~~[2201]~~
$N_{battery}$	No of batteries attached to lawn mower	1	N/A	[221]~~[2201]~~
U	Annual gasoline consumption	36	gallons	[221]~~[2201]~~
CF	Electric coincidence factor	Lookup in Table 2-154	N/A	
EUL	Effective useful life	See Measure Life ~~Measure Life~~	Years	[221]~~[2201]~~

Peak Factors

Table 2-154 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.5	[226]~~[2256]~~

49 Annual hours of use divided by Working Time Per Charge **Error! Reference source not found.**.
50 Battery Charging Time to 100% divided by 60 minutes **Error! Reference source not found.**

Measure Life

The effective useful life (EUL) is 10 years [221]~~[2201]~~.

References

~~[224]~~[225] Department of Public Services, *2022 Tier III TRM Characterizations*. 2022, Page 56, https://publicservice.vermont.gov/document/2022-tier-iii-trm-characterizations

~~[225]~~[226] Placeholder value until further research conducted.

Field Code Changed

2.6 SHELL

2.6.1 RESIDENTIAL/LOW-RISE MULTIFAMILY AIR SEALING

Market	Residential/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Shell
Measure Last Reviewed	January 2023
Changes Since Last Version	• Added default ΔCFM values for midstream delivery products

Description

This section provides energy savings algorithms for the sealing air leakage paths to reduce the natural air infiltration rate through the installation of products and repairs to the building envelope. It is assumed that air sealing is the first priority among candidate space conditioning measures. Expected percentage savings is based on previous experiences with measured savings from similar programs.

Methods are provided below for single-family, low-rise multifamily and high-rise multifamily applications with and without blower door testing conducted before and after implementation of air sealing treatments. A blower door test is performed to measure the leakage rate by depressurizing the building to a standard pressure difference of 50 Pascals or 0.2 inches of water.

Blower door tests shall be performed whenever possible. This method provided below for single family/low-rise multifamily without blower door testing should ~~only~~ be used if blower door testing is not feasible due to health or safety concerns, ~~e.g.~~or if the ~~presence of a hazardous material like asbestos or mold, ongoing construction~~site-specific details are unknown such as in ~~the home or concerns regarding COVID-19~~a midstream delivery method.

Baseline Case

The baseline case is a building envelope with natural air infiltration through air leakage paths.

Efficient Case

The exterior envelope, as well as interior walls/partitions between conditioned and unconditioned spaces should be inspected and all gaps sealed. At a minimum, the following items shall be inspected, and sealing measures may be implemented based upon inspection results:

- Caulk and weather strip doors and windows that leak air
- Repair or replace doors leading from conditioned to unconditioned space

- Seal air leaks between unconditioned (including unconditioned basement and attics) and conditioned spaces to include, but not limited to, plumbing, ducting, electrical wiring, wall top plates, chimneys, flues, and dropped soffits
- Use foam sealant on larger gaps around windows, baseboards, and other places where air leakage, either infiltration or exfiltration may occur

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \left(\frac{\Delta CFM_{50}}{F_n \times F_h}\right) \times \left(\frac{\Delta kWh}{CFM}\right)$$

Annual Fuel Savings

$$\Delta Therms = \left(\frac{\Delta CFM_{50}}{F_n \times F_h}\right) \times \left(\frac{\Delta therms}{CFM}\right)$$

Peak Demand Savings

$$\Delta kW_{Peak} = \left(\frac{\Delta CFM_{50}}{F_n \times F_h}\right) \times \left(\frac{\Delta kW}{CFM}\right) \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-155 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	

Variable	Description	Value	Units	Ref
ΔCFM_{50}	Reduction in air leakage from blower door tests at 50 Pascals pressure difference	Site-specific, if unknown calculate[51] as ΔCFM_{50} =0.50xSF~~[52]~~ If SF unknown, look up in Table 2-159	CFM	
F_n	Infiltration-Leakage Ratio, used to convert pressurized blower door testing results to natural infiltration rates, climate zone factor	19	N/A	[227]~~[226~~7~~]~~
F_h	Infiltration-Leakage Ratio, used to convert pressurized blower door testing results to natural infiltration rates, building height factor	Look up in Table 2-156	N/A	[227]~~[226~~7~~]~~
ΔkWh/CFM	Annual electric energy savings per cubic foot per minute of reduced air leakage at 50 Pa	Look up in Table 2-157 or Table 2-158	kWh/CFM	[228]~~[227~~8~~]~~
ΔkW/CFM	Peak coincident demand electric savings per cubic foot per minute of reduced air leakage at 50 Pa	Look up in Table 2-157 or Table 2-158	kW/CFM	[228]~~[227~~8~~]~~
Δtherms/CFM	Annual fossil fuel energy savings per cubic foot per minute of reduced air leakage at 50 Pa	Look up in Table 2-157 or Table 2-158	therms/CFM	[228]~~[227~~8~~]~~
CF	Coincidence factor	Look up in Table 2-160~~Table 2-159~~160	N/A	
PDF	Gas peak day factor	Look up in Table 2-160~~Table 2-159~~160	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 2-156 Infiltration-Leakage Ratio, building height factor

Number of conditioned stories	F_h
1 story	1.00
1.5 stories	0.90
2 stories	0.81
2.5 stories	0.76
3 + stories	0.70

[51] For single-family and low-rise multifamily homes, if conducting a blower door test is not feasible due to health and safety concerns, multiply affected area square footage by a deemed ΔCFM_{50}/SF of 0.50 (i.e., ΔCFM_{50} = 0.50 x SF). Default ΔCFM_{50}/SF of 0.50 is the median value of single-family blower door test data provided by ConEdison, conducted 2018-2020.

~~[52] For single-family and low-rise multifamily homes, if conducting a blower door test is not feasible due to health and safety concerns, multiply affected area square footage by a deemed ΔCFM50/SF of 0.50 (i.e., ΔCFM50 = 0.50 x SF). Default ΔCFM50/SF of 0.50 is the median value of single-family blower door test data provided by ConEdison, conducted 2018-2020.~~

Table 2-157 Impact per CFM for Single-family Residential Infiltration Reduction

	ΔkWh/CFM	ΔkW/CFM	Δtherms/CFM
AC Fuel Heat	2.3	0.004	1.7
Heat Pump	21.0	0.003	N/A
AC Electric Heat	39.8	0.004	N/A
Fuel Heat Only	0.8	0.000	1.7
Electric heat Only	38.4	0.000	N/A

Table 2-158 Impact per CFM for Multifamily Low-rise Infiltration Reduction

	ΔkWh/CFM	ΔkW/CFM	Δtherms/CFM
AC Fuel Heat	1.5	0.003	1.9
Heat Pump	21.2	0.003	N/A
AC Electric Heat	29.6	0.003	N/A
Fuel Heat Only	1.1	0.000	1.9
Electric heat Only	29.2	0.000	N/A

Table 2-159 Default ΔCFM50 for Midstream Delivery Products

Product	ΔCFM50 (cfm/lin.ft)
Door sweep	0.639
Door sealing material	0.639
Spray foam	0.689

Peak Factors

Table 2-160~~159~~160 Peak Factors

Peak Factor	Value	Ref
Coincidence factor	0.69	[229]~~[2289]~~
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The effective useful life (EUL) is 15 years [230]~~[229230]~~.

References

~~[226]~~[227] Lawrence Berkeley Laboratory, Estimation of Infiltration from Leakage and Climate Indicators, Sherman, M., December 1986, http://eta-publications.lbl.gov/sites/default/files/estimation_of_infiltration_from_leakage_and_climate_indicators.pdf

~~[227]~~[228] New York State Joint Utilities, New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs, V10, January 2023, Appendix E, Pg 1221. NYC values were used due to proximity to NJ.

~~[228]~~[229] Based on BG&E 'Development of Residential Load Profile for Central Air Conditioners and Heat Pumps' research, the Maryland Peak Definition coincidence factor is 0.69. This study is not publicly available, but is referenced by M. M. Straub, Using Available Information for Efficient Evaluation of Demand-Side Management Programs, Electricity Journal, September 2011 and supported by research conducted by Cadmus on behalf of the RM Management Committee.

~~[229]~~[230] GDS Associates, Inc. Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures. 2007. https://library.cee1.org/sites/default/files/library/8842/CEE_Eval_MeasureLifeStudyLights&HVACGDS_1Jun2007.pdf

Field Code Changed

Field Code Changed

2.6.2 INSULATION

Market	Residential/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Shell
Measure Last Reviewed	January 2023
Changes Since Last Version	~~Updated HDD/CDD values~~

Description

This measure applies to the installation of insulation to the attic floor, roof assembly, walls, and floors to reduce the thermal conductance of the building envelope. Energy and demand savings are realized through reductions in the building's heating and cooling loads. Existing (baseline) and installed (qualifying) shell R-values must be captured to estimate energy savings.

This measure is only applicable as a retrofit in existing single and multifamily buildings, excluding gut rehab/major renovation projects. These projects entail whole-building envelope alterations that trigger more stringent code provisions, limiting potential incremental savings.

For applications involving insulation on more than one component, evaluate each component separately via the method below and sum together to determine total estimated energy savings. If the age of the baseline equipment cannot be determined, assume two-third of the EUL has lapsed.

Baseline Case

The existing condition is a residential building envelope with insufficient insulation.

Efficient Case

The efficient condition is a residential building envelope with increased insulation meeting or exceeding applicable construction code requirements.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{cooling} + \Delta kWh_{heating}$$

Savings from reduction in Air Conditioning Load:

$$\Delta kWh_{cooling} = \frac{\left(\frac{1}{R_b} - \frac{1}{R_q}\right) \times CDD \times 24 \times Area \times (1 - F_{framing})}{1{,}000 \times SEER}$$

Savings for homes with electric heat (Heat Pump or resistance):

$$\Delta kWh_{heating} = \frac{\left(\frac{1}{R_b} - \frac{1}{R_q}\right) \times HDD \times 24 \times Area \times (1 - F_{framing})}{1{,}000 \times HSPF}$$

Annual Fuel Savings

$$\Delta Therms = \frac{\left(\frac{1}{R_b} - \frac{1}{R_q}\right) \times HDD \times 24 \times Area \times (1 - F_{framing})}{Fuel\ Btu \times AFUE}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\left(\frac{1}{R_b} - \frac{1}{R_q}\right) \times Area \times (1 - F_{framing})}{1{,}000 \times EER} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-161~~160~~161 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$\Delta kWh_{cooling}$	Annual electric cooling energy savings	Calculated	kWh/yr	
$\Delta kWh_{heating}$	Annual electric heating energy savings	Calculated	kWh/yr	
R_b	R-value of existing insulation	Site-specific, if unknown	h.ft².°F/Btu	

Variable	Description	Value	Units	Ref
		look up in Table 2-163~~Table 2-162~~163		
R_q	R-value of new insulation	Site-specific	h.ft^2.°F/Btu	
CDD	Cooling degree days: number of degrees the average daily temperature is above 65°F	Loo kup in Table 2-164~~Table 2-163~~164	°F-day/yr	[231]~~[2301]~~
Area	Area of insulated surface	Site-specific	ft^2	
$F_{framing}$	Framing factor	Look up in Table 2-162~~Table 2-161~~162	N/A	[233]~~[2323]~~
1,000	Conversion Factor from W to kW	N/A	W/kW	
SEER/SEER2	Efficiency in SEER of Air Conditioning equipment	Site specific, if unknown look up in Table 2-165~~Table 2-164~~165	Btu/watt-hr	[234]~~[2334]~~
EER/EER2	Efficiency in EER of Air Conditioning equipment	Site-specific. If unknown, see **Error! Reference source not found.**~~Appendix E: Code Compliant Efficiencies~~	Btu/watt-hr	[234]~~[2334]~~
HDD	Heating degree days: number of degrees the average daily temperature is below 65°F	Look up in Table 2-164~~Table 2-163~~164	°F-day/yr	[231]~~[2301]~~
HSPF/HSPF2	Heating Seasonal Performance Factor	Site specific, if unknown look up in Table 2-166~~Table 2-165~~166	Btu/watt-hr	[234]~~[2334]~~
Fuel Btu	Conversion Factor to Therms	Look up in Table 2-169~~Table 2-168~~169		
AFUE	Annual Fuel Utilization Efficiency – Boilers & Furnaces	Site-specific, if unknown look up in Table 2-167~~Table 2-166~~167, Table 2-168~~Table 2-167~~168	N/A	[234]~~[2334]~~
AFUE	Annual Fuel Utilization Efficiency – Electric Resistance Heating	35%	N/A	[235]~~[2345]~~
CF	Electric coincidence factor	Look up in Table 2-170~~Table 2-169~~170	N/A	
PDF	Gas peak day factor	Look up in Table 2-170~~Table 2-169~~170	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 2-162~~161~~162 Framing Factor

Insulation Location	Value	Ref
Framing factor - Ceiling	7%	[233]~~[2323]~~
Framing factor - Wall	25%	[233]~~[2323]~~
Framing factor - Floor	12%	[233]~~[2323]~~

Table 2-163~~162~~163 Existing Insulation R-Value (R_b)

Building Envelope Component	Value
Fiberglass - Batt	3.14
Fiberglass – Blown Attic	2.2
Fiberglass – Blown Wall	3.2
Rock Wool - Batt	3.14
Rock Wool – Blown Attic	3.1
Rock Wool – Blown Wall	3.03
Cellulose – Blown Attic	3.13
Cellulose – Blown Wall	3.7
Vermiculite	2.13
Air-entrained Concrete	3.9
Urea Terpolymer Foam	4.48
Rigid Fiberglass (> 4 lb/ft^3)	4
Expanded Polystyrene (Beadboard)	4
Extruded Polystyrene	5
Polyurethane (Foamed-in-place)	6.25
Polyisocynaurate (Foil-face)	7.2

Table 2-164~~163~~164 Heating and Cooling Degree Days (65°F set point)

Climate Zone	HDD	CDD
Northern	6,136	934
Southwest	5,658	1,048
Coastal	4,795	886
Central	5,588	1,008
Pine Barrens	5,529	945
Statewide Average	5,553	973

Table 2-165~~164~~165 Cooling Equipment SEER

Cooling Equipment	SEER	SEER2
Split System (A/C)	13	13.4
Split System (HP)	14	14.3
Single Package (A/C)	14	13.4
Single Package (HP)	14	13.4

Table 2-166~~165~~166 Cooling Equipment HSPF

Cooling Equipment	HSPF	HSPF2
Split System (HP)	8.2	7.5
Single Package (HP)	8.0	6.7

Table 2-167~~166~~167 AFUE of Residential Boilers

Product Class	AFUE (Manufactured before Sep 1, 2012)	AFUE (Manufactured on and after Sep 1, 2012 and before Jan 15, 2021)	AFUE (Manufactured on and after January 15, 2021)
Gas-fired hot water boiler	0.80	0.82	0.84
Gas-fired steam boiler	0.75	0.80	0.82
Oil-fired hot water boiler	0.80	0.84	0.86
Oil-fired steam boiler	0.80	0.82	0.85

Table 2-168~~167~~168 AFUE of Residential Furnaces

Product Class	AFUE	Compliance Date	AFUE (Manufactured before compliance Date)
Non-weatherized gas furnaces (not including mobile home furnaces)	0.80	November 19, 2015.	0.78
Mobile Home gas furnaces	0.80	November 19, 2015.	0.75
Non-weatherized oil-fired furnaces (not including mobile home furnaces)	0.83	May 1, 2013.	0.78

Product Class	AFUE	Compliance Date	AFUE (Manufactured before compliance Date)
Mobile Home oil-fired furnaces	0.75	September 1, 1990.	0.75
Weatherized gas furnaces	0.81	January 1, 2015.	0.78
Weatherized oil-fired furnaces	0.78	January 1, 1992.	0.78

Table 2-169~~168~~169 BTU Conversion Factors

Conversion Factor	Value	Units
Natural Gas - BTU to Therms	100,000	Btu/Therms
Heating Oil - BTU to Gallons to Therms	138,000 x 0.916	Btu/Therms
Propane - BTU to Gallons Therms	92,000 x 1.4	Btu/Therms

Peak Factors

Table 2-170~~169~~170 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.69	[232]~~[2312]~~
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The effective useful life (EUL) is 25 years [236]~~[2356]~~.

References

~~[230]~~[231] ONJSC: Monthly/Annual Temperature Normals (1991-2020). http://climate.rutgers.edu/stateclim_v1/norms/monthly/index.html.

~~[231]~~[232] BG&E: Development of Residential Load Profile for Central Air Conditioners and Heat Pumps, as reported in NEEP, Mid-Atlantic Technical Reference Manual, V8. 2018, p. 260

~~[232]~~[233] ASHRAE, 2001, "Characterization of Framing Factors for New Low-Rise Residential Building Envelopes (904-RP)," Table 7.1.

~~[233]~~[234] Code of Federal Regulations. 2022. Review of Title 10, Chapter II, Subchapter D, Part 430 eCFR. December 1, 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430

~~[234]~~[235] Electric resistance heating calculated by determining overall fuel cycle efficiency by dividing the average PJM heat rate (9,642 btu/kWh) by the btu's per kWh (3,413 btu/kWh), resulting in 2.83 btuin per 1 btuout.

Field Code Changed

Field Code Changed

~~[235]~~[236] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures.

2.6.3 WINDOW INSULATION

Market	Residential
Baseline Condition	Retrofit
Baseline	Existing
End Use Subcategory	Window
Measure Last Reviewed	March 2024
Changes Since Last Version	~~New measure~~

Description

This measure covers the installation of plastic window insulation film covering the interior side of a window frame. The film is sealed around the frame with adhesive tape, creating an insulating air gap between the window glass and the plastic film. This gap can only be achieved if the film is maintained without any cuts or slits. The reduced thermal conduction saves energy by decreasing heating loads on the dwelling's heating systems.

This measure claims only energy savings from heating a dwelling since it is assumed that the plastic window insulation is removed outside of the heating season to allow the windows to be opened.

Baseline Case

Existing window without insulation film.

Efficient Case

Windows with insulation film sealed with the help of adhesive tape.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{\left(\frac{1}{R_w} - \frac{1}{R_w + R_I}\right) \times A \times HDD \times 24}{COP \times 3{,}412} \times F_{ElecHeat}$$

Annual Fuel Savings

$$\Delta Therms = \frac{\left(\frac{1}{R_w} - \frac{1}{R_w + R_I}\right) \times A \times HDD \times 24}{Eff_{FuelHeat} \times 100{,}000} \times F_{FuelHeat}$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-171~~170~~171 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated or look up in Table 2-173~~Table 2-172~~173	kWh/yr	
ΔTherms	Annual fuel savings	Calculated or look up in Table 2-173~~Table 2-172~~173	Therms/yr	
$\Delta Therms_{Peak}$	Peak day gas savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
A	Glazing area of impacted windows[53] in square feet	Site-specific, if unknown use 6 square feet per window	ft^2	[237]~~[236~~7]
COP	Coefficient of performance of electric heating equipment (convert HSPF to COP by dividing by 3.412)	Site-specific, if unknown look up in Appendix E for existing efficiency of heating equipment, if heating	N/A	[237]~~[236~~7]

[53] Average Window Size - homedit.com

Variable	Description	Value	Units	Ref
		equipment unknown, assume 1.37[54]		
$Eff_{FuelHeat}$	Efficiency of fuel heating equipment	Site-specific, if unknown look up in Appendix E for existing efficiency of heating equipment, if heating equipment unknown, assume 0.79[55]	N/A	[237]~~[236]~~7
HDD	Heating degree days (basis 65°F)	Lookup in Table 2-172 HDD65 values for various NJ Location~~Table 2-171~~2 ~~HDD65 values for various NJ Location~~	N/A	[238]~~[237]~~8
R_w	R-value of existing windows	Site-specific, if unknown use 1.13	h.ft². °F/Btu	[237]~~[236]~~7
R_I	R-value added as a result of plastic window insulation[56]	1.74	h.ft². °F/Btu	[237]~~[236]~~7
$F_{ElecHeat}$	Electric heating factor	Electric heating: 1.0 Otherwise: 0.0 If unknown: look up in Appendix K	N/A	[237]~~[236]~~7
$F_{FuelHeat}$	Fossil fuel heating factor	Fuel heating: 1.0 Otherwise: 0.0 If unknown: look up in Appendix K	N/A	[237]~~[236]~~7
PDF	Peak Day Factor	See Appendix	N/A	
24	Hours in a day	24	Hrs	
3,412	Unit conversion, Btu/kWh	3,412	Btu/kWh	
100,000	Unit conversion, Btu/therm	100,000	Btu/therm	
EUL	Effective useful life	See Measure Life section	Years	

[54] Based on RECS microdata weights for prevalence of heat pumps and electric resistance heating and 2013 heat pump efficiencies
[55] Average of gas-fired hot water boiler, steam boiler, and furnace 2013 minimum efficiencies
[56] Inspectapedia air gap R value of 0.87 per inch, assuming 2 inches air gap between interior glazing surface and front of interior window frame trim.

Table 2-172~~171~~172 HDD65 values for various NJ Location

Location	HDD65
Northern	6,136
Southwest	5,658
Coastal	4,795
Central	5,588
Pine Barrens	5,529
Statewide Average	**5,553**

If the default values for all the parameters are used, the calculations result in the deemed values below.

Table 2-173~~172~~173 Deemed kWh and Therms Savings Value, per Window

Location	ΔkWh	ΔTherms
Northern	101.42	6.08
Southwest	93.52	5.60
Coastal	79.25	4.75
Central	92.36	5.53
Pine Barrens	91.38	5.48
Statewide Average	**91.58**	**5.49**

Peak Factors

Table 14 Peak Factors

Peak Factor	Value	Ref
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) is 1 year[57] [237]~~[2367]~~.

References

~~[236]~~[237] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs, Version 11, Effective Date January 2024, https://dps.ny.gov/technical-resource-manual-trm

Field Code Changed

57 1 year is assumed to be the EUL since plastic window insulation comes in the form of single-use kits that are disposed of when the heating season ends.

~~[237]~~[238] HDD65 calculated with TMY3 weather data for representative weather stations for each NJ climate zone. See Appendix A.

2.7 WATER HEATING

2.7.1 HEAT PUMP WATER HEATER

Market	Residential/Multifamily
Baseline Condition	NC/TOS/DI/EREP
Baseline	Code/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	January 2023
Changes Since Last Version	• ~~Moved code compliant efficiency look ups to appendix~~ • ~~Added unknown derating and location factors based on ResStock data~~

Description

Heat pump water heaters take heat from the surrounding air and transfer it to the water in the tank, unlike conventional water heaters, which use either gas (or sometimes other fuel) burners or electric resistance heating coils to heat the water.Due to the interactivity of the heat pump water heater with the building's HVAC system, there is a decrease in a home's cooling energy consumption and an increase in the heating energy consumption if the heat pump water heater is located in conditioned space.

Baseline Case

TOS/NC baseline equipment is a minimally code compliant, electric storage type water heater.[58] EREP/DI baseline equipment is a minimally code compliant system of the same type and fuel as the existing equipment.

Efficient Case

The efficient condition is an ENERGY STAR V. 5.0 qualified heat pump water heater.

[58] Note that heat pump water heaters are code required for tanks greater than 55 gallons.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{dhw} + \Delta kWh_{cooling} - \Delta kWh_{heating}$$

Where,

$$\Delta kWh_{dhw} = \frac{Load_{dhw}}{3{,}412} \times \left(\frac{F_{dhw,electric}}{UEF_b} - \frac{1}{UEF_q \times F_{derate}}\right)$$

$$\Delta kWh_{cooling} = \frac{Load_{dhw}}{1{,}000} \times \left(1 - \frac{1}{UEF_q}\right) \times F_{location} \times \frac{F_{cool}}{SEER}$$

$$\Delta kWh_{heating} = \frac{Load_{dhw}}{1{,}000} \times \left(1 - \frac{1}{UEF_q}\right) \times F_{location} \times F_{heat,electric} \times \frac{F_{heat}}{HSPF}$$

$$Load_{dhw} = GPD \times 365 \times 8.33 \times (T_{set} - T_{main})$$

$$GPD = 17.2 \times N_{ppl}$$

Annual Fuel Savings

$$\Delta Therms = \Delta Therms_{dhw} - \Delta Therms_{heating}$$

Where,

$$\Delta Therms_{dhw} = \frac{Load_{dhw}}{100000} \times \left(\frac{F_{dhw,ff}}{UEF_b} + \frac{F_{dhw,boiler}}{AFUE}\right)$$

$$\Delta Therms_{heating} = \frac{Load_{dhw}}{100000} \times \left(1 - \frac{1}{UEF_q}\right) \times F_{location} \times F_{heat,ff} \times \frac{F_{heat}}{AFUE}$$

Peak Demand Savings[59]

For water heaters with a rated storage volume of 55 gallons or less:

$$\Delta kW_{Peak} = 0.09 \times \frac{UEF_q}{3.41}$$

For water heaters with a rated storage volume greater than 55 gallons:

$$\Delta kW_{Peak} = 0.11 \times \frac{UEF_q}{3.34}$$

[59] Constants in peak demand equations from Mid-Atlantic TRM v10: "Analysis of special study. Cadmus, "EmPOWER Maryland Heat Pump Water Heater Baseline and Market Analysis", February 2020. The study leveraged HPWH load shapes from "Field Testing of Pre-Production Prototype Residential Heat Pump Water Heaters" (https://www.energy.gov/sites/prod/files/2014/01/f7/heat_pump_water_heater_testing.pdf)."

Field Code Changed

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 2-174~~173174~~ Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkWh_{dhw}	Annual domestic hot water electric energy savings	Calculated	kWh/yr	
$\Delta kWh_{cooling}$	Annual cooling electric energy savings	Calculated	kWh/yr	
$\Delta kWh_{heating}$	Annual heating electric energy impacts	Calculated	kWh/yr	
$\Delta Therms$	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{dhw}$	Annual domestic hot water fuel savings	Calculated	Therms/yr	
$\Delta Therms_{heat}$	Annual space heating fuel impacts	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$Load_{dhw}$	Annual hot water load	Calculated	Btu	

Variable	Description	Value	Units	Ref
v_t	Tank volume	Site-specific	Gal	
UEF_q	Uniform energy factor of efficient unit	Site-specific, if unknown look up in Table 2-176~~Table 2-175~~176	N/A	[245]~~[244~~5]
AFUE	Annual fuel utilization efficiency of existing space heating or domestic hot water boiler or furnace	Site-specific, if unknown look up in Table 2-179~~Table 2-178~~179	N/A	[242]~~[241~~2]
GPD	Gallons per day	Calculated, if N_{ppl} unknown use 46	Gal/day	[239]~~[238~~9]
N_{ppl}	Number of people in the home	Site-specific, if unknown use default 2.65	persons	[248]~~[247~~8]
$F_{DHW,electric}$	Electric water heating factor	Look up in Table 2-175~~Table 2-174~~175	N/A	
$F_{DHW,g}$	Gas water heating factor	Look up in Table 2-175~~Table 2-174~~175	N/A	
$F_{DHW,boiler}$	Gas boiler water heating factor	Look up in Table 2-175~~Table 2-174~~175	N/A	
$F_{heat,electric}$	Electric space heating factor	Look up in Table 2-175~~Table 2-174~~175	N/A	
$F_{heat,g}$	Gas space heating factor	Look up in Table 2-175~~Table 2-174~~175	N/A	
UEF_b	Uniform energy factor of baseline unit as a function of baseline fuel type.	Look up in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~	N/A	[242]~~[241~~2][243]~~[242~~3]
F_{derate}	Efficiency derating factor	Look up in Table 2-177~~Table 2-176~~177	N/A	[244]~~[243~~4][245]~~[244~~5]
$F_{location}$	Installation location factor	Look up in Table 2-177~~Table 2-176~~177	N/A	
SEER	Seasonal energy efficiency ratio of existing air conditioning system	Look up in Table 2-178~~Table 2-177~~178	Btu/W·hr	
HSPF	Heating seasonal performance factor of existing electric heating system	Look up in Table 2-178~~Table 2-177~~178	Btu/W·hr	
CF	Electric coincidence factor	Look up in Table 2-180~~Table 2-179~~180	N/A	

Variable	Description	Value	Units	Ref
PDF	Gas peak day factor	Look up in Table 2-180~~Table 2-179~~180	N/A	
T_{set}	Water heater setpoint temperature	125	°F	[240]~~[239~~240]
T_{main}	Supply water temperature in water main	60	°F	[241]~~[240~~1]
F_{cool}	Cooling factor	0.51	N/A	[243]~~[242~~3]
F_{heat}	Heating factor	0.49	N/A	[243]~~[242~~3]
365	Days per year	365	Days/yr	
8.33	Unit conversion, Btu/gal·°F	8.33	Btu/gal·°F	
3,412	Unit conversion, Btu/kWh	3,412	Btu/kWh	
3.412	Unit conversion, Btu/W·hr	3.412	Btu/W·hr	
1000	Unit conversion, Watt/kW	1000	W/kW	
100,000	Unit conversion, Btu/therm	100,000	Btu/therm	
EUL	Effective useful life	See Measure Life Section	Years	

Table 2-175~~174~~175 DHW and Heating Factors

Baseline Scenario	$F_{DHW,electric}$	$F_{DHW,g}$	$F_{DHW,boiler}$	$F_{heat,electric}$	$F_{heat,g}$
TOS/NC: use electric baseline	1.0	0	0	1.0	0
EREP/DI with existing electric water heater and space heat	1.0	0	0	1.0	0
EREP/DI with existing gas water heater and space heat	0	1.0	1.0	0	1.0

Table 2-176~~175~~176 Efficient UEF

Product Class	Criteria	UEF
Electric Storage Water Heater	Integrated HPWH	3.30
	Integrated HPWH, 120 Volt/15 Amp Circuit	2.20
	Split-system HPWH	2.20

Table 2-177~~176~~177 Derating Factors

Area	F_{derate}	$F_{location}$
Unconditioned Basement	0.86	0

Area	F_{derate}	$F_{location}$
Garage	0.83	0
Conditioned Space	1.00	1.00
Unknown[60]	0.95	0.62

Table 2-178~~177~~178 SEER and HSPF Values

Type	SEER	HSPF
Air-Source Heat Pump	14.0	8.0
Ground-Source Heat Pump	15.0	10.9
CAC	14.0	N/A
Mini Split HP	15.0	8.8

Table 2-179~~178~~179 AFUE Values

Equipment Type	Size Range	AFUE
Warm Air Furnace, Gas Fired	All Capacities	0.80
Boiler, Hot Water, Gas Fired	All Capacities	0.82
Boiler, Steam, Gas Fired	All Capacities	0.80

Peak Factors

Peak coincidence is accounted for in the peak demand savings algorithm section above.

Table 2-180~~179~~180 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

[60] Unknown derating and location factors based on ResStock data

Table 2-~~181~~~~180~~181 Measure Life

Equipment	EUL	RUL	Ref
Heat Pump Water Heater	10	3.33	[247]~~[2467]~~

References

~~[238]~~[239] EmPOWER heat pump water heater program participation in 2018-2019 and participant survey data; per Mid-Atlantic TRM v10, pg. 150. https://neep.org/sites/default/files/media-files/trmv10.pdf

~~[239]~~[240] NMR Group, Inc., 2018 Pennsylvania Statewide Act 129 Residential Baseline Study (Feb 2018). https://www.puc.pa.gov/Electric/pdf/Act129/SWE-Phase3_Res_Baseline_Study_Rpt021219.pdf

~~[240]~~[241] Using Rock Spring, PA (Site 2036) as a proxy, the mean of soil temperature at 40 inch depth is 51.861. Calculated using Daily SCAN Standard - Period of Record data from April 1999 to December 2018 from the Natural Resource Conservation Service Database. https://wcc.sc.egov.usda.gov/nwcc/rgrpt?report=daily_scan_por&state=PA. Methodology follows Missouri TRM 2017 Volume 2: Commercial and Industrial Measures. p. 78. https://energy.mo.gov/sites/energy/files/MOTRM2017Volume2.pdf

~~[241]~~[242] 10 CFR Subpart C of Part 430, https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32

~~[242]~~[243] 10 CFR Subpart B of Part 429, https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-429/subpart-B/section-429.17

~~[243]~~[244] Bonneville Power Administration, Residential Heat Pump Water Heater Evaluation: Lab Testing & Energy Use Estimates. (November 2011), https://rpsc.energy.gov/sites/default/files/tech-resource/attachment/BPA_HPWH_Lab_Evaluation_11-9-2011.pdf

~~[244]~~[245] Fluid Market Strategies, NEEA Heat Pump Water Heater Field Study Report. (2013), https://neea.org/img/uploads/heat-pump-water-heater-field-study-report.pdf

~~[245]~~[246] ENERGY STAR Program Requirements Product Specification for Residential Water Heaters, Eligibility Criteria, Version 4.0. (2021), https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Version%204.0%20Water%20Heaters%20Final%20Specification%20and%20Partner%20Commitments_0.pdf

~~[246]~~[247] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

~~[247]~~[248] Water Research Foundation: Residential End Uses of Water, Version 2, April 2016, p. 5; 17.2 GPD equated from the report findings indicating an average 2.65 people per household and 45.5 GPD per household, April 2016

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

2.7.2 INDIRECT WATER HEATER

Market	Residential/Multifamily
Baseline Condition	TOS/NC/EREP
Baseline	Code/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	December 2022

Description

This measure covers the installation of a fossil fuel indirect-fired storage water heating system in which the stored water is heated via hot water produced by a fossil fuel boiler rather than direct input from electric elements or fossil fuel burners. In such a system, a heat exchanger separates the potable water in the water heater from the boiler water. This measure applies to indirect-fired systems comprising a boiler with input heating capacity less than 300,000 Btu/h and a storage tank with a capacity of 20 to 120 gallons installed in residential applications.

This measure estimates savings associated with the delivery of potable hot water only and assumes the installation of zone priority controls to interrupt demand for space heating hot water until domestic hot water demand is met.

Baseline Case

The baseline condition is a minimally code-compliant indirect fired, fossil fuel storage type water heater with a recovery efficiency of 75%, tank volume equal to the energy efficient condition.

Efficient Case

Theefficient case is an indirect fossil fuel-fired water heating system with efficiency meeting or exceeding 0.85 AFUE.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Annual Fuel Savings

$$\Delta Therms = units \times \left(\frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{100{,}000} \times \left(\frac{1}{Eff_b} - \frac{1}{Eff_q} \right) + \left(\frac{UA_b}{Eff_b} - \frac{UA_q}{Eff_q} \right) \times \frac{\Delta T_{amb} \times 8{,}760}{100{,}000} \right)$$

Where,

$$\Delta T_{main} = T_{set} - T_{main}$$

$$\Delta T_{amb} = T_{set} - T_{amb}$$

$$GPD = 17.2 \times N_{ppl}$$

$$UA_q = \frac{SL_q}{70} \times v_q \times 8.33$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 2-182~~181~~182 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
GPD	Gallons per day	Calculated, if N_{ppl} unknown use 46	Gal/day	[249]~~[2489]~~

Variable	Description	Value	Units	Ref
ΔT_{main}	Average temperature difference between water heater set point temperature (T_{set}) and the supply water temperature in water main (T_{main})	Calculated	°F	
ΔT_{amb}	Average temperature difference between water heater set point temperature (T_{set}) and the surrounding ambient air temperature (T_{amb})	Calculated	°F	
UA_q	Overall heat loss coefficient of the energy efficient equipment	Calculated, if SL_q unknown use 5.4	(Btu/h-°F).	[254]~~[253~~4~~]~~
Eff_q	Efficiency of energy efficient connected boiler (AFUE)	Site-specific. If unknown use 0.85[61]	N/A	
N_{ppl}	Number of people in household	Site-specific, if unknown use default 2.65	N/A	[254]~~[253~~4~~]~~
SL_q	Standby loss specification of installed equipment. Use given UAq assumption if SLq is unknown.	Site-specific	°F/hr	
v_q	Rated storage capacity of installed equipment	Site-specific	Gal	
UA_b	Overall heat loss coefficient of the baseline condition	7.85	(Btu/h-°F).	[252]~~[251~~2~~]~~
T_{set}	Water heater set point temperature	125	°F	[250]~~[249~~250~~]~~
T_{main}	Supply water temperature in water main	60	°F	[251]~~[250~~1~~]~~
T_{amb}	Surrounding ambient air temperature	70[62]	°F	
Eff_b	Efficiency of the baseline condition, deemed (AFUE)	0.75	N/A	[252]~~[251~~2~~]~~
365	Days per year	365	Days/yr	
8,760	Hours per year	8,760	Hr/yr	
8.33	Energy required (Btu) to heat one gallon of water by one degree Fahrenheit	8.33	Btu/gal°F	
100,000	Conversion from Btu to therms	100,000	Btu/therm	
EUL	Effective useful life	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

[61] ASHRAE 90.1 2019 Compliant AFUE values range from 82% to 84%. Assumed conservative estimate of 85%

[62] Water heaters are generally located in conditioned or partially conditioned spaces with a typical average temperature of 65°F to 70°F to avoid freezing. A value of 70°F is used for the purposes of estimating ambient air temperature

Peak Factors

Table 2-~~183~~~~182~~183 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 2-184~~183~~184 Measure Life

Equipment	EUL	RUL	Ref
Indirect Water Heater	11	3.67	[255]~~[2545]~~

References

~~[248]~~[249] Water Research Foundation: *Residential End Uses of Water*, Version 2, April 2016, p. 5; 17.2 GPD equated from the report findings indicating an average 2.65 people per household and 45.5 GPD per household, April 2016

~~[249]~~[250] Code of Federal Regulations, Title 10, Chapter II, Subchapter D, Part 430, Appendix E to Subpart B of Part 430 Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature, December 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-B.

~~[250]~~[251] Burch, Jay and Christensen, Craig, *Towards Development of an Algorithm for Mains Water Temperature*. National Renewable Energy Laboratory, 2022.

~~[251]~~[252] Per 10 CFR 430, typical recovery efficiency of a gas water heater, which is used for the purposes of this measure as a proxy for thermal efficiency, is 0.75. See for example, 10 CFR 430 Subpart B Appendix C1, 5.6.1.1., December 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-B.

~~[252]~~[253] Based on computation of heat loss coefficients via conversion equations found in 10 CFR 429, 430, and 431 Docket No. EERE-2015-BT-TP-0007, Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment, December 2022.

~~[253]~~[254] Based on the average standby loss specification (in °F/hr) of AHRI-certified Indirect Water Heater storage tanks, per the AHRI Directory, Air Conditioning, Heating, and Refrigeration Institute, December 2022. https://ahridirectory.org.

~~[254]~~[255] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (TRM), Version 9, January 2022. https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V9.pdf

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

2.7.3 STORAGE WATER HEATER

Market	Residential/Multifamily
Baseline Condition	NC/TOS
Baseline	Code
End Use Subcategory	Equipment
Measure Last Reviewed	January 2023

Description

This measure covers the installation of storage tank water heaters designed to heat and store water at a thermostatically controlled temperature. This measure applies to potable hot water delivery only; it is not applicable to hot water heaters used for process loads or space heating. Additionally, qualifying equipment must be designed to heat water to a temperature no greater than 180°F.

Storage type units include residential gas storage water heaters with an input of 75,000 Btu per hour or less.

This measure applies to replacement of existing storage type water heaters using the same heating fuel as the efficient case and assumes baseline to be a minimally code compliant water heater of the same type and heating fuel as the efficient case. For new construction, this measure assumes baseline to be a minimally code compliant storage-type water heater using the same heating fuel as the efficient case.

Baseline Case

The baseline condition is a minimally code compliant water heater equivalent to the existing water heater and with tank volume, input capacity and draw pattern equivalent to the efficient water heater. For new construction, the baseline condition is a minimally code compliant storage-type water heater with tank volume, input capacity and draw pattern equivalent to the efficient water heater.

Efficient Case

The compliance condition is an ENERGY STAR® rated gas storage water heater as directed by the measure description. Efficient storage tank water heaters must be eligible under ENERGY STAR® Program Requirements for Residential Water Heaters, Eligibility Criteria Version 5.0, effective April 2023. [261]~~[2601]~~ Minimum UEF qualification for ENERGY STAR® equipment is shown in Table 2-186~~Table 2-185~~186.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Annual Fuel Savings

$$\Delta Therms = \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{100{,}000} \times \left(\frac{1}{UEF_b} - \frac{1}{UEF_q}\right)$$

Where,

$$GPD = 17.2 \times N_{ppl}$$

$$\Delta T_{main} = T_{set} - T_{main}$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \mathrm{N/A}$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-185~~184~~185 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
GPD	Gallons per day	Calculated, if unknown use 46	Gal/day	[256]~~[2556]~~
ΔT_{main}	Average temperature difference between water heater set point temperature and the supply water temperature in water main	Calculated	°F	
UEF_q	Uniform Energy Factor of the energy efficient measure	Site-specific, if unknonwn look up in Table 2-186~~Table 2-185~~186	N/A	

Variable	Description	Value	Units	Ref
N_{ppl}	Number of people served by the system	Site-specific, if unknown use default 2.65	persons	[256]~~[2556]~~
T_{set}	Water heater set point temperature	125	°F	[257]~~[2567]~~
T_{main}	Supply water temperature in water main[63]	60	°F	[258]~~[2578]~~
UEF_b	Uniform Energy Factor of the baseline condition, based on tank volume	Look up in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~	N/A	
8,760	Hours per year	8,760	Hours/yr	
365	Days per year	365	Days/yr	
3,412	Conversion from Btu to kWh	3,412	Btu/kWh	
8.33	Energy required (Btu) to heat one gallon of water by one degree Fahrenheit	8.33	Btu/gal°F	
100,000	Conversion from Btu to therms	100,000	Btu/therm	
17.2	Assumed gallons of hot water used per day per person in household	17.2	Gal/day/person	[256]~~[2556]~~
CF	Electric coincidence factor	Look up in Table 2-187~~Table 2-186~~187	N/A	
PDF	Gas peak day factor	Look up in Table 2-187~~Table 2-186~~187	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 2-186~~185~~186 Residential Water Heaters Energy Star Criteria

Product Class	Rated Storage Volume and Input Rating	Draw Pattern	Minimum UEF
Gas-Fired Storage Water Heater	> 20 gal and ≤ 55 gal	Medium	0.81
	> 20 gal and ≤ 55 gal	High	0.86
	> 55 gal	Medium	0.86

[63] Average value across NJ climate zones, calculated as average ambient air temperature + 6 °F.

Peak Factors

Table 2-~~187~~186~~187~~ Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.8	[260]~~[259260]~~
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The effective useful life (EUL) is 11 years for gas water heaters and 13 years for electric water heaters. [259]~~[2589]~~

References

~~[255]~~[256] Water Research Foundation: "Residential End Uses of Water, Version 2: Executive Report", April 2016, https://www.mrwa.com/PDF/2016WaterEndUseReport.pdf

~~[256]~~[257] 10 CFR 430 Appendix E to Subpart B of Part 430 Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part430/sybpart-B/appendix-E

~~[257]~~[258] Calculated from annual NJ temperatures using methodology in Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory, 2022

~~[258]~~[259] California Public Utilities Commission EUL Table, version 027 (updated November 12, 2022). Accessed December 30, 2022. https://www.caetrm.com/shared-data/value-table/EUL/

~~[259]~~[260] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (TRM), Version 9, January 2022. https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V9.pdf.

~~[260]~~[261] Energy Star Residential Water Heaters Specification Final Draft v5.0 https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Version%205.0%20Residential%20Water%20Heaters%20Final%20Draft%20Specification.pdf

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

2.7.4 TANKLESS WATER HEATER

Market	Residential/Multifamily
Baseline Condition	NC/RF/DI
Baseline	Code/Existing/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	December 2022

Description

This measure covers the installation of instantaneous type water heaters, which heat water but contain no more than one gallon of water per 4,000 Btu per hour of input. This measure applies to potable hot water delivery only; it is not applicable to hot water heaters used for process loads or space heating. Additionally, qualifying equipment must be designed to heat water to a temperature no greater than 180°F and, if electric power is required for operation, must use a single-phase external power supply.

Instantaneous type units include fossil fuel instantaneous water heaters with a rated input capacity of greater than or equal to 50,000 and less than 200,000 Btu per hour and a manufacturer's specified storage capacity of less than 2 gallons, residential electric instantaneous water heaters with an input of 12 kilowatts or less and a manufacturer's specified storage capacity of less than 2 gallons.

Baseline Case

The retrofit baseline condition is a minimally code compliant water heater of type (storage-type or instantaneous) equivalent to the existing water heater and with tank volume (where applicable), input capacity and draw pattern equivalent to the efficient water heater. For new construction, the baseline condition is a minimally code compliant 40-gallon storage-type with draw pattern equivalent to the efficient water heater (assume medium if unknown).

Efficient Case

The efficient case is an energy efficient fossil fuel or electric instantaneous type water heater as defined by the measure description.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = kWh_b - kWh_q$$

Where,

$$kWh_b = \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{3{,}412 \times UEF_b}\ (Electric\ Baseline)$$

$$kWh_b = 0\ (Fossil\ Fuel\ Baseline)$$

$$kWh_q = \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{3{,}412 \times UEF_q}(Electric\ Energy\ Efficient\ Case)$$

$$kWh_q = 0\ (Fossil\ Fuel\ Energy\ Efficient\ Case)$$

$$GPD = 17.2 \times N_{ppl}$$

$$\Delta T_{main} = T_{set} - T_{main}$$

$$\Delta T_{amb} = T_{set} - T_{amb}$$

Annual Fuel Savings

$$\Delta Therms = Therms_b - Therms_q$$

Where,

$$Therms_b = \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{100{,}000 \times UEF_b}\ (Fossil\ Fuel\ Baseline)$$

$$Therms_b = 0\ (Electric\ Baseline)$$

$$Therms_q = \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{100{,}000 \times UEF_q}\ (Fossil\ Fuel\ Energy\ Efficient\ Case)$$

$$Therms_q = 0\ (Electric\ Energy\ Efficient\ Case)$$

$$GPD = 17.2 \times N_{ppl}$$

$$\Delta T_{main} = T_{set} - T_{main}$$

$$\Delta T_{amb} = T_{set} - T_{amb}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\left(UA_b - UA_q\right) \times \Delta T_{amb}}{3{,}412} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms - day_{peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 2-188~~187~~188 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms\text{-}day_{Peak}$	Daily peak fuel savings	N/A	Therms/day	
ΔT_{main}	Average temperature difference between water heater set point temperature and the supply water temperature in water main (°F)	Calculated	°F	
ΔT_{amb}	Average temperature difference between water heater set point temperature and the surrounding ambient air temperature (°F)	Calculated	°F	
GPD	Gallons per day	Calculated, if N_{ppl} unknown, use 46	Gal/day	[262]~~[2612]~~
N_{ppl}	Number of people in household	Site-specific. If unknown, use 2.65	N/A	[269]~~[2689]~~
T_{set}	Water heater set point temperature	Site-specific. If unknown, use 125	°F	[263]~~[2623]~~
T_{main}	Supply water temperature in water main	60	°F	[264]~~[2634]~~
T_{amb}	Surrounding ambient air temperature	70	°F	

Variable	Description	Value	Units	Ref
UEF_b	Uniform Energy Factor of the baseline condition	Retrofit: Site-specific New construction: Look up in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~	N/A	[267]~~[2667]~~
UEF_q	Uniform Energy Factor of the energy efficient measure.	Site-specific	N/A	
UA_b	Overall heat loss coefficient of the baseline condition.	Storage water heater baseline: $UA_b = 7.85$ Indirect water heater baseline: $UA_b = 0$	(Btu/h-°F).	[265]~~[2645]~~
UA_q	Overall heat loss coefficient of the energy efficient measure.	0	(Btu/h-°F).	[266]~~[2656]~~
365	Days per year	365	Days/yr	
3,412	Conversion from Btu to kWh	3,412	Btu/kWh	
8.33	Energy required (Btu) to heat one gallon of water by one degree Fahrenheit	8.33	Btu/gal-°F	
100,000	Conversion from Btu to therms	100,000	Btu/therm	
CF	Electric coincidence factor	Look up in Table 2-189~~Table 2-188~~189	N/A	
PDF	Peak day factor	Look up in Table 2-189~~Table 2-188~~189	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Peak Factors

Table 2-189~~188~~189 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.8	[268]~~[2678]~~
Natural gas peak day factor (PDF)	N/A	

Measure Life

The remaining useful life (RUL) for retrofit projects is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 2-~~190~~189190 Measure Life

Equipment	New construction EUL	Retrofit RUL	Ref
Instantaneous Water Heater	20	6.66	[268]~~[2678]~~

References

~~[261]~~[262] Water Research Foundation: Residential End Uses of Water, Version 2, April 2016, p. 5; 17.2 GPD equated from the report findings indicating an average 2.65 people per household and 45.5 GPD per household, April 2016.

~~[262]~~[263] 10 CFR 430 Appendix E to Subpart B of Part 430 Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature, December 2022.

~~[263]~~[264] Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory, 2022.

~~[264]~~[265] Based on computation of heat loss coefficients via conversion equations found in 10 CFR 429, 430, and 431 Docket No. EERE-2015-BT-TP-0007, Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment, December 2022.

~~[265]~~[266] Based on the average standby loss specification (in °F/hr) of AHRI-certified Indirect Water Heater storage tanks, per the AHRI Directory, December 2022.

~~[266]~~[267] 10 CFR 430.32(d), December 2022.

~~[267]~~[268] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (TRM), Version 9, January 2022. https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V9.pdf

~~[268]~~[269] *Residential End Uses of Water: Version 2 Executive Report (Water Research Foundation)*, Pg 8. https://www.circleofblue.org/wp-content/uploads/2016/04/WRF_REU2016.pdf

Field Code Changed

Field Code Changed

2.7.5 COMBINATION BOILER

Market	Residential
Baseline Type	TOS/NC/EREP
Baseline	Code/Existing/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	January 2024
Changes Since Last Version	~~New measure~~

Description

This section provides energy savings algorithms for qualifying gas combination boilers installed in residential settings. A combination boiler is a space heating system that also has the capability to provide instantaneous domestic hot water. The input values are based on the specifications of the actual equipment being installed, federal equipment efficiency standards, and regional estimates of average baseline water heating energy usage.

For new construction, and time of sale replacement of failed equipment at the end of the boiler useful life, the baseline unit is a code compliant unit with an efficiency as required by IECC 2021, which is the current code adopted by the State of New Jersey.

For early replacement programs, the baseline efficiency is the existing boiler efficiency for the remaining life of the existing boiler and a code efficiency boiler for the remaining life of the measure.

Baseline Case

Space Heating Component:

- NC/TOS: Single baseline of boiler of the same fuel type as the installed equipment which is compliant with IECC 2021.
- EREP: Dual baseline
    - First baseline for existing equipment RUL: Existing boiler efficiency. If unknown, use minimally code-compliant efficiency from code in force at time of installation. If installation year is unknown, assume ⅔ EUL has elapsed.
    - Second baseline for remainder of measure EUL: Boiler compliant with IECC 2021.

Domestic Hot Water Component:

- NC/TOS: Single baseline of a storage water heater of the same fuel type as the installed equipment which is compliant with IECC 2021.
- EREP: Dual baseline
    - First baseline for existing equipment RUL: Existing water heater efficiency. If unknown, use minimally code-compliant efficiency for a storage water heater from code in force at time of installation. If installation year is unknown, assume ⅔ EUL has elapsed.
    - Second baseline for remainder of measure EUL: Storage water heater compliant with IECC 2021.

Efficient Case

The compliance condition is a combi-boiler unit with a heating efficiency higher than code. Qualifying systems must not have a water storage tank.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Annual Fuel Savings

$$\Delta Therms = \Delta Therms_{Boiler} + \Delta Therms_{DHW}$$

Where,

$$\Delta Therms_{Boiler} = Cap_{in} \times EFLH_h \times \frac{AFUE_q/AFUE_b - 1}{100}$$

$$\Delta Therms_{DHW} = \frac{GPD \times 365 \times 8.33 \times (T_{set} - T_{main})}{100{,}000} \times \left(\frac{1}{UEF_b} - \frac{1}{UEF_q}\right)$$

$$GPD = 17.2 \times N_{people}$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms:

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 2-191~~190191~~ Calculation Parameters

Variable	Description	Value	Units	Ref
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$\Delta Therms_{Boiler}$	Annual fuel savings from space heating	Calculated	Therms/day	
$\Delta Therms_{DHW}$	Annual fuel savings from water heating	Calculated	Therms/day	
GPD	Gallons per day of hot water use	Calculated, if unknown use 46	Gal/day	[277]~~[2767]~~
Cap_{in}	Input capacity of qualifying boiler	Site-specific	kBtu/hr	
$AFUE_q$	Boiler proposed efficiency	Site-specific	N/A	
N_{People}	Number of people served by the system	Site-specific	people	
T_{set}	Water heater setpoint temperature	Site-specific, if unknown, use 125	°F	[84]
UEF_q	Efficient case water heater Uniform Energy Factor	Site-specific, if unknown use 0.87[64]	N/A	
$EFLH_h$	Boiler equivalent full load hours of operation during heating season	Look up in Appendix C**Error! Reference source not found.**~~Appendix C:~~	Hours	[83]
$AFUE_b$	Boiler baseline efficiency	TOS/NC: Code compliant baseline values given in Table 2-192~~Table 2-191192~~ EREP: Site-specific, if unknown use code efficiency in force when equipment was new. If vintage unknown, assume ⅔ EUL has elapsed.	N/A	[271]~~[2701]~~
UEF_b	Baseline water heater Uniform Energy Factor	TOS/NC: Code compliant baseline values if unknown use 0.657 EREP: Site-specific, if unknown use code efficiency in force when equipment was new. If vintage unknown, assume ⅔ EUL has elapsed.	N/A	[86]
T_{main}	Incoming water main temperature[65]	60	°F	[85]
100	Unit conversion from kBtu to therm	100	kBtu/therm	
365	Days per year	365	Day/yr	

[64] Minimum UEF for instantaneous (tankless) water heaters from Energy Star

[65] Average value across 5 NJ climate zones. Calculated from annual average ambient air temperature + 6 deg F.

Variable	Description	Value	Units	Ref
8.33	Unit conversion, Btu/gal·F	8.33	Btu/gal·F	
100,000	Unit conversion, Btu/therm	100,000	Btu/therm	
8,760	Hours in one year	8760	Hours	
PDF	Peak day factor	Look up in Table 3-382~~Table 3-367~~383	N/A	
EUL	Estimated useful life	See Measure Life Section	Years	[88]

Table 2-192~~191~~192 Baseline AFUE of Single Family Boilers

Product Class	AFUE Manufactured before Sep 1, 2012	AFUE (Manufactured on and after Sep 1, 2012 and before Jan 15, 2021)	AFUE (Manufactured on and after January 15, 2021)
Gas-fired hot water boiler	0.80	0.82	0.84
Gas-fired steam boiler	0.75	0.80	0.82
Oil-fired hot water boiler	0.80	0.84	0.86
Oil-fired steam boiler	0.80	0.82	0.85

Peak Factors

Table 2-193~~192~~193 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See Appendix	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 2-194~~193~~194 Measure Life

Equipment	EUL	RUL	Ref
Combination Boiler	22	7.3	[88]

References

~~[269]~~[270] Simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

~~[270]~~[271] 10 CFR 430 Appendix E to Subpart B of Part 430 Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature, December 2022.

~~[271]~~[272] Burch, Jay and Christensen, Craig, *Towards Development of an Algorithm for Mains Water Temperature* (National Renewable Energy Laboratory). https://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/water_heaters/AlgorithmForMainsWaterTemperature.pdf

~~[272]~~[273] The referenced federal standards for the baseline UEF are dependent on both draw pattern and tank size. A weighted average baseline UEF was calculated with a medium draw pattern from the referenced federal standards and water heating equipment market data from the Energy Information Association 2009 residential energy consumption survey for NJ[66] assuming tank sizes of 30 gallons for small water heaters, 40 gallons for medium water heaters, and 55 gallons for large water heaters.

~~[273]~~[274] "Regulations.gov." n.d. www.regulations.gov. Accessed December 13, 2022. Based on computation of heat loss coefficients via conversion equations found in 10 CFR 429, 430, and 431 Docket No. EERE-2015-BT-TP-0007, Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment: Test Procedures for Consumer and Commercial Water Heaters. Heat loss coefficient was calculated for a minimally code compliant fuel storage water heater found to be the most typical in terms of storage and input capacity, representing storage type water heaters of between 20 and 55 gallon capacity (40 gallon, 40,000 Btu/h assumed). Results of heat loss coefficient evaluation for this assumed baseline is used to represent the UAbaseline term.

~~[274]~~[275] https://www.regulations.gov/document/EERE-2015-BT-TP-0007-0004

~~[275]~~[276] Food Service Technology Center, Design Guide – Energy Efficient Heating, Delivery and Use, Table 1. Typical hot water system cost for restaurants, March 2010

~~[276]~~[277] Water Research Foundation: Residential End Uses of Water, Version 2, April 2016, p. 5; 17.2 GPD equated from the report findings indicating an average 2.65 people per household and 45.5 GPD per household.

Field Code Changed

[66] Available at: https://www.eia.gov/consumption/residential/data/2009/hc/hc8.8.xls

Field Code Changed

2.7.6 WATER HEATING SETBACK

Market	Residential/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	December 2022
Changes Since Last Version	~~Removed references to DI Baseline Condition and dual baseline~~

Description

This measure relates to turning down an existing hot water tank thermostat setting that is at 130 degrees or higher. Savings are provided to account for the resulting reduction in standby losses. This is a retrofit measure.

Baseline Case

The baseline condition is a hot water tank with a thermostat setting that is 130 degrees or higher. Note if there are more than one DHW tanks in the home at or higher than 130 degrees and they are all turned down, then the savings per tank can be multiplied by the number of tanks.

Efficient Case

The efficient condition is a hot water tank with the thermostat reduced to no lower than 120 degrees.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = \left(\frac{U \times A \times (T_b - T_q) \times Hrs}{3{,}412 \times RE_{electric}}\right)$$

Annual Fuel Savings

$$\Delta Therms = \left(\frac{U \times A \times (T_b - T_q) \times Hrs}{1{,}00{,}000 \times RE_{gas}}\right)$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-195~~194~~195 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms\text{-}day_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
$\Delta kWh_{Lifetime}$	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Lifetime}$	Lifetime fuel savings	Calculated	Therms	
U	Overall heat transfer coefficient of tank	Site-specific, if unknown use 0.083[67]	(Btu/Hr-°F-ft^2)	
A	Surface area of storage tank	Site-specific, if unknown look up in Table 2-196~~Table 2-195~~196	Ft^2	[278]~~[2778]~~
T_b	Hot water setpoint prior to adjustment	Site-specific, if unknown use 130	°F	[281]~~[2801]~~
T_q	New hot water setpoint	Site-specific, if unknown, use 120	°F	[280]~~[279280]~~
Hours	Number of hours in a year	8760	Hrs/yr	
$RE_{electric}$	Recovery efficiency of water heater	Electric Hot Water Heater: 0.98 Heat Pump Water Heater: 2.1	N/A	[278]~~[2778]~~
RE_{gas}	Recovery efficiency of gas water heater	0.8	N/A	[279]~~[2789]~~
3,412	Conversion from Btu to kWh	3,412	Btu/kWh	

[67] Assumes R-12 water tank

Variable	Description	Value	Units	Ref
100,000	Conversion from Btu to therms	100,000	Btu/therm	
CF	Electric coincidence factor	Look up in Table 2-197~~Table 2-196~~197	N/A	
EUL	Effective useful life	See Measure Life	Years	
RUL	Remaining useful life of existing unit	See Measure Life	Years	

Table 2-196~~195~~196 Assumed Surface Area of Storage Tank by Capacity

Capacity (in gallons)	Area (in square feet)
30	19.16
40	23.18
50	24.99
80	31.84

If capacity is unknown, assume a 50 gallon tank.

Peak Factors

Table 2-197~~196~~197 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life for water heating setback is the smaller of 2 years or the remaining useful life of the water heater [280]~~[279~~280].

References

~~[277]~~[278] Assumptions from Pennsylvania TRM. Area values were calculated from average dimensions of several commercially available units, with radius values measured to the center of the insulation, December 2022. https://www.puc.pa.gov/filing-resources/issues-laws-regulations/act-129/technical-reference-manual/Code of Federal Regulations, Title 10, Chapter II, Subchapter D, Part 430, Subpart B, Appendix E – Uniform Test Method for Measuring the Energy Consumption of Water Heaters: *6.3.2 Recovery Efficiency,* December 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-B#Appendix-E-to-Subpart-B-of-Part-430.

~~[278]~~[279] Code of Federal Regulations, Title 10, Chapter II, Subchapter D, Part 431, Section 431.110 (a) – Energy Conservation Standards and their Effective Dates. December 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-431#431.110.

Field Code Changed

Field Code Changed

~~[279]~~[280] Mid-Atlantic TRM V10, December 2022. https://neep.org/sites/default/files/resources/Mid_Atlantic_TRM_V9_Final_clean_wUpdateSummary%20-%20CT%20FORMAT.pdf.

~~[280]~~[281] *Technical Reference Manual Volume 2: Residential Measures (2019)*; Pg 73, https://www.puc.pa.gov/filing-resources/issues-laws-regulations/act-129/technical-reference-manual/

Field Code Changed

2.7.7 FAUCET AERATORS AND SHOWERHEADS

Market	Residential/Multifamily
Baseline Condition	RF/TOS
Baseline	Existing/Code
End Use Subcategory	Water Conservation
Measure Last Reviewed	February 2024
Changes Since Last Version	• ~~Updated baseline and efficient case description~~ • ~~Updated baseline and efficient flowrates~~ • ~~Updated default variable values in Table 2-198~~ • ~~Updated non-energy impact calculations~~ • ~~Added calculations assumptiosn for 'unknown' location~~

Description

This measure presents the assumptions, analysis, and savings from adding low-flow aerators to faucets in kitchens and bathrooms, and for replacing standard showerheads with low-flow showerheads.

Savings for low-flow fixture measures are determined using the total change in flow rate (gallons per minute) per unit from the baseline (existing) fixture to the efficient low-flow fixture. This measure applies to residential and multifamily buildings.

Baseline Case

TOS: the baseline is a standard faucet or a showerhead meeting maximum flow given in the NJ A5160 [73].

RF: the baseline is the actual flow rate of the existing faucet. If unknown, default to the TOS baseline of a standard faucet or a showerhead meeting maximum flow given in the NJ A5160.

Efficient Case

The efficient condition is an energy efficient faucet aerator or showerhead with rated flow rate less than maximum flow rate given in the NJ A5160 [73]. Actual flow rates of the installed fixture are used to estimate the savings.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = \Delta H_2O \times \Delta T_{main} \times \frac{8.33}{3{,}412} \times \frac{1}{UEF} \times F_{elec}$$

Where,

$$\text{Aerators: } \Delta T_{main} = T_{faucet} - T_{main}$$

$$\text{Showerheads: } \Delta T_{main} = T_{shower} - T_{main}$$

Aerators:

$$\Delta H_2O = (GPM_b \times F_{Throttle,b} - GPM_q \times F_{Throttle,q}) \times \frac{1}{N_{faucet}} \times t_{use} \times N_{persons} \times 365$$

Showerhead:

$$\Delta H_2O = (GPM_b \times F_{Throttle,b} - GPM_q \times F_{Throttle,q}) \times \frac{1}{N_{shower}} \times t_{use} \times N_{persons} \times 365$$

Annual Fuel Savings

$$\Delta Therms = \Delta H_2O \times \Delta T_{main} \times \frac{8.33}{100{,}000} \times \frac{1}{UEF} \times F_{gas}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \Delta kWh \times ETDF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-~~198~~~~197~~198 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	

Variable	Description	Value	Units	Ref
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ΔH_2O	Annual water savings	Calculated	Gal/yr	
ΔT_{main}	Average temperature different between faucet operating temperature and the supply water temperature	Calculated. If unknown, use 25.	°F	
UEF	Uniform Energy Factor[68]	Site-specific. If unknown, assume 0.92 (electric) or 0.58 (gas)	N/A	[289]~~[2889]~~
N_{faucet}	Faucets per household	Site-specific. If unknown, look up in Table 2-199~~Table 2-198~~199	N/A	[288]~~[2878]~~
N_{shower}	Showers per household	Site-specific. If unknown, look up in Table 2-199~~Table 2-198~~199	N/A	[288]~~[2878]~~
$N_{persons}$	Average number of people per household	Site-specific. If unknown, assume 2.66	Person/ household	[282]~~[2812]~~
GPM_b	Baseline flowrate	RF: Site-specific, if unknown look up in Table 2-199~~Table 2-198~~199 TOS: Look up in Table 2-199~~Table 2-198~~199	Gal/min	[284]~~[2834]~~, [287]~~[2867]~~
GPM_q	Efficient flowrate	Site-specific	Gal/min	[287]~~[2867]~~
T_{faucet}	Faucet existing temperature	Site-specific. If unknown, look up in Table 2-199~~Table 2-198~~199	°F	[290]~~[2890]~~
T_{shower}	Showerhead existing temperature	Site specific, use 105 if unknown	°F	[292]~~[2912]~~
F_{elec}	Factor to account for presence or absence of electric water heater	1 if electric water heater; 0 if gas water heater; if unknown look up in Appendix K**Error! Reference source not found.**~~Appendix K: DHW and~~	N/A	

[68] Take UEF from application using the existing water heater's model number lookup. If unknown, then UEF is determined by the Department of Energy's test method outlined in 10 CFR Part 430, Subpart B, Appendix E (accessible here: https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32).
Assume medium draw pattern if unknown. If storage capacity is also unknown, use the assumptions above for a 40 gallon, medium draw, electric or gas storage water heater.

Field Code Changed

Variable	Description	Value	Units	Ref
		~~Space Heat Fuel Split~~ or default[69] = 0.25		
F_{gas}	Factor to account for presence or absence of fossil fuel water heater	1 if gas water heater; 0 if electric water heater; if unknown look up in Appendix K or default[70] = 0.71	N/A	
t_{use}	Average minutes of use per person per fixture per day	Look up in Table 2-199~~Table 2-198~~199	Minutes/ person/day	[283]~~[2823]~~, [293]~~[2923]~~
$F_{throttle, b}$	Ratio of user setting to full throttle flow rate for baseline fixture	Aerator: 0.83 Showerhead: 0.9	N/A	[286]~~[2856]~~, [293]~~[2923]~~
$F_{throttle, q}$	Ratio of user setting to full throttle flow rate for low flow fixture	Aerator: 0.95 Showerhead: 0.9	N/A	[286]~~[2856]~~, [293]~~[2923]~~
T_{main}	Supply water temperature in water main[71]	60	°F	[285]~~[2845]~~
ETDF	Energy to Demand Factor	Aerator: 0.000134 Showerhead: 0.00008014	kW/kWh/yr	[284]~~[2834]~~
8.33	Energy required to heat one gallon of water by one degree Farenheit	8.33	Btu/gal°F	
3,412	Conversion factor from Btu/h to kW	3,412	Btu/h/kW	
100,000	Conversion factor from Btu to therms	100,000	Btu/therm	
365	Number of days per year	365	Days/yr	
PDF	Peak day factor	Look up in Table 2-200~~Table 2-199~~200	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

[69] From 2015 RECS microdata for Middle Atlantic Div 8. Of 228 households, fuel mix for water heating is 71% gas and 25% electric. No savings are attributed to 4% of households which use other fuel sources.
[70] From 2015 RECS microdata for Middle Atlantic Div 8. Of 228 households, fuel mix for water heating is 71% gas and 25% electric. No savings are attributed to 4% of households which use other fuel sources.
[71] Average value across 5 NJ climate zones. Calculated from annual average ambient air temperature + 6°F. See Reference [285]~~[2845]~~.

Table 2-199~~198~~199 Calculation Assumptions per Fixture Type

Fixture Type	Location	Baseline gallons per minute (GPM_b)	Daily use duration (t_{use})	Operating temperature (T_{faucet}, T_{shower}) (°F)	Faucets/household (N_{faucet})
Faucet aerator	Kitchen	1.8 2.39 (ETG) 2.58 (SJG)	4.5	93	1
	Private restroom	1.5 2.33 (ETG) 2.82 (SJG)	1.6	86	1.75
	Unknown	1.6	2.5	88	1.5
Showerhead	Any	2.0 2.37 (ETG) 2.62 (SJG)	6.15	105	QHEC[72]: 1.56 HPwES[6]: 2.46

Peak Factors

Electric coincidence is included in the ETDF factor.

Table 2-200~~199~~200 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See Appendix G. Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) for both aerators and showerheads is 10 year [291]~~[2901]~~.

Non-Energy Impacts

Aerators:

$$\Delta H_2O = (GPM_b \times F_{Throttle,b} - GPM_q \times F_{Throttle,q}) \times \frac{1}{N_{faucet}} \times t_{use} \times N_{persons} \times 365$$

Showerhead:

[72] QHEC = Quick Home Energy Check-up; HPwES = Home Performance with ENERGY STAR Program

$$\Delta H_2O = (GPM_b \times F_{Throttle,b} - GPM_q \times F_{Throttle,q}) \times \frac{1}{N_{shower}} \times t_{use} \times N_{persons} \times 365$$

References

~~[281]~~[282] Explore Census Data. n.d. Data.census.gov. Accessed December 1, 2022. https://data.census.gov/table?q=average+household+size&g=0400000US34&y=2020&tid=ACSDT5Y2020.B25010

~~[282]~~[283] Cadmus and Opinion Dynamics Evaluation Team. Showerhead and Faucet Aerator Meter Study. For Michigan Evaluation Working Group. June 2013.

~~[283]~~[284] Pennsylvania Technical Reference Manual; effective June 2016, pp. 114ff. http://www.puc.pa.gov/pcdocs/1370278.docx

~~[284]~~[285] Burch, Jay and Christensen, Craig, *Towards Development of an Algorithm for Mains Water Temperature*. National Renewable Energy Laboratory. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.515.6885&rep=rep1&type=pdf

~~[285]~~[286] American Council for an Energy-Efficient Economy, *Energy Related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes*, August 2008, pg. 1-265.

~~[286]~~[287] Baseline flow rates established by State of New Jersey, 219th Legislature, Assembly No 5610

~~[287]~~[288] American Housing Survey Table Creator, United States Census Bureau, Housing Unit Characteristics, New York 2017 Accessed December 1, 2022 https://www.census.gov/programs-surveys/ahs/data/interactive/ahstablecreator.html?s_areas=35620&s_year=2021&s_tablename=TABLE0&s_bygroup1=1&s_bygroup2=1&s_filtergroup1=1&s_filtergroup

~~[288]~~[289] UEF assumptions per 10 CFR Part 430, Subpart B, Appendix E. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32; assuming medium draw pattern, 40 gallon storage water heater.

~~[289]~~[290] *Michigan Evaluation Working Group Showerhead and Faucet Aerator Meter Study.* June 2013, via 2014 Demand-Side Management Evaluation Final Report, Cadmus, June 30, 2015, Table 93.

~~[290]~~[291] California eTRM, CPUC Support Tables: Effective Useful Life and Remaining Useful Life https://www.caetrm.com/cpuc/table/effusefullife/; EUL ID: WtrHt-WH-Aertr, WtrHt-WH-Shrhd

~~[291]~~[292] Lutz, Jim. 2011. "Water and Energy Wasted during Residential Shower Events: Findings from a Pilot Field Study of Hot Water Distribution Systems." https://eta-publications.lbl.gov/sites/default/files/water_and_energy_wasted_during_residential_shower_events_findings_from_a_pilot_field_study_of_hot_water_distribution_systems_lbnl-5115e.pdf.

~~[292]~~[293] Biermayer, Peter, and Ernest Lawrence. 2006. "LBNL-58601-Revised Potential Water and Energy Savings from Showerheads." https://www.map-testing.com/assets/reports/LBNL%20Showerhead-final%20rpt.pdf.

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

2.7.8 THERMOSTATIC SHOWERHEADS

Market	Residential/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Water Conservation
Measure Last Reviewed	December 2022
Changes Since Last Version	~~Removed references to DI Baseline Condition and dual baseline~~

Description

This measure covers the installation of thermostatic shower restriction valves, which are valves attached to a showerhead supply for reduction of domestic hot water flow and associated energy usage in a single or multifamily household.

The device restricts hot water flow through the showerhead by activating the trickle or stop flow mode when water reaches a predetermined set temperature, as designed by the manufacturer.

The throttle factor should be used only when rated flows are used and not the actual measured flow.

Baseline Case

The baseline equipment is the residential showerhead without the restrictor valve installed.

Efficient Case

To qualify for this measure the installed equipment must be a thermostatic restrictor shower valve installed on a residential showerhead.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = GPM \times F_{Throttle} \times Min_{Waste} \times \frac{Person}{Household} \times \frac{Showers}{Person/Day} \times \frac{365}{N_{Shower}} \times 8.33 \times \frac{T_{Shower} - T_{Main}}{UEF \times 3{,}412} \times ISR \times F_{Elec}$$

Annual Fuel Savings

$$\Delta Therms = GPM \times F_{Throttle} \times Min_{Waste} \times \frac{Person}{Household} \times \frac{Showers}{Person/Day} \times \frac{365}{N_{Shower}} \times 8.33 \times \frac{T_{Shower} - T_{Main}}{UEF \times 100{,}000} \times ISR \times F_{NG}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \Delta kWh \times ETDF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-201~~200201~~ Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{life}$	Lifetime fuel savings	Calculated	Therms	
GPM	Flow rate of the showerhead	Site-specific, if unknown look up in Table 2-202~~Table 2-201202~~	Gal/min	[294]~~[2934]~~[301]~~[3001]~~
Person/Household	Average number of people per household	Site-specific, if unknown assume 3.36 (ETG) 2.46 (SJG) 2.66 (All others)	Person/ household	[296]~~[2956]~~
Showers/person/day	Showers Per Capita Per Day	Site-specific, if unknown assume 0.75	Showers/person/day	[297]~~[2967]~~
N_{Shower}	Average number of showerheads Per Household	Site-specific, if unknown assume 1.10	N/A	[298]~~[2978]~~

Variable	Description	Value	Units	Ref
UEF	Uniform Energy Factor	Site-specific, if unknown assume 0.92 (electric) or 0.58 (gas)	N/A	[302]~~[3012]~~
F_{Elec}	Water heater fuel factor - electric	Look up in Table 2-203~~Table 2-202~~203	N/A	
F_{NG}	Water heater fuel factor - gas	Look up in Table 2-203~~Table 2-202~~203	N/A	
$F_{Throttle}$	Ratio of actual shower gpm to showerhead rated gpm	0.9	N/A	[297]~~[2967]~~
Min_{Waste}	Hot water waste time avoided due to thermostatic restrictor valve	0.98	Minutes	[295]~~[2945]~~
T_{Shower}	Temperature at showerhead	105	°F	[299]~~[2989]~~
T_{Main}	Supply water temperature in water main[73]	60	°F	
ISR	In-Service Rate	Look up by program in **Error! Reference source not found.**~~Appendix J: In-Service Rates~~, or use default value = 1	N/A	
8.33	Energy required to heat one gallon of water by one degree Farenheit	8.33	Btu/gal°F	
3,412	Conversion factor from Btu/h to kW	3,412	Btu/h/kW	
100,000	Conversion factor from Btu to therms	100,000	Btu/therm	
365	Number of days per year	365	Days/yr	
ETDF	Energy to Demand Factor	0.00008014	(kW/ kWh/yr)	[300]~~[299300]~~
CF	Electric coincidence factor	Look up in Table 2-204~~Table 2-203~~204	N/A	

[73] Average value across 5 NJ climate zones. Calculated from annual average ambient air temperature + 6°F.

Variable	Description	Value	Units	Ref
PDF	Gas peak demand factor	Look up in Table 2-204~~Table 2-203~~204	N/A	
EUL	Effective useful life of new unit	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 2-202~~201~~202 GPM

Installation case	GPM
Existing Showerhead	2.5
New Conventional Showerhead	2.0
Low Flow Showerhead	1.5

Table 2-203~~202~~203 Water Heater Fuel Factors

Water Heater Fuel Type	F_{Elec}	F_{NG}
Electric	1	0
Gas	0	1
Unknown	Look up in **Error! Reference source not found.**~~Appendix K: DHW and Space Heat Fuel Split~~ or default = 0.18	Look up in **Error! Reference source not found.**~~Appendix K: DHW and Space Heat Fuel Split~~ or default = 0.82

Peak Factors

Table 2-204~~203~~204 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A[74]	
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

[74] Peak electric demand embedded in ETDF.

Measure Life

Table 2-~~205~~~~204~~205 Measure Life

Equipment	EUL	RUL	Ref
Thermostatic Showerheads	10	3.3	[303]~~[3023]~~

References

~~[293]~~[294] Cadmus and Opinion Dynamics Evaluation Team. *Showerhead and Faucet Aerator Meter Study: For Michigan Evaluation Working Group.* (June, 2013).

~~[294]~~[295] Cadmus memo to PPL Electric. *PPL Electric 2014 ShowerStart Pilot Study*. (November 2014).

~~[295]~~[296] Explore Census Data." n.d. Data.census.gov. Accessed December 1, 2022. https://data.census.gov/table?q=average+household+size&g=0400000US34&y=2020&tid=ACSDT5Y2020.B25010.

~~[296]~~[297] Biermayer, Peter. 2006. "LBNL-58601-Revised Potential Water and Energy Savings from Showerheads." https://www.map-testing.com/assets/reports/LBNL%20Showerhead-final%20rpt.pdf.

~~[297]~~[298] American Housing Survey (AHS) - AHS Table Creator." n.d. Www.census.gov. Accessed December 1, 2022. https://www.census.gov/programs-surveys/ahs/data/interactive/ahstablecreator.html?s_areas=35620&s_year=2021&s_tablename=TABLE0&s_bygroup1=1&s_bygroup2=1&s_filtergroup1=1&s_filtergroup

~~[298]~~[299] Lutz, Jim. 2011. "Water and Energy Wasted during Residential Shower Events: Findings from a Pilot Field Study of Hot Water Distribution Systems." https://eta-publications.lbl.gov/sites/default/files/water_and_energy_wasted_during_residential_shower_events_findings_from_a_pilot_field_study_of_hot_water_distribution_systems_lbnl-5115e.pdf.

~~[299]~~[300] Aquacraft, Inc., Water Engineering and Management. The end use of hot water in single family homes from flow trace analysis. 2001. https://www.researchgate.net/publication/252083793_THE_END_USES_OF_HOT_WATER_IN_SINGLE_FAMILY_HOMES_FROM_FLOW_TRACE_ANALYSIS The CF for showerheads is found to be 0.00371: [% showerhead use during peak × (TPerson-Day× NPerson) /(S/home)] / 240 (minutes in peak period) = [11.7% × (7.8 x 2.6 x 0.6 / 1.6)] / 240 = 0.00371. The Hours for showerheads is found to be 46.3: (TPerson-Day× NPersons× 365) /(S/home) / 60 = (7.8 x 2.6 x 0.6 x 365) / 1.6 / 60 = 46.3. The resulting FED is calculated to be 0.00008013: CF / Hours = 0.00371 / 46.3 = 0.00008013.

~~[300]~~[301] Maximum flowrates for new showerheads taken from New Jersey P.L. 2021, c. 464 Enacted January 2022. https://legiscan.com/NJ/bill/A5160/2020

~~[301]~~[302] Take UEF from application using the existing water heater's model number lookup. If unkown, then UEF is determined by the Department of Energy's test method outlined in 10 CFR Part 430, Subpart B, Appendix E (accessible here: https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32). Assume medium draw pattern if unknown. If storage capacity is also unknown, use the assumptions above for a 40 gallon, medium draw, electric or gas storage water heater.

~~[302]~~[303] California Public Utilities Commission EUL Table, version 027 (updated November 12, 2022). Accessed December 30, 2022. https://www.caetrm.com/shared-data/value-table/EUL/

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

2.7.9 PIPE INSULATION

Market	Residential/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Insulation
Measure Last Reviewed	November 2022
Changes Since Last Version	~~Removed references to DI Baseline Condition and dual baseline~~

Description

This measure covers the installation of fiberglass, rigid foam, and cellular glass pipe insulation on exposed and uninsulated metal or steel piping with a nominal diameter between 0.50” and 4.00” for hot water and steam type space heating and/or domestic hot water (DHW) distribution systems in residential buildings. The measure is restricted to insulation of hot water distribution pipe in unconditioned spaces only. Space heating pipe insulation is limited to insulation installed in unheated spaces only. Insulation of CPVC, PEX, and HDPE piping is not eligible for savings under this measure due to low potential of savings.

In New Jersey the 2021 International Energy Conservation Code (IECC) generally defines the residential energy efficiency code requirements, but the IECC does not include residential service water heating provisions, leaving federal equipment efficiency standards to define baseline.

This measure caters for all insulation type given that they are IECC 2021 code compliant and are installed by certified professionals. The R-value of an insulation is the thermal resistance of its constituent material, which is derived by dividing the thickness of the material by the material’s thermal conductivity, or k-value. Thermal transmittance, or the material’s U-factor, is the inverse of the R-value.

Baseline Case

The baseline condition is uninsulated copper or steel domestic hot water or space heating piping located in an unconditioned space.

Efficient Case

The efficient case is insulated copper or steel domestic hot water or space heating piping located in an unconditioned space conforming to the requirements of IECC 2021 Section R403.5.2 which require hot water piping with 3/4" nominal diameter and larger to be insulated with a minimum thermal resistance of R-3.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = \frac{\left[\left(\frac{UA}{L}\right)_b - \left(\frac{UA}{L}\right)_q\right] \times L \times \left(T_{pipe} - T_{amb}\right) \times hrs \times SF_{elec}}{Et_{elec} \times 3{,}412}$$

Annual Fuel Savings

$$\Delta Therms = \frac{\left[\left(\frac{UA}{L}\right)_b - \left(\frac{UA}{L}\right)_q\right] \times L \times \left(T_{pipe} - T_{amb}\right) \times hrs \times SF_{fuel}}{Et_{fuel} \times 100{,}000}$$

Peak Demand Savings

$$\Delta kW_{peak} = \frac{\Delta kWh}{8{,}760} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-206~~205~~206 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	

Variable	Description	Value	Units	Ref
L	Length of installed insulation	Site-specific	ft	
T_{pipe}	Average temperature of hot water or steam in distribution system piping	Site-specific, if unknown: DHW: 125 HW Boiler[75]: 160 Steam Boiler[76]: 212	°F	[308]~~[3078]~~
T_{amb}	Surrounding average ambient air temperature	Site-specific, if unknown: DHW: 70 Space Heat: 50	°F	[311]~~[3101]~~
Et_{fuel}	Recovery Efficiency of fuel water heaters or AFUE of boiler for space heating	Site-specific, if unknown: DHW[77]: 0.75 Space Heating Boilers: Look up in Table 2-209~~Table 2-208~~209	N/A	[306]~~[3056]~~[313]~~[3123]~~
Et_{elec}	Recovery Efficiency of electric water heaters	Site-specific, if unknown: Non- Heat Pump DHW[78]: 0.98 Heat Pump DHW: Look up in Table 2-210~~Table 2-209~~210	N/A	[307]~~[3067]~~[309]~~[3089]~~
hrs	Annual operating hours	For DHW: 8,760 Boilers: Look up heating EFLH in **Error! Reference source not found.**~~Appendix C: Heating and Cooling EFLH~~	hrs	[314]~~[3134]~~
$(UA/L)_b$	Product of Overall Heat Transfer Coefficient and Pipe Area (UA) per foot from uninsulated pipe[79]	Look up in Table 2-207~~Table 2-206~~207	Btu/hr-°F-ft	[310]~~[3109]~~
$(UA/L)_q$	Product of Overall Heat Transfer Coefficient and Pipe Area (UA) per foot from insulated pipe[79][77][78]	Look up in Table 2-208~~Table 2-207~~208	Btu/hr-°F-ft	[315]~~[3145]~~
SF_{elec}	Adjustment to electric water heating energy savings based on water heating fuel	Electric WH: 1.0 Fossil Fuel WH: 0	N/A	[312]~~[3112]~~

[75] Average of lowest typical hot water boiler setting of (120°F) and highest typical setting of (200°F).
[76] Residential boiler's steam temperature shall be the boiling point of water at sea level (212°F).
[77] Nominal gas or oil water heater recovery efficiency taken by CFR is 75% for deriving water energy consumption of consumer products such as dishwashers, etc. [306]~~[3056]~~
[78] The CFR Uniform Test Method for the measurement of Standby Loss of Electric Storage Water Heaters, electric Storage-Type Instantaneous Water Heaters, and electric Instantaneous Water Heaters (Other Than Storage-Type Instantaneous Water Heaters) uses 98% efficiency for electric water heaters with immersed heating elements. [306]~~[3056]~~
[79] Also called Building Load Coefficient per unit length.

Variable	Description	Value	Units	Ref
		Unknown WH: Look up in **Error! Reference source not found.**~~Appendix K: DHW and Space Heat Fuel Split~~ or default[80] = 0.18		
SF_{fuel}	Adjustment to fossil fuel water heating energy savings based on water heating fuel	Electric WH: 0 Fossil Fuel WH: 1.0 Unknown WH: Look up in **Error! Reference source not found.**~~Appendix K: DHW and Space Heat Fuel Split~~ or default[81] = 0.82	N/A	[312]~~[3112]~~
CF	Electric coincidence factor	Look up in Table 2-211~~Table 2-210~~211	N/A	
PDF	Gas peak day factor	Look up in Table 2-211~~Table 2-210~~211	N/A	
EUL	Effective useful life	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 2-207~~206~~207 (UA/L)$_{baseline}$

Nominal Pipe Diameter (in)	Bare Copper Piping			Bare Steel Piping	
	Domestic Hot Water	Hot Water Heat	Steam Heat	Hot Water Heat	Steam Heat
0.50	0.44	0.48	0.53	0.53	0.59
0.75	0.54	0.58	0.64	0.65	0.72
1.00	0.65	0.70	0.78	0.79	0.88
1.25	0.80	0.86	0.96	0.97	1.09
1.50	0.90	0.97	1.09	1.10	1.23
2.00	1.10	1.19	1.33	1.34	1.51
2.50	1.31	1.42	1.58	1.60	1.80
3.00	1.57	1.70	1.90	1.92	2.16
3.50	1.77	1.92	2.15	2.18	2.45
4.00	1.98	2.14	2.40	2.43	2.73

[80] "Unknown" calculated as the number of homes with electric water heating divided by the total number of homes with water heating in EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States, Table HC8.7.
[81] "Unknown" calculated as the number of homes with gas water heating divided by the total number of homes with water heating in EIA Residential Energy Consumption Survey (RECS) 2015 for Middle Atlantic States, Table HC8.7.

Table 2-208~~207~~208 $(UA/L)_q$

Nominal Pipe Diameter (in)	Fiberglass						Rigid Foam/Cellular Glass					
	0.5 in	1 in	1.5 in	2 in	2.5 in	3 in	0.5 in	1 in	1.5 in	2 in	2.5 in	3 in
0.50	0.13	0.09	0.08	0.07	0.06	0.06	0.15	0.12	0.10	0.09	0.09	0.08
0.75	0.14	0.11	0.09	0.08	0.07	0.07	0.17	0.13	0.11	0.10	0.10	0.09
1.00	0.17	0.12	0.10	0.09	0.08	0.07	0.19	0.15	0.13	0.12	0.11	0.10
1.25	0.20	0.14	0.11	0.10	0.09	0.08	0.23	0.17	0.15	0.13	0.12	0.11
1.50	0.22	0.15	0.12	0.11	0.10	0.09	0.25	0.19	0.16	0.14	0.13	0.12
2.00	0.26	0.18	0.14	0.12	0.11	0.10	0.29	0.22	0.18	0.16	0.14	0.13
2.50	0.30	0.20	0.16	0.14	0.12	0.11	0.34	0.25	0.20	0.18	0.16	0.15
3.00	0.35	0.24	0.18	0.16	0.14	0.12	0.39	0.29	0.23	0.20	0.18	0.16
3.50	0.40	0.26	0.20	0.17	0.15	0.13	0.44	0.32	0.26	0.22	0.20	0.18
4.00	0.44	0.29	0.22	0.18	0.16	0.14	0.48	0.35	0.28	0.24	0.21	0.19

Table 2-209~~208~~209 Et_{fuel} for Space Heating Boilers

Product Class	AFUE (Manufactured before 9/1/2012)	AFUE (Manufactured on/after 9/1/2012, before 1/15/2021)	AFUE (Manufactured on/after 1/15/2021)
Gas-fired hot water boiler	0.80	0.82	0.84
Gas-fired steam boiler	0.75	0.80	0.82
Oil-fired hot water boiler	0.80	0.84	0.86
Oil-fired steam boiler	0.80	0.82	0.85

Table 2-210~~209~~210 Et_{elec} for Domestic Hot Water Heaters

Size (Gallons)	UEF	Et_{elec}
50	3.30	2.83
50	3.50	2.92
50	3.75	3.14
65	3.30	2.85
65	3.50	2.94

Size (Gallons)	UEF	Et_{elec}
65	3.75	3.24
80	3.30	2.85
80	3.50	3.01
80	3.75	3.38
Unknown Size[82]	-	3.016

Peak Factors

Table 2-212~~210~~211 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	DHW: 1.0 Space Heat: N/A	
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 2-212~~211~~212 Measure Life

Equipment	EUL	RUL	Ref
Electric Water Heaters	13	4.33	[316]~~[3156]~~
Gas Water Heaters	11	3.66	[316]~~[3156]~~

References

~~[303]~~[304] 2022 Illinois Statewide Technical Reference Manual for Energy Efficiency. 2021, Page 88. https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010122_v10.0_Vol_3_Res_09242021.pdf

~~[304]~~[305] Pipe Sizing Charts Tables | Energy-Models.com. 2013. Energy-Models.com. 2013. https://energy-models.com/pipe-sizing-charts-tables.

Field Code Changed

Field Code Changed

[82] Unknown COP is the average of storage tank heat pump water heater's COP for medium to high draw types covering a storage capacity range of 50 gallons to 80 gallons taken from California Energy Data and Reporting System's DEER Water Heater Calculator [307]~~[3067]~~.

~~[305]~~[306] Code of Federal Regulations. 2022. Review of Title 10, Chapter II, Subchapter D, Part 430 eCFR. December 1, 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430

~~[306]~~[307] 2022 California Public Utilities Commission. n.d. Review of DEER Resources - Water Heater - DEER Water Heater Calculator. Cedars - California Energy Data and Reporting System. https://cedars.sound-data.com/deer-resources/tools/water-heaters/.

~~[307]~~[308] Code of Federal Regulations. 2022. Review of Title 10, Chapter II, Subchapter B, Part 430, Appendix E - Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-B

~~[308]~~[309] Code of Federal Regulations. 2022. Review of Title 10, Chapter II, Subchapter D, Part 431. Appendix B to Subpart G of Part 431 - Uniform Test Method for the Measurement of Standby Loss of Electric Storage Water Heaters and Storage-Type Instantaneous Water Heaters, eCFR. December 1, 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-431/subpart-G

~~[309]~~[310] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – Version 9 (New York State Joint Utilities, 2021), Pg 76. https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V9.pdf

~~[310]~~[311] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – Version 9. (New York State Joint Utilities, 2021), Pg 74. https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V9.pdf

~~[311]~~[312] NREL. 2022. Review of US Residential Sector circa 2018. ResStock. September 2022. https://resstock.nrel.gov/dataviewer/building-characteristics/?datasetName=vizstock_resstock_amy2018_release_2022_1_by_state_view.

~~[312]~~[313] Code of Federal Regulations. 2022. Review of Title 10, Chapter II, Subchapter D, Part 430, Subpart C, 430.32 d) eCFR. November 28, 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32

~~[313]~~[314] Simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

~~[314]~~[315] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – Version 9. (New York State Joint Utilities, 2021), Pg 509, https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V9.pdf

~~[315]~~[316] California Public Utilities Commission EUL Table, version 027 (updated November 12, 2022). Accessed December 30, 2022. https://www.caetrm.com/shared-data/value-table/EUL/

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

2.7.10 POOL PUMPS

Market	Residential/Multifamily
Baseline Condition	TOS/NC
Baseline	Code
End Use Subcategory	Swimming Pools
Measure Last Reviewed	December 2022

Description

This measure covers the installation of ENERGY STAR® certified variable frequency drive (VFD) pool pumps in residential buildings and multifamily buildings. An ENERGY STAR® certified pool pump can run at different speeds and be programmed to match the pool operation with its appropriate pool pump speed. The measure is applicable to new construction, or time of sale baseline conditions.

Baseline Case

The baseline case is a self-priming (aboveground) or non-self-priming (inground) pool filter pump with a minimum allowable weighted energy factor defined by the Code of Federal Regulations [317]~~[3167]~~. Starting July 19, 2021, all pool pumps must be rated according to Weighted Energy Factor (WEF), i.e., kilogallons of water pumped per unit kWh [318]~~[3178]~~.

Efficient Case

The efficient case is an ENERGY STAR® version 3.1 qualified variable-speed self-priming (inground) or non-self-priming (aboveground) pool filter pump. The weighted energy factor of the efficient pump must be greater than or equal to the Energy Star WEF requirement set for a given hydraulic horsepower (HHP) class of pool pumps. The HHP is the overall pumping power that is available from the motor and is different than the shaft power. The HHP can be derived from the proposed ENERGY STAR® pump's spec sheet from the ENERGY STAR® Database [319]~~[3189]~~.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = units\ x\ days\ x\ V_{pool}\ x\ N_{turnover}\ x\ \left(\frac{1}{WEFb} - \frac{1}{WEFq}\right)/1{,}000$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \Delta kWh\ x\ ETDF$$

Where,

$$ETDF = \frac{CF}{Hrs}$$

$$Hrs = Hrs_{daily}\ x\ days$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 2-213~~212~~213 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Hrs	Annual hours of operation	Calculated	hr	
units	Number of measures installed	Site-specific	N/A	
days	Number of days of operation of the pool pump annually	Site-specific, if unknown use 122	N/A	[320]~~[319320]~~
V_{pool}	Volume of pool	Site-specific, if unknown use 22,000 gallons (inground) 7,540 (above ground)	Gallons	[321]~~[3201]~~[325]~~[3245]~~
$N_{turnover}$	Number of turnovers per day, where a turnover is a full cycling of pool water by the pump through the filter or the cleaner	Site-specific, if unknown use 2	N/A	[321]~~[3201]~~
WEF_b	Minimum allowable Federal Weighted Energy Factors	Look up in Table 2-214~~Table 2-213214~~	kgal/kWh	[318]~~[3178]~~[319]~~[3189]~~
WEF_q	Energy Efficient Pool Pumps Weighted Energy factor, per Energy Star certificate	Site-specific, min qualifying in Table 2-214~~Table 2-213214~~	kgal/kWh	[318]~~[3178]~~[319]~~[3189]~~

Variable	Description	Value	Units	Ref
HHP	Hydraulic horsepower, per energy star certificate	Site-specific	hp	[319]~~[3189]~~
Hrs_{daily}	Daily hours of pump operation	Site-specific, if unknown use 5.18	hrs	[322]~~[3212]~~
CF	Coincidence factor	Look up in Table 2-215~~Table 2-214~~215	N/A	[323]~~[3223]~~
PDF	Peak day factor	Look up in Table 2-215~~Table 2-214~~215	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 2-214~~213~~214 Minimum Allowable WEF Rating

Dedicated-Purpose Pool Pump Type	HHP Applicability	Motor Phase	Baseline WEF Score (kgal/kWh)	Qualifying WEF Score (kgal/kWh)
Self-priming pool filter pumps	0.711 hp ≤hhp <2.5 hp	Single	−2.30 x ln(hhp) + 6.59	-2.45 x ln(hhp) + 8.4
Self-priming pool filter pumps	0.13 hp < hhp <0.711 hp	Single	−1.30 x ln(hhp) + 2.90	-2.45 x ln(hhp) + 8.4
Self-priming pool filter pumps	hhp ≤0.13 hp	Single	5.55	13.4
Non-self-priming pool filter pumps	0.13 hp < hhp < 2.5 hp	Any	−0.85 x ln(hhp) + 2.87	-1.00 x ln(hhp) + 3.85
Non-self-priming pool filter pumps	hhp ≤0.13 hp	Any	4.60	4.92

Peak Factors

Table 2-215~~214~~215 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.27	[323]~~[3223]~~
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 10 years [324]~~[3234]~~.

References

~~[316]~~[317] Code of Federal Regulations. Review of Title 10, Chapter II, Subchapter D, Part 431, Subpart Y, 431.465 f). ECFR. September 19, 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-431/subpart-Y.

Field Code Changed

~~[317]~~[318] ENERGY STAR® Pool Pump ver 3.1 Final Specification Sheet. https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Version%203.1%20Pool%20Pumps%20Final%20Specification.pdf

Field Code Changed

~~[318]~~[319] ENERGY STAR®, ENERGY STAR® Product Finder. https://www.energystar.gov/productfinder/product/certified-pool-pumps

Field Code Changed

~~[319]~~[320] CEE, Consortium for Energy Efficiency. 2013. Review of CEESM High Efficiency Residential Swimming Pool Initiative. Edited by Eileen Eaton. January 2013. https://library.cee1.org/system/files/library/9986/CEE_Res_SwimmingPoolInitiative_01Jan2013_Corrected.pdf

Field Code Changed

~~[320]~~[321] "Energy Star Pool Pump Calculator | Building America Solution Center." n.d. Basc.pnnl.gov. Accessed December 1, 2022. https://basc.pnnl.gov/library/energy-star-pool-pump-calculator

Field Code Changed

~~[321]~~[322] "Mid-Atlantic Technical Reference Manual (TRM) V10 | Northeast Energy Efficiency Partnerships." n.d. Neep.org. Accessed December 1, 2022. https://neep.org/mid-atlantic-technical-reference-manual-trm-v10

Field Code Changed

~~[322]~~[323] Design & Engineering Services, *INTEGRATION of DEMAND RESPONSE into TITLE 20 for RESIDENTIAL POOL PUMPS*. 2009. https://www.etcc-ca.com/sites/default/files/OLD/images/stories/dr_09.05.10_residentialpoolpumps_v7_10-0312.pdf.

Field Code Changed

~~[323]~~[324] DEER 2014 EUL ID: OutD-PoolPump

~~[324]~~[325] *Evaluation of Potential Best Management Practices – Pools, Spas, and Fountains,* (The California Urban Water Conservation Council, 2010) Pg 3. https://calwep.org/wp-content/uploads/2021/03/Pools-Spas-and-Fountains-PBMP-2010.pdf

Field Code Changed

2.8 WHOLE BUILDING

2.8.1 BEHAVIORAL CHANGE

Market	Residential/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Category	Whole Building
Measure Last Reviewed	January 2023

Description

This measure covers enrollment in a residential behavioral program that is designed to encourage lower energy usage through behavioral messaging. These behavioral messages can be periodic normative reports or messages that present the customers with timely information on their energy usage and a call to action to reduce or save energy. Behavioral messages can be delivered through many avenues, including paper, email, and text messages.

Because the characteristics of behavioral programs make them amenable to randomized, controlled trials (RCT), and because the program design includes an annual evaluation of its behavioral energy efficiency programs, use of evaluated savings estimates is required for each program year. Evaluations should be conducted, and savings calculated in accordance with the NJ Evaluation Guidelines: Behavioral Program Process and Impact Evaluations, Prepared by NJ Statewide Evaluator (SWE). If the program design changes and an annual evaluation is not conducted, savings as a percent of annual billed consumption from the most recent approved evaluation study must be used. Results from the NJ Triennium 1 Program year 1 evaluations are shown in Table yy.

The measure life for each participating customer is 1 year. Once the customer stops participation, savings may be claimed for the last participating year plus one additional year at the discretion of the program implementer.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

ΔkWh = Savings derived from annual evaluation compliant with Behavioral Guidance Document

Annual Fuel Savings

$\Delta Therms$ = Savings derived from annual evaluation compliant with Behavioral Guidance Document

Peak Demand Savings

ΔkW_{peak} = Savings derived from annual evaluation compliant with Behavioral Guidance Document

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = 0$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 2-216~~215~~216 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated per NJ Behavioral Program Guideline	kWh	[326]~~[3256]~~
ΔTherm	Annual natural gas savings	Calculated per NJ Behavioral Program Guideline	therms	[326]~~[3256]~~
ΔkW_{Peak}	Peak Demand Savings	Calculated per NJ Behavioral Program Guideline	kW	[326]~~[3256]~~
$\Delta Therms_{Peak}$	Daily peak fuel savings	0	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$\Delta Therms_{Peak}$	Daily peak fuel savings	0	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
EUL	Effective useful life	See Measure Life Section	yr	[331]~~[3301]~~

Table 2-217~~216~~217 Annual Savings Percentage from Tri 1 PY1 Evaluations

Percent Savings [327]~~[3267]~~[328]~~[3278]~~[329]~~[3289]~~[330]~~[329330]~~		
Utility	Electricity	Natural Gas
PSE&G	0.56%	0.41%
ETG		0.50%
SJG		1.07%
RECO	0.20%	

Measure Life

The measure life for each participating customer is 1 year. Once the customer stops participation, savings can be claimed for the last participating year plus one additional year at the discretion of the program implementer [331]~~[3301]~~.

References

~~[325]~~[326] NJ Evaluation Guidelines: Behavioral Program Process and Impact Evaluations, Prepared by NJ Statewide Evaluator (SWE). April 2023.
~~[326]~~[327] Cadmus. Public Service Electric & Gas Clean Energy Future Program Year 2021/2022 Evaluation Report, February 3, 2023.
~~[327]~~[328] ADM. EM&V Report, Prepared for South Jersey Industries Utility, Elizabethtown Gas, Program Year 1: July 1, 2021 – June 30, 2021. February 21, 2023.
~~[328]~~[329] ADM. EM&V Report, Prepared for South Jersey Industries Utility, South Jersey Gas, Program Year 1: July 1, 2021 – June 30, 2021. February 21, 2023.
~~[329]~~[330] AEG. Memorandum, PY1 Behavioral Program Evaluation, RECO, January 26, 2023.
~~[330]~~[331] NMR "R1606 Eversource Behavior Program Persistence Evaluation." Oct. 15, 2017. https://energizect.com/sites/default/files/documents/R1606_Eversource%20Behavior%20Persistence%20Evaluation_FINAL_10.15.17%20(1).pdf

2.8.2 HOME PERFORMANCE WITH ENERGY STAR (HPWES)

Market	Residential/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Category	Whole Building
Measure Last Reviewed	January 2023

Description

This measure addresses whole building upgrades to residential and multifamily low-rise buildings compliant with the Home Performance with Energy Star (HPwES) version 1.5 requirements [332]~~[3312]~~. In order to implement Home Performance with ENERGY STAR, there are various standards, a program implementer must adhere to . The HPwES program implemented in NJ uses software that meets national standards for savings calculations from whole-house approaches such as home performance. The difference in modeled annual energy consumption between the program and existing home is the project savings for heating, hot water, cooling, lighting, and appliance end uses.

The software the program implementer uses must adhere to at least one of the following standards:

- A software tool whose performance has passed testing according to the National Renewable Energy Laboratory's HERS BESTEST software energy simulation testing protocol [333]~~[3323]~~.
- Software approved by the US Department of Energy's Weatherization Assistance Program [334]~~[3334]~~.
- RESNET approved rating software [335]~~[3345]~~.

There are numerous software packages that comply with these standards. Some examples of the software packages are SnuggPro[83][336]~~[3356]~~, REM/Rate, EnergyGauge and TREAT.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = From\ Approved\ Software$$

Annual Fuel Savings

$$\Delta Therms = From\ Approved\ Software$$

Peak Demand Savings

$$\Delta kW_{Peak} = \Delta kWh\ x\ ETDF$$

[83] SnuggPro uses the OptiMiser energy modeling engine

Where,

$$ETDF = 0.0006033$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms\ x\ PDF$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms\ x\ EUL$$

Calculation Parameters

Table 2-218~~217~~218 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated by Approved Software	kWh/yr	
$\Delta Therms$	Annual fuel savings	Calculated by Approved Software	Therm/yr	
ΔkW_{Peak}	Peak demand savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ETDF	Energy to demand factor	0.000364	kW/kWh	
PDF	Natural gas peak day factor	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	Day/yr	

References

~~[331]~~[332] Home Performance with Energy Star (HPwES) version 1.5 requirements Program Requirements | ENERGY STAR

~~[332]~~[333] Information about BESTEST-EX can be found at http://www.nrel.gov/buildings/bestest- ex.html

~~[333]~~[334] A listing of software approved by US DOE available at https://www.energy.gov/scep/wap/weatherization-energy-audits

~~[334]~~[335] A listing of the approved RESNET software available at https://www.resnet.us/providers/accredited-providers/hers-software-tools/

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

~~[335]~~[336] SnuggPro software https://snuggpro.com/
~~[336]~~[337] SJG PY2 Impact Evaluation

Field Code Changed

2.8.3 NEW CONSTRUCTION

Market	Residential/Multifamily
Baseline Condition	NC
Baseline	Building Code
End Use Category	Whole Building
Measure Last Reviewed	August 2024
	~~Revised measure description and UDRH baseline values~~

Description

This measure addresses high performance residential and multifamily new building design and construction. High performance new construction projects must satisfy the requirements prescribed by the ENERGY STAR certification effective at the time the project permit is pulled, following either the Single-Family New Homes program [338]~~[3378]~~ or the Multifamily New Construction program [339]~~[3389]~~, US DOE Zero Energy Ready Home program [340]~~[339340]~~, Passive House Institute US (PHIUS) [341]~~[3401]~~ or Passive House Institute (PHI) [342]~~[3412]~~.

High performance new construction projects in NJ shall estimate energy savings based on the difference in modeled annual energy consumption between the proposed new building design and a minimally code compliant building of equivalent area. Peak demand savings, if not reported by the software, should be calculated as a function of the energy savings as shown below:

$$\Delta kW = \Delta kWh \times \frac{CF}{EFLH_{cool}}$$

Where:

CF = cooling coincidence factor from Section 2.3.1

$EFLH_{cool}$= cooling equivalent full load hours from Section 2.3.1

Minimum energy performance requirements for all new construction projects are measured from baselines reflecting effective, applicable energy codes and standards (e.g., IECC and ASHRAE 90.1) at the time the project permit is pulled. Modeling software requirements shall be dictated by the selected high performance new construction compliance program (i.e., those listed above). Energy and demand savings for measures included in the program but not modeled by the software should be calculated using the appropriate TRM measure section.

For projects pursuing passive house certifications, savings shall be estimated based on a comparison of baseline and proposed/as-built OR minimally passive house compliant prototype models developed in approved program simulation software. Baseline models shall reflect input parameters relevant to climate zones 4A/5A and minimally compliant with effective, applicable energy codes and standards based on project permit date. Submitted proposed/as-built design models are compared against the corresponding baseline model to establish energy consumption savings by fuel type. For electric peak demand savings, where end use-level kWh savings are reported by simulation software, peak kW shall be established per end use and aggregated for project-level reporting. In the absence of end use-level savings, peak kW savings may be approximated per the equation shown above.

To support and provide transparency to ongoing processing of project applications under the Residential New Construction ("RNC") Program, and for applications under the New Construction Program ("NCP"), details of the approach for estimating energy savings relative to a baseline reference home are presented below.

Whole building energy savings are calculated using outputs from RESNET accredited Home Energy Rating System (HERS) modeling software [343][3423]. All program homes are modeled using accredited software to estimate annual energy consumption for heating, cooling, hot water, and other end uses within the HERS asset rating.

The program home is then modeled to a baseline specification using a program-specific reference home (referred to in some software as a User Defined Reference Home or UDRH) feature. The program reference home specifications are set according to the lowest efficiency specified by applicable codes and standards, thereby representing a New Jersey specific baseline home against which the improved efficiency of program homes is measured.

The UDRH is designed to reflect the efficiency values of HERS Minimum Rated Features based on the following:

- The prescriptive minimum values of the IECC version applicable to the home for which savings are being calculated;
- The Federal Minimum Efficiency Standards applicable to each rated feature at the time of permitting (e.g., minimum AFUE and SEER ratings for heating and air conditioning equipment, etc.);
- An assessment of baseline practice, as available, in the event that either of the above standards reference a non-specific value (e.g., "visual inspection");
- Exclusion of specific rated features from the savings calculation in order to remove penalties for building science based best practice requirements of the program (e.g., by setting the reference and rated home to the same value for program-required mechanical ventilation); and
- Other approved adjustments as may be deemed necessary.

The difference in modeled annual energy consumption between the program and applicable baseline reference home is the projected savings for heating, hot water, cooling, lighting, appliances, and other end uses in the HERS Minimum Rated Features, as well as on-site renewable gereration, when applicable. Coincident peak demand savings are also derived from rated modeled outputs. The following table describes the baseline characteristics of Climate Zone 4 and 5 reference homes for single-family, multi-single and low-rise multifamily buildings per IECC 2021, or as otherwise specified in the "Source" column.

Table 2-219218219 User Defined Reference Home Definition*

Input Parameter	Climate Zone 4	Climate Zone 5	Source	Ref
Ceiling Insulation	U= 0.024	U=0.024	IECC 2021, R402.1.2 (see NOTE 1 below)	[344][3434]
Radiant Barrier	None	None		
Rim/Band Joist	U=0.045	U=0.045	IECC 2021, R402.1.2 (see NOTE 1 below)	[344][3434]
Exterior Walls - Wood	U=0.045	U=0.045	IECC 2021 R402.1.2 (see NOTE 1 below)	[344][3434]

Input Parameter	Climate Zone 4	Climate Zone 5	Source	Ref
Exterior Walls - Steel	U=0.045	U=0.045	IECC 2021 R402.1.2 (see NOTE 1 below)	[344]~~[3434]~~
Foundation Walls	U=0.059	U=0.050	IECC 2021 R402.1.2 (see NOTE 1 below)	[344]~~[3434]~~
Doors	U=0.30	U=0.30	IECC 2021 R402.1.2 (see NOTE 1 below)	[344]~~[3434]~~
Windows	U=0.30 , SHGC=0.30	U=0.30 , SHGC=0.30	U-value IECC 2021 R402.1.2, SHGC changed to 0.3 to match the change the EPA made on their V3.2 and v1.2 reference home (see NOTE 1 below).	[344]~~[3434]~~, [345]~~[3445]~~, [346]~~[3456]~~
Glass Doors	U=0.30 , SHGC=0.30	U=0.30 , SHGC=0.30	U-value IECC 2021 R402.1.2, SHGC changed to 0.3 to match the change the EPA made on their V3.2 and v1.2 reference home (see NOTE 1 below).	[344]~~[3434]~~, [345]~~[3445]~~, [346]~~[3456]~~
Skylights	U=0.55 , SHGC=0.40	U=0.55 , SHGC=0.40	IECC 2021 R402.1.2 (see NOTE 1 below)	[344]~~[3434]~~
Floor	U=0.047	U=0.033	IECC 2021 R402.1.2 (see NOTE 2 below)	[344]~~[3434]~~
Unheated Slab on Grade	R-10, 4 ft	R-10, 4 ft	IECC 2021 R402.1.3	[344]~~[3434]~~
Heated Slab on Grade	R-15, 4 ft	R-15, 4 ft	IECC 2021 R402.1.3	[344]~~[3434]~~
Air Infiltration Rate	5 ACH50	5 ACH50	Based on NJ Energy code Compliance Study, June 2022, completed by DNV, ref Table 4-13	[347]~~[3467]~~
Duct Leakage	4 cfm25 per 100ft^2 CFA	4 cfm25 per 100ft^2 CFA	IECC 2021, R403.3.6	[344]~~[3434]~~
Mechanical Ventilation	Match to Proposed	Match to Proposed		
Lighting	100% High Efficacy	100% High Efficacy	IECC 2021, R404.1	[344]~~[3434]~~
Ceiling Fan (CFM/W)	70.53	70.53	eCFR: 10 CFR Part 430 Subpart C, 50" Diameter default	[348]~~[3478]~~
Clothes Dryer - CEF	3.3	3.3	eCFR: 10 CFR Part 430 Subpart C , for clothes dryers manufactured on or after 1/1/15, vented gas	[348]~~[3478]~~
Clothes Washer - IMEF	1.57	1.57	eCFR: 10 CFR Part 430 Subpart C, minimum IMEF for standard capacity top loading clothes washers manufactured on or after 1/1/2018	[348]~~[3478]~~
Clothes Washer - kWh/yr	284	284	Appliance Standard 2018+Defaults	[338]

Input Parameter	Climate Zone 4	Climate Zone 5	Source	Ref
Dishwasher - kWh/yr	307	307	ANSI/RESNET/ICC 301-2022, Page 64, Table 4.2.2.6.2.9 NAECA	[349]~~[3489]~~
Refrigerator - kWh/yr	411	411	eCFR: 10 CFR Part 430 Subpart C, top freezer, no ice maker (scenario 3) Default Size: 22 cf	[348]~~[3478]~~
Cooling Setpoint	75	75	IECC 2021, R403.1.1: 75 cooling and 70 heating	[344]~~[3434]~~
Heating Setpoint	70	70		
Thermostat	Programmable	Programmable	IECC 2021 R403.1.1	[344]~~[3434]~~
Furnace	80% AFUE	80% AFUE	eCFR: 10 CFR Part 340 Subpart C	[348]~~[3478]~~
Boiler	84% AFUE	84% AFUE	eCFR: 10 CFR Part 340 Subpart C	[348]~~[3478]~~
Combo Water Heater	N/A - default heating to Boiler and HW to Natural Gas Standalone	N/A - default heating to Boiler and HW to Natural Gas Standalone		
Air Source Heat Pump (Heating)	N/A - default to Furnace	N/A - default to Furnace		
Central Air Conditioning & Window AC units	14.1 SEER/13.4 SEER2	14.1 SEER/13.4 SEER2	eCFR: 10 CFR Part 340 Subpart C 14.1 SEER is the conversion from 13.4 SEER2 back to SEER, using the factor of 0.95	[348]~~[3478]~~
Air Source Heat Pump (Cooling)	N/A - default to CAC/Window AC	N/A - default to CAC/Window AC		
Electric Standalone Tank Water Heater	N/A - default to Natural Gas Standalone	N/A - default to Natural Gas Standalone		
Natural Gas Standalone Tank Water Heater	0.6270 UEF	0.6270 UEF	eCFR: 10 CFR Part 340 Subpart C; assumes High Draw Pattern and a 50 gallon tank (see NOTE 3 below).	[348]~~[3478]~~
Electric Instantaneous Water Heater	N/A - default to Natural Gas Standalone	N/A - default to Natural Gas Standalone		
Natural Gas Instantaneous Water Heater	N/A - default to Natural Gas Standalone	N/A - default to Natural Gas Standalone		
Water Heater Tank Insulation	None	None		
Duct Insulation, Attic	R-8	R-8	IECC 2021 R403.3.3	[344]~~[3434]~~

Input Parameter	Climate Zone 4	Climate Zone 5	Source	Ref
Duct Insulation, All Other	R-8	R-8	IECC 2021 R403.3.2; assumes ducts >=3"	[344]~~[3434]~~

* - Applicable to buildings permitted on or after March 6, 2023
1 – U-values represent total system U-value, including all components (i.e., clear wall, windows, doors).

- Type A-1 - Detached one and two family dwellings.
- Type A-2 - All other residential buildings, three stories in height or less.

2 – All frame floors shall meet this requirement. There is no requirement for floors over basements and/or unvented crawl spaces when the basement and/or unvented crawl space walls are insulated.
3 – Based on the Federal Government standard for calculating UEF (50 gallon, high-draw pattern assumed): UEF = 0.6920 - (0.0013 x Rated Storage Volume in gallons)

References

~~[337]~~[338] Energy Star V3.1 Single Family New Homes requirements
~~[338]~~[339] Energy Star V1.1 Multifamily New Construction requirements
~~[339]~~[340] DOE Zero Energy Ready Home (ZERH) Program requirements.
~~[340]~~[341] Passive House Institute US requirements
~~[341]~~[342] Passive House Institute requirements
~~[342]~~[343] Accredited Home Energy Rating Systems (HERS) software
~~[343]~~[344] 2021 International Energy Conservation Code (IECC 2021)
~~[344]~~[345] Energy Star V3.2 Single Family New Homes requirements
~~[345]~~[346] Energy Star V1.2 Multifamily New Construction requirements
~~[346]~~[347] New Jersey Energy Code Compliance Study
~~[347]~~[348] Code of Federal Regulations: 10 CFR Part 430 Subpart C
~~[348]~~[349] ANSI/RESNET/ICC 301-2022 Standard for the Calculation and Labeling of the Energy Performance of Dwelling and Sleeping Units using an Energy Rating Index
~~[349]~~[350] Ekotrope Appliance Default Values

Field Code Changed
Field Code Changed
Field Code Changed
Field Code Changed
Field Code Changed
Field Code Changed
Field Code Changed
Field Code Changed
Field Code Changed
Field Code Changed
Field Code Changed
Field Code Changed

2.8.4 CUSTOM

Market	Residential
Baseline Condition	TOS/NC/RF/EREP/ERET/DI
Baseline	Code/ISP/Existing/Dual
End Use Category	Custom
Measure Last Reviewed	January 2023

Description

In addition to the typical measures for which savings algorithms have been developed, it is important to identify and address additional opportunities for energy savings. Custom measures can often provide significant energy savings and can be tailored to the specific needs of a project. If necessary, the utilities may develop specific guidelines for frequent custom measures for use in reporting and contractor tracking. This will ensure that the custom measures are implemented correctly and consistently; and that the energy savings are accurately reported. Additionally, it is important to continuously monitor and evaluate the effectiveness of the custom measures implemented and make adjustments as needed.

To implement custom measures, it is necessary to develop individual calculations for each measure to determine the energy savings. These calculations should take into account factors such as the cost of implementation and the expected energy savings. Once the calculations are complete, the project should be reviewed for reasonableness. Before a full review of the project is started, the project package should first be checked for completeness and compliance with program eligibility rules. Once the project review is complete, savings can be reported based on these individual calculations.

Baseline

The project baseline depends on the baseline condition. For time of sale (TOS) and new construction (NC) measures, the baseline is the applicable equipment energy code or standard; or industry standard practice (ISP). For retrofit (RF), early replacement (EREP), early retirement (ER) and direct install (DI) measures, the baseline is the existing equipment. Early replacement and direct install projects replacing functioning equipment must use a dual baseline approach, where the existing equipment defines the first baseline and code or ISP defines the second baseline. In all cases, the baseline should be more efficient than the existing equipment; if the efficiency of the existing equipment exceeds code or ISP, the existing equipment baseline should also be used for the second baseline calculations. When existing functioning equipment is replaced and savings are based on early replacement, documentation of the existing equipment viability should be provided. Such documentation includes a customer affidavit affirming the viability of the equipment to function over its remaining useful life and a video or picture demonstrating the equipment in action.

Industry Standard Practice (ISP) shall take precedence over a code baseline when ISP can be established. Projects not subject to codes or standards shall define and document an ISP baseline as part of the project development package. ISP for specific custom projects can be established through interviews with equipment vendors or subject matter experts.

Efficient Case

The efficiency of the measure shall exceed the first (and if applicable the second) baseline efficiency, and a rationale for how the project saves energy shall be provided.

Energy Savings Algorithm

Energy and demand savings are calculated on a custom basis for each customer's specific situation. Savings are calculated as the difference between baseline energy usage/peak demand and the energy use/peak demand after implementation of the custom measure. Energy savings calculations vary according to the custom project requirements, but generally fall into the following classifications:[84]

Simple Engineering Equations

Custom engineering calculations may be developed to estimate energy savings. These may be presented as a series of simple engineering equations tailored to the custom project measure. The engineering calculations must be documented, and spreadsheets used to calculate the savings must be provided with live calculations. The engineering analysis must be sufficiently documented to allow an independent calculation of the measure savings.

Bin Methods

One method for calculating energy savings for custom energy efficiency measures is through the use of weather based bin analysis. This method involves analyzing weather data and grouping it into "bins" based on temperature, humidity, and other environmental factors. The bin analysis presents the number hours a particular weather condition exists during the year. Note, bin data to not consider time of day; hours tabulated for each weather bin are disconnected in time. Bin analysis is generally not applicable to time dependent measures.

Simulation

Another method for calculating energy savings for custom energy efficiency measures is through the use of whole building energy simulations. This approach involves creating a computer model of a building that takes into account factors such as the building's layout, construction materials, HVAC systems, lighting, and other equipment. The model is then used to simulate different scenarios and analyze the building's energy consumption under different conditions. This can be useful for identifying opportunities for energy savings and for evaluating the potential impact of different custom measures. For example, a whole building simulation can be used to analyze the impact of different insulation materials, HVAC equipment, or window treatments on energy consumption. Whole building modeling simulations can be a powerful tool for identifying and addressing opportunities for energy savings across a package of measures where significant measure interactions are expected.

Pre/Post Billing Analysis

[84] See the California Evaluation Framework [351]~~[350~~1~~]~~ Chapters 6 and 7 for more information about engineering methods.

Energy savings may be calculated through an analysis of whole building or submetered energy consumption before and after measure installation. The billing analysis should use a linear or multi-variate regression approach that normalizes the savings for differences in weather conditions during the pre and post periods, and also corrects for energy consumption not related to the measures, such as the addition of photovoltaic systems or electric vehicle chargers. The pre/post billing analysis should follow the International Measurement and Verification Protocol (IPMVP) Option C and/or ASHRAE Guideline 14. Open source software products compliant with IPMVP Option C or ASHRAE Guideline 14 such as OpenEEMeter are acceptable methods to evaluate energy savings under conditions where the energy consumption data can be fit to outdoor temperature or degree-day data, and savings can be adjusted to account for changes in energy consumption not related to the project.

Pre/Post Billing Analysis approaches are best suited for EREP, ERET and DI projects where an existing equipment baseline is appropriate. Pre/Post Billing Analysis approaches are not suitable for NC and TOS projects. When calculating lifetime savings, EREP, ERET and DI projects must adjust savings from an existing equipment baseline to a code or ISP baseline during the second baseline period.

Calculation Parameters

Energy savings calculations must identify the source of each parameter used in the analysis. Parameters that are uncertain should be identified as candidates for project specific measurement and verification (M&V).

Measurement and Verification

Projects where the input assumptions and savings estimates are uncertain may benefit from site specific measurement and verification (M&V). Project developers and reviewers should consider whether the value savings at risk is sufficient to justify the additional M&V costs. For projects that include M&V, a site specific measurement and verification plan should be developed that documents measurement activities and their use in the energy savings analysis. Depending on the level of uncertainty, M&V may be conducted before measure installation (pre installation M&V) and/or after measure installation (post installation M&V). The International Measurement and Verification Protocol (IPMVP) and/or ASHRAE Guideline 14 should be referenced when developing an M&V plan. The M&V plans may follow IPMVP Option A (partially measured retrofit isolation), Option B (fully measure retrofit isolation) Option C (Whole building billing analysis) or Option D (Calibrated simulation) approaches.

Lifetime Energy Savings Algorithms

Lifetime energy savings for Time of Sale (TOS) and New Construction (NC) projects are calculated as the product of the first year kWh and/or therm savings and the measure effective useful life (EUL). Projects with multiple measures having different EULs shall use a savings weighted average EUL across all measures in the project.

Lifetime savings for early replacement (EREP), early retirement (ERET) and direct installation (DI) measures where functioning equipment is replaced must use a dual baseline approach. The first baseline savings considers the difference between the existing equipment consumption and the measure consumption for the remaining life (RUL) of the existing equipment. The second baseline savings considers the difference between code or standard practice equipment consumption and the measure consumption for the remaining life of the measure (EUL-RUL).

Peak Factors

The summer coincident peak demand savings shall be calculated consistent with the system peak definition presented in Chapter 1.

Measure Life

Measure life will be specific to each custom measure. For custom measures using technologies that are the same or similar to those addressed in other TRM measures, refer to the TRM for measure lives. For measures not covered by the TRM, measure life assumptions shall be documented and justified in the project documentation package. The EUL for retrofit (RF) measures shall be calculated as the smaller of the measure EUL or the host equipment remaining useful life (RUL). The overall project EUL shall be the savings weighted EUL of the measures included in the project.

References

~~[350]~~[351] California Evaluation Framework. Available at https://www.cpuc.ca.gov/-/media/cpuc-website/files/uploadedfiles/cpuc_public_website/content/utilities_and_industries/energy/energy_programs/demand_side_management/ee_and_energy_savings_assist/caevaluationframework.pdf

~~[351]~~[352] International Measurement and Verification Protocol (IPMVP) available at https://evo-world.org/en/products-services-mainmenu-en/protocols/ipmvp

~~[352]~~[353] ASHRAE Guideline 14-2014. Available at https://webstore.ansi.org/standards/ashrae/ashraeguideline142014

~~[353]~~[354] Linux Foundation, OpenEEMeter https://lfenergy.org/projects/openeemeter/ Accessed 5/18/23.

Field Code Changed

Field Code Changed

Field Code Changed

3 COMMERCIAL & INDUSTRIAL

3.1 AGRICULTURE

3.1.1 AUTO MILKER TAKEOFF

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Equipment
Measure Last Reviewed	January 2023

Description

This section provides energy savings and demand savings algorithms for replacement of manual milker takeoffs with automatic milker takeoffs on dairy milking vacuum pump systems. Automatic milker takeoffs have flow sensors which help shut off the suction on teats once a minimum flow rate is achieved. This reduces the load on the vacuum pump.

Equipment with existing automatic milker takeoffs is not eligible. In addition, the vacuum pump system serving the impacted milking units must be equipped with a variable speed drive (VSD) to qualify for incentives. Without a VSD, little or no savings will be realized.

Baseline Case

Pre-existing manual takeoffs on constant speed dairy milking vacuum pump systems.

Efficient Case

Automatic milker takeoffs. Vacuum pump system serving the impacted milking units must be equipped with a variable speed drive (VSD).

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = N_{cows} \times \Delta ESC$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \Delta kWh \times ETDF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \text{N/A}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \text{N/A}$$

Calculation Parameters

Table 3-1 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
N_{cows}	Number of cows milked per day	Site specific	Cows	
ΔESC	Annual energy savings per cow	34[85]	kWh/cow	[356]~~[3556]~~[357]~~[3567]~~[358]~~[3578]~~[359]~~[3589]~~
ETDF	Energy to demand factor	0.00017	kW/kWh	[360]~~[359360]~~
CF	Electric coincidence factor	Look up in Table 3-2	N/A	
PDF	Gas peak demand factor	Look up in Table 3-2	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

[85] Annual energy savings per cow was calculated based on the following assumptions.

- An average herd size of 102 cows [359]~~[3589]~~
- Typical dairy vacuum pump size of 10 HP per herd size [360]~~[359360]~~
- Average pump operating hours are estimated at 10 hours per day [358]~~[3578]~~
- A 12.5% Energy savings factor [359]~~[3589]~~

Peak Factors

Table 3-2 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 10 years [355]~~[3545]~~.

References

~~[354]~~[355] Idaho Power Demand Side Management Report, Supplement 1. March 15, 2022. https://docs.idahopower.com/pdfs/EnergyEfficiency/Reports/2021%20Supplement%201.pdf

~~[355]~~[356] Chuck Nicholson, Mark Stephenson, Andrew Novakovic, *Study to Support Growth and Competitiveness of the Pennsylvania Dairy Industry*, (2017) . https://dairymarkets.org/PA/Growth_and_Competitiveness_Study_DRAFT_Final_Report_June_2018.pdf PA Values were assumed to be similar to NJ Values because of the States' close proximity.

~~[356]~~[357] Average dairy vacuum pump size was estimated based on the Minnesota Dairy Project literature.

~~[357]~~[358] Mark Mayer, David Kammel, *Dairy Modernization Works for Family Farms* (2008). https://archives.joe.org/joe/2010october/pdf/JOE_v48_5rb7.pdf.

~~[358]~~[359] Public Utilities Commission of Pennsylvania, *Technical Reference Manual: Volume 3: Commercial and Industrial Measures (2019),* Pg 298, https://www.puc.pa.gov/filing-resources/issues-laws-regulations/act-129/technical-reference-manual/

~~[359]~~[360] Regional Technical Forum (RTF) as part of the Northwest Power & Conservation Council, *Deemed Measures List. Agricultural: Variable Frequency Drives-Dairy, FY2012, V1.2*. https://rtf.nwcouncil.org/measure/dairy-milking-machines-vacuum-pump

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

3.1.2 DAIRY PUMP VFD

Market	Commercial
Baseline Condition	NC/RF
Baseline	Code/Existing
End Use Subcategory	Control
Measure Last Reviewed	January 2023

Description

Milking vacuum systems consume large amounts of electricity on dairy farms. A conventional system runs a vacuum pump motor at full speed and a mechanical vacuum regulator creates an intentional air leak or “bleed” to regulate the system pressure regardless of the amount of milk being pumped. When the system requires a higher level of vacuum, the regulator closes and the vacuum level increases.

This measure modifies the milking vacuum system and installs a variable speed drive (VSD) to control the vacuum pump motor. The VSD controls the speed of the vacuum pump motor, slowing it down when the milking units are attached to the udders, reducing electrical power demand and saving electricity usage. A milking vacuum system controlled with a VSD consists of three main parts: a three - phase electric motor, a VSD unit, and a differential pressure transducer. The VSD modulates the vacuum pump motor speed based on the control signal from the differential pressure transducer. The baseline for this measure reflects a standard vacuum pump motor operating at constant speed. If the motor is being replaced as part of this measure, the “New Motor” efficiency in the Standard Motor Efficiency table below shall be used. Otherwise, the “Existing Motor” efficiency shall be used.

Baseline Case

The baseline condition is a constant speed dairy vacuum pump with a motor size between 2.5-10hp that is controlled with a mechanical vacuum regulator.

Efficient Case

The compliance condition is a dairy vacuum pump with a variable speed drive installed.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \left[\left(\frac{hp \ \times LF \times 0.746}{Eff}\right) - (0.05 \times 2 \times MU + 1.7729)\right] \times hrs$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \left[\left(\frac{hp \times LF \times 0.746}{Eff}\right) - (0.05 \times 2 \times MU + 1.7729)\right] \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 3-3 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
hp	Rated horsepower of vacuum pump motor	Site-specific (limited to 10hp or lesser)	hp	
MU	Number of milking units equipped with a vacuum pump and controlled by VSD	Site-specific, if unknown: 5 hp motor = 3 MU 7.5hp motor = 12 MU 10 hp motor = 22 MU	N/A	
LF	Average load factor for a constant speed vacuum pump	Site-specific, if unknown use 0.76	N/A	[361]~~[3601]~~
Eff	Rated pump motor efficiency	Site-specific, if unknown look up in Table 3-4	N/A	[362]~~[3612]~~[363]~~[3623]~~
hrs	Annual hours of pump operation	Site-specific, if unknown use 4,380	hours	[364]~~[3634]~~
0.746	Conversion factor from kW to hp	0.746	kW/hp	
0.05	Regression coefficient for the average speed of a VSD and processed milk units	0.05	N/A	[367]~~[3667]~~
2	Air flow rate of milking unit	2	CFM	[367]~~[3667]~~

Variable	Description	Value	Units	Ref
1.7729	Regression constant for the average speed of a VSD and processed milk units	1.7729	N/A	[367]~~[3667]~~
CF	Electric coincidence factor	Look up in Table 3-5	N/A	
PDF	Gas peak demand factor	Look up in Table 3-5	N/A	
EUL	Effective useful life	See Measure Life	Years	

Table 3-4 Standard Motor Efficiency

Motor Classification	Size (hp)	Existing Motor	New Motor
Milk: Vacuum Pump with Adjustable Speed Drive Package – 5 HP	5	87.5%	89.5%
Milk: Vacuum Pump with Adjustable Speed Drive Package – 7.5 HP	7.5	88.5%	91.7%
Milk: Vacuum Pump with Adjustable Speed Drive Package – 10 HP	10	89.5%	91.7%

Peak Factors

Table 3-5 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.4	[365]~~[3645]~~
Natural gas peak day factor (PDF)	N/A	

Measure Life

Table 3-6 Measure Life

Equipment	EUL	RUL	Ref
Dairy Pump VFD	15	5	[366]~~[3656]~~

References

~~[360]~~[361] Cascade Energy. "Proposed Standard Savings Estimation Protocol for Ultra-Premium Efficiency Motors." Table 6: Load Factor by Nameplate hp and End Use. November 5, 2012. https://nwcouncil.app.box.com/s/fkxkcwm1is88dnttb8ve7eb5rhs9qhmv

~~[361]~~[362] The Energy Independence and Security Act of 2007 (EISA), 1800 RPM, TEFC assumed as typical for Dairy vacuum pump motors, see https://www.govinfo.gov/content/pkg/PLAW-110publ140/pdf/PLAW-110publ140.pdf

Field Code Changed

Field Code Changed

~~[362]~~[363] US Department of Energy, Office of Energy Efficiency & Renewable Energy, "Premium Efficiency Motor Selection and Application Guide: A Handbook for Industry". Table 2-1. 1800 RPM, TEFC assumed as typical for Dairy vacuum pump motors, https://www.energy.gov/sites/prod/files/2014/04/f15/amo_motors_handbook_web.pdf

Field Code Changed

~~[363]~~[364] Assuming 2 milking and cleaning sessions per day, 5 hours per milking session, 1 hour per cleaning session, and 365 days of milking per year.

~~[364]~~[365] Regional Technical Forum (RTF) as part of the Northwest Power & Conservation Council, Deemed Measures List. Agricultural: Variable Frequency Drives-Dairy, FY2012, V1.2. https://rtf.nwcouncil.org/measure/dairy-milking-machines-vacuum-pump/

Field Code Changed

~~[365]~~[366] California Public Utilities Commission EUL Table, version 027 (updated November 12, 2022). Accessed December 30, 2022. https://www.caetrm.com/shared-data/value-table/EUL/

~~[366]~~[367] Sanford, Scott (University of Wisconsin–Madison). "Milking System Air Consumption When Using a Variable Speed Vacuum Pump", Figure 2. The regression coefficient of 0.0018 LPM is converted into 0.05 CFM. An air leakage rate of 2 CFM is chosen as a conservative estimate for which to perform regression analysis.

3.1.3 DAIRY REFRIGERATION TUNE UP

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Maintenance
Measure Last Reviewed	January 2023

Description

This section provides energy savings and demand savings algorithms for tune-ups on all refrigeration equipment in commercial-grade dairy settings with the intention being to reduce electrical consumption.

Baseline Case

Refrigeration equipment associated with a commercial-grade dairy farm facility that has not been inspected or tuned up in more than 12 months.

Efficient Case

The efficient condition is refrigeration equipment associated with a commercial-grade dairy farm facility that has been inspected and tuned up by a U.S. EPA 608 Certified Service Provider. The certified technician must abide by all rules and regulations related to refrigerant testing and safety protocol and must conduct the following tasks:

- Clean and inspect condenser and evaporator coils;
- Clean drain pan;
- Inspect/clean fans, screens, grills, filters, and drier cores;
- Inspect/adjust heat reclaim operation;
- Tighten all line voltage connections;
- Inspect/replace relays and capacitors as needed; and
- Add/remove refrigerant charge as needed.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{N_{cows} \times lbs_{milk} \times C_{p,milk} \times \Delta T}{AEER \times 1{,}000} \times SF$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \mathrm{N/A}$$

Calculation Parameters

Table 3-7 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
N_{cows}	Number of cows	Site-specific	N/A	
lbs_{milk}	Average pounds of milk produced per cow per year	Site-specific, if unknown use 19,800	Lbs/yr	[368]~~[3678]~~
$C_{p,milk}$	Specific heating capacity of milk	0.93	Btu/lb-°F	[369]~~[3689]~~
ΔT	Difference in temperature between milk entering the bulk tank and final stored temperature of cooled milk	Look up in Table 3-8	°F	[370]~~[369370]~~[371]~~[3701]~~
SF	Energy savings factor	0.05	N/A	[372]~~[3712]~~
AEER	Annual energy efficiency ratio of refrigeration compressor	15.39	Btu/watt-hr	[371]~~[3701]~~
1,000	Conversion from watts to kilowatts	1,000	W/kW	
CF	Electric coincidence factor	Look up in Table 3-9	N/A	
PDF	Gas peak demand factor	Look up in Table 3-9	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-8 Milk Temperature Differential (°F)

Type of cooling	Temperature (°F)
No pre-cooler used in operation	60
Pre-cooler used	30
Pre-cooler unit and VFD Pump are used	18.3

Peak Factors

Table 3-9 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 1 year [371]~~[3701]~~.

References

~~[367]~~[368] New Jersey Dept of Agriculture, 2021 Annual Report and Agricultural Statistics. (2021), page 21. https://www.nass.usda.gov/Statistics_by_State/New_Jersey/Publications/Annual_Statistical_Bulletin/2021/2021AnnualReportFinal.pdf

~~[368]~~[369] 2018 ASHRAE Handbook – Refrigeration, Specific heat of whole milk, Table 3: Unfrozen Composition Data, Initial Freezing Point, and Specific Heat of Foods.

~~[369]~~[370] Scott Sanford, *Well water precoolers.* (Energy Conservation in Agriculture,2003), Pg 1, https://cdn.shopify.com/s/files/1/0145/8808/4272/files/A3784-03.pdf

~~[370]~~[371] Sanford, Scott (University of Wisconsin–Madison). "Well Water Precoolers." Publication A3784-3. October 2003. http://learningstore.uwex.edu/Assets/pdfs/A3784-03.pdf

~~[371]~~[372] *Best Management Practices for Dairy Farms* (Massachusetts Farm Energy Program, 2012), Pg 30, https://massfarmenergy.com/wp-content/uploads/2014/03/Dairy%20Farms%20Best%20Practices.pdf

Field Code Changed

Field Code Changed

Field Code Changed

3.1.4 DAIRY SCROLL COMPRESSOR

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Equipment
Measure Last Reviewed	January 2023

Description

This measure covers the replacement of reciprocating compressors with scroll compressors in milk cooling dairy farm applications. A scroll compressor is a device used to compress refrigerant and is more efficient and reliable than traditional reciprocating compressors. Scroll compressors are now the predominant compressor type sold on the market in these applications; therefore, this measure is only applicable in retrofit scenarios. Lifecycle savings are calculated through the end of the remaining life of the existing compressor.

Baseline Case

The baseline condition for this measure is a dairy operation using a reciprocating compressor for milk cooling.

Efficient Case

The compliance condition is the replacement of a reciprocating compressor with a scroll compressor for milk cooling.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{Btu/h_q}{Btu/h_{total}} \times lbs_{milk} \times cows \times \Delta T \times 0.93 \times \left[\left(\frac{1}{EER_b \times 1{,}000}\right) - \left(\frac{1}{EER_q \times 1{,}000}\right)\right]$$

Where,

$$EER_q = \frac{Btu/h_q}{W_q}$$

$$EER_b = \frac{Btu/h_b}{W_b}$$

If EER_b is unknown use

$$EER_b = 0.85 \times EER_q$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{8{,}760} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \mathrm{N/A}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \mathrm{N/A}$$

Calculation Parameters

Table 3-10 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Btu/h_q	Nameplate Btu/h of installed scroll compressor	Site-specific	Btu/h	
Btu/h_{total}	Total cooling capacity of compressors on dairy farm	Site-specific	Btu/h	
Btu/h_b	Nameplate Btu/h of existing recip compressor	Site-specific	Btu/h	
lbs_{milk}	Average pounds of milk produced per cow per year	19,800	lb	[373]~~[3723]~~
cows	Number of milking cows on farm	Site-specific	N/A	
ΔT	Difference in temperature between the milk entering the bulk tank and final stored temperature of cooled milk	Look up in Table 3-11	(°F)	[374]~~[3734]~~
W_b	Nameplate wattage of existing reciprocating compressor	Site-specific	watts	

Variable	Description	Value	Units	Ref
W_q	Nameplate wattage of installed scroll compressor	Site-specific	watts	
EER_q	Energy efficiency ratio of scroll compressor based on nameplate Btu/h and wattage	Calculated	$\frac{\text{Btu/h}}{\text{watts}}$	[375]~~[3745]~~
EER_b	Energy efficiency ratio of reciprocating compressor based on nameplate Btu/h and wattage	Calculated	$\frac{\text{Btu/h}}{\text{watts}}$	[375]~~[3745]~~
0.93	Specific heat of milk	0.93	Btu/lb-°F	[376]~~[3756]~~
1,000	Conversion Factor kW to watts	1,000	Kw/watts	
8,760	Hours in one year	8,760	hours	
CF	Electric coincidence factor	Look up in Table 3-12	N/A	
PDF	Gas peak day factor	Look up in Table 3-12	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-11 Difference in temperature for various equipments

Equipment	ΔT
No Pre-Cooler	60
Standard Pre-Cooler	30
Variable Speed Pre-Cooler	18.3

Peak Factors

Table 3-12 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is limited to the Remaining Useful Life (RUL) of the existing compressor with a default value of 4 years.

References

~~[372]~~[373] USDA, National Agricultural Statistics Service, *2021 Annual Report and Agricultural Statistics*, pg. 21. https://www.nass.usda.gov/Statistics_by_State/New_Jersey/Publications/Annual_Statistical_Bulletin/2021/2021AnnualReportFinal.pdf

Field Code Changed

~~[373]~~[374] Sanford, Scott (University of Wisconsin–Madison). *Energy Efficiency for Dairy Enterprises*. Presentation to Agricultural and Life Sciences Program staff. It was determined that a plate cooler alone can reduce milk temperature to 68 ˚F and a plate cooler paired with a milk transfer pump VSD can reduce milk temperature to 56.3 ˚F. The additional benefits of the milk transfer pump VSD over the plate cooler is 11.7 ˚F. Milk is stored at 38°F, therefore 56.3°F-38°F=18.3°F. December 2014. https://aeeibse.wp.prod.es.cloud.vt.edu/wp-content/uploads/2018/01/EC-for-Dairy-Enterprises-Nov-2017.pdf

Field Code Changed

~~[374]~~[375] *Massachusetts Farm Energy Best Management Practices for Dairy Farms*, United States Department of Agriculture (USDA), Natural Resource Conservation Service (NRCS), 2012. https://massfarmenergy.com/wp-content/uploads/2014/03/Dairy%20Farms%20Best%20Practices.pdf

Field Code Changed

~~[375]~~[376] 2018 ASHRAE Handbook – Refrigeration, Specific heat of whole milk, Table 3: Unfrozen Composition Data, Initial Freezing Point, and Specific Heat of Foods.

3.1.5 LIVESTOCK WATERER

Market	Commercial
Baseline Condition	EREP/TOS/NC
Baseline	Existing/ISP/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	January 2023

Description

This measure covers the installation of energy-efficient livestock waterers. A livestock waterer provides clean drinking water for livestock. Regular livestock waterers employ the use of large electric resistance heaters to prevent water from freezing. Energy efficient livestock waterers use super insulation (insulation of at least 2 inches) to maintain water temperature above freezing temperature.

Baseline Case

Early replacement (EREP) of an existing livestock waterer: First baseline, for remaining useful life of existing equipment: Electrically heated livestock waterer with no insulation. Second baseline, for remainder of measure life: Industry standard practice (ISP).

Time of sale (TOS) of an existing livestock waterer: Industry standard practice (ISP).

Addition of a new (NC) livestock waterer: Industry standard practice (ISP).

Efficient Case

Energy efficient livestock watering system that is thermostatically controlled and has factory-installed insulation with a minimum thickness of 2 inches.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{W_b - W_q}{1{,}000} \times hrs \times F_{runtime}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-13 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
W_b	Rated wattage of baseline livestock waterer heating element	Site-specific. If unknown: Existing: 1,100W ISP: 500W	Watts	[377]~~[3767]~~
W_q	Rated wattage of efficient livestock waterer heating element	Site-specific	Watts	
hrs	Annual hours of operation during the winter when temperature is below 32°F	Site-specific. If unknown, look up in Table 3-14	hrs	[378]~~[3778]~~
$F_{runtime}$	Fraction of heater runtime	0.8	N/A	[379]~~[3789]~~
CF	Electric coincidence factor	Look up in Table 3-15	N/A	
PDF	Gas peak day factor	Look up in Table 3-15	N/A	
EUL	Effective useful life	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 3-14 Annual operating hours

Climate Zone	Hours below 32°F
Northern	1337
Southwest	1220
Coastal	583
Central	1,069
Pine Barrens	1,021
Statewide Average	1,048

Peak Factors

Table 3-15 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	[381]~~[3801]~~
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 10 years [380]~~[379380]~~. For early replacement projects, if the remaining useful life (RUL) of the existing equipment is unknown, assume 1/3 of the EUL = 3.3 years.

References

~~[376]~~[377] *New York Standard for Estimating Energy Savings from Energy Efficiency Programs Version 10*. (New York State Joint Utilities, 2021), pg 385.

~~[377]~~[378] Based on TMY3 data for various climate zones in New Jersey.

~~[378]~~[379] The Regional Technical Forum (RTF) analyzed metered data from three baseline livestock waterers and found the average run time of electric resistance heaters in the waterers to be approximately 80% for average monthly temperatures similar to Pennsylvania climate zones. This run time factor accounts for warmer make-up water being introduced to the tank as livestock drinking occurs. *Dairy Milking Machines Vacuum Pump Variable Frequency Drive.* n.d. Rtf.nwcouncil.org. Accessed January 13, 2023. https://rtf.nwcouncil.org/measure/dairy-milking-machines-vacuum-pump/

~~[379]~~[380] State of Wisconsin, *Focus on Energy Evaluation, Business Program: Measure Life Study Final Report*: *Appendix B* (August 25, 2009). https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf

~~[380]~~[381] No demand savings are expected for this measure, as the energy savings occur during the winter months.

Field Code Changed

Field Code Changed

3.1.6 LOW PRESSURE IRRIGATION

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	January 2023

Description

This section provides energy and demand savings algorithms for the installation of a low-pressure irrigation system, which reduces the amount of energy required to apply the same amount of water as a baseline system.

The amount of energy saved per acre is a factor of the number of nozzles, the amount of water applied, the actual reduction in operating pressure, the pumping plant efficiency, and sprinkler or micro irrigation system conversions made to the system.

This measure requires a minimum 50% decrease in irrigation pumping pressure through the installation of a low-pressure irrigation system in agriculture applications. Pressure reduction can be achieved in several ways, such as nozzle or valve replacement, sprinkler head replacement, alterations or retrofits to the pumping plant, or drip irrigation system installation. Pre and post retrofit pump pressure measurements are required.

Baseline Case

High-pressure irrigation system with a baseline pump pressure, must be measured and recorded prior to installing low-pressure irrigation equipment.

Efficient Case

Low-pressure irrigation system in agriculture applications with a minimum of 50% reduction in pumping pressure.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{\{N_{acres} \times (PSI_b - PSI_q) \times GPM\}}{1{,}714 \times Eff_{motor}} \times \left(\frac{0.746\ kW}{HP}\right) \times HRS$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \Delta kWh \times ETDF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \mathrm{N/A}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \mathrm{N/A}$$

Calculation Parameters

Table 3-16 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
N_{acres}	Number of acres irrigated	Site-specific	Acres	
PSI_b	Baseline pump pressure, must be measured and recorded prior to installing low-pressure irrigation equipment	Site-specific	Pounds per square inch (psi)	
PSI_q	Installed pump pressure, must be measured and recorded after the installation of low-pressure irrigation equipment by the installer	Site-specific	Pounds per square inch (psi)	
GPM	Pump flow rate per acre	Site-specific	Gallons Per Minute (GPM) /acre	
HRS	Average irrigation hours per growing season	Site-specific	Hours	
Eff_{motor}	Pump motor efficiency	Site-specific, if unknown look up in Table 3-17	N/A	[382]~~[3812]~~
0.746	Conversion from kW to HP	0.746	kW/HP	
1,714	Constant used to calculate hydraulic horsepower for conversion between horsepower and pressure and flow	1,714	$PSI \times GPM / HP$	

Variable	Description	Value	Units	Ref
EDTF	Energy to Demand Factor	0.0026	kW/kWh	[384]~~[3834]~~ [385]~~[3845]~~
CF	Electric coincidence factor	Look up in Table 3-18	N/A	
PDF	Gas peak demand factor	Look up in Table 3-18	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-17 Motor Baseline Efficiencies

Motor HP	Motor Nominal Full-Load Efficiencies (percent)					
	4 Pole (1800 RPM)		6 Pole (1200 RPM)		8 Pole (900 RPM)	
	Enclosed	Open	Enclosed	Open	Enclosed	Open
1	85.5	85.5	82.5	82.5	75.5	75.5
1.5	86.5	86.5	87.5	86.5	78.5	77.0
2	86.5	86.5	88.5	87.5	84.0	86.5
3	89.5	89.5	89.5	88.5	85.5	87.5
5	89.5	89.5	89.5	89.5	86.5	88.5
7.5	91.7	91.0	91.0	90.2	86.5	89.5
10	91.7	91.7	91.0	91.7	89.5	90.2
15	92.4	93.0	91.7	91.7	89.5	90.2
20	93.0	93.0	91.7	92.4	90.2	91.0
25	93.6	93.6	93.0	93.0	90.2	91.0
30	93.6	94.1	93.0	93.6	91.7	91.7
40	94.1	94.1	94.1	94.1	91.7	91.7
50	94.5	94.5	94.1	94.1	92.4	92.4
60	95.0	95.0	94.5	94.5	92.4	93.0
75	95.4	95.0	94.5	94.5	93.6	94.1
100	95.4	95.4	95.0	95.0	93.6	94.1
125	95.4	95.4	95.0	95.0	94.1	94.1
150	95.8	95.8	95.8	95.4	94.1	94.1
200	96.2	95.8	95.8	95.4	94.5	94.1

Peak Factors

Table 3-18 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 5 years [383]~~[3823]~~.

References

~~[381]~~[382] *Energy Conservation Program: Energy Conservation Standards for Commercial and Industrial Electric Motors; Final Rule: 79 Federal Register 103* (2014) https://www.gpo.gov/fdsys/pkg/FR-2014-05-29/html/2014-11201.htm

~~[382]~~[383] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx Accessed January 2023.

~~[383]~~[384] Kanagy, Pamela K., *Farm and Ranch Irrigation*. Pennsylvania Agricultural Statistics, 2009-2010. https://www.nass.usda.gov/Statistics_by_State/Pennsylvania/Publications/Annual_Statistical_Bulletin/2009_2010/fris.pdf. Accessed January 2023.

~~[384]~~[385] Irrigation Water Withdrawals, 2015 by the U.S. Geological Society. Table 7. https://pubs.usgs.gov/circ/1441/circ1441.pdf. Accessed January 2023.

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

3.1.7 VENTILATION FANS

Market	Commercial
Baseline Condition	TOS/NC/EREP
Baseline	Existing/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	January 2023

Description

This measure is applicable to the installation of high speed, high efficiency fans and high-volume low speed (HVLS) fans installed in agricultural applications. For the purposes of this measure, a high speed fan shall consist of the blade and motor assembly. Ventilation, exhaust and circulating high speed fans improve animal comfort, control moisture and maintain indoor air quality for livestock and other agricultural applications. Variable frequency drives (VFD) may be installed along with high speed fans to increase energy savings and the associated savings are quantified by this methodology. If VFD savings are claimed via this measure, additional savings may not be claimed for VFDs utilizing a separate methodology. Qualifying fans must be rated by an Air Movement and Control Association (AMCA) accredited laboratory such as Bioenvironmental and Structural Systems (BESS) Laboratories.[86]

Baseline Case

The baseline condition for this measure is a standard efficiency exhaust, ventilation or circulating fan.

Efficient Case

The compliance condition for this measure is a high speed exhaust, ventilation, circulating, of HVLS fan that meets or exceeds the minimum efficiency requirements.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

Exhaust and Ventilation Fans:

$$\Delta kWh = \left(\frac{\frac{CFM_b}{(CFM/W)_b} - \frac{CFM_q}{(CFM/W)_q} \times F_{VFD,q}}{1{,}000} \right) \times hrs$$

Internal circulation fans and HVLS fans:

[86] BESS Laboratories is a research, product testing, and educational laboratory at the University of Illinois.

$$\Delta kWh = \left(\frac{lbf_b}{(lbf/kW)_b} - \frac{lbf_q}{(lbf/kW)_q} \times F_{VFD,q}\right) \times hrs$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-19 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	

Variable	Description	Value	Units	Ref
CFM_b	Cubic feet per minute of existing fan	Site-specific[87], if unknown use CFM_q	Ft^3/min	[389]~~[3889]~~
CFM_q	Cubic feet per minute of installed fan	Site specific	Ft^3/min	
$(CFM/W)_q$	Ventilating efficiency ratio of installed fan	Site-specific, if unknown look up in Table 3-20	CFM/W	
$(lbf/kW)_q$	Thrust efficiency ratio of installed fan	Site-specific, if unknown look up in Table 3-20	Lbf/kW	
$(CFM/W)_b$	Ventilating efficiency ratio of existing fan	Look up in Table 3-20	CFM/W	
$(lbf/kW)_b$	Thrust efficiency ratio of existing fan	Look up in Table 3-20	Lbf/kW	
lbf_b	Thrust of existing fan	Site specific[88], if unknown use lbf_q	Lbs/force	[389]~~[3889]~~
lbf_q	Thrust of installed fan	Site-specific	Lbs/force	
$F_{VFD,q}$	Reduced consumption resultant from VFD control	Look up in Table 3-21	N/A	[387]~~[3867]~~
Hrs	Operating hours	Look up in Table 3-22	Hours	
CF	Electric coincidence factor	Look up in Table 3-23	N/A	
PDF	Gas peak demand factor	Look up in Table 3-23	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-20 Baseline and Efficient Condition Efficiencies

Fan Diameter	Baseline [89]		Efficient[90]	
	Circulation, Ventilation and Exhaust Fans (CFM/W)	Circulating Fans (lbf/kW)	Circulation, Ventilation and Exhaust Fans (CFM/W)	Circulating Fans (lbf/kW)
24”-35”	9.4	10.5	14.0	15.0
36”-47”	12.2	12.9	17.0	20.0
48”-52”	15.1	19.8	19.9	24.2
53”+	16.7	20.8	22.0	24.6

[87] look up from BESS Labs database based on manufacturer and model number.
[88] look up from BESS Labs database based on manufacturer and model number.
[89] Default baseline efficiency was determined by calculating the 10th percentile of the efficiencies of all fans in the active BESS Labs database for the respective fan diameter ranges. Many low efficiency fans are often not tested by BESS Labs, therefore the average tested fan is more efficient than the average market available fan. Ventilation and exhaust fan CFM and circulating fan lbf represent the averages of each diameter range, regardless of fan efficiency. The database includes single and three phase fans at four voltages.
[90] Minimum qualifying fan efficiency is equivalent to the 75th percentile of all BESS Labs tested in the respective fan diameters. The database includes single and three phase fans at four voltages

Table 3-21 VFD Factor

Fan Application	Value
No VFD	1.00
Greenhouse	0.64
Poultry/Livestock	0.75

Table 3-22 Operating Hours

City	Circulating/HVLS Fan Hours[91]	Exhaust/Ventilation Fan Hours[92]
Northern	4,362	6,570
Southwest	4,632	6,570
Coastal	5,017	6,570
Central	4,636	6,570
Pine Barrens	4,684	6,570
Statewide Average	4,655	6,570

Peak Factors

Table 3-23 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1.0	[388]~~[3878]~~
Natural gas peak day factor (PDF)	N/A	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-24 Measure Life

Equipment	EUL	RUL	Ref
Ventialtion Fans	15	5	[386]~~[3856]~~

[91] Default hours are developed from NOAA hourly normals by summing annual hours dry bulb temperature above 50°F; NOAA National Centers for Environmental information – NCEI 2010 Hourly Normals

[92] Exhaust/Ventilation fans are assumed to operate 75% of total annual hours (8,760 x 0.75 = 6,570)

References

~~[385]~~[386] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx.

~~[386]~~[387] Teitel, M. & Levi, Asher & Zhao, Yun & Barak, Moti & Bar-lev, Eli & Shmuel, David. (2008). Energy saving in agricultural buildings through fan motor control by variable frequency drives. Energy and Buildings. 40. 953-960. 10.1016/j.enbuild.2007.07.010

~~[387]~~[388] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – Residential, Multifamily, and Commercial/Industrial Measures. January 1, 2023.

~~[388]~~[389] Circulating Fans, Bioenvironmental and Structural Systems Laboratory, University of Illinois, Department of Agricultural and Biological Engineering, Accessed January 12, 2023. Available from: http://bess.illinois.edu/

Field Code Changed

3.1.8 HEAT RECLAIMERS

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Equipment
Measure Last Reviewed	January 2023

Description

This measure covers the installation of a refrigeration heat recovery (RHR) system on bulk tank compressors on dairy farms. Heat recovery systems recover waste heat from bulk tank compressors used in milk cooling processes. This waste heat is used to pre-heat water before it is transferred to a water heater, thus reducing the load of the water heater. Hot water is used in various farm applications such as cleaning and livestock watering.

There are two methods of calculating savings. One is to calculate the amount of energy that can be recovered by the heat recovery system in the milk cooling process. This method is reflected in the ΔBTU_{milk} equation. The second method is to calculate the energy required to heat the water in the storage tank to the set point. This method is reflected in the ΔBTU_{hru}, equation. The smaller of the two shall be selected. If ΔBTU_{milk} is smaller than ΔBTU_{hru}, this implies that the energy recovered by the heat recovery system is not sufficient to fully heat the water to the setpoint, and therefore represents the upper limit of savings. If ΔBTU_{hru} is smaller than ΔBTU_{milk} this implies the energy required to heat the water to the setpoint is less than the energy that is recovered by the heat recovery system, and therefore represents the upper limit of savings.

Baseline Case

Baseline condition for this measure is a dairy farm without a heat recovery system to feed preheated water to the water heater.

Efficient Case

The efficient condition is a dairy farm with a heat recovery system to preheat water to the waterheater.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{MIN[\Delta \mathrm{BTU_{milk}} \ or \ \Delta \mathrm{BTU_{hru}}]}{3{,}412 \times E_{t,elec}}$$

Where,

$$\Delta BTU_{milk} = lbs_{milk} \times cows \times \Delta T_{milk} \times 0.93 \times ESF$$

$$\Delta BTU_{hru} = v_{hru} \times \Delta T_{water} \times 8.33 \times 365 \times cows$$

$$\Delta T_{water} = T_{set} - T_{main}$$

Annual Fuel Savings

$$\Delta Therms = \frac{MIN[\Delta BTU_{milk}\ or\ \Delta BTU_{hru}]}{100{,}000 \times E_{t,fuel}}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-25 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ΔBTU_{milk}	Recoverable energy from milk cooling process	Calculated	Btu	
ΔBTU_{hru}	Required energy to heat water in the storage tank unit to set temperature	Calculated	Btu	
ΔT_{water}	Change in water temperature attributable to heat recovery system	Calculated	°F	
Lbs_{milk}	Average pounds of milk produced per cow per year	19,800	Lbs/yr	[390]~~[3890]~~
Cows	Average number of cows milked per day	Site-specific	cow/day	

Variable	Description	Value	Units	Ref
ΔT_{milk}	Difference in temperature between milk entering the bulk tank and final stored temperature of cooled milk	Look up in Table 3-26	°F	[392]~~[391~~2]
ESF	Energy Savings Factor	0.4	N/A	[393]~~[392~~3]
V_{hru}	Volume of hot water for washing and cleaning per day per cow, in gallons	Site specific, if unknown use 6.3gal/cow/day	Gal/cow/day	[394]~~[393~~4]
T_{set}	Expected temperature an RHR unit can pre-heat well water up to	Site-specific, if unknown look up in Table 3-27	°F	[393]~~[392~~3]
T_{main}	Water main inlet temperature	Look up in Table 3-28	°F	[395]~~[394~~5]
$E_{t,elec}$	Thermal efficiency of electric water heater	Site-specific, if unknown use 0.98	N/A	[397]~~[396~~7]
$E_{t,fuel}$	Thermal efficiency of fossil fuel water heater	Site-specific, if unknown use 0.8	N/A	[398]~~[397~~8]
Hrs	Hours per year	Site-specific, if unknown use 2,920	Hrs/yr	[396]~~[395~~6]
0.93	Specific heat of milk	0.93	BTU/lb °F	[399]~~[398~~9]
8.33	Energy required to heat one gallon of water by one degree	8.33	BTU	
3,412	Conversion factor BTU to kWh	3,412	BTU/kWh	
100,000	Conversion factor BTUs to Therms	100,000	BTU/Therm	
CF	Electric coincidence factor	Look up in Table 3-29	N/A	
PDF	Gas peak day factor	Look up in Table 3-29	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-26 Difference in Milk Temperature (ΔT_{milk} °F)

No Pre-Cooler	Standard Pre-Cooler	Variable Speed Pre-Cooler
60 °F	30 °F	18.3 °F

Table 3-27 RHR Setpoint Temperature (T_{set})

Fully condensing RHR system	Desuperheater RHR condenser
130 °F	105 °F

Table 3-28 Cold Water Inlet Temperature (T_{main})

NJ Climate Region	Annual Average Outdoor Temperature (°F)	T_{main} (°F)
Northern	50.75	56.75
Southwest	52.37	58.37
Coastal	54.29	60.29
Central	52.45	58.45
Pine Barrens	52.44	58.44
Statewide Average	52.45	58.45

Peak Factors

Table 3-29 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.8	N/A
Natural gas peak day factor (PDF)	See	

Measure Life

The effective useful life (EUL) is 14 years. [390]~~[3890]~~

References

~~[389]~~[390] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx.

~~[390]~~[391] New Jersey Dept of Agriculture, *2021 Annual Report and Agricultural Statistics.* (2021), page 21. 2021AnnualReportFinal.pdf (usda.gov)

~~[391]~~[392] Sanford, Scott (University of Wisconsin–Madison). "Well Water Precoolers." Publication A37843. October 2003. It was determined that a plate cooler alone can reduce milk temperature to 68 ˚F and a plate cooler paired with a milk transfer pump VSD can reduce milk temperature to 56.3 ˚F. The additional benefits of the milk transfer pump VSD over the plate cooler is 11.7 ˚F. Milk is stored at 38°F, therefore 56.3°F-38°F=18.3°F.

~~[392]~~[393] DeLaval. "Dairy Farm Energy Efficiency". (April 20, 2011.) A heat recovery system can recover 20%-60% of the energy required in the milk cooling process.

~~[393]~~[394] "Water Use on Dairy Farms." 2011. MSU Extension. 2011 https://www.canr.msu.edu/news/water_use_on_dairy_farms.

~~[394]~~[395] Burch, Jay, and Craig Christensen. n.d. "TOWARDS DEVELOPMENT of an ALGORITHM for MAINS WATER TEMPERATURE." https://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/water_heaters/AlgorithmForMainsWaterTemperature.pdf.

Field Code Changed

Field Code Changed

Field Code Changed

~~[395]~~[396] “Dairy Farm Energy Management Guide: California.” n.d. Www.energy.wsu.edu. Accessed January 12, 2023. https://www.energy.wsu.edu/EnergyLibrary/AgricultureMatters/CatalogItemDetail.aspx?id=429.

~~[396]~~[397] 10 CFR 430 Subpart B Appendix E – Uniform Test Method for Measuring the Energy Consumption of Water Heaters: *6.3.2 Recovery Efficiency.* https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-B#p-Appendix-E-to-Subpart-B-of-Part-430(6.)(6.3)(6.3.2).

~~[397]~~[398] 10 CFR 431.110 (a) – Energy conservation standards and their effective dates. https://www.ecfr.gov/current/title-10/chapter-II/subcharpter-D/part431/subpart-G/

~~[398]~~[399] 2018 ASHRAE Handbook – Refrigeration, Specific heat of whole milk, Table 3: Unfrozen Composition Data, Initial Freezing Point, and Specific Heat of Foods.

Field Code Changed

Field Code Changed

Field Code Changed

3.1.9 ENGINE BLOCK HEATER TIMER

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	January 2023

Description

This section provides energy savings algorithms for the installation of timers used to control engine block heaters on existing farm equipment. Engine block heaters are generally used during cold weather to warm an engine prior to use. Block heaters without automation are typicially plugged in throughout the night. Using timers allows the heater to come on at a preset time rather than being on throughout the night. There are no peak demand savings associated with this measure since it does not affect peak period usage.

Baseline Case

Engine block heater without a timer that is manually controlled.

Efficient Case

Engine block heater controlled by a timer.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{W_{heater}}{1{,}000} \times (hrs_b - hrs_q) \times Days \times UF$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \mathrm{N/A}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \text{N/A}$$

Calculation Parameters

Table 3-30 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
W_{heater}	Wattage of engine block heater	Site-specific, if unknown use 1,000	W	[402][4012]
hrs_b	Baseline hours of use per day	Site-specific, if unknown use 10	Hrs/day	[402][4012]
hrs_q	Energy efficient hours of use per day	Site-specific, if unknown use 2	Hrs/day	[402][4012]
Days	Days of use per year	Site-specific, if unknown use 90	Days/yr	[402][4012]
UF	Usage Factor	Site-specific, if unknown use 0.97	N/A	[400][399400]
CF	Electric coincidence factor	Look up in Table 3-31	N/A	
PDF	Gas peak demand factor	Look up in Table 3-31	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Peak Factors

Table 3-31 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 15 years [401][4001].

References

~~[399]~~[400] Wisconsin Focus on Energy 2018 Technical Reference Manual. Public Service Commission of Wisconsin. The Cadmus Group, Inc. 2018. Pg. 590. https://www.focusonenergy.com/sites/default/files/TRM%202018%20Final%20Version%20Dec%202017_1.pdf

~~[400]~~[401] Gutierrez, Alfredo. Circulating Block Heater. Prepared for the California Technical Forum. http://static1.squarespace.com/static/53c96e16e4b003bdba4f4fee/t/556f7c9ee4b0b65c3515c80c/1433369758093/Circulating+Block+Heater+Presentation_ver+2.pdf

~~[401]~~[402] 2018 Wisconsin Association of FFA to Farm Engine Block Heater Timer Fundraiser Fact Sheet. https://s3.us-east-1.amazonaws.com/focusonenergy/staging/inline-files/EBHT_Trifold_2018_1.pdf

Field Code Changed

Field Code Changed

3.1.10 ELECTRIC LEAF BLOWER

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Equipment
Measure Last Reviewed	February 2024
Changes Since Last Version	~~New measure~~

Description

This measure claims savings for the replacement of an existing commercial gasoline leaf blower with an all-electric leaf blower.

Baseline Case

The baseline condition is assumed to be a commercial gasoline powered leaf blower.

Efficient Case

The efficient condition is a commercial all-electric leaf blower.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = -kW_{battery} \times Hrs$$

When calculated with the default values in Table 3-32, ΔkWh = -163.5 kWh/yr

Annual Fuel Savings (Another Fuel)

$$\Delta Gal_{gasoline} = U \times Hrs$$

When calculated with the default values in Table 3-32, $\Delta Gal_{Gasoline}$ = 121.3 Gal/yr

Annual Peak Demand Savings

$$\Delta kW_{Peak} = -kW_{battery}\ x\ CF$$

Daily Peak Fuel Savings

$$N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings (Another Fuel)

$$\Delta Gal_{Gasoline,\,Life} = \Delta Gal_{gasoline} \times EUL$$

Calculation Parameters

Table 3-32 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated or use default - 163.5	kWh/yr	
ΔkW_{Peak}	Annual peak demand savings	Calculated	kW/yr	
$\Delta Gal_{Gasoline}$	Annual fuel savings (gasoline)	Calculated or use default 121.3	Gal/yr	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Gal_{Gasoline,\,Life}$	Lifetime fuel savings (gasoline)	Calculated	Gal	
kW_{blower}	Electric demand of a commercial electric leaf blower[93]	0.58	kW	[406]~~[4056]~~
Hrs	Annual hours of use	282	Hrs	[405]~~[4045]~~
U	Average gallons of gasoline that a baseline leaf blower consumes in one hour[94]	0.43	Gal/hr	[406]~~[4056]~~
CF	Electric demand coincidence factor	Look up in Table 3-33	N/A	
EUL	Effective useful life	See Measure Life ~~Measure Life~~ section	Years	[403]~~[4023]~~

93 Assumes the higher range of possible electric lawn blower electric demand **Error! Reference source not found.**.

Peak Factors

Table 3-33 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.5	[407]~~[4067]~~

Measure Life

The effective useful life (EUL) is 5 years [221]~~[2201]~~.

References

~~[402]~~[403] Department of Public Services, *2022 Tier III TRM Characterizations*. 2022, Page 59, https://publicservice.vermont.gov/document/2022-tier-iii-trm-characterizations. Assumed measure life is sourced from a review of available warranties on electric leaf blowers in the market. It was found that there are many models available currently with a manufacturer 5 year warranty.

~~[403]~~[404] Assuming the battery will be charged on a 120v outlet, 4.8a x 120v = -0.58 kW. Charger amperage assumption from STIHL manufacturer: https://www.stihlusa.com/WebContent/CMSFileLibrary/InstructionManuals/STIHL-AR-2000-L-3000-L-Owners-Instruction-Manual.pdf

~~[404]~~[405] Quiet Communities and US Environmental Protection Agency, *National Emissions from Lawn and Garden Equipment,* 2015, Page 6, Table 3, https://www.epa.gov/sites/default/files/2015-09/documents/banks.pdf

~~[405]~~[406] Quiet Clean PDX, *Gas Powered Leaf Blower Noise and Emissions Factsheet*, 2019

~~[406]~~[407] Placeholder assumption until further research conducted.

Field Code Changed

Field Code Changed

Field Code Changed

3.1.11 ELECTRIC RIDING LAWN MOWER

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Equipment
Measure Last Reviewed	February 2024
Changes Since Last Version	~~New measure~~

Description

This measure claims savings for the replacement of an existing gasoline powered ride-on lawnmower with a new all-electric ride-on lawnmower. This measure is characterized for commercial applications.

Baseline Case

The baseline condition is assumed to be a gasoline powered ride-on lawnmower.

Efficient Case

The efficient condition is an all-electric ride-on lawnmower.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = -Q \times Q_{time} \times kW_{Draw} \times N_{battery}$$

Annual Fuel Savings (Another Fuel)

$$\Delta Gal_{gasoline} = U$$

Annual Peak Demand Savings

$$\Delta kW_{Peak} = -kW_{draw} \times N_{battery} \times CF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings (Another Fuel)

$$\Delta Gal_{Gasoline,\,Life} = \Delta Gal_{Gasoline} \times EUL$$

Calculation Parameters

Table 3-34 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings, deemed value calculated using default variables below	Calculated (Default –3,150)	kWh/yr	[221]~~[2201]~~
ΔkW	Annual peak demand savings	Calculated (Default -0.56)	kW	
$\Delta Gal_{gasoline}$	Annual gasoline savings, deemed value calculated using default variables below	Calculated (Default 900)	gal	[221]~~[2201]~~
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Gal_{gasoline,life}$	Lifetime gasoline savings	Calculated	gal	
Q	Number of full charges in a year[95]	700	N/A	[221]~~[2201]~~
Q_{time}	Time required to fully charge battery[96]	4	Hrs	[221]~~[2201]~~
kW_{draw}	Demand draw of battery while charging	0.56	kW	[221]~~[2201]~~
$N_{battery}$	No batteries attached to lawn mower	2	N/A	[221]~~[2201]~~
U	Annual gasoline consumption	900	gallons	[221]~~[2201]~~
CF	Electric coincidence factor	Look up in Table 3-35	N/A	
EUL	Effective useful life	See Measure Life ~~Measure Life~~ section	Years	[221]~~[2201]~~

Peak Factors

Table 3-35 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.5	[409]~~[4089]~~

95 Annual hours of use divided by Working Time Per Charge.
96 Battery Charging Time to 100% divided by 60 minutes.

Measure Life

The effective useful life (EUL) is 6 years [221]~~[2201]~~.

References

~~[407]~~[408] Department of Public Services, *2022 Tier III TRM Characterizations*. 2022, Page 56, https://publicservice.vermont.gov/document/2022-tier-iii-trm-characterizations. Commercial Riding measure life was collected by industry data from Steve W. of Eco Equipment Supply (EES).

~~[408]~~[409] Placeholder assumption until further research conducted.

Field Code Changed

3.1.12 HEDGE TRIMMERS, PUSH LAWNMOWERS, AND CHAINSAWS

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Equipment
Measure Last Reviewed	March 2024
Changes Since Last Version	~~New Measure~~

Description

This measure applies to the purchase of new commercial lawn equipment, which includes hedge trimmers, push lawnmowers (not self-propelled or riding, but has an electric motor driving a blade), and chainsaws to replace gas lawn equipment.

Baseline Case

The baseline equipment gasoline-powered commercial hedge trimmers, push lawnmowers, and chainsaws.

Efficient Case

The energy efficient equipment is all-electric commercial hedge trimmers, push lawnmowers, and chainsaws.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = Look\ up\ in\ \textbf{Table 2-150}\cancel{\text{Table 2-150}}$$

Deemed annual energy savings in Table 2-150 calculated as follows:

$$\Delta kWh = -\frac{Hrs}{t_{charge}} \times E_{battery} \times \frac{D}{Eff_{charger}} \times \frac{1}{1{,}000}$$

Annual Fuel Savings (Alternate Fuel)

$$\Delta Gal_{Gasoline} = Look\ up\ in\ \textbf{Table 2-150}\cancel{\text{Table 2-150}}$$

Annual Peak Demand Saving

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hrs} \times CF$$

Daily Peak Fuel Savings

$$N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Gal_{Life} = \Delta Gal_{Gasoline} \times EUL$$

Calculation Parameters

Table 3-36 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Look up in Table 2-150	kWh/yr	[221]~~[2201]~~
$\Delta Gal_{gasoline}$	Annual gallons gasoline savings	Look up in Table 2-150	Gallons	[221]~~[2201]~~
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
ΔGal_{Life}	Lifetime fuel savings	Calculated	Gallons	
ΔkW_{Peak}	Annual peak demand savings	Calculated	kW	
Hrs	Annual operating hours	Look up in Table 2-149	Hrs	
t_{charge}	Run time per charge	Look up in Table 2-149	Hrs	[411]~~[4101]~~
$E_{battery}$	Rated energy of the battery	Look up in Table 2-149	Wh	[221]~~[2201]~~
D	Discharge rate	0.90	%	[411]~~[4101]~~
$Eff_{charger}$	Efficiency of the charger	0.92	%	[411]~~[4101]~~
1,000	Unit conversion, Wh/kWh	1,000	Wh/kWh	
CF	Electric demand coincidence factor	Look up in Table 3-39	N/A	[412]~~[4112]~~
EUL	Effective useful life	See Measure Life ~~Measure Life~~	Years	[221]~~[2201]~~

The table below presents the parameters used to calculate the deemed energy impacts.

Table 3-37 Parameters Values

Type of Electric Equipment	Hrs	t_{charge}	$E_{battery}$
Trimmer	125	0.5	1HP Replacement: 100 2HP Replacement: 240
Push Lawnmower	810	1	300
Chainsaw	80	0.09	150

When calculated using the assumptions above, the energy impacts are equal to the values below. These deemed impacts may be used instead of calculating site-specific savings if reliable input parameters are not available.

Table 3-38 Deemed Energy Impacts

Type of Electric Equipment	ΔkWh	$\Delta Gal_{gasoline}$
Trimmer	1HP Replacement: -24.5 2HP Replacement: -58.7	1HP Replacement: 21.5 2HP Replacement: 115
Push Lawnmower	-238	134
Chainsaw	-130	115

Peak Factors

Table 3-39 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.5	[412]~~[4112]~~
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is given in Table 2-152 [221]~~[2201]~~.

Table 3-40 Measure Life

Type of Electric Equipment	Measure Life (yrs)
Trimmer	2
Push Lawnmower	6
Chainsaw	2

References

~~[409]~~[410] PSEG CEF-EE II Filing 12.1.23
~~[410]~~[411] PSEG-LI TRM
~~[411]~~[412] Placeholder assumption until further research conducted.

3.2 APPLIANCES

3.2.1 CLOTHES WASHER

Market	Commercial/Multifamily
Baseline Condition	TOS/NC
Baseline	Code
End Use Subcategory	Clothes Washer
Measure Last Reviewed	January 2023

Description

This measure relates to the purchase (time of sale) and installation of a commercial clothes washer (i.e., soft-mounted front-loading or soft-mounted top-loading clothes washer that is designed for use in applications in which the occupants of more than one household will be using the clothes washer, such as multifamily housing common areas and coin laundries) exceeding the ENERGY STAR minimum qualifying efficiency standards. The Modified Energy Factor (MEF) measures energy consumption of the total laundry cycle (washing and drying). It indicates how many cubic feet of laundry can be washed and dried with one kWh of electricity; the higher the number, the greater the efficiency. The Water Factor (WF) is the number of gallons needed for each cubic foot of laundry. A lower number indicates lower consumption and more efficient use of water. Rather than filling the tub with water, efficient wash cycles are achieved by spinning or flipping clothes through a stream of water. Efficient rinse cycles are achieved through high-pressure spraying instead of soaking clothes. Reduced dryer load represents additional energy savings associated with the thorough removal of water from the clothes in the washer. Clothes washers that have earned the ENERGY STAR® label use approximately 25% less energy and 33% less water than comparable non-qualified models.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

The baseline efficiency is minimum efficiency defined in the Code of Federal Regulations at 10 CFR 431.156. Efficiency is defined by the Modified Energy Factor (MEF) that takes into account the energy and water required per clothes washer cycle, including energy required by the clothes dryer per clothes washer cycle.

Efficient Case

The efficient condition is a commercial clothes washer meeting the ENERGY STAR v. 8.1 efficiency criteria.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{washer} + \Delta kWh_{DHW} + \Delta kWh_{dryer}$$

Where,

$$\Delta kWh_{washer} = \Delta kWh_{unit} \times F_{washer}$$

$$\Delta kWh_{DHW} = \Delta kWh_{unit} \times F_{DHW} \times SF_{DHW,electric}$$

$$\Delta kWh_{dryer} = (\Delta kWh_{total} - \Delta kWh_{unit}) \times \frac{F_{loads}}{F_{dryer}} \times F_{dryer,mod} \times SF_{dryer,electric}$$

$$\Delta kWh_{unit} = \left(kWh_{unit,b} - kWh_{unit,q}\right) \times \frac{N_{cycles}}{N_{cycles,ref}}$$

$$\Delta kWh_{total} = Cap \times N_{cycles} \times \left(\frac{1}{MEF_b} - \frac{1}{MEF_q}\right)$$

Annual Fuel Savings

$$\Delta Therms = \Delta Therms_{DHW} + \Delta Therms_{dryer}$$

Where,

$$\Delta Therms_{DHW} = \Delta kWh_{unit} \times \frac{F_{DHW}}{Eff_{DHW}} \times SF_{DHW,ff} \times 0.03412$$

$$\Delta Therms_{Dryer} = (\Delta kWh_{total} - \Delta kWh_{unit}) \times \frac{F_{loads}}{F_{dryer}} \times F_{dyer,mod} \times F_{dryer,corr} \times SF_{dryer,ff} \times 0.03412$$

$$\Delta kWh_{unit} = \left(kWh_{unit,b} - kWh_{unit,q}\right) \times \frac{N_{cycles}}{N_{cycles,ref}}$$

$$\Delta kWh_{total} = Cap \times N_{cycles} \times \left(\frac{1}{MEF_b} - \frac{1}{MEF_q}\right)$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-41 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkWh_{washer}	Annual electric energy savings attributed to clothes washer operation	Calculated	kWh/yr	
ΔkWh_{DHW}	Annual electric energy savings attributed to water heating	Calculated	kWh/yr	
ΔkWh_{dryer}	Annual electric energy savings attributed to dryer operation	Calculated	kWh/yr	
ΔkWh_{unit}	Annual electric energy savings of a unit exclusive of dryer operation	Calculated	kWh/yr	
ΔkWh_{total}	Annual electric energy savings of a unit inclusive of dryer operation	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{DHW}$	Annual fuel savings attributed to water heating	Calculated	Therms/yr	
$\Delta Therms_{dryer}$	Annual fuel savings attributed to dryer operation	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ΔH2O	Annual water savings	Calculated	Gal/yr	
Cap	Clothes washer capacity	Site-specific. If unknown, use 3.43	ft^3	[416]~~[4156]~~
N_{cycles}	Number of cycles per year	Site-specific. If unknown, look up in Table 3-44	cycles	[413]~~[4123]~~

Variable	Description	Value	Units	Ref
$kWh_{unit,b}$	Baseline rated unit electricity consumption	Site-specific. If unknown, use 241	kWh/yr	[413]~~[4123]~~
$kWh_{unit,q}$	Efficient rated unit electricity consumption	Site-specific. If unknown, use 97	kWh/yr	[413]~~[4123]~~
F_{washer}	Fraction of energy consumption attributed to clothes washer operation	Site-specific. If unknown, assume 0.20	N/A	[413]~~[4123]~~
F_{DHW}	Fraction of energy consumption attributed to water heating	Site-specific. If unknown, assume 0.80	N/A	[413]~~[4123]~~
F_{loads}	Fraction of washer loads dried in machine	Site-specific. If unknown, use 1.0	N/A	
Eff_{DHW}	Fuel water heater efficiency	Site-specific. If unknown, use 0.75	N/A	
WF_q	Water factor for efficient unit	Site-specific. If unknown, look up in Table 3-45	Gal/(cycle·ft³)	[416]~~[4156]~~[417]~~[4167]~~
MEF_b	Modified Energy Factor of baseline unit	Look up in Table 3-42	N/A	[416]~~[4156]~~[417]~~[4167]~~
MEF_q	Modified Energy Factor of efficient unit	Look up in Table 3-42	N/A	[416]~~[4156]~~[417]~~[4167]~~
$SF_{DHW,electric}$	Electric DHW savings factor	Look up in Table 3-43	N/A	
$SF_{dryer,electric}$	Electric dryer savings factor	Look up in Table 3-43	N/A	
$SF_{DHW,ff}$	Fossil fuel DHW savings factor	Look up in Table 3-43	N/A	
$SF_{dryer,ff}$	Fossil fuel dryer savings factor	Look up in Table 3-43	N/A	
WF_b	Water factor for baseline unit	Look up in Table 3-45	Gal/(cycle·ft³)	[416]~~[4156]~~[417]~~[4167]~~
CF	Electric coincidence factor	Look up in Table 3-46	N/A	[413]~~[4123]~~
PDF	Gas peak day factor	Look up in Table 3-46	N/A	
Hrs	Annual operating hours	265	Hrs/yr	[413]~~[4123]~~
$N_{cycles, ref}$	Reference number of cycles per year	392	cycles	[413]~~[4123]~~
F_{dryer}	Dryer usage factor	0.84	N/A	[413]~~[4123]~~

Variable	Description	Value	Units	Ref
$F_{dryer,mod}$	Dryer usage factor in buildings with dryer and washer	0.95	N/A	[413]~~[4123]~~
$F_{dryer,corr}$	Fossil fuel dryer correction factor	1.12	N/A	[413]~~[4123]~~
0.03412	Unit conversion, therm/kWh	0.03412	Therm/kWh	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-42 Modified Energy Factor of Baseline and Efficient Unit

Efficiency Level	Front Loading	Top Loading
Federal Standard	Before January 1, 2018	
	2.00	1.60
	On or After January 1, 2018	
	2.00	1.35
ENERGY STAR	2.20	

Table 3-43 DHW and Dryer Savings Factors

Fuel	$SF_{DHW,electric}$	$SF_{dryer,electric}$	$SF_{DHW,ff}$	$SF_{dryer,ff}$	Source
Electric	1.00	1.00	0	0	
Fossil Fuel	0	0	1.00	1.00	
Unknown	Look up in **Error! Reference source not found.**~~Appendix K: DHW and Space Heat Fuel Split~~	0.89	Look up in **Error! Reference source not found.**~~Appendix K: DHW and Space Heat Fuel Split~~	0.11	[418]~~[4178]~~

Table 3-44 Annual Cycles

Type	Number of Cycles
Multifamily Common Area	1,241
Laundromats	2,190

Table 3-45 Water Factor of Baseline and Efficient Unit

Efficiency Level	Front Loading	Top Loading
Federal Standard	Before January 1, 2018	
	5.5	8.5
	On or After January 1, 2018	
	4.1	8.8
ENERGY STAR	4.0	

Peak Factors

Table 3-46 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.029	[413]~~[4123]~~
Natural gas peak day factor (PDF)	See **Error! Reference source not found.** ~~Appendix G: Natural Gas Peak Day Factors~~	

Non-Energy Impacts

$$\Delta H2O = Cap \times (WF_b - WF_q) \times N_{cycles}$$

Measure Life

The effective useful life (EUL) for a multifamily common area is 11.3 years. The EUL for laundromats is 7.1 years. [413]~~[4123]~~

References

~~[412]~~[413] Regulations.gov, Energy Conservation Program: Energy Conservation Standards for Commercial Clothes Washers; Final Rule (2014). https://www.regulations.gov/document/EERE-2012-BT-STD-0020-0037

~~[413]~~[414] Metered data from Navigant Consulting, *EmPOWER Maryland Draft Final Evaluation Report Evaluation Year 4 (June 1, 2012 – May 31, 2013) Appliance Rebate Program.* March 21, 2014, page 36. This data applies to residential applications. In the absence of metered data specific to multifamily common area and commercial laundromat applications, this coincidence value is used as a proxy given consistency with the PJM peak definition; however, this value is likely conservatively low for commercial applications and is a candidate for update should more applicable data become available .

~~[414]~~[415] Clothes Washer Calculations for the ENERGY STAR Appliance Calculator. 2022. https://www.sfwmd.gov/sites/default/files/documents/calculator_energy_star_res_appliance_savings.xlsx.

Field Code Changed

Field Code Changed

~~[415]~~[416] Based on the average commercial clothes washer volume of all units meeting ENERGY STAR V8.1 criteria listed in the ENERGY STAR database of certified products accessed on 03/07/2016. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Version%208.1%20Clothes%20Washer%20Final%20Specification%20-%20Partner%20Commitments%20and%20Eligibility%20Criteria.pdf

~~[416]~~[417] Office of Energy Efficiency and Renewable Energy, Department of Energy, Energy Conservation Program: Energy Conservation Standards for Commercial Clothes Washers. https://www.federalregister.gov/documents/2021/12/20/2021-27461/energy-conservation-program-energy-conservation-standards-for-commercial-clothes-washers

~~[417]~~[418] Space heat and DHW factors in Appendix from program data. Dryer fuel data from EIA Residential Energy Consumption Survey 2015, Table HC3.1, buildings with 5 or more units. https://www.eia.gov/consumption/residential/data/2015/#appliances

Field Code Changed

Field Code Changed

Field Code Changed

3.2.2 CLOTHES DRYERS

Market	Commercial/Multifamily
Baseline Condition	TOS
Baseline	Code
End Use Subcategory	Clothes Washer
Measure Last Reviewed	January 2023

Description

This measure covers residential grade clothes dryers meeting the criteria established under the ENERGY STAR® Program, Version 1.1, effective May 5, 2017, installed in small commercial settings. ENERGY STAR® clothes dryers have a higher combined energy factor (CEF), and save energy through a combination of more efficient drying and reduced runtime of the drying cycle. More efficient drying is achieved through increased insulation, modifying operating conditions, improving air circulation, and improved efficiency of motors. Reduced dryer runtime is achieved through automatic termination of the dryer cycles based on temperature and moisture sensors. Clothes dryers originally qualified for the ENERGY STAR® label in May 2014. Clothes dryers that have earned this label are approximately 20% more efficient than non-qualified models.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

The baseline for energy savings calculations is a clothes dryer meeting the federal minimum combined energy factor for machines manufactured after January 2015. The minimum combined energy factor varies by clothes dryer type.

Efficient Case

A clothes dryer that is an ENERGY STAR® version 1.1 qualifying model.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = Cycles_{annual} \times Load \times \left(\frac{F_{elec,b}}{CEF_b} - \frac{F_{elec,q}}{CEF_q}\right)$$

Annual Fuel Savings

$$\Delta Therms = Cycles_{annual} \times Load \times \left(\frac{F_{fuel,b}}{CEF_b} - \frac{F_{fuel,q}}{CEF_q}\right) \times \frac{3{,}412}{100{,}000}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-47 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
$\Delta Therms$	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$Cycles_{Annual}$	Number of dryer cycles per year	Site-specific. If unknown, look up in Table 3-49	Cycles	[419]~~[418~~9]
Load	Average total weight of clothes per drying cycle	Look up in Table 3-48	lbs	[419]~~[418~~9]
$F_{elec,b}$	Percentage of energy consumed that is derived from electricity for baseline dryer	Look up in Table 3-48	%	[425]~~[424~~5][426]~~[425~~6]
$F_{elec,q}$	Percentage of energy consumed that is derived from electricity for efficient dryer	Look up in Table 3-48	%	[425]~~[424~~5][426]~~[425~~6]
$F_{fuel,b}$	Percentage of energy consumed that is derived from fossil fuel for baseline dryer	Look up in Table 3-48	%	[425]~~[424~~5][426]~~[425~~6]

Variable	Description	Value	Units	Ref
$F_{fuel,q}$	Percentage of energy consumed that is derived from fossil fuel for efficient dryer	Look up in Table 3-48	%	[425]~~[424~~5~~]~~[426]~~[425~~6~~]~~
CEF_b	Combined energy factor for baseline dryer	Look up in Table 3-48	lb/kWh	[421]~~[420~~1~~]~~
CEF_q	Combined energy factor for efficient dryer	Look up in Table 3-48	lb/kWh	[420]~~[419~~420~~]~~
Hrs	Annual run hours of clothes dryer	Site-specific. If unknown look up in Table 3-49	Hrs/yr	[419]~~[418~~9~~]~~[424]~~[423~~4~~]~~
CF	Electric coincidence factor	Look up in Table 3-50	N/A	[422]~~[421~~2~~]~~
PDF	Gas peak day factor	Look up in Table 3-50	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-48 Clothes Dryer Values

Variable	Vented Gas Dryer	Ventless or Vented Electric, Standard ≥ 4.4 ft^3	Ventless or Vented Electric, Compact (120V) < 4.4 ft^3	Vented Electric, Compact (240V) < 4.4 ft^3	Ventless Electric, Compact (240V) < 4.4 ft^3
Load	8.45	8.45	3.00	3.00	3.00
$F_{elec,b}$[97]	0.16	1.00	1.00	1.00	1.00
$F_{elec,q}$	0.16	1.00	1.00	1.00	1.00
$F_{fuel,b}$[98]	0.84	0.00	0.00	0.00	0.00
$F_{fuel,q}$	0.84	0.00	0.00	0.00	0.00
CEF_b	3.30	3.73	3.61	3.27	2.55
CEF_q	3.48	3.93	3.80	3.45	2.68
Energy Star Most Efficient CEF_q		4.3	4.3	4.3	3.7

[97] %Electric accounts for the fact that some of the savings on gas dryers comes from electricity (motors, controls, etc). 16% was determined using a ratio of the electric to total savings from gas dryers given by ENERGY STAR Draft 2 Version 1.0 Clothes Dryers Data and Analysis.

[98] %Gas accounts for the fact that some of the savings on gas dryers comes from electricity (motors, controls, etc). 84% was determined using a ratio of the gas to total savings from gas dryers given by ENERGY STAR Draft 2 Version 1.0 Clothes Dryers Data and Analysis.

Table 3-49 Annual Dryer Cycles

Facility Type	Commercial – Multifamily	Laundromat
$Cycles_{Annual}$	1,241	2,190
Hrs[99]	1,158	2,044

Peak Factors

Table 3-50 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.029	[422]~~[4212]~~
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The effective useful life (EUL) is 12 years [423]~~[4223]~~.

References

~~[418]~~[419] Savings Calculator for ENERGY STAR Qualified Appliances, ENERGY STAR, 2012. https://www.sfwmd.gov/sites/default/files/documents/calculator_energy_star_res_appliance_savings.xlsx

~~[419]~~[420] *ENERGY STAR Program Requirements for Clothes Dryers -Partner Commitments Criteria ENERGY STAR ® Program Requirements Product Specification for Clothes Dryers Partner Commitments*. n.d. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Final%20Version%201.1%20Clothes%20Dryers%20Specification%20-%20Program%20Commitment%20Criteria%20and%20Eligibility%20Criteria_0.pdf

~~[420]~~[421] PART 430 - ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS n.d. https://federalregister.gov. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430#430.32

~~[421]~~[422] *Mid-Atlantic Technical Reference Manual (TRM) V10*. (2020), https://neep.org/sites/default/files/media-files/trmv10.pdf

~~[422]~~[423] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

~~[423]~~[424] Northwest Energy Efficiency Alliance (NEEA), 'Dryer Field Study', November 2014 https://ecotope-publications-database.ecotope.com/2014_005_1_DryerStudy.pdf

~~[424]~~[425] *Mid-Atlantic Technical Reference Manual (TRM) V10* (2020). https://neep.org/sites/default/files/media-files/trmv10.pdf

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

[99] Assumes average of 56 minutes per cycle based on Ecova, 'Dryer Field Study', Northwest Energy Efficiency Alliance (NEEA) 2014.

~~[425]~~[426] ENERGY STAR Draft 2 Version 1.0 Clothes Dryers Data and Analysis, August 2013. https://www.energystar.gov/sites/default/files/specs/ENERGY%20STAR%20Draft%202%20Version%201.0%20Clothes%20Dryers%20Data%20and%20Analysis.xlsx

Field Code Changed

3.2.3 CLOTHES DRYER MODULATING VALVE

Market	Commercial/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Clothes Washer
Measure Last Reviewed	January 2023

Description

This measure relates to the installation of a two-stage modulating gas valve retrofit kit on a standard commercial non-modulating gas dryer. Commercial gas clothes dryers found in coin-operated laundromats or on-premise laundromats (hospitals, hotels, health clubs, etc.) traditionally have a single firing rate which is sized properly for highest heat required in initial drying stages but is oversized for later drying stages requiring lesser heat. This causes the burner to cycle on/off frequently, resulting in less efficient drying and wasted gas. Replacing the single stage gas valve with a two-stage gas valve allows the firing rate to adjust to the changing heat demand, thereby reducing overall gas consumption.

Accurately estimating dryer energy consumption is complicated and challenging due to a variety of factors that influence cycle times and characteristics and ultimately drying energy requirements. Clothing loads can vary by weight, volume, fiber composition, physical structure, and initial water content, meaning that drying energy requirements can differ for any given cycle. Additionally, dryer settings selected by the user andinteractions with the site's HVAC systems are known to influence dryer performance. As better information becomes available, this characterization can be modified to allow for a more site-specific estimation of savings.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

A 30- to 250- pound capacity commercial gas dryer with no modulating capabilities.

Efficient Case

A 30- to 250-pound capacity commercial gas dryer retrofitted with a two-stage modulating gas valve kit.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Annual Fuel Savings

$$\Delta Therms = N_{Cycles} \times SF$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \text{N/A}$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-51 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
N_{Cycles}	Number of dryer cycles per year	Site-specific. If unknown, look up in Table 3-52	Cycles/yr	[427]~~[4267]~~
SF	Savings factor	0.18	Therms/cycle	[428]~~[4278]~~[427]~~[4267]~~
PDF	Gas peak day factor	Look up in Table 3-53	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-52 Estimated Dryer Cycles per Year

Application	Cycles per Year
Coin-Operated Laundromats	1,483
Multifamily Dryers	1,074
On-Premise Laundromats	3,607

Peak Factors

Table 3-53 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The effective useful life (EUL) is equal to 10 years[427]~~[4267]~~.

References

~~[426]~~[427] *IL 2022 Illinois Statewide Technical Reference Manual for Energy Efficiency : Version 10* (2022), Pg 734. https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010122_v10.0_Vol_2_C_and_I_09242021.pdf

~~[427]~~[428] IL TRM v10, pg 734. Based on Illinois weather data, and average dryer performance for laundromat (30 to 45lb) and hotel (75 to 170 lb) dryers.

Field Code Changed

3.2.4 REFRIGERATORS

Market	Commercial/Multifamily
Baseline Condition	TOS/NC/EREP/DI
Baseline	Code/ISP/ Dual
End Use Subcategory	Kitchen
Measure Last Reviewed	January 2023

Description

This measure includes the installation of ENERGY STAR® compliant commercial refrigerators with an integral compressor and condenser. This measure is only applicable to horizontal or vertical self-contained refrigerators with solid or transparent doors.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

Early Replacement: The baseline condition for the Early Replacement measure is the existing commercial refrigerator for the remaining useful life of the unit, and then for the remainder of the measure life the baseline becomes a new replacement unit meeting the minimum federal efficiency standard.

Time of Sale: The baseline condition is a standard-efficiency commercial refrigerator meeting, but not exceeding, federal energy efficiency standards.

Efficient Case

The efficient condition is a high-efficiency packaged commercial refrigerator meeting ENERGY STAR® Version 5.0 requirements.

Annual Electric Energy Savings

$$\Delta kWh = \left(kWh_b - kWh_q\right) \times (1 + HVAC_c) \times Days$$

Annual Fuel Savings

$$\Delta Therms = \left(kWh_b - kWh_q\right) \times HVAC_{ff} \times 10 \times Days$$

Peak Demand Savings

$$\Delta kW_{Peak} = \left(\frac{kWh_b - kWh_q}{Daily\ Hours}\right) \times (1 + HVAC_d) \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-54 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric savings	Calculated	kWh/yr	
$\Delta Therms$	Annual fue savings compared to existing unit	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings compared to existing unit	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
V	Refrigerator volume	Site-specific	ft^3	
Days	Number of days of operations in a year	Site-specific. If unknown, use 365 days	days	
Daily Hours	Hours of operation in a day	Site-specific. If unknown, use 24 hours	hours	
kWh_q	Annual energy consumption of qualifying efficient unit	Look up in Table 3-57	kWh	[430]~~[429430]~~

Variable	Description	Value	Units	Ref
kWh_b	Annual energy consumption of code-compliant baseline unit	Site-specific or look up in Table 3-56, Table 3-57	kWh	[429]~~[4289]~~
$HVAC_c$	HVAC interaction factor for annual electric energy consumption	0.080	N/A	
$HVAC_d$	HVAC interaction factor for peak demand at utility summer peak hour	0.175	N/A	
$HVAC_{ff}$	HVAC interaction factor for annual fossil fuel energy consumption	-0.002	MMBtu/kWh	
10	Unit conversion, Therm/MMBtu	10	Therm/MMBtu	
CF	Electric coincidence factor	Look up in Table 3-58	N/A	
PDF	Gas peak day factor	Look up in Table 3-58	N/A	
EUL	Effective useful life of new unit	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 3-55 Daily Energy Consumption of Code-Compliant Baseline Unit

Product Class	Daily Refrigerator Energy (kWh_b)
Vertical Closed	
Solid	*VCS.SC.M**
All volumes	*0.05 x V+1.36*
Transparent	*VCT.SC.M*
All volumes	*0.1 x V+0.86*
Horizontal Closed	
Solid	*HCS.SC.M*
All volumes	*0.05 x V+0.91*
Transparent	*HCT.SC.M*
All volumes	*0.06 x V+0.37*

Where V = unit volume in cubic feet
* DOE Equipment Class designations relevant to ENERGY STAR eligible product scope
(1) Equipment family code (HCS= horizontal closed solid, HCT=horizontal closed transparent, VCS= vertical closed solid, VCT=vertical closed transparent).
(2) Operating mode (SC=self-contained).
(3) Rating Temperature (M=medium temperature (38 °F), L=low temperature (0 °F)).

Table 3-56 Daily Energy Consumption of Existing Unit

Product Class	Daily Refrigerator Energy when existing unit was manufactured before 03/26/2017 (kWh_{ex})	Daily Refrigerator Energy when existing unit was manufactured after 03/27/2017 (kWh_{ex})
Vertical Closed		
Solid	*VCS.SC.M*	*VCS.SC.M*
All volumes	*0.10 x V+2.04*	*0.05 x V+1.36*
Transparent	*VCT.SC.M*	*VCT.SC.M*
All volumes	(0.12V + 3.34) x 365	(0.1 x V+0.86) x 365
Horizontal Closed		
Solid	*HCS.SC.M*	*HCS.SC.M*
All volumes	(0.10V+2.04) x 365	(0.05 x V+0.91) x 365
Transparent	*HCT.SC.M*	*HCT.SC.M*
All volumes	(0.12V + 3.34) x 365	(0.06 x V+0.37) x 365

Where V = unit volume in cubic feet

Table 3-57 Daily Energy Consumption of Qualifying Efficient Unit

Product Class	Daily Refrigerator Energy (kWh_q)
Vertical Closed	
Solid	*VCS.SC.M*
0 < V < 15	*0.0267 x V+0.8*
15 ≤ V < 30	*0.05 x V+0.45*
30 ≤ V < 50	*0.05 x V+0.45*
50 ≤ V	*0.025 x V+1.6991*
Transparent	*VCT.SC.M*
0 < V < 15	*0.095 x V+0.445*
15 ≤ V < 30	*0.05 x V+1.12*
30 ≤ V < 50	*0.076 x V+0.34*
50 ≤ V	*0.105 x V-1.111*
Horizontal Closed	
Solid or Transparent	*HCT.SC.M, HCS.SC.M*
All volumes	*0.05 x V+0.28*

Where V = unit volume in cubic feet

Peak Factors

Table 3-58 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1.0	
Natural gas peak day factor (PDF)	**Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

Table 3-59 Measure Life

Equipment	EUL	RUL	Ref
Commercial Reach-in Refrigerator	12	Site-specific. If unknown use 4 years	[432]~~[4312]~~

References

~~[428]~~[429] Code of Federal Regulations, Energy Efficiency Program for Certain Commercial and Industrial Equipment, title 10, sec. 431.66 (2010).

~~[429]~~[430] ENERGY STAR Program Requirements Product Specification for Commercial Refrigerators and Freezers Eligibility Criteria Version 5.0, ENERGY STAR ®, December 2022.

~~[430]~~[431] Code of Federal Regulations, Energy Efficiency Program for Certain Commercial and Industrial Equipment, title 10, sec. 431.66 (2013).

~~[431]~~[432] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020. http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

Field Code Changed

3.2.5 FREEZERS

Market	Commercial/Multifamily
Baseline Condition	TOS/NC/EREP/DI
Baseline	Code/ISP/Dual
End Use Subcategory	Kitchen
Measure Last Reviewed	January 2023

Description

This measure covers the installation of ENERGY STAR® compliant commercial freezers operating with an integral compressor and condenser. Eligible equipment includes commercial freezers and refrigerator-freezers. This measure is only applicable to horizontal or vertical self-contained equipment with solid or transparent doors.

In the case of early replacement of a working unit where the unit would have otherwise been installed until failure, remaining useful life (RUL) savings are claimed additional to the estimated useful life (EUL) savings of the new unit. Early replacement savings are calculated between existing unit and efficient unit consumption during the assumed remaining life of the existing unit, and between new baseline unit and efficient unit consumption for the remainder of the measure life. Assume that the remaining useful life of the existing unit equals 1/3 of the measure's effective useful life.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

Early Replacement (EREP) and Direct Install (DI): Early replacement and DI uses a dual baseline. The baseline is the existing unit for the remaining life of the existing unit and the baseline is a code-compliant/standard efficiency unit for the full measure life of the installed equipment.

Time of Sale (TOS) and New Construction (NC): The baseline condition is a minimally code compliant commercial freezer.

Baseline annual electric consumption shall align with federally mandated maximum energy use associated with the Product Class and the chilled or frozen compartment volume (V) of the qualifying equipment [433]~~[4323]~~. Volume specification shall be taken from ENERGY STAR® qualified products listing or specification sheet of the proposed equipment.

Efficient Case

The compliance condition is an ENERGY STAR® version 5.0 qualified commercial refrigerator-freezer or freezer. Annual electric energy consumption of the qualifying equipment shall come from application. Volume specification shall be taken from ENERGY STAR® qualified products listing or specification sheet of the proposed equipment.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \left(kWh_b - kWh_q\right) \times (1 + HVAC_c) \times Days$$

Annual Fuel Savings

$$\Delta Therms = \left(kWh_b - kWh_q\right) \times HVAC_f \times 10 \ \times Days$$

Peak Demand Savings

$$\Delta kW_{Peak} = \left(\frac{kWh_b - kWh_q}{Daily\ Hours}\right) \times (1 + HVAC_d) \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Time of Sale (compared to code baseline):

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-60 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings for Time of Sale	Calculated	Therms/yr	

Variable	Description	Value	Units	Ref
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
V	Freezer unit volume	Site-specific	ft³	
Days	Number of days of operations in a year	Site-specific. If unknown, use 365 days	days	
Daily Hours	Hours of operation in a day	Site-specific. If unknown, use 24 hours	hours	
kWh_q	Annual energy consumption of qualifying efficiency unit	Site-specific. If unknown, look up in Table 3-62	kWh/yr	[435]~~[4345]~~
kWh_b	Annual energy consumption of code-compliant baseline unit	Site-specific or look up in Table 3-61, Table 3-62	kWh/yr	[433]~~[4323]~~
CF	Electric coincidence factor	Look up in Table 3-64	N/A	
PDF	Gas peak day factor	Look up in Table 3-64	N/A	
$HVAC_c$	HVAC interaction factor for annual electric energy consumption	0.080	N/A	
$HVAC_d$	HVAC interaction factor for peak demand at utility summer peak hour	0.175	N/A	
$HVAC_{ff}$	HVAC interaction factor for annual fossil fuel energy consumption	-0.002	MMBtu/kWh	
8,760	Hours per year	8,760	Hrs/yr	
10	Unit conversion, Therm/MMBtu	10	Therm/MMBtu	
EUL	Effective useful life of new unit	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 3-61 Current Federal Standard Baseline Equipment Daily Energy Consumption

Type	Freezer	
	Solid Door	Transparent Door
Vertical	$0.22 \times V + 1.38$	$0.29 \times V + 2.95$
Horizontal	$0.06 \times V + 1.12$	$0.08 \times V + 1.23$

Table 3-62 Energy Star Equipment Daily Energy Consumption

Volume (ft^3)	Vertical Closed Freezer		Horizontal Closed Freezer
	Solid Door	Transparent Door	Solid or Transparent Door
$0 < V < 15$	$0.21 \times V + 0.9$	$0.232 \times V + 2.36$	$0.057 \times V + 0.55$
$15 \leq V < 30$	$0.12 \times V + 2.248$	$0.232 \times V + 2.36$	$0.057 \times V + 0.55$
$30 \leq V < 50$	$0.258 \times V - 2.703$	$0.232 \times V + 2.36$	$0.057 \times V + 0.55$
$50 \leq V$	$0.142 \times V + 4.445$	$0.232 \times V + 2.36$	$0.057 \times V + 0.55$

Table 3-63 Existing Equipment Daily Energy Consumption

Type	Freezer	
	Solid Door	Transparent Door
Manufactured after 03/27/2017		
Vertical	$0.22 \times V + 1.38$	$0.29 \times V + 2.95$
Horizontal	$0.06 \times V + 1.12$	$0.08 \times V + 1.23$
Manufactured before 03/27/2017		
Vertical	$0.40 \times V + 1.38$	$0.75 \times V + 4.10$
Horizontal	$0.40 \times V + 1.38$	$0.75 \times V + 4.10$

Peak Factors

Table 3-64 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1	[433]~~[4323]~~
Natural gas peak day factor (PDF)	N/A	

Measure Life

Table 3-65 Measure Life

Equipment	EUL	RUL	Ref
Freezer	12	Site-specific. If unknown, use 4 years	[434]~~[4334]~~

References

~~[432]~~[433] 10 CFR Appendix A to Subpart C of Part 431 – Uniform Test Method for the Measurement of Energy Consumption of Commercial Refrigerators, Freezers, and Refrigerator-Freezers. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-431/subpart-C/subject-group-ECFR8115bf7451f830f/section-431.66

~~[433]~~[434] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, *Effective/Remaining Useful Life Values*, California Public Utilities Commission (December 16, 2008).

~~[434]~~[435] ENERGY STAR® Program Requirements Product Specification for Commercial Refrigerators and Freezers, Eligibility Criteria Version 5.0. (2022).

Field Code Changed

3.2.6 DEHUMIDIFIER

Market	Commercial/Multifamily
Baseline Condition	TOS/NC
Baseline	Code/ISP
End Use Subcategory	Indoor Environment
Measure Last Reviewed	January 2023

Description

This measure covers the installation of commercial stand-alone or ducted dehumidifiers meeting the minimum qualifying efficiency standards established under the ENERGY STAR® Program, Version 5.0, effective October 31, 2019. With a higher Energy Factor than comparable non-qualified models, ENERGY STAR® dehumidifiers have more efficient refrigeration coils, compressors, and fans that use less energy to remove moisture in Commercial buildings. Dehumidifiers originally qualified for the ENERGY STAR® label in January 2001. Dehumidifiers that have earned this label are approximately 15% more efficient than non-qualified models. This measure is restricted to dehumidifiers with a product moisture removal capacity of less than or equal to 185 pints/day.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

The baseline condition is a stand-alone or ducted dehumidifier meeting the minimum effective federal standard for performance.

Dehumidifiers manufactured and distributed in commerce on or after June 13, 2019 must meet the energy conservation standards, rated in Integrated Energy Factor as specified in the Code of Federal Regulations.

Efficient Case

The compliance condition is an ENERGY STAR® v. 5 qualified stand-alone or whole-house dehumidifier.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{pints/day \times 0.473 \times hrs}{24} \times \left(\frac{1}{IEF_b} - \frac{1}{IEF_q}\right)$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Lfe} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 3-66 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Pints/day	Product capacity to remove moisture	Site-specific	pints/day	
hrs	Annual run hours of dehumidifier	1,632	N/A	[436]~~[435~~6~~]~~
IEF_b	Basline Integrated Energy Factor	Look up in Table 3-67 & Table 3-68	liters/kWh	[437]~~[436~~7~~]~~
IEF_q	Energy Efficient Integrated Energy Factor	Site-specific. If unknown, look up in Table 3-69 & Table 3-70	liters/kWh	[438]~~[437~~8~~]~~
0.473	Conversion factor from liters to pint	0.473	liters/pint	
24	Hours in one day	24	N/A	
CF	Electric coincidence factor	0.405	N/A	[439]~~[438~~9~~]~~
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-67 Stand-Alone Dehumidifiers Baseline Integrated Energy Factor

Product Capacity (pints/day)	Integrated Energy Factor (liters/kWh)
≤ 25.00	1.30

Product Capacity (pints/day)	Integrated Energy Factor (liters/kWh)
25.01 to 50.00	1.60
≥50.01	2.80

Table 3-68 Whole-Home (Ducted) Dehumidifiers Baseline Integrated Energy Factor

Product Case Volume (ft^3)	Integrated Energy Factor (liters/kWh)
≤ 8.0	≥1.77
> 8.0	≥2.41

Table 3-69 Stand-Alone Dehumidfiers Energy Efficient Integrated Energy Factor

Product Capacity (pints/day)	Integrated Energy Factor (liters/kWh)
≤ 25.00	≥1.57
25.01 to 50.00	≥1.80
≥50.01	≥3.30

Table 3-70 Whole-Home (Ducted) Dehumidifiers Energy Efficient Integrated Energy Factor

Product Case Volume (ft^3)	Integrated Energy Factor (liters/kWh)
≤ 8.0	≥2.09
> 8.0	≥3.30

Peak Factors

Table 3-71 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 12 years [440]~~[439440]~~.

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-72 Measure Life

Equipment	EUL	RUL	Ref
Dehumidifier	12	4	[440]~~[439440]~~

References

~~[435]~~[436] "ENERGY STAR Appliance Calculator". https://www.energy.gov/energysaver/maps/appliance-energy-calculator. n.d. Accessed December 21, 2022.

~~[436]~~[437] 10 CFR 430.32(v)(2), January 2023 https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32#p-430.32(v)(2)

~~[437]~~[438] ENERGY STAR® Program Requirements Product Specification for Dehumidifiers, Eligibility Criteria Version 5.0, October 2019.

~~[438]~~[439] Dehumidifier Metering in PA and Ohio by ADM from 7/17/2013 to 9/22/2013. 31 Units metered. Assumes all non-coincident peaks occur within window and that the average load during this window is representative of the June PJM days as well.

~~[439]~~[440] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (TRM), Version 9, January 2022. https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V9.pdf

Field Code Changed

Field Code Changed

Field Code Changed

3.2.7 ROOM AIR CONDITIONER

Market	Commercial/Multifamily
Baseline Condition	TOS/NC/DI
Baseline	Code/Dual
End Use Subcategory	Indoor Environment
Measure Last Reviewed	January 2023
Changes Since Last Version	• ~~Clarified baseline definitions in parameters table~~ • ~~Moved code-compliant efficiencies look up to appendix~~

Description

This measure relates to the purchase and installation of a room air conditioning unit that meets the ENERGY STAR minimum qualifying efficiency specifications as presented in this section. This measure is for ENERGY STAR room air conditioner units installed in small commercial spaces. All HVAC applications other than comfort cooling and heating, such as process cooling, are defined as non-standard applications and are ineligible for this measure.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

Room air conditioner having energy efficiency ratio (EER) as per Code of Federal Regulation's combined energy efficiency ratio (CEER).

Efficient Case

Room air conditioner meeting the requirements of Energy Star 4.2 room air conditioner specification.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = EFLH_c \times Cap \times \left(\frac{1}{CEER_b} - \frac{1}{CEER_q}\right)/1{,}000$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{EFLH_c} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-73 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Cap	Cooling capacity of efficient equipment	Site-specific	Btu/hr	
$EFLH_c$	Equivalent Full Load Hours of operation for the average unit during the cooling season	Lookup in **Error! Reference source not found.**~~Appendix C:~~ Heating and Cooling EFLH, limit to small commercial buildings	Hours	[441]~~[4401]~~
$CEER_b$	Efficiency of baseline unit	EREP/DI: Site-specific existing efficiency, if unknown look up vintage code in in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~ TOS: Look up current code in **Error!**	Btu/hr/watt	[442]~~[4412]~~

Variable	Description	Value	Units	Ref
		Reference source not found.~~Appendix E: Code-Compliant Efficiencies~~		
$CEER_q$	Efficiency of efficient unit	Site specific or defaults in lookup in Table 3-74	Btu/hr/watt	[443]~~[4423]~~
CF	Electric coincidence factor	Look up in Table 3-75	N/A	
EUL	Effective useful life	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	
1,000	Conversion from watts to kW	1,000	Watts/kW	

Table 3-74 ENERGY STAR CEER values for room air conditioner

Product Type and Class (Btu/hour)		ENERGY STAR with louvered sides (CEER)	ENERGY STAR without louvered sides (CEER)
Without reverse cycle	<6,000	12.1	11.0
	6,000 to 7,999	12.1	11.0
	8,000 to 10,999	12.0	10.6
	11,000 to 13,999	12.0	10.5
	14,000 to 19,999	11.8	10.2
	20,000 to 27,999	10.3	10.3
	≥28,000	9.9	10.3
With reverse cycle	<14,000	N/A	10.2
	≥14,000	N/A	9.6
	<20,000	10.8	N/A
	≥20,000	10.2	N/A
Casement-only[100]		10.5	
Casement slider[101]		11.4	

[100] Casement-only refers to a RAC designed for mounting in a casement window with an encased assembly with a width of ≤ 14.8 inches and a height of ≤ 11.2 inches.

[101] Casement-slider refers to a RAC with an encased assembly designed for mounting in a sliding or casement window with a width of ≤ 15.5 inches.

Peak Factors

Table 3-75 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.31	[444]~~[4434]~~
Natural gas peak day factor (PDF)	N/A	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-76 Measure Life

Equipment	EUL	RUL	Ref
Room Air Conditioner	9	3	[445]~~[4445]~~

References

~~[440]~~[441] Simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022.

~~[441]~~[442] Code of Federal Regulations – Title 10, Chapter II, Subchapter D, Part 430, Subpart C, §430.32., January 2023 https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32

~~[442]~~[443] ENERGY STAR Program Requirements for Room Air Conditioners, Eligibility Criteria, Version 4.0, January 2023 https://www.energystar.gov/products/heating_cooling/air_conditioning_room/key_product_criteria

~~[443]~~[444] NEEP, Mid-Atlantic Technical Reference Manual, V8. pp 77-80., May 2018 https://neep.org/sites/default/files/resources/Mid_Atlantic_TRM_V8_0.pdf

~~[444]~~[445] PA TRM Energy Efficiency and Conservation Programs (TRM), Version 9, January 2023.

Field Code Changed

Field Code Changed

Field Code Changed

3.2.8 WATER COOLER

Market	Commercial/Multifamily
Baseline Condition	NC/TOS
Baseline	Code
End Use Subcategory	Kitchen
Measure Last Reviewed	January 2023

Description

This measure estimates savings for installing ENERGY STAR Water Coolers compared to standard efficiency equipment in commercial applications. The measurement of energy and demand savings is based on a deemed savings value multiplied by the quantity of the measure.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

Water cooler meeting Energy Star v. 2.0 Water Cooler requirements as directed by N.J. PL 2021, c. 464.

Efficient Case

ENERGY STAR v. 3.0 compliant water cooler.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \left(kWh_b - kWh_q\right) \times 365$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hr} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 3-77 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Hr	Annual hours of operation	Site-specific, if unknown assume 8,760	Hrs	
kWh_b	Energy use of baseline water cooler	Look up in Table 3-78	kWh/day	[446]~~[4456]~~
kWh_q	Energy use of energy efficient water cooler	Site-specific, if unknown look up in Table 3-78	kWh/day	[447]~~[4467]~~
CF	Electric coincidence factor	Look up in Table 3-79	N/A	
PDF	Gas peak day factor	Look up in Table 3-79	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-78 Water Cooler Energy Use

Energy Star Water Cooler Type Product Capacity Class, and Conditioning Method	Baseline kWh_b (kWh/day)	Default Efficient kWh_q (kWh/day)
Cold Only	0.16	0.16
Hot & Cold – Low Capacity[102]	0.87	0.68
Hot & Cold – High Capacity[103]	0.87	0.80
Hot & Cold On-Demand	0.18	0.18

[102] A water cooler with a cold-water dispenser capacity of 0.50 gallons per hour or less, as measured per ANSI/ASHRAE Standard 18. For units that also provide hot water, the unit must have a hot-water dispenser capacity that is equal to or less than 41 exact 6 oz. cups per hour, as rated per ANSI/ASHRAE Standard 18.

[103] A water cooler with a cold-water dispenser capacity that is greater than 0.50 gallons per hour, as measured per ANSI/ASHRAE Standard 18. For units that also provide hot water, the unit must have a hot-water dispenser capacity greater than 41 exact 6 oz. cups per hour, as rated per ANSI/ASHRAE Standard 18.

Peak Factors

Table 3-79 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1.0	[448]~~[4478]~~
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 10 years. [446]~~[4456]~~

References

~~[445]~~[446] ENERGY STAR Product Specifications for Water Coolers Version 2.0. https://www.energystar.gov/sites/default/files/specs//ES%20WC%20V2%200%20Spec.pdf

~~[446]~~[447] ENERGY STAR Product Specifications for Water Coolers Version 3.0. https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Verison%203.0%20Water%20Coolers%20Final%20Specification_0.pdf

~~[447]~~[448] Assumes 24/7 operation. Site-specific load shape information should be used if known.

Field Code Changed

Field Code Changed

3.3 APPLIANCE RECYCLING

3.3.1 REFRIGERATOR & FREEZER RECYCLING

Market	Commercial
Baseline Condition	ERET
Baseline	Existing
End Use Subcategory	Recycling
Measure Last Reviewed	January 2023

Description

In many cases, when a refrigerator or freezer is replaced by a building owner, the existing unit is retained, sold, or donated for use elsewhere, representing additional load on the grid. This measure covers recycling of the existing, functional equipment, thereby eliminating the consumption associated with that equipment. Refrigerator and freezer recycling programs (also called "bounty" programs) receive energy savings credit for permanently removing inefficient, functional refrigerators and freezers from the electric grid.

This measure covers the recycling of primary (i.e., installed in a kitchen) and secondary (i.e., installed elsewhere) refrigerators, refrigerator-freezers and freezers. To account for the fact that secondary equipment is occasionally installed and operating for only part of the year, a part-time use adjustment factor has been developed and embedded within the gross savings estimate for secondary units to establish average annual per unit deemed electric savings.

This measure does not cover the recycling of equipment classified by the Code of Federal Regulations as "Compact refrigerator/refrigerator-freezer/freezer". This refers to any refrigerator, refrigerator-freezer or freezer with a total refrigerated volume of less than 7.75 ft3 (220 liters), where the total refrigerated volume has been determined in accordance with the procedure prescribed in Appendix A (refrigerators and refrigerator-freezers) or B (freezers) of 10 CFR 430 Subpart B.112.

Note: The following values are developed for residential equipment installed in commercial buildings. There currently is no methodology for recycling of commercial scale refrigerators and freezers.

Baseline Case

The savings calculations below apply to recycling of a functioning primary or secondary refrigerator, refrigerator-freezer, or freezer with total refrigerated volume of 7.75 ft3 (220 liters) or more.

Efficient Case

The compliance condition is the recycling of an existing refrigerator or freezer as defined in the Measure Description section above.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \left(\frac{\Delta kWh}{unit}\right)$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \left(\frac{\Delta kW}{unit}\right)$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \mathrm{N/A}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \mathrm{N/A}$$

Calculation Parameters

Table 3-80 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
ΔkWh/unit	Energy Savings	Lookup in Table 3-81	kWh	[450]~~[449~~450~~]~~
ΔkW/unit	Demand Savings per unit	Lookup in Table 3-81	kWh	[450]~~[449~~450~~]~~
CF	Electric coincidence factor	Look up in Table 3-82	N/A	
PDF	Gas peak demand factor	Look up in Table 3-82	N/A	
EUL	Effective useful life	See	Years	[449]~~[448~~9~~]~~

Table 3-81 Default Values for Annual Energy and Peak Demand Savings

	Primary Refrigerator	Secondary Refrigerator	Freezer
ΔkWh/unit	958	581	593
ΔkW/unit	0.15	0.10	0.10

Peak Factors

Table 3-82 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 5 years for a refrigerator and 4 years for a freezer [449]~~[4489]~~.

References

~~[448]~~[449] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

~~[449]~~[450] DNV, Appliance Recycling Program Impact Evaluation Study, June 2021 https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7BE846898E-5EAE-4F42-9F97-385982740AC6%7D

Field Code Changed

3.3.2 ROOM AC UNIT RECYCLING

Market	Commercial
Baseline Condition	ERET
Baseline	Existing
End Use Subcategory	Recycling
Measure Last Reviewed	January 2023

Description

In many cases where a business removes an appliance, the existing unit is retained, sold, or donated for use elsewhere and represents additional load on the grid. This measure covers removing the existing functional equipment before its natural end of life, thereby eliminating the consumption associated with that equipment. This measure is applicable to commercial and multifamily high-rise buildings.

A room air conditioner is an appliance, other than a "packaged terminal air conditioner," which is powered by a single-phase electric current and that is an encased assembly designed as a unit for mounting in a window or through the wall for the purpose of delivering conditioned air to an enclosed space.

Baseline Case

The baseline condition is the existing room air conditioning unit.

Efficient Case

The existing room air conditioning unit is removed from service.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{Hrs \times Btu/h}{EER \times 1{,}000} \times PartUse$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{Btu/h}{EER \times 1{,}000} \times PartUse \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 3-83 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Btu/h	Capacity of replaced unit	Site-specific, if unknown assume 8,500	Btu/hr	[453]~~[4523]~~
EER	Efficiency of existing unit	Site-specific, if unknown assume 9.8	Btu/W/hr	[454]~~[4534]~~
Hrs	Run hours of A/C unit	Site-specific, if unknown assume 325	Hours	[452]~~[4512]~~
PartUse	Factor to account for units that are not in daily use throughout entire cooling season, as reported by applicant	Site-specific, if unknown assume 0.34	N/A	[457]~~[4567]~~
CF	Electric coincidence factor	Look up in Table 3-84	N/A	
PDF	Gas peak day factor	Look up in Table 3-84	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Peak Factors

Table 3-84 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.3	[453]~~[4523]~~
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 3 years. [451]~~[4501]~~

References

~~[450]~~[451] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx .

~~[451]~~[452] From MidAtlantic TRM v10: "VEIC calculated the average ratio of FLH for Room AC (provided in RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008) to FLH for Central Cooling at 31%. Applying this to the FLH for Central Cooling provided for Baltimore (1050) we get 325 FLH for Room AC."

~~[452]~~[453] RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners (June 23, 2008 p. 22). Btu/h in this measure based on maximum capacity average in report, CF in this measure consistent with factors presented in report. https://www.puc.nh.gov/electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/124_SPWG%20Room%20%20AC%20Evaluation%20FINALReport%20June%2023%20ver7.pdf

~~[453]~~[454] Minimum Federal Standard for most common room AC type (8000-14,999 capacity range with louvered sides) per federal standards from 10/1/2000 to 5/31/2014.

~~[454]~~[455] Minimum Federal Standard for most common Room AC type (8000-14,999 capacity range with louvered sides). Current federal standards use CEER while previous federal standards used EER for efficiency levels.

~~[455]~~[456] *Mid-Atlantic TRM Manual: Version 10* (NEEP, 2020), Pg 110 https://neep.org/mid-atlantic-technical-reference-manual-trm-v10.

~~[456]~~[457] Cadmus analysis, EmPOWER 2018 P1 & P2 ARP participant survey

Field Code Changed

Field Code Changed

3.3.3 DEHUMIDIFIER RECYCLING

Market	Commercial
Baseline Condition	ERET
Baseline	Existing
End Use Subcategory	N/A
Measure Last Reviewed	January 2023

Description

In many cases, when a dehumidifier is replaced by a building owner, the existing unit is retained, sold or donated for use elsewhere, representing additional load on the grid. This measure covers recycling of existing, functional, portable dehumidifiers, thereby eliminating the consumption associated with that equipment. This measure should target, but not be limited to dehumidifiers put into service prior to June 2019. If provided data indicates the unit is replaced rather than retired, savings shall be based on the Commercial Dehumidifier measure in this TRM.

Baseline Case

The baseline condition is the existing inefficient dehumidifier.

Efficient Case

The existing inefficient dehumidifier is removed from service and not replaced.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = capacity \times \frac{0.473}{24} \times hrs \times \frac{1}{L/kWh}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \mathrm{N/A}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times RUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 3-85 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Capacity	Capacity of the unit	Site-specific. If unknown, use 56	pints/day	[464]~~[4634]~~
L/kWh	Dehumidifier Efficiency	Look up in Table 3-86	L/kWh	[459]~~[4589]~~[461]~~[4601]~~[462]~~[4612]~~
0.473	Conversion factor	0.473	L/pint	
24	Conversion factor	24	Hr/day	
Hrs	Hours of use	1632	Hours	[459]~~[4589]~~
CF	Electric coincidence factor	Look up in Table 3-87	N/A	
PDF	Gas peak day factor	Look up inTable 3-87	N/A	
RUL	Remaining useful life	See Measure Life Section	Years	

Table 3-86 Dehumidifier Capacity and Efficiency

Capacity Range (pints/day)	ENERGY STAR Labeled (L/kWh)	Non-ENERGY STAR Labeled	
		Manufacture date before Oct. 2012 (≥L/kWh)	Manufacture date of Oct. 2012 or later (≥L/kWh)
≤ 25	1.57	1.00	1.35
>25 to ≤ 35	1.80	1.20	1.35
>35 to ≤ 45	1.80	1.30	1.50
>45 to ≤ 50	1.80	1.30	1.60
>50 to ≤ 55	3.30	1.30	1.60
>54 to ≤ 75	3.30	1.50	1.70

Capacity Range (pints/day)	ENERGY STAR Labeled (L/kWh)	Non-ENERGY STAR Labeled	
		Manufacture date before Oct. 2012 (≥L/kWh)	Manufacture date of Oct. 2012 or later (≥L/kWh)
>75 to ≤ 185	3.30	2.25	2.50

Peak Factors

Table 3-87 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.405	[463]~~[4623]~~
Natural gas peak day factor (PDF)	N/A	

Measure Life

The remaining useful life (RUL) is 4 years [458]~~[4578]~~.

References

~~[457]~~[458] CA DEER gives the following rule-of-thumb for remaining useful life: RUL = (1/3) X EUL. As the Energy Star Dehumidifier [replacement] uses an EUL of 12 years, we have a suggested RUL of (1/3) X 12 years = 4 years.

~~[458]~~[459] Savings Calculator for ENERGY STAR® Qualified Appliances Version 3.0 Last Updated October 1, 2012.

~~[459]~~[460] ENERGY STAR® Program Requirements for Dehumidifiers, Version 5.0, February 2019.

~~[460]~~[461] 42 U.S.C, Title 42 Chapter 77, Subchapter III, Part A, (cc)(1) and (cc)(2). https://uscode.house.gov/view.xhtml?path=/prelim@title42/chapter77/subchapter3&edition=prelim

~~[461]~~[462] Code of Federal Regulations Title 10, Chapter 2, Subchapter D, Part 430, Subpart C (v)(1). https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C

~~[462]~~[463] Dehumidifier Metering in PA and Ohio by ADM from 7/17/2013 to 9/22/2013. 31 Units metered. Assumes all non-coincident peaks occur within window and that the average load during this window is representative of the June PJM days as well.

~~[463]~~[464] *Mid-Atlantic Technical Reference Manual (TRM) V10*. (2020), https://neep.org/sites/default/files/media-files/trmv10.pdf

Field Code Changed

Field Code Changed

Field Code Changed

3.4 FOODSERVICE

3.4.1 OVENS, FRYER, STEAMER & GRIDDLE

Market	Commercial
Baseline Condition	TOS
Baseline	Code
End Use Subcategory	Cooking equipment
Measure Last Reviewed	January 2023

Description

This measure covers the installation of qualified commercial kitchen equipment that exceeds the efficiency standards specified in the New Jersey P.L. 2021, c. 464 meets the descriptions below.

- Convection Ovens [466]~~[4656]~~ – This measure includes gas and electric commercial convection ovens. A convection oven forces hot dry air over the surface of a food product. A full-size convection oven can accommodate standard full-size sheet pans measuring 18 x 26 x 1 inch. A half-size convection oven can accommodate half-size sheet pans measuring 18 x 13 x 1 inch. Though not subject to minimum standards specified in the New Jersey P.L. 2021, c. 464, the baseline for half-size gas convection ovens were taken from a Pacific Gas & Electric workpaper [470]~~[469470]~~.
- Rack Ovens [466]~~[4656]~~ – This measure includes gas commercial rack ovens. A rack oven is a high-capacity oven in which a rack is wheeled into the oven and can be rotated during the baking process. Single and double rack ovens are included in this measure.
- Steamers [467]~~[4667]~~ – This measure includes gas and electric commercial steamers, also known as compartment steamers. A steamer is a device that contains one or more food steaming compartments in which the energy in the steam is transferred to the food by direct contact. To calculate the savings for this measure, the number of pans must be known. Countertop, wall-mounted, and floor models mounted on a stand, pedestal, or cabinet-style base are included. Commercial steamer microwave ovens are not included in this measure.
- Fryers [468]~~[4678]~~– This measure includes gas and electric commercial deep-fat fryers. A deep-fat fryer is an appliance in which oils are placed to such a depth that the cooking food is essentially supported by displacement of the cooking fluid rather than by the bottom of the vessel. Depending on the fryer type, heat is delivered to the cooking fluid by means of an immersed electric element or band-wrapped vessel (electric fryers), or by heat transfer from gas burners through either the walls of the fryer or through tubes passing through the cooking fluid (gas fryers). Standard fryers and large vat fryers are included in this measure.
- Griddles [469]~~[4689]~~ – This measure includes single-sided gas and electric commercial griddles. A single-sided commercial griddle is a commercial appliance designed for cooking food in oil or its own juices by direct contact with either a flat, smooth, hot surface or a hot channeled cooking surface where plate temperature is thermostatically controlled. To calculate the energy savings in this measure, the griddle dimensions must be known. This measure does not include double-sided gas or electric commercial griddles.

- Gas Conveyor Ovens – Though not eligible for ENERGY STAR® qualification, this measure additionally covers the installation of energy efficient gas conveyor ovens. Conveyor ovens cook food by carrying it on a moving belt through a heated chamber. Qualifying conveyor ovens have baking efficiencies greater than or equal to 42% and idle energy rates less than or equal to 57,000 Btu/h, per assumed efficiency of qualified equipment by Pacific Gas and Electric workpaper, where 1 pizza equals 0.76 lbs [471]~~[4701]~~.

Baseline Case

The baseline idle energy and cooking efficiency is compliant with the New Jersey P.L. 2021, c. 464 minimum standards, which establishes Energy Star Program Requirements for Commercial Oven Version 2.2 as the baseline for electric and gas convection ovens and gas rack ovens, Energy Star Program Requirements for Commercial Fryers Version 2.0 as the baseline for electric and gas fryers and Energy Star Program Requirements for Commercial Steam Cookers, Version 1.2 as the baseline for electric and gas steamers.[104] Preheat energy and all values for half size gas convection ovens, conveyor ovens and griddles are reported from referenced FSTC sources.

Table 3-88 Equipment Baselines Case Default Characteristics

Equipment	$Btu_{preheat,baseline}$ (Btu)	$Btu/h_{idle,baseline}$ (Btu/h)	$(lbs/hr)_{baseline}$	$Eff_{baseline}$	Ref
Convection Oven, Electric, Full Size	5,118	5,459	70	0.71	[470]~~[469470]~~[466]~~[4656]~~
Convection Oven, Electric, Half Size	3,412	3,412	45	0.71	[470]~~[469470]~~[466]~~[4656]~~
Convection Oven, Gas, Full Size	19,000	12,000	70	0.46	[470]~~[469470]~~[466]~~[4656]~~
Convection Oven, Gas, Half Size	13,000	12,000	45	0.30	[470]~~[469470]~~
Conveyor Oven, Gas	21,270	55,000	114	0.30	[480]~~[479480]~~
Rack Oven, Gas, Double Rack	100,000	30,000	250	0.52	[472]~~[4712]~~[466]~~[4656]~~
Rack Oven, Gas, Single Rack	50,000	25,000	130	0.48	[476]~~[4756]~~[466]~~[4656]~~
Steamer, Electric	5,118	3-pan: 1,365 4-pan: 1,808 5-pan: 2,286 6-pan and larger: 2,730	11.7 x No. of pans	0.50	[467]~~[4667]~~[473]~~[4723]~~
Steamer, Gas	20,000	3-pan: 6,250 4-pan: 8,350	23.3 x No. of pans	0.38	[467]~~[4667]~~[473]~~[4723]~~

[104] https://legiscan.com/NJ/bill/A5160/2020.

Field Code Changed

Equipment	$Btu_{preheat,baseline}$ (Btu)	$Btu/h_{idle,baseline}$ (Btu/h)	$(lbs/hr)_{baseline}$	$Eff_{baseline}$	Ref
		5-pan: 10,400 6-pan and larger: 12,500			
Fryer, Electric	8,189	3,412	65	0.80	[474][4734][481][4801]
Fryer, Gas	18,500	9,000	60	0.50	[474][4734][481][4801]
Griddle, Electric	4,436 x Griddle Width (ft)	2,730 x Griddle Width (ft)	11.7 x Griddle Width (ft)	0.60	[475][4745]
Griddle, Gas	7,000 x Griddle Width (ft)	7,000 x Griddle Width (ft)	8.4 x Griddle Width (ft)	0.30	[475][4745]

Efficient Case

The compliance condition is food service equipment that exceeds the minimum efficiency specified in New Jersey P.L. 2021, c. 464 or, in the case of conveyor ovens, half-size gas convection ovens and griddles, equipment aligning with FSTC assumptions for energy efficient products meeting the minimum performance specifications listed in the table below. Operating characteristics shall be taken from application. When unavailable, default characteristics shall be taken from Table 3-89.

Table 3-89 Equipment Efficient Case Default Characteristics

Equipment	$Btu_{preheat,ee}$ (Btu)	$Btu/h_{idle,ee}$ (Btu/h)	$(lbs/hr)_{ee}$	Eff_{ee}	Ref
Convection Oven, Electric, Full Size	3,412	4,606	82	0.76	[470][469470][482][4812]
Convection Oven, Electric, Half Size	3,071	2,593	53	0.76	[470][469470][482][4812]
Convection Oven, Gas, Full Size	11,000	9,349	82	0.51	[470][469470][482][4812]
Convection Oven, Gas, Half Size	7,500	4,293	53	0.53	[470][469470][482][4812]
Conveyor Oven, Gas	15,000	40,000	158	0.46	[471][4701][480][479480]
Rack Oven, Gas, Double Rack	85,000	24,600	280	0.56	[472][4712][483][4823]
Rack Oven, Gas, Single Rack	44,000	19,733	140	0.51	[476][4756][483][4823]
Steamer, Electric	5,118	990	14.7 x No. of pans	0.70	[473][4723][484][4834]
Steamer, Gas	9,000	1,221	20.8 x No. of pans	0.47	[473][4723][484][4834]

Equipment	$Btu_{preheat,ee}$ (Btu)	$Btu/h_{idle,ee}$ (Btu/h)	$(lbs/hr)_{ee}$	Eff_{ee}	Ref
Fryer, Electric, Standard	6,483	2,327	71	0.86	[474]~~[4734]~~[485]~~[4845]~~
Fryer, Gas, Standard	16,000	7,571	67	0.52	[474]~~[4734]~~[485]~~[4845]~~
Griddle, Electric	2,389 x Griddle Width (ft)	1,000 x Griddle Area (ft^2)	16.3 x Griddle Width (ft)	0.75	[475]~~[4745]~~
Griddle, Gas	5,000 x Griddle Width (ft)	2,068 x Griddle Area (ft^2)	16.4 x Griddle Width (ft)	0.46	[475]~~[4745]~~

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = days \times \frac{(\Delta Btu_{preheat} + \Delta Btu_{idle} + \Delta Btu_{cooking})}{3412}$$

Annual Fuel Savings

$$\Delta Therms = days \times \frac{(\Delta Btu_{preheat} + \Delta Btu_{idle} + \Delta Btu_{cooking})}{100{,}000}$$

Where:

$$\Delta Btu_{preheat} = N_{preheat} \times (Btu_{preheat,baseline} - Btu_{preheat,ee})$$

$$\Delta BTU_{idle} = Btu/h_{idle,baseline} \times [hrs - N_{preheat} \times hrs_{preheat} - \frac{lbs}{(lbs/hr)_{baseline}}] - Btu/h_{idle,ee} \times [hrs - N_{preheat} \times hrs_{preheat} - \frac{lbs}{(lbs/hr)_{ee}}]$$

$$\Delta Btu_{cooking} = lbs \times Q_{food} \times (\frac{1}{Eff_{baseline}} - \frac{1}{Eff_{ee}})$$

NOTE: $\Delta Btu_{preheat}$, ΔBtu_{idle} and $\Delta Btu_{cooking}$ terms can be calculated per the equations above using either actual qualifying equipment specs or default values as defined in the Common Variables, Baseline Efficiencies, Compliance Efficiency, and Operating Hours sections below, or looked up from Table 3-92.

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{(days \times hrs)} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-90 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$\Delta Btu_{preheat}$	Daily preheat energy savings	Calculate based on calculations above or look up in Table 3-92	Btu	
ΔBtu_{idle}	Daily idle energy savings	Calculate based on calculations above or look up in Table 3-92	Btu	
$\Delta Btu_{cooking}$	Daily cooking energy savings	Calculate based on calculations above or look up in Table 3-92	Btu	
days	Operating days per year	Site-specific, if unknown look up based on facility type in Table 3-91	Btu	
hrs	Daily operating hours	Site-specific, if unknown look up based on facility type in Table 3-91	hours	
$Btu_{preheat,baseline}$	Basline Equipment preheat energy	Look up based on qualifying equipment type in Table 3-88	Btu	
$Btu_{preheat,ee}$	Energy Efficient Equipment preheat energy	Site-specific, if unknown look up based on qualifying equipment type in Table 3-89	Btu	

Variable	Description	Value	Units	Ref
$N_{preheat}$	Number of preheats per day	1		
$hrs_{preheat}$	Preheat duration	Look up based on qualifying equipment type in Table 3-93 ~~Table 3-93~~	hours	
$Btu/h_{idle,baseline}$	Baseline Equipment idle energy rate	Look up based on qualifying equipment type in Table 3-88	Btu/h	
$Btu/h_{idle,ee}$	Energy Efficient Equipment idle energy rate	Site-specific, if unknown look up based on qualifying equipment type in Table 3-89	Btu/h	
$(lbs/hr)_{baseline}$	Baseline Equipment production capacity	Look up based on qualifying equipment type in Table 3-88	lbs/hr	
$(lbs/hr)_{ee}$	Energy Efficient Equipment production capacity	Site-specific, if unknown look up based on qualifying equipment type in Table 3-89	lbs/hr	
lbs	Total daily food production	Site-specific, if unknown look up based on qualifying equipment type in Table 3-93 ~~Table 3-93~~	lbs	
Q_{food}	Heat to food	Look up based on qualifying equipment type in Table 3-93 ~~Table 3-93~~	Btu/lb	
$Eff_{baseline}$	Baseline Equipment convection/steam mode cooking efficiency	Look up based on qualifying equipment type in Table 3-88	N/A	
Eff_{ee}	Energy Efficient Equipment convection/steam mode cooking efficiency	Site-specific, if unknown look up based on qualifying equipment type in Table 3-89	N/A	
CF	Electric coincidence factor	Lookup in Table 3-94	N/A	[486]~~[4856]~~
PDF	Gas peak day factor	Lookup in Table 3-94	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-91 Operating Hours

Building Type	Days/Year	Hours/Day
Education – Primary School	180	8
Education -Secondary School	210	11
Education – Community College	237	16
Education – University	192	16
Grocery	364	16
Medical – Hospital	364	24
Medical – Clinic	351	12
Lodging Motel	364	24
Office – Large	234	12
Office – Small	234	12
Restaurant – Sit-Down	364	12
Restaurant – Fast-Food	364	17
Average = Miscellaneous	288	15

Table 3-92 contains values and simplified calculations for $\Delta Btu_{preheat}$, ΔBtu_{idle} and $\Delta Btu_{cooking}$ terms that may be used in the formulation of estimated savings in lieu of utilizing the calculations prescribed above for these terms. These values were established by performing those calculations using assumed values from the Common Variables, Baseline Efficiencies, and Compliance Efficiency sections.

Table 3-92 Default Values

Equipment	$\Delta Btu_{preheat}$	ΔBtu_{idle}	$\Delta Btu_{cooking}$
Convection Oven, Electric, Full Size	1,706	853 x hrs - 2395	2,317
Convection Oven, Electric, Half Size	341	819 x hrs - 2895	2,317
Convection Oven, Gas, Full Size	8,000	2651 x hrs - 6404	5,328
Convection Oven, Gas, Half Size	5,500	7707 x hrs - 20493	36,164
Conveyor Oven, Gas	6,270	15000 x hrs - 47315	55,072
Rack Oven, Gas, Double Rack	15,000	5400 x hrs - 40353	38,736
Rack Oven, Gas, Single Rack	6,000	5267 x hrs - 32553	17,279
Steamer, Electric[105]	0	1740 x hrs - 3201	6,000
Steamer, Gas[106]	11,000	11279 x hrs - 10783	5,291

[105] Assumes 6 pans
[106] Assumes 6 pans

Equipment	ΔBtu$_{preheat}$	ΔBtu$_{idle}$	ΔBtu$_{cooking}$
Fryer, Electric, Standard	1,706	1085 x hrs - 3229	7,456
Fryer, Gas, Standard	2,500	1429 x hrs - 5906	6,577
Griddle, Electric[107]	6,141	2190 x hrs - 11611	15,833
Griddle, Gas[108]	6,000	8592 x hrs - 60262	55,072

Table 3-93 Common Variables

Equipment	hrs$_{preheat}$	lbs	Q$_{food}$(Btu/lb)	Ref
Convection Oven, Electric, Full Size	0.25	100	250	[470]~~[469~~470~~]~~
Convection Oven, Electric, Half Size	0.25	100	250	[470]~~[469~~470~~]~~
Convection Oven, Gas, Full Size	0.25	100	250	[470]~~[469~~470~~]~~
Convection Oven, Gas, Half Size	0.25	100	250	[470]~~[469~~470~~]~~
Conveyor Oven, Gas	0.25	190	250	[471]~~[470~~1~~]~~
Rack Oven, Gas, Double Rack	0.33	1200	235	[472]~~[471~~2~~]~~
Rack Oven, Gas, Single Rack	0.33	600	235	[472]~~[471~~2~~]~~
Steamer, Electric	0.25	100	105	[472]~~[471~~2~~]~~
Steamer, Gas	0.25	100	105	[473]~~[472~~3~~]~~
Fryer, Electric, Standard	0.25	150	570	[474]~~[473~~4~~]~~
Fryer, Gas, Standard	0.25	150	570	[474]~~[473~~4~~]~~
Griddle, Electric	0.25	100	475	[475]~~[474~~5~~]~~
Griddle, Gas	0.25	100	475	[475]~~[474~~5~~]~~

Peak Factors

Table 3-94 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.9	[486]~~[485~~6~~]~~
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The effective useful life (EUL) is 12 years[109].

[107] Assumes 3-foot griddle width, 2-foot griddle depth
[108] Assumes 3-foot griddle width, 2-foot griddle depth
[109] Shared assumption from all PG&E Work Papers referenced in this measure

References

~~[464]~~[465] ENERGY STAR® Commercial Food Service Calculator, https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/save-energy/purchase-energy-saving-products

~~[465]~~[466] ENERGY STAR® Program Requirements Product Specification for Commercial Ovens, Eligibility Criteria Version 2.2, October 2015, https://www.energystar.gov/sites/default/files/Commercial%20Ovens%20Final%20Version%202.2%20Specification_0.pdf

~~[466]~~[467] ENERGY STAR® Program Requirements Product Specification for Commercial Steam Cookers, Eligibility Criteria Version 1.2, August 2003, https://www.energystar.gov/sites/default/files/specs//private/Commercial_Steam_Cookers_Program_Requirements%20v1_2.pdf

~~[467]~~[468] ENERGY STAR® Program Requirements Product Specification for Commercial Fryers, Eligibility Criteria Final Draft Version 3.0, October 2016, https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Commercial%20Fryers%20Version%203.0%20%28Rev.%20December%20-%202020%29%20Specification.pdf

~~[468]~~[469] ENERGY STAR® Program Requirements Product Specification for Commercial Griddles, Eligibility Criteria Version 1.2, August 2009, https://www.energystar.gov/sites/default/files/Commercial%20Griddles%20Version%201.2%20%28Rev%20December%20-%202020%29.pdf

~~[469]~~[470] Pacific Gas & Electric Company, Work Paper PGECOFST101 Commercial Convection Oven-Electric and Gas, Revision 6, August 2016

~~[470]~~[471] Pacific Gas & Electric Company, Work Paper PGECOFST117 Commercial Conveyor Oven-Gas, Revision 5, May 2014

~~[471]~~[472] Pacific Gas & Electric Company, Work Paper PGECOFST109 Commercial Rack Oven-Gas, Revision 1, October 2018

~~[472]~~[473] Pacific Gas & Electric Company, Work Paper PGECOFST104 Commercial Steam Cooker-Electric and Gas, Revision 6, June 2016

~~[473]~~[474] Pacific Gas & Electric Company, Work Paper PGECOFST102 Commercial Fryer-Electric and Gas, Revision 6, June 2016

~~[474]~~[475] California Technical Forum, Work Paper SWFS004, Commercial Griddle-Electric and Gas, Revision 1, January 2020, available at http://deeresources.net/workpapers

~~[475]~~[476] Food Service Technology Center: Gas Rack Oven Life-Cycle Cost Calculator, https://caenergywise.com/calculators/natural-gas-rack-ovens/#calc

~~[476]~~[477] Food Service Technology Center: Electric Fryer Life-Cycle Cost Calculator, https://caenergywise.com/calculators/electric-fryers/#calc

~~[477]~~[478] Food Service Technology Center: Gas Fryer Life-Cycle Cost Calculator, https://caenergywise.com/calculators/natural-gas-fryers/#calc

~~[478]~~[479] California Energy Commission, Energy Research and Development Division, Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Foodservice Equipment, October 2014, http://www.energy.ca.gov/2014publications/CEC-500-2014-095/CEC-500-2014-095.pdf

~~[479]~~[480] California Public Utilities Commission, SWFS008, Conveyor Oven, Gas, Commercial, Revision 1, January 2020 available at Ex Ante Database Archive (deeresources.net)

~~[480]~~[481] ENERGY STAR® Program Requirements Product Specification for Commercial Fryers, Eligibility Criteria Final Draft Version 2.0, October 2016, https://www.energystar.gov/ia/partners/prod_development/revisions/downloads/commercial_fryers/Final_Version_2.0_Commercial_Fryer_Specification.pdf?6f81-cd61

~~[481]~~[482] California Public Utilities Commission, SWFS001 Commercial Covection Oven – Electric and Gas, Revision 2, May 2020 available at Ex Ante Database Archive (deeresources.net)

~~[482]~~[483] California Public Utilities Commission, SWFS014 Rack Oven, Revision 2, May 2020 available at Ex Ante Database Archive (deeresources.net)

~~[483]~~[484] California Public Utilities Commission, SWFS005 Commercial Steam Cooker, Revision 2, May 2020 available at Ex Ante Database Archive (deeresources.net)

~~[484]~~[485] California Public Utilities Commission, SWFS011 Fryer,Commercial, Revision 4, March 2022 available at Ex Ante Database Archive (deeresources.net)

~~[485]~~[486] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs v10, effective date January 1, 2023.

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

3.4.2 HOLDING CABINETS

Market	Commercial
Baseline Condition	TOS
Baseline	Code
End Use Subcategory	N/A
Measure Last Reviewed	January 2023

Description

This measure covers the installation of ENERGY STAR® qualified electric commercial hot food holding cabinets. A food holding cabinet is a fully enclosed compartment designed to maintain the temperature of hot food that has been cooked in a separate appliance. Half-size, full-size, and large-size holding cabinets are included in this measure. Half-size holding cabinets are defined as any holding cabinet with an internal measured volume of less than 13 ft^3. Full-size holding cabinets are defined as any holding cabinet with an internal measured volume of greater than or equal to 13 ft^3 and less than or equal to 28 ft^3. Large-size holding cabinets are defined as any holding cabinet with an internal measure volume of greater than 28 ft^3. This measure does not include cook-and-hold or re-therm equipment.

Baseline Case

The baseline condition is an insulated holding cabinet as defined in the Measure Description above with operating characteristics per Table 3-95.

Efficient Case

The compliance condition is ENERGY STAR® food service equipment as defined in the Measure Description above. Operating characteristics shall be taken from application. When unavailable, default characteristics shall be taken from the Summary of Variables and Data Sources table below. Savings for this measure can be claimed only if there is an increase in the qualifying efficiency from the baseline condition.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = hrs \times days \times \frac{\Delta \mathrm{W_{idle}}}{1{,}000}$$

Where,

$$\Delta W_{idle} = W_{idle,b} - W_{idle,q}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{hrs \times days} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \mathrm{N/A}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 3-95 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
ΔW_{idle}	Daily idle energy savings	Calculated	Watt	
Hrs	Daily operating hours	Site-specific. If unknown, use 15	Hours/day	[489]~~[4889]~~
Days	Operating days per year	Site-specific. If unknown, look up in Table 3-96	Days/yr	[488]~~[4878]~~
1,000	Conversion factor, one kW equals 1,000 watts	1,000	Watts	
$W_{idle,b}$	Baseline equipment idle energy rate by volume	Look up in Table 3-97	Watts	[490]~~[4890]~~
$W_{idle,q}$	Energy efficient equipment idle energy rate by volume	Site-specific	Watts	
V	Volume of holding cabinet	Site-specific. If unknown, look up in Table 3-97	ft³	[491]~~[4901]~~
CF	Electric coincidence factor	Look up in Table 3-98	N/A	
PDF	Gas peak day factor	Look up in Table 3-98	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-96 Operating Days per Year

Building Type	Operating Days per Year
Assembly	355
Auto	355
Big Box	355
Community College	284
Dormitory	355
Fast Food	355
Full Service Restaurant	303
Grocery	365
Hospital	365
Hotel	365
Large Office	303
Light Industrial	251
Motel	365
Multi-story Retail	355
Primary School	218
Religious	355
Secondary School	218
Small Office	303
Small Retail	355
University	284
Warehouse	251

Table 3-97 Default Values

Equipment	$W_{idle,b}$	V
Insulated Holding Cabinet, Large-Size (28 ≤ V)	3.8v + 203.5	35
Insulated Holding Cabinet, Full-Size (13 ≤ V < 28)	2v + 254	25
Insulated Holding Cabinet, Half-Size (0 < V < 13)	21.5v	10

Peak Factors

Table 3-98 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.9	[489]~~[4889]~~
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 12 years [487]~~[4867]~~.

References

~~[486]~~[487] DEER 2014 EUL IDs: Various. http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx

~~[487]~~[488] California Energy Commission, Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Foodservice Equipment, Appendix E.

~~[488]~~[489] PG&E Work Paper PGECOFST105 Revision 5, pg. 7. Available to download at http://deeresources.net/workpapers

~~[489]~~[490] ENERGY STAR® Program Requirements for Commercial Hot Food Holding Cabinets, Eligibility Criteria Version 2.0, July 2011, where v is holding cabinet volume (ft^3). https://www.energystar.gov/sites/default/files/asset/document/Commercial_HFHC_Program_Requirements_2.0.pdf#:~:text=ENERGY%20STAR%C2%AE%20Program%20Requirements%20Product%20Specification%20for%20Commercial,has%20also%20been%20changed%20from%202010%20to%202011.

~~[490]~~[491] PG&E Work Paper PGECOFST105 Revision 5, Table 6, pg. 5.

Field Code Changed

Field Code Changed

Field Code Changed

3.4.3 DISHWASHERS

Market	Commercial
Baseline Condition	TOS
Baseline	Code
End Use Subcategory	N/A
Measure Last Reviewed	January 2023
Changes Since Last Version	~~Added fuel parameters and default assumption~~

Description

This measure describes the installation of ENERGY STAR qualified, high-efficiency stationary and conveyor-type commercial dishwashers used in commercial kitchen establishments that use non-disposable dishes, glassware, and utensils. Commercial dishwashers can clean and sanitize a large quantity of kitchenware in a short amount of time by utilizing hot water, soap, rinse chemicals, and significant amounts of energy. ENERGY STAR qualified models use less water and have lower idling rates than non-ENERGY STAR rated models.

The savings derived below are heavily dependent on the assumed dishwasher hours of operation, which are consistent with a high-usage restaurant or cafeteria operation. If dishwashers are found to be installed in applications with significantly different hours of operation, the hours and savings shall be revised in a custom calculation.

This measure is not applicable to flight machines, which are continuous conveyor machines built specifically for large institutions.

Baseline Case

This is defined as a time of sale measure. The baseline condition is a commercial dishwasher meeting ENERGY STAR Version 2.0 requirements.[492]~~[4912]~~

Efficient Case

The efficient condition is a high-efficiency commercial dishwasher meeting ENERGY STAR Version 3.0 requirements. [493]~~[4923]~~

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{WaterHeater} + \Delta kWh_{BoosterHeater} + \Delta kWh_{Idle}$$

Where,

$$\Delta kWh_{WaterHeater} = \left(WU_b - WU_q\right) \times RW \times Days \times \frac{\Delta T_{in} \times 1.0 \times 8.2}{RE \times 3{,}412} \times F_{Elec,WH}$$

$$\Delta kWh_{Idle} = \left(kW_b \times Days \times \left(HD - \frac{RW \times WT}{60}\right)\right) - \left(kW_q \times Days \times \left(HD - \frac{RW \times WT}{60}\right)\right)$$

If electric booster heater installed:

$$\Delta kWh_{BoosterHeater} = \left(WU_b - WU_q\right) \times RW \times Days \times \frac{\Delta T_{in} \times 1.0 \times 8.2}{RE \times 3{,}412}$$

If no electric booster heater installed:

$$\Delta kWh_{BoosterHeater} = 0$$

Annual Fuel Savings

$$\Delta Therms = \Delta Therms_{WaterHeater} = \left(WU_b - W_q\right) \times RW \times Days \times \frac{\Delta T_{in} \times 1.0 \times 8.2}{RE \times 100{,}000} \times F_{FF,WH}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \Delta \mathrm{kWh} \times \frac{CF}{HD \times Days}$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-99 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	

Variable	Description	Value	Units	Ref
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$\Delta kWh_{WaterHeater}$	Annual water heater electric energy savings	Calculated	kWh/yr	
$\Delta kWh_{BoosterHeater}$	Annual booster heater electric energy savings	Calculated	kWh/yr	
ΔkWh_{Idle}	Annual dishwasher idle electric energy savings	Calculated	kWh/yr	
WU_q	Water use per rack of qualifying dishwasher, varies by machine type and sanitation method	Site-specific	Gallons	
kW_q	Idle power draw of ENERGY STAR 3.0 dishwasher, varies by machine type and sanitation method	Site-specific	kW	
Days	Annual days of dishwasher consumption per year	Site-specific, if unknown use 365	Days/Year	[492]~~[4912]~~
WU_b	Water use per rack of baseline dishwasher, varies by machine type and sanitation method	Look up in Table 3-100	Gallons	[493]~~[4923]~~
RW	Number of racks washed per day, varies by machine type and sanitation method	Look up in Table 3-100	Racks Washed/Day	[492]~~[4912]~~
ΔT_{in}	Temperature rise in water delivered by building water heater or booster water heater, value varies by type of water heater source	Building WH = 70 Booster WH = 40	°F	[492]~~[4912]~~
RE	Recovery efficiency of water heater	Site-specific, if unknown use 0.98 for electric and 0.80 for gas		[492]~~[4912]~~
kW_b	Idle power draw of baseline dishwasher, varies by machine type and sanitation method	Look up in Table 3-100	kW	[493]~~[4923]~~
HD	Hours per day of dishwasher operation	Site-specific, if unknown use 18 hours/day	Hours/Day	[492]~~[4912]~~
WT	Wash time per dishwasher, varies by machine type and sanitation method	Look up in Table 3-100	Minutes	[492]~~[4912]~~
$H2O_b$	Annual water consumption of baseline unit	Look up in Table 3-101	gallons	[492]~~[4912]~~
$H2O_q$	Annual water consumption of efficient unit	Look up in Table 3-101	gallons	[492]~~[4912]~~
$F_{Elec,WH}$	Factor to account for building water heat	If building water heat is electric: 1 If building water heat is not electric: 0 If unknown: 0.28		

Variable	Description	Value	Units	Ref
$F_{FF,WH}$	Factor to account for fossil fuel building water heat	If building water heat is electric: 0 If building water heat is not electric: 1 If unknown: 0.79		
8.2	Density of Water	8.2	Lbs/gal	[494]~~[4934]~~
60	Conversion factor	60	Min/hr	
3,412	Conversion factor	3,412	Btu/kWh	
1.0	Conversion factor	1.0	Btu/lb-°F	
100,000	Conversion factor	100,000	Btu/therm	
CF	Electric coincidence factor	Look up in Table 3-102	N/A	[495]~~[4945]~~
PDF	Gas peak day factor	Look up in Table 3-102	N/A	
EUL	Effective useful life	See Measure Life	Years	

Table 3-100 Default Inputs for ENERGY STAR 2.0 Commercial Dishwasher

Machine Type	Temperature	WU_{base}	RW	WT	kW_{base}
Under Counter	Low	1.19	75	2.0	0.50
Stationary Single Tank Door		1.18	280	1.5	0.60
Single Tank Conveyor		0.79	400	0.3	1.50
Multi Tank Conveyor		0.54	600	0.3	2.00
Under Counter	High	0.86	75	2.0	0.5
Stationary Single Tank Door		0.89	280	1.0	0.7
Single Tank Conveyor		0.70	400	0.3	1.5
Multi Tank Conveyor		0.54	600	0.2	2.25
Pot, Pan, and Utensil		0.58	280	3.0	1.20

Table 3-101 Annual Water Consumption

Machine Type	Temperature	$H2O_b$	$H2O_q$
Under Counter	Low	47,359	32,576
Stationary Single Tank Door		214,620	120,596
Single Tank Conveyor		191,260	115,340

Machine Type	Temperature	$H2O_b$	$H2O_q$
Multi Tank Conveyor		227,760	118,260
Under Counter	High	29,839	23,543
Stationary Single Tank Door		131,838	90,958
Single Tank Conveyor		127,020	102,200
Multi Tank Conveyor		212,430	118,260
Pot, Pan, and Utensil		71,540	59,276

Peak Factors

Table 3-102 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.9	[495]~~[4945]~~
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Non-Energy Impacts

$$\Delta H2O = H2O_b - H2O_q$$

Measure Life

The effective useful life (EUL) is listed in Table 3-103 [492]~~[4912]~~.

Table 3-103 Measure Life

Machine Type	Measure Life (years)
Under Counter	10
Stationary Single Tank Door	15
Single Tank Conveyor	20
Multi Tank Conveyor	20
Pot, Pan, and Utensil	10

References

~~[491]~~[492] ENERGY STAR Savings Calculator for Certified Commercial Kitchen Equipment. http://www.energystar.gov/buildings/sites/default/uploads/files/commercial_kitchen_equipment_calculator.xlsx

~~[492]~~[493] ENERGY STAR Program Requirements for Commercial Dishwashers Version 2.0, ENERGY STAR, February 2013.

~~[493]~~[494] Dishwasher inlet temperature assumed at 140 degrees F. https://water.usgs.gov/edu/density.html.

~~[494]~~[495] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs v10, effective date January 1, 2023.

Field Code Changed

Field Code Changed

3.4.4 ICE MACHINES

Market	Commercial
Baseline Condition	TOS/DI
Baseline	Code/Dual
End Use Subcategory	N/A
Measure Last Reviewed	January 2023

Description

This measure covers the installation of ENERGY STAR® qualified ice makers. Ice makers are factory-made assemblies consisting of a condensing unit and ice-making section operating as an integrated unit, with means for making and harvesting ice. This measure includes batch-type (cube type) and continuous-type (flake or nugget type) ice makers. Batch-type ice makers have distinct freezing and harvesting periods whereas continuous-type ice makers produce ice through a continuous freezing and harvesting process. Ice makers that have earned the ENERGY STAR® label use approximately 11% less energy and 25% less water than comparable non-qualified models [496]~~[4956]~~.

This measure covers ice making head, remote condensing, and self-contained air-cooled ice makers. Water-cooled ice makers, ice and water dispensing systems, and air-cooled remote condensing units that are designed only for connection to remote rack compressors are not eligible for energy savings.

Baseline Case

TOS: The baseline condition is a commercial ice maker as defined in the Measure Description section above with Equipment Type and Ice Harvest Rate equivalent to the efficient case. Baseline daily energy use per 100 lbs of ice shall be established based on efficient equipment Ice Harvest Rate in accordance with current federal standards for batch type [497]~~[4967]~~ and continuous type [497]~~[4967]~~ ice makers, as specified in the Code of Federal Regulations and provided in Table 3-105.

DI: Use dual baseline. For the remaining useful life of the replaced equipment, the baseline is the site-specific existing unit. For the duration of the measure life of the installed unit, use TOS baseline described above.

Efficient Case

The compliance condition is an ENERGY STAR® version 3.0 qualified commercial ice maker as defined in the Measure Description above. Efficient condition daily energy use per 100 pounds of ice are established based on efficient equipment Ice Harvest Rate in accordance with ENERGY STAR® v. 3.0 maximum qualifying specifications, as shown in Table 3-105 [498]~~[4978]~~. An efficient ice maker also needs to meet the potable water consumption requirement as shown in Table 3-105 [498]~~[4978]~~.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \left(kWh_b - kWh_q\right) \times 365 \times Cycle \times \left(\frac{IHR}{100}\right)$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta \text{kWh}}{8{,}760 \times \text{Cycle}} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \text{N/A}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-104 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	

Variable	Description	Value	Units	Ref
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
kWh_b	Baseline electric energy consumption per 100 pounds of ice	Look up in Table 3-105	kWh/lbs	[497]~~[4967]~~
kWh_q	Energy efficient electric energy consumption per 100 pounds of ice	Site-specific. If unknown, look up in Table 3-105	kWh/lbs	[498]~~[4978]~~
IHR	Rated Ice Harvest Rate of the energy efficient measure	Site-specific	lbs/day	
Cycle	Duty cycle, defined as the ratio of the actual ice harvest rate to the equipment rated ice harvest rate	0.75	N/A	[500]~~[499500]~~
365	Days per year	365	Days/yr	
100	Factor to convert IHR to units of 100 lbs/day	100	lbs/day	
8,760	Hours in one year	8,760	Hrs/yr	
CF	Electric coincidence factor	Look up in Table 3-106	N/A	[499]~~[4989]~~
PDF	Gas peak day factor	Look up in Table 3-106	N/A	
EUL	Effective useful life	See Measure Life Section	Years	[501]~~[5001]~~
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 3-105 Equipment Type and Ice Harvest Rate

Equipment Type	Ice Harvest Rate (IHR)	Baseline Daily Energy Use per 100 ilbs (kWh_b)	Measure Daily Energy Use per 100 lbs (kWh_q)	Potable Water Use (gal/100 lbs ice)
Batch Type, Ice-Making Head	< 300	10 – 0.01233 x IHR	9.20 – 0.01134 x IHR	≤ 20.0
	≥ 300 and < 800	7.05 – 0.0025 x IHR	6.49 – 0.0023 x IHR	≤ 20.0
	≥ 800 and < 1,500	5.55 – 0.00063 x IHR	5.11 – 0.00058 x IHR	≤ 20.0
	≥ 1,500 and < 4,000	4.61	4.24	≤ 20.0
Batch Type, Remote Condensing	< 988	7.97 – 0.00342 x IHR	7.17 – 0.00308 x IHR	≤ 20.0
	≥ 988 and < 4,000	4.59	4.13	≤ 20.0
Batch Type, Self-Contained	< 110	14.79 – 0.0469 x IHR	12.57 – 0.0399 x IHR	≤ 25.0
	≥ 110 and < 200	12.42 – 0.02533 x IHR	10.56 – 0.0215 x IHR	≤ 25.0
	≥ 200 and < 4,000	7.35	6.25	≤ 25.0
Continuous Type, Ice-Making Head	< 310	9.19 – 0.00629 x IHR	7.90 – 0.005409 x IHR	≤ 15.0
	≥ 310 and < 820	8.23 – 0.0032 x IHR	7.08 – 0.002752 x IHR	≤ 15.0

Equipment Type	Ice Harvest Rate (IHR)	Baseline Daily Energy Use per 100 ilbs (kWh_b)	Measure Daily Energy Use per 100 lbs (kWh_q)	Potable Water Use (gal/100 lbs ice)
	≥ 820 and < 4,000	5.61	4.82	≤ 15.0
Continuous Type, Remote Condensing	< 800	9.7 – 0.0058 x IHR	7.76 – 0.00464 x IHR	≤ 15.0
	≥ 800 and < 4,000	5.06	4.05	≤ 15.0
Continuous Type, Self-Contained	< 200	14.22 – 0.03 x IHR	12.37 – 0.0261 x IHR	≤ 15.0
	≥ 200 and < 700	9.47 – 0.00624 x IHR	8.24 – 0.005429 x IHR	≤ 15.0
	≥ 700 and < 4,000	5.1	4.44	≤ 15.0

Peak Factors

Table 3-106 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.9	[499]~~[4989]~~
Natural gas peak day factor (PDF)	N/A	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-107 Measure Life

Equipment	EUL	RUL	Ref
Ice Machines	10	3.3	[501]~~[5001]~~

References

~~[495]~~[496] “Commercial Ice Maker Key Product Criteria.” n.d. www.energystar.gov. Accessed January 17, 2023. https://www.energystar.gov/products/commercial_food_service_equipment/commercial_ice_makers/key_product_criteria

~~[496]~~[497] “10 CFR § 431.136 (c) and (d) - Energy Conservation Standards and Their Effective Dates.” n.d. LII / Legal Information Institute. Accessed January 17, 2023. https://www.law.cornell.edu/cfr/text/10/431.136

~~[497]~~[498] “ENERGY STAR Program Requirements for Automatic Commercial Ice Makers -Partner Commitments ENERGY STAR ® Program Requirements for Automatic Commercial Ice Makers Partner Commitments.” n.d. Accessed January 17, 2023. https://www.energystar.gov/sites/default/files/Final%20V3.0%20ACIM%20Specification%205-17-17_1.pdf

~~[498]~~[499] Pacific Gas & Electric Work Paper SWFS SWFS006-01 Commercial Ice Machines, January 2020, pg. 12. www.deeresources.net/workpapers

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

~~[499]~~[500] Pacific Gas & Electric Work Paper SWFS SWFS006-01 Commercial Ice Machines, January 2020, pg. 9. www.deeresources.net/workpapers

~~[500]~~[501] Pacific Gas & Electric Work Paper SWFS SWFS006-01 Commercial Ice Machines, January 2020, pg. 11. www.deeresources.net/workpapers

Field Code Changed

Field Code Changed

3.5 HVAC

3.5.1 AIR CONDITIONER, MINI-SPLIT AC, AND PTAC

Market	Commercial/Multifamily
Baseline Condition	TOS/NC/EREP/DI
Baseline	Code/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	March 2024
Changes Since Last Version	• ~~New measure (separated cooling-only equipment from air-source heat pump measure)~~ • ~~Updated peak demand algorithms to use EER2 instead of SEER2~~Removed reference to specific ENERGY STAR certification in efficient case description

Description

This measure targets the use of air conditioners and packaged terminal air conditioners (PTAC) in commercial and multifamily high-rise applications as further described below. This measure may apply to early replacement of an existing system, replacement on burnout, or installation of a new unit in a new or existing commercial or multifamily high-rise building for HVAC applications.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol as outlined in Table 3-113~~Table 3-113~~, Table 3-109 and Table 3-110 below.

Baseline Case

For time of sale or new construction projects, the baseline equipment is an air conditioner or packaged terminal system (PTAC) minimally compliant with ASHRAE 90.1-2019 (see Appendix E).

For early replacement or direct install projects, use dual baselines:

- For the remaining useful life (RUL) of the existing equipment, the baseline is the actual existing equipment. If the site specific efficiency of the existing equipment is unknown, use the equipment efficiency from the ASHRAE 90.1 version in force when the equipment was new (if equipment vintage is unknown, use ASHRAE 90.1 2013 efficiency requirements from Appendix E).
- For the duration of the measure life after the end of the RUL, the baseline is a current code-compliant version of the replaced equipment.

Efficient Case

A air conditioner or packaged terminal system (PTAC) that meets ~~ENERGY STAR Light Commercial HVAC v4.0 criteria [508], or otherwise meets program eligibility~~meets or exceeds program requirements.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = kWh_b - kWh_q$$

Calculate kWh_b using the algorithms in Table 3-113~~Table 3-113~~ for the appropriate baseline equipment type.

Calculate kWh_q using the algorithms in Table 3-114 for the appropriate efficient equipment type.

Note: Conversions from SEER to SEER2 and EER to EER2 can be found in Appendix E.

Table 3-108 Baseline Energy Consumption Equations

Baseline Equipment	Baseline Cooling kWh (kWh_b)
Air Conditioner (Cooling Capacity < 65 kBtu/h)	$\frac{Cap_c}{SEER2_b \times 1{,}000} \times EFLH_c$
Air Conditioner (Cooling Capacity ≥ 65 kBtu/h)	$\frac{Cap_c}{IEER_b \times 1{,}000} \times EFLH_c$
PTAC	$\frac{Cap_c}{EER_b \times 1{,}000} \times EFLH_c$

Table 3-109 Energy Efficient Energy Consumption Equations

Qualifying Equipment	Efficient Cooling kWh (kWh_q)
Air Conditioner (Cooling Capacity < 65 kBtu/h)	$\frac{Cap_c}{SEER2_q \times 1{,}000} \times EFLH_c$
Air Conditioner (Cooling Capacity ≥ 65 kBtu/h)	$\frac{Cap_c}{IEER_q \times 1{,}000} \times EFLH_c$
PTAC	$\frac{Cap_c}{EER_q \times 1{,}000} \times EFLH_c$

Peak Demand Savings

Table 3-110 Peak Demand Savings Equations

Qualifying Equipment	Peak Demand Savings (ΔkW_{Peak})
Air Conditioner (Cooling Capacity < 65 kBtu/h)	$\Delta kW_{Peak} = Cap_c \times \frac{1}{1{,}000} \times \left(\frac{1}{EER2_b} - \frac{1}{EER2_q}\right) \times CF$
Air Conditioner (Cooling Capacity ≥ 65 kBtu/h)	$\Delta kW_{Peak} = Cap_c \times \frac{1}{1{,}000} \times \left(\frac{1}{EER2_b} - \frac{1}{EER2_q}\right) \times CF$

Qualifying Equipment	Peak Demand Savings (ΔkW_{Peak})
PTAC	$\Delta kW_{Peak} = Cap_c \times \frac{1}{1{,}000} \times \left(\frac{1}{EER_b} - \frac{1}{EER_q}\right) \times CF$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-111 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
kWh_b	Baseline electrical consumption	Calculated	kWh/yr	
kWh_q	Energy efficient electrical consumption	Calculated	kWh/yr	
Cap_c	Cooling capacity of installed unit	Site-specific	Btu/hr	
$SEER2_q$	SEER2 of qualifying unit[110]	Site-specific	Btu/W-h	
$IEER_q$	IEER of qualifying unit	Site-specific	Btu/W-h	
EER_q	EER of qualifying unit	Site-specific	Btu/W-h	
$EER2_q$	EER of qualifying unit	Site-specific	Btu/W-h	
$SEER2_b$	SEER2 of baseline unit[1]	TOS/NC: Look up in Appendix E for current code-compliant efficiency	Btu/W-h	[509]~~[5089]~~[511]~~[5101]~~

[110] SEER to SEER2 conversion found in Appendix E.

Variable	Description	Value	Units	Ref
		EREP/DI: Site-specific, if unknown use code efficiency in force when equipment was new or ASHRAE 2013 if vintage is unknown		
$IEER_b$	IEER of baseline unit	TOS/NC: Look up in Appendix E for current code-compliant efficiency EREP/DI: Site-specific, if unknown use code efficiency in force when equipment was new or ASHRAE 2013 if vintage is unknown	Btu/W-h	[509]~~[5089]~~[511]~~[5101]~~
EER_b	EER of baseline unit	TOS/NC: Look up in Appendix E for current code-compliant efficiency EREP/DI: Site-specific, if unknown use code efficiency in force when equipment was new or ASHRAE 2013 if vintage is unknown	Btu/W-h	[509]~~[5089]~~[511]~~[5101]~~
$EER2_b$	EER2 of baseline unit	TOS/NC: Look up in Appendix E for current code-compliant efficiency EREP/DI: Site-specific, if unknown use code efficiency in force when equipment was new or ASHRAE 2013 if vintage is unknown	Btu/W-h	
$EFLH_c$	Equivalent Full Load Hours of operation for the average unit during the cooling season	Look up in Appendix C	Hours	[512]~~[5112]~~
1,000	Conversion from hp to Kw	1,000	w/kW	
CF	Electric coincidence factor	0.5	N/A	[513]~~[5123]~~
EUL	Effective useful life	See Measure Life Section	Years	[514]~~[5134]~~

Measure Life

For dual baseline scenarios, the remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-112 Measure Life

Equipment	EUL	RUL	Ref
A/C and PTAC	15	5	[514]~~[5134]~~

References

~~[501]~~[502] ENERGY STAR Light Commercial HVAC Version 4.0, https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20LC%20HVAC%20Version%204.0%20Specification%20Rev%20April%202022.pdf?_gl=1*n9oet2*_ga*MTUwMjg5MDYyNC4xNjY0NDc5NDA0*_ga_S0KJTVVLQ6*MTY4MDU0NjcxNi4zNS4xLjE2ODA1NDY5NjAuMC4wLjA

~~[502]~~[503] ASHRAE Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-5, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

~~[503]~~[504] ASHRAE Standard 90.1-2013, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-5, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

~~[504]~~[505] Simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

~~[505]~~[506] C&I Unitary HVAC Load Shape Project Final Report. August 2011, v.1.1, p. 12, Table O-5. The CF reported here is a center point for NJ chosen between the CF for urban NY and for the Mid-Atlantic region in the PJM peak periods.

~~[506]~~[507] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

~~[507]~~[508] Code of Federal Regulations. 2022. Review of Title 10, Chapter II, Subchapter D, Part 430, Subpart C, section 430.32 b) Room Air Conditioners,

Field Code Changed

Field Code Changed

3.5.2 AIR SOURCE HEAT PUMPS AND MINI-SPLIT HEAT PUMPS

Market	Commercial/Multifamily
Baseline Condition	TOS/NC/EREP/DI
Baseline	Code/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	May 2024
Changes Since Last Version	• ~~Moved cooling-only equipment (central A/C, PTAC)~~Clarified guidance on baselines assumptions for midstream applications: when to ~~separate measure~~ • ~~Added~~assume partial vs. whole displacement ~~algorithm, updated~~and fuel-switching vs. non-fuel switching • Removed reference to specific ENERGY STAR certification in efficient case description ~~accordingly~~

Description

This prescriptive measure targets the use of air source heat pumps (ASHP) and mini split heat pumps in commercial and multifamily high-rise applications. This measure may apply to early replacement of an existing system, replacement on burnout, or installation of a new unit in a new or existing commercial or multifamily high-rise building for HVAC applications.

In certain instances, air source heat pumps and mini-split heat pumps may only partially meet the heating load, requiring a supplementary heating system to meet the facility's full heating load. As such, this measure presents two displacement scenarios: partial and whole.

- **Partial displacement:** the heat pump fulfils a portion of the facility's heating load. Partial displacements occur in either of the two scenarios: 1) the installation of a heat pump that shares the facility's heating load with a separate supplemental heating system or 2) the installation of a "dual fuel" heat pump that incorporates a backup fossil fuel furnace to supplement the heat pump output. Partial displacements are addressed in the equations below by a load factor parameter (F_{load}), which represents the actual heating output of the heat pump as compared to the total theoretical heating output.[111] The partial displacement scenario only applies to heating displacement; this measure assumes that the installed heat pump will serve the entire cooling load of the zone(s) affected by the installation. If the installed heat pump is not a cold-climate heat pump, assume a partial displacement scenario unless there is evidence for a whole displacement installation (such as proof that any pre-existing heating systems were removed).

[111] F_{load} is represented by the fraction of annual heating degree hours that are above the switchover temperature. See Table 2-64~~Table 2-642 64~~ for more information.

- **Whole displacement:** the heat pump and any integrated supplemental resistance meets the facility's entire heating load, with no supplemental equipment. May assume whole displacement scenario if the installed heat pump is a cold-climate heat pump.

This measure does not accommodate the interactive effects of concurrent weatherization upgrades.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol presented in this measure. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

For whole building new construction, the baseline equipment is a unitary packaged or split-system heat pump meeting the compliance requirements of ASHRAE 90.1-2019 for commercial and multifamily high-rise buildings (see **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~). For multifamily low-rise buildings (three stories or lower), refer to residential measure (Section 3.3.1).

For replacement of failed equipment, or end of useful life, the baseline would be a minimally code compliant version of the replaced system type and fuel. If the baseline system fuel is unknown, such as in a midstream delivery method, calculate savings using a gas baseline (fuel switching project, assume ~~14~~37% boilers and ~~86~~63% furnaces as baseline equipment, per NREL ComStock data for New Jersey) and electric baseline (non fuel switching project, assume ASHP as baseline equipment) and calculate the weighted average using the weights in the table below.[112]

	Fuel switch	Non fuel switch
ACE	0.13~~0~~	0.87~~0~~
JCPL	0.~~216~~22	0.78~~4~~
RECO	0.01~~3~~	0.~~987~~99
PSEG	0.~~412~~61	0.~~588~~39
Average	**0.~~193~~24**	**0.~~807~~76**

For early replacement projects, use dual baselines:

- For the remaining useful life (RUL) of the existing equipment, the baseline is the actual existing equipment. If the site specific efficiency of the existing equipment is unknown, use the equipment efficiency from the ASHRAE 90.1 version in force when the equipment was new (if equipment vintage is unknown, use ASHRAE 90.1 2013 efficiency requirements from **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~).

  For the duration of the measure life after the end of the RUL, the baseline is a code-compliant version of the replaced equipment.

For spaces with no existing heating: For previously unheated spaces in an existing building that has an existing central heating system, the customer may have planned to install a heat pump regardless of program intervention, or the

[112] Weights calculated by quantity of heat pump projects designated as fuel switching by measure name in the Tri 2 utility filings workbooks.

customer may have planned to extend the existing central HVAC system to heat the new space. The baseline can therefore vary between a new equipment scenario and a retrofit scenario. For such installations, the baseline energy consumption algorithm is designed to blend the baseline energy consumptions of the new equipment scenario and retrofit scenario using a baseline factor, $F_{baseline,h}$.[113]

$$\begin{pmatrix}\text{Baseline heating}\\ \text{consumption}\end{pmatrix} = F_{baseline,h} \times \begin{pmatrix}\text{New equipment}\\ \text{scenario consumption}\end{pmatrix} + (1 - F_{baseline,h}) \times \begin{pmatrix}\text{Existing equipment}\\ \text{scenario consumption}\end{pmatrix}$$

- New equipment scenario: absent the program, the customer would have purchased new heating equipment instead of extending the existing central heating system. The new equipment scenario baseline is a code-compliant air-source heat pump of the same size as the installed heat pump.
- Retrofit scenario: absent the program, the customer would have extended the existing central heating system instead of purchasing new heating equipment. The retrofit scenario baseline is the existing central heating equipment.

For spaces with no existing cooling: For buildings without existing cooling, or spaces without cooling in an existing home that has an existing central cooling system, the customer may have planned to install a cooling regardless of program intervention, or the customer may have planned to leave the space without any cooling. The baseline can therefore vary between a new load scenario and a non-new load scenario. For such installations, the baseline energy consumption algorithm is designed to blend the baseline energy consumptions of the new equipment scenario and retrofit scenario using a baseline factor, $F_{baseline,c}$.[114]

$$\begin{pmatrix}\text{Baseline cooling}\\ \text{consumption}\end{pmatrix} = F_{baseline,c} \times \begin{pmatrix}\text{New load}\\ \text{scenario consumption}\end{pmatrix} + (1 - F_{baseline,c}) \times \begin{pmatrix}\text{Non} - \text{new load}\\ \text{consumption}\end{pmatrix}$$

- New load scenario: absent the program, the customer would not install any cooling. The new load scenario baseline is no existing cooling.
- Non-new load scenario: absent the program, the customer would have added cooling to the space. The non-new load scenario cooling baseline is the existing central cooling system if one exists, or a code-compliant air conditioner of the same cooling capacity as the installed heat pump.

Efficient Case

An air source heat pump or mini split heat pump that meets ~~ENERGY STAR Light Commercial HVAC v4.0 criteria [508], or otherwise exceeds ASHRAE 90.1-2019 requirements if not included in ENERGY STAR specification~~or exceeds program eligibility requirements.

[113] The baseline heating factors presented in Table 2-63~~Table 2-632-63~~ are based on reference [521]~~[5201]~~. $F_{baseline,h}$ is calculated as the total percent of respondents who would install new baseline equipment, averaged across heating fuel types in table 2-17 of the report.

[114] The baseline cooling factors presented in Table 2-63~~Table 2-632-63~~ are based on reference [521]~~[5201]~~**Error! Reference source not found.**. $F_{baseline,c}$ is calculated as the percent of respondents without existing cooling who would not have installed an alternative cooling system without the heat pump. The percent of respondents who installed a central heat pump with no existing cooling was assumed to be 46%, based on the known proportion of respondents who installed a minisplit with no existing cooling.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = kWh_b - kWh_q$$

Where,

$$kWh_b = kWh_{c,b} + kWh_{h,b}$$

For partial displacement applications,

$$kWh_q = kWh_{c,q} + F_{load} \times kWh_{h,q} + (1 - F_{load}) \times kWh_{supplement}$$

If supplemental heat is an existing electric resistance heating system:

$$kWh_{supplement} = \frac{Cap_h}{3.412 \times 1{,}000} \times EFLH_h$$

If supplemental heat is an existing fossil fuel system:

$$kWh_{supplement} = 0$$

For whole displacement applications,

$$kWh_q = kWh_{c,q} + kWh_{h,q}$$

Calculate $kWh_{c,b}$, $kWh_{h,b}$, $Kwh_{supplement}$ using the algorithms in Table 3-113~~Table 3-113~~ for the appropriate baseline and supplemental equipment type, if applicable.

Calculate $kWh_{c,q}$ and $kWh_{h,q}$ using the algorithms in Table 3-114~~Table 3-114~~ for the appropriate efficient equipment type.

Note:

- Conversions from SEER to SEER2, EER to EER2, and HSPF to HSPF2 can be found in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~.
- The oversize derating factor (OSF) in the equations above is applicable for heat pump applications where the heat pump is sized based on heating capacity but is oversized for cooling. The appropriate OSF should be determined from site-specific conditions if possible, otherwise use the default values provided below.

Table 3-113 Baseline Electric Energy Consumption Equations

Baseline Equipment	Cooling kWh ($kWh_{c,b}$)	Heating kWh ($kWh_{h,b}$ or $kWh_{supplement}$)
No existing cooling	$(1 - F_{baseline,c}) \times \frac{Cap_c}{SEER2_b \times 1{,}000} \times EFLH_c$	N/A
No existing heating, central fossil fuel system	N/A	$F_{baseline,h} \times \frac{Cap_h}{HSPF2_b \times 1{,}000} \times EFLH_h$

Baseline Equipment	Cooling kWh ($kWh_{c,b}$)	Heating kWh ($kWh_{h,b}$ or $kWh_{supplement}$)
No existing heating, central electric resistance/electric furnace	N/A	$F_{baseline,h} \times \frac{Cap_h}{HSPF2_b \times 1{,}000} \times EFLH_h + (1 - F_{baseline,h}) \times \frac{Cap_h}{3.412 \times 1{,}000} \times EFLH_h$
Mini-split heat pump, ASHP (Cooling Capacity < 65 kBtu/h) or whole building new construction	$OSF \times \frac{Cap_c}{SEER2_b \times 1{,}000} \times EFLH_c$	$\frac{Cap_h}{HSPF2_b \times 1{,}000} \times EFLH_h$
ASHP (Cooling Capacity > 65 kBtu/h & IEER Available)	$OSF \times \frac{Cap_c}{IEER_b \times 1{,}000} \times EFLH_c$	$\frac{Cap_h}{COP_b \times 3.412 \times 1{,}000} \times EFLH_h$
ASHP (Cooling Capacity > 65 kBtu/h & IEER not available)	$OSF \times \frac{Cap_c}{EER2_b \times 1{,}000} \times EFLH_c$	$\frac{Cap_h}{COP_b \times 3.412 \times 1{,}000} \times EFLH_h$
Air Source Air Conditioner (Cooling Capacity < 65 kBtu/h)	$\frac{Cap_c}{SEER2_b \times 1{,}000} \times EFLH_c$	N/A
Air Source Air Conditioner (Cooling Capacity > 65 kBtu/h & IEER Available)	$\frac{Cap_c}{IEER_b \times 1{,}000} \times EFLH_c$	N/A
Air Source Air Conditioner (Cooling Capacity > 65 kBtu/h & IEER not available)	$\frac{Cap_c}{EER2_b \times 1{,}000} \times EFLH_c$	N/A
PTAC with electric resistance heat	$\frac{Cap_c}{EER2_b \times 1{,}000} \times EFLH_c$	$\frac{Cap_h}{3.412 \times 1{,}000} \times EFLH_h$
PTAC with fossil fuel heat	$\frac{Cap_c}{EER2_b \times 1{,}000} \times EFLH_c$	N/A
PTHP	$OSF \times \frac{Cap_c}{EER2_b \times 1{,}000} \times EFLH_c$	$\frac{Cap_h}{COP_b \times 3.412 \times 1{,}000} \times EFLH_h$
Electric resistance/electric furnace heating	N/A	$\frac{Cap_h}{3.412 \times 1{,}000} \times EFLH_h$
Room Air Conditioner	$\frac{Cap_c}{CEER_b \times 1{,}000} \times EFLH_c$	N/A

Table 3-114 Energy Efficient Electric Energy Consumption Equations

Qualifying Equipment	Efficient Cooling kWh ($kWh_{c,q}$)	Efficient Heating kWh ($kWh_{h,q}$)
Mini-split heat pump, ASHP (Cooling Capacity < 65 kBtu/h)	$OSF \times \frac{Cap_c}{SEER2_q \times 1{,}000} \times EFLH_c$	$\frac{Cap_h}{HSPF2_q \times 1{,}000} \times EFLH_h$
ASHP (Cooling Capacity > 65 kBtu/h & IEER Available)	$OSF \times \frac{Cap_c}{IEER_q \times 1{,}000} \times EFLH_c$	$\frac{Cap_h}{COP_q \times 3.412 \times 1{,}000} \times EFLH_h$
ASHP (Cooling Capacity > 65 kBtu/h & IEER not available)	$OSF \times \frac{Cap_c}{EER2_q \times 1{,}000} \times EFLH_c$	$\frac{Cap_h}{COP_q \times 3.412 \times 1{,}000} \times EFLH_h$
PTHP	$OSF \times \frac{Cap_c}{EER2_q \times 1{,}000} \times EFLH_c$	$\frac{Cap_h}{COP_q \times 3.412 \times 1{,}000} \times EFLH_h$

Annual Fuel Savings

$$\Delta Therms = Therms_b - Therms_q$$

Where,

$$Therms_b = see\ \text{Table 3-115}\ \cancel{\text{Table 3-115}}\ for\ appropriate\ baseline\ equipment\ type$$

For partial displacement applications where the heat pump adds on to an existing fossil fuel system,

$$Therms_q = (1 - F_{load}) \times Therms_b$$

For partial displacement applications where a new supplemental fossil fuel heating system is installed,

$$Therms_q = (1 - F_{load}) \times Therms_{q,ff}$$

$$Therms_{q,ff} = see\ \text{Table 3-116}\ \cancel{\text{Table 3-116}}\ for\ appropriate\ qualifying\ equipment\ type$$

For whole displacement applications,

$$Therms_q = 0$$

Table 3-115 Baseline Fossil Fuel Consumption

Baseline Equipment	Baseline fuel consumption ($Therms_b$)
Fossil Fuel (Gas, Oil, Propane) Furnace/Boiler	$\frac{Cap_h}{Eff_{b,fuel} \times 100{,}000} \times EFLH_h$
No existing heating	$(1 - F_{baseline,h}) \times \frac{Cap_h}{Eff_{b,fuel} \times 100{,}000} \times EFLH_h$

Table 3-116 Energy Efficient Fossil Fuel Consumption

Qualifying Equipment	Efficient fuel consumption ($Therms_{q,ff}$)
New Supplemental Fossil Fuel (Gas, Oil, Propane) Furnace/Boiler	$\frac{Cap_h}{Eff_{q,fuel} \times 100{,}000} \times EFLH_h$

To calculate savings in gallons of delivered fuel, use Table 3-200.

Table 3-117 Fuel Savings in Gallons

Delivered Fuel	Fuel savings (gallons)
Oil	$\Delta Gal_{oil} = \frac{\Delta Therms}{1.4}$

Delivered Fuel	Fuel savings (gallons)
Propane	$\Delta Gal_{Propane} = \frac{\Delta Therms}{0.916}$

Peak Demand Savings

$$\Delta kW_{Peak} = OSF \times Cap_c \times \frac{1}{1{,}000} \times \left(\frac{1}{EER2_b} - \frac{1}{EER2_q}\right) \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Use single baseline for whole displacement new construction and replace on failure.

Use dual baseline for early replacement and addition to existing equipment. In both cases, the RUL is defined by the smaller of the pre-existing heating or cooling system RUL.

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-118 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	

Variable	Description	Value	Units	Ref
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ΔGal_{Oil}	Oil savings	Calculated	Gallons	
$\Delta Gal_{Propane}$	Propane savings	Calculated	Gallons	
kWh_b	Baseline electrical consumption	Calculated	kWh/yr	
kWh_q	Energy efficient electrical consumption	Calculated	kWh/yr	
Cap_c	Cooling capacity of installed unit	Site-specific	Btu/hr	
Cap_h	Heating capacity of installed heat pump heating equipment	Site-specific	Btu/hr	
$SEER2_q$	SEER2 of qualifying unit	Site-specific	Btu/W-h	
$IEER_q$	IEER of qualifying unit	Site-specific	Btu/W-h	
$EER2_q$	EER2 of qualifying unit	Site-specific	Btu/W-h	
COP_q	Coefficient of performance at 47F of the qualifying unit	Site-specific	N/A	
$HSPF_q$	Heating seasonal performance factor of the installed unit	Site-specific	Btu/W-h	
$SEER2_b$	SEER of baseline unit	Site-specific, if unknown look up in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~	Btu/W-h	[509]~~[5089]~~[511]~~[5101]~~
$IEER_b$	IEER of baseline unit	Site-specific, if unknown look up in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~	Btu/W-h	[509]~~[5089]~~[511]~~[5101]~~
$EER2_b$	EER2 of baseline unit	Site-specific, if unknown look up in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~	Btu/W-h	[509]~~[5089]~~[511]~~[5101]~~
$HSPF2_b$	Heating seasonal performance factor of the baseline unit	Site-specific, if unknown look up in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~.	Btu/W-h	[509]~~[5089]~~[511]~~[5101]~~

Variable	Description	Value	Units	Ref
$CEER_b$	Combined Energy Efficiency Ratio of baseline room air conditioner[115]	Use federal standard values in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~. If unknown, use 11.0	Btu/W-h	[515]~~[5145]~~
$Eff_{b,fuel}$	Efficiency of baseline boiler/furnace	Site-specific, if unknown look up in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~	N/A	[509]~~[5089]~~[511]~~[5101]~~
$Eff_{q,fuel}$	Efficiency of newly installed supplemental boiler/furnace	Site-specific	N/A	
OSF	Oversize derating factor[116]	Site-specific, if unknown use 0.8	N/A	
F_{load}	Partial Displacement Factor to account for the portion of heating load met by the heat pump	Lookup in Table 2-64, using switchover point of 35°F unless site-specific switchover point is known and documented	N/A	[88][90]
$F_{baseline,h}$	Fraction of projects where, absent the program, the customer would have purchased new heating equipment for a previously unheated space instead of extending existing central system	If installed heat pump is a ductless minisplit: 0.18 If installed heat pump is a ducted ASHP: 0.27	N/A	[521]~~[5201]~~
$F_{baseline,c}$	Fraction of projects where, absent the program, the customer would not have installed cooling in previously uncooled space, so the added cooling represented added electrical load	If installed heat pump is a ductless minisplit: 0.74 If installed heat pump is a ducted ASHP: 0.34	N/A	[521]~~[5201]~~
$kWh_{c,b}$	Baseline cooling electrical consumption	Look up in Table 3-113~~Table 3-113~~	kWh/yr	
$kWh_{h,b}$	Baseline heating electrical consumption	Look up in Table 3-113~~Table 3-113~~	kWh/yr	
$kWh_{c,q}$	Energy efficient cooling electrical consumption	Look up in Table 3-114~~Table 3-114~~	kWh/yr	

[115] Default value (11.0) is the CEER value from minimum Federal Standard for the most common room AC type – <8000 capacity range with louvered sides

[116] Heat pump systems may be sized to meet the peak heating load and will be oversized for cooling. The cooling EFLH assumes a nominal 20% oversizing. This derating factor has been added to account for the oversizing of heat pump cooling capacity when the unit is sized based on heating capacity. A user with a more accurate estimation of the oversizing can use a different factor than the one mentioned above to account for oversizing.

Variable	Description	Value	Units	Ref
$kWh_{h,q}$	Energy efficient heating electrical consumption	Look up in Table 3-114~~Table 3-114~~	kWh/yr	
$kWh_{supplement}$	Energy efficient heating electrical consumption of supplemental heating system	Calculated	kWh/yr	
$Therms_b$	Baseline fuel consumption	Look up in Table 3-115~~Table 3-115~~	Therms/yr	
$Therms_q$	Energy efficient fuel consumption	Calculated	Therms/yr	
$Therms_{q,ff}$	Fuel consumption of new efficient fuel equipment for partial displacement applications where a new supplemental fossil fuel heating system is installed	Calculated	Therms/yr	
$EFLH_c$	Equivalent Full Load Hours of operation for the average unit during the cooling season	Lookup in **Error! Reference source not found.**~~Appendix C:~~ Heating and Cooling EFLH	Hours	[512]~~[5112]~~
$EFLH_h$	Equivalent Full Load Hours of operation for the average unit during the heating season	Lookup in **Error! Reference source not found.**~~Appendix C:~~ Heating and Cooling EFLH	Hours	[512]~~[5112]~~
COP_b	Coefficient of performance of the baseline unit at 47F	Look up in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~	N/A	[509]~~[5089]~~[511]~~[5101]~~
1,000	Conversion from W to kW	1,000	w/kW	
3.412	Conversion factor from kWh to kBtu	3.412	kBtu/kWh	
1.4	Conversion from therms to gallons	1.4	Therms/gal	0
0.916	Conversion from therms to gallons	0.916	Therms/gal	0
CF	Cooling coincidence factor	Look up in Table 3-120~~Table 3-120~~	N/A	[513]~~[5123]~~
PDF	Gas peak day factor	Look up in Table 3-120~~Table 3-120~~	N/A	
EUL	Effective useful life	See Measure Life Section	Years	[514]~~[5134]~~
RUL	Remaining useful life	See Measure Life Section	Years	

Table 3-119 Partial Displacement Factors at Different Switchover Points[117]

NJ Climate Region	Switchover Point					
	15°F	25°F	30°F	35°F (default)	40°F	45°F
Northern	0.95	0.78	0.68	0.43	0.29	0.17
Southern	0.99	0.82	0.71	0.43	0.29	0.19
Coastal	0.98	0.91	0.85	0.64	0.46	0.30
Central	0.99	0.83	0.74	0.47	0.31	0.19
Pine Barrens	1.00	0.86	0.76	0.46	0.31	0.19
Statewide Average	**0.98**	**0.84**	**0.75**	**0.48**	**0.33**	**0.20**

Use switchover point of 35°F unless alternative site-specific switchover point is known and supported with documentation such as a photo of programmed controls.

Peak Factors

Table 3-120 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.5	[513]~~[5123]~~
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-121 Measure Life

Equipment	EUL	RUL	Ref
Central A/C	15	5	[514]~~[5134]~~
Air source heat pump	15	5	[514]~~[5134]~~
Mini split heat pump	15	5	[514]~~[5134]~~

[117] Partial displacement factor represents the fraction of the heating load provided by the heat pump. It is based on the percentage of heating degree hours above the "switchover point," or the point at which heating is assumed to switch from the heat pump to the supplemental system. Assume a default switchover point of 35°F unless a site-specific switchover point is known and supported with documentation such as a photo of programmed controls.

Equipment	EUL	RUL	Ref
PTAC/PTHP	15	5	[514]~~[5134]~~
Room air conditioner	12	4	[514]~~[5134]~~
Fossil fuel furnace/boiler	20	6.7	[514]~~[5134]~~
Electric resistance/electric furnace	20	6.7	[514]~~[5134]~~

References

~~[508]~~[509] ENERGY STAR Light Commercial HVAC Version 4.0, https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20LC%20HVAC%20Version%204.0%20Specification%20Rev%20April%202022.pdf?_gl=1*n9oet2*_ga*MTUwMjg5MDYyNC4xNjY0NDc5NDA0*_ga_S0KJTVVLQ6*MTY4MDU0NjcxNi4zNS4xLjE2ODA1NDY5NjAuMC4wLjA

~~[509]~~[510] ASHRAE Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-5, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

~~[510]~~[511] ASHRAE Standard 90.1-2013, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-5, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

~~[511]~~[512] Simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

~~[512]~~[513] C&I Unitary HVAC Load Shape Project Final Report. August 2011, v.1.1, p. 12, Table O-5. The CF reported here is a center point for NJ chosen between the CF for urban NY and for the Mid-Atlantic region in the PJM peak periods.

~~[513]~~[514] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

~~[514]~~[515] Code of Federal Regulations. 2022. Review of Title 10, Chapter II, Subchapter D, Part 430, Subpart C, section 430.32 b) Room Air Conditioners,

~~[515]~~[516] Oak Ridge National Laboratory, *Fuel Conversions Needed in the Weatherization Assistant*, https://weatherization.ornl.gov/wp-content/uploads/2018/05/FuelConversions.pdf

~~[516]~~[517] TMY3 data for NJ climate zone representative cities: Northern – Allentown, PA; Central – Trenton, NJ; Pine Barrens – McGuire AFB NJ; Southwest – Philadelphia, PA International Airport; Coastal – Atlantic City, NJ.

~~[517]~~[518] Determined by calculating the percentage of the heating degree hours (using 65°F balance point) exceeding the switchover point, which represents the proportion of the heating load presumed to be met by the heat pump. Metered data from New York shows that customers typically switch from heat pump to supplemental heating at around 35°F.

~~[518]~~[519] GDS Associates, Inc. 2007. *Review of Energy Efficiency Measures/Programs Reference Document for the ISO Forward Capacity Market (FCM)*. Https://Library.cee1.org. June 2007. https://library.cee1.org/system/files/library/8842/CEE_Eval_MeasureLifeStudyLights%2526HVACGDS_1Jun2007.pdf

~~[519]~~[520] *Energy Saver 101: Everything you need to know about Home Heating* https://www.energy.gov/sites/prod/files/2014/01/f6/homeHeating.pdf

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

~~[520]~~[521] Guidehouse, *[R2246] Residential Heat Pump Metering Study*, May 2024. https://app.box.com/s/6u94k3zij1ocwmqlh7oxl5vnie1fmn7c

Field Code Changed

3.5.3 GEOTHERMAL AND WATER SOURCE HEAT PUMPS

Market	Commercial/Multifamily
Baseline Condition	TOS/NC/EREP/DI
Baseline	Code/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	May 2024
Changes Since Last Version	~~Algorithm revisions~~

Description

This prescriptive measure targets the use of water-to-air ground loop heat pumps, water-to-air groundwater heat pumps, brine-to-air ground loop heat pumps, brine-to-air groundwater loop heat pumps in commercial and multifamily applications as further described below. This measure may apply to early replacement of an existing system, replacement on burnout, or installation of a new unit in a new or existing commercial or multifamily building for HVAC applications.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

This measure is limited to single-zone equipment; complex built-up systems should follow custom analysis. This measure requires that:

- The heat pump system will be installed in lost opportunity projects *or* in retrofit/early retirement projects in buildings with viable existing ductwork.
- The heat pump system will be the sole source of heating and cooling in the space; it will not be installed in association with another non-electric source of auxiliary heat.

Baseline Case

For whole building new construction and time of sale applications, the baseline equipment is a unitary packaged or split-system air source heat pump (or other industry standard equipment type for the facility) compliant with ASHRAE 90.1-2019 (see **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~).

For replacement of failed equipment, or end of useful life, the baseline would be a minimally code compliant version of the replaced system type and fuel.

For early replacement projects, use dual baselines:

- For the remaining useful life (RUL) of the existing equipment, the baseline is the actual existing equipment. If the site specific efficiency of the existing equipment is unknown, use the equipment efficiency from the ASHRAE 90.1 version in force when the equipment was new (if equipment vintage is unknown, use ASHRAE 90.1 2013 efficiency requirements from **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~).
- For the duration of the measure life after the end of the RUL, the baseline is a current code-compliant version of the replaced equipment.

Note: the algorithms in this section assume that the installed heat pump replaces 100% of the heating and cooling load of the existing equipment. In a partial displacement scenario, the consumption algorithms must be adjusted to account for the actual percent of building load supplied by HVAC equipment.

Efficient Case

A water-to-air groundwater loop water-to-air ground loop, brine-to-air groundwater loop, or brine-to-air ground loop heat pump that meets or exceeds code requirements.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = kWh_b - kWh_q$$

Where,

$$kWh_b = kWh_{c,b} + kWh_{h,b} + kWh_{p,b}$$

$$kWh_q = kWh_{c,q} + kWh_{h,q} + kWh_{p,q}$$

Calculate $kWh_{c,b}$, $kWh_{h,b}$, and $kWh_{p,b}$ using the algorithms in Table 3-122 for the appropriate baseline equipment type.

Calculate $kWh_{c,q}$, $kWh_{h,q}$, and $kWh_{p,q}$ using the algorithms in Table 3-123 for the appropriate efficient equipment type.

Note: Conversions from SEER to SEER2, EER to EER2, and HSPF to HSPF2 can be found in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~.

The cooling output of the installed unit (Qc) and the heating output of the installed unit (Qh) are calculated as follows.

$$Q_c = Cap_c \times EFLH_c \times OSF$$

$$Q_h = Cap_h \times EFLH_h$$

Note: The oversize derating factor (OSF) in the equations above is applicable for heat pump applications where the heat pump is sized based on heating capacity but is oversized for cooling. The appropriate OSF should be determined from site-specific conditions if possible, otherwise use a default value of 0.8.

Table 3-122 Baseline Energy Consumption Equations

Baseline Equipment	Baseline Cooling kWh ($kWh_{c,b}$)	Baseline Heating kWh ($kWh_{h,b}$)	Auxiliary Energy Use kWh ($kWh_{au,b}$)[118]
Air Source Heat Pump (< 65 kBtu/h)	$\frac{Q_c}{SEER2_b \times 1{,}000}$	$\frac{Q_h}{HSPF2_b \times 1{,}000}$	N/A
Air Source Air Conditioner (< 65 kBtu/h)	$\frac{Q_c}{SEER2_b \times 1{,}000}$	N/A	N/A
Air Source Heat Pump (≥ 65 kBtu/h)	$\frac{Q_c}{IEER_b \times 1{,}000}$	$\frac{Q_h}{COP_b \times 3.412 \times 1{,}000}$	N/A
Air Source Air Conditioner (≥ 65 kBtu/h)	$\frac{Q_c}{IEER_b \times 1{,}000}$	N/A	N/A
PTAC with electric resistance heat	$\frac{Q_c}{EER2_b \times 1{,}000}$	$\frac{Q_h}{3.412 \times 1{,}000}$	N/A
PTHP	$\frac{Q_c}{EER2_b \times 1{,}000}$	$\frac{Q_h}{COP_b \times 3.412 \times 1{,}000}$	N/A
Ground Source Heat Pump (< 65 kBtu/h)	$\frac{Q_c}{EER_b \times 1{,}000}$	$\frac{Q_h}{COP_b \times 3.412 \times 1{,}000}$	$\frac{0.746 \times HP_b \times FLH_{pump}}{Eff_{motor,b}}$
GSHP (Cooling Capacity > 65 kBtu/h)	$\frac{Q_c}{EER_b \times 1{,}000}$	$\frac{Q_h}{COP_b \times 3.412 \times 1{,}000}$	$\frac{0.746 \times HP_b \times FLH_{pump}}{Eff_{motor,b}}$
Electric Resistance/electric furnace heating	N/A	$\frac{Q_h}{3.412 \times 1{,}000}$	N/A
Room Air Conditioner	$\frac{Q_c}{CEER_b \times 1{,}000}$	N/A	N/A
Fossil Fuel Furnace[119]	N/A	N/A	$4.9 \times Cap_{furnace} + 128.1$

Table 3-123 Energy Efficient Energy Consumption Equations

Efficient Cooling kWh ($kWh_{c,q}$)	Efficient Heating kWh ($kWh_{h,q}$)	Efficient Circulating Pump kWh ($kWh_{p,q}$)
$\frac{Q_c}{EER_{season,q} \times 1{,}000}$	$\frac{Q_h}{COP_{season,q} \times 3.412 \times 1{,}000}$	$\frac{0.746 \times HP_q \times FLH_{pump}}{Eff_{motor,q}}$

Calculate seasonal efficiencies as follows:

If heat pump is part-load capable:

[118] This parameter represents the additional energy consumption aside from direct cooling or heating. For ground source heat pumps, it represents the pump energy to circulate the heat exchange fluid through the ground loop. For furnaces, it represents the fan energy to distribute the heated air.
[119] This equation was derived by constructing a simple linear regression model that relates the output furnace heating capacity to the fan auxiliary usage using data downloaded from the AHRI website for all active residential-sized furnaces.

$$EER_{season,q} = F_{full} \times EER_{full,q} \times 1.09 \times F_{pump,full} + F_{part} \times EER_{part,q} \times F_{pump,part}$$

$$COP_{season,q} = F_{full} \times COP_{full,q} \times 1.08 \times F_{pump,full} + F_{part} \times COP_{part,q} \times F_{pump,part}$$

If heat pump is not part-load capable:

$$EER_{season,q} = rated\ EER$$

$$COP_{season,q} = rated\ COP$$

Annual Fuel Savings

$$\Delta Therms = Therms_b - Therms_q$$

Where,

$Therms_b$ = *see* Table 3-124~~Table 3-124~~ *for appropriate baseline equipment type*

$Therms_q = 0$ *(If the unit uses a furnace backup, use equation from Table 3-124)*

Table 3-124 Baseline Fuel Consumption

Baseline Equipment	Baseline fuel consumption ($Therms_b$)
Fossil fuel furnace	$\frac{Q_h}{Eff_{b,fuel} \times 100{,}000}$
Electric heating (heat pump, electric resistance)	0

To calculate savings in gallons of delivered fuel, use Table 3-125

Table 3-125 Fuel Savings in Gallons

Delivered Fuel	Fuel savings (gallons)
Oil	$\Delta Gal_{Oil} = \frac{\Delta Therms}{1.4}$
Propane	$\Delta Gal_{Propane} = \frac{\Delta Therms}{0.916}$

Peak Demand Savings

$$\Delta kW_{Peak} = kW_{peak,cool} + kW_{peak,pump}$$

Where,

$$\Delta kW_{peak,cool} = Cap_c \times \frac{1}{1{,}000} \times \left(\frac{1}{EER2_b} - \frac{1}{EER2_q}\right) \times CF_c$$

$$\Delta kW_{peak,pump} = 0.746 \times \left\{ \left(HP_b \times LF \times \frac{1}{Eff_{motor,b}} \right) - \left(HP_q \times LF \times \frac{1}{Eff_{motor,q}} \times DSF_{VFD} \right) \right\} \times CF_{pump}$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-126 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ΔGal_{Oil}	Oil savings	Calculated	Gallons	
$\Delta Gal_{Propane}$	Propane savings	Calculated	Gallons	
kWh_b	Baseline electrical consumption	Calculated	kWh/yr	
kWh_q	Energy efficient electrical consumption	Calculated	kWh/yr	

Variable	Description	Value	Units	Ref
Q_c	Cooling output of qualifying unit	Calculated	Btu	
Q_h	Heating output of qualifying unit	Calculated	Btu	
Cap_c	Cooling capacity of qualifying unit	Site-specific	Btu/hr	
Cap_h	Heating capacity of qualifying unit	Site-specific	Btu/hr	
$Cap_{furnace}$	Heating capacity of pre-existing furnace (MBH)	Site-specific	MBH	
F_{full}	Seasonal weighting factor for full load efficiency	0.25	N/A	[524]~~[5234]~~
$EER_{season,q}$	Adjusted EER of qualifying unit	Calculated	Btu/W-h	
$EER_{full,q}$	Full load EER of qualifying unit	Site-specific	Btu/W-h	
$F_{pump,full}$	Factor to adjust the full load efficiency to account for additional pumping power used by the system	0.90	N/A	[524]~~[5234]~~
F_{part}	Seasonal weighting factor for part load efficiency	0.75	N/A	[524]~~[5234]~~
$EER_{part,q}$	Part load EER of qualifying unit (if part load capable), per manufacturer literature or AHRI certification	Site-specific	Btu/W-h	
$F_{pump,part}$	Factor to adjust the part load efficiency to account for additional pumping power used by the system	0.84	N/A	[524]~~[5234]~~
$COP_{season,q}$	Adjusted coefficient of performance of the qualifying unit	Calculated	N/A	
$COP_{full,q}$	Full load coefficient of performance of the qualifying unit, per manufacturer literature or AHRI certification	Site-specific	N/A	
$COP_{part,q}$	Part load coefficient of performance of the qualifying unit (if part-load capable), per manufacturer literature or AHRI certification	Site-specific	N/A	
HP_q	Horsepower of qualifying ground/groundwater loop circulating pump motor	Site-specific	HP	

Variable	Description	Value	Units	Ref
HP_b	Horsepower of base case ground/groundwater loop circulating pump motor	Site-specific, if unknown use HP_q	HP	
$SEER2_b$	SEER2 of baseline unit	Site-specific, if unknown look up in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~	Btu/W-h	[529]~~[5289]~~[530]~~[529530]~~
$IEER_b$	IEER of baseline unit	Site-specific, if unknown look up in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~	Btu/W-h	[529]~~[5289]~~[530]~~[529530]~~
$EER2_b$	EER2 of baseline unit	Site-specific, if unknown look up in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~	Btu/W-h	[529]~~[5289]~~[530]~~[529530]~~
$HSPF2_b$	Heating seasonal performance factor of the baseline unit	Site-specific, if unknown look up in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~.	Btu/W-h	[529]~~[5289]~~[530]~~[529530]~~
$CEER_b$	Combined Energy Efficiency Ratio of baseline room air conditioner[120]	Use federal standard values in Appendix E, if unknown, use 11.0	Btu/W-h	See footnote
$Eff_{motor,b}$	Efficiency of base case ground/groundwater loop circulating pump motor	Site-specific, if unknown look up in Table 3-127	N/A	[531]~~[5301]~~
$Eff_{motor,q}$	Efficiency of qualifying ground/groundwater loop circulating pump motor	Site-specific, if unknown look up in Table 3-127	N/A	[531]~~[5301]~~
$Eff_{b,fuel}$	Efficiency of baseline of furnace	Site-specific, if unknown look up in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~	N/A	[529]~~[5289]~~[530]~~[529530]~~
OSF	Oversize derating factor	Site-specific, if unknown use 0.8	N/A	
$kWh_{c,b}$	Baseline cooling electrical consumption	Look up in Table 3-122	kWh/yr	
$kWh_{h,b}$	Baseline heating electrical consumption	Look up in Table 3-122	kWh/yr	

[120] Default value (11.0) is the CEER value from minimum Federal Standard for the most common room AC type – <8000 capacity range with louvered sides

Variable	Description	Value	Units	Ref
$kWh_{p,b}$	Baseline pump electrical consumption	Look up in Table 3-122	kWh/yr	
$kWh_{c,q}$	Energy efficient cooling electrical consumption	Look up in Table 3-123	kWh/yr	
$kWh_{h,q}$	Energy efficient heating electrical consumption	Look up in Table 3-123	kWh/yr	
$kWh_{p,q}$	Energy efficient ground/groundwater loop circulating pump electrical consumption	Look up in Table 3-123	kWh/yr	
$Therms_b$	Baseline fuel consumption	Look up in Table 3-124	Therms/yr	
$Therms_q$	Energy efficient fuel consumption	0	Therms/yr	
$EFLH_c$	Equivalent Full Load Hours of operation for the average unit during the cooling season	Lookup in Error! Reference source not found.~~Appendix C: Heating and Cooling EFLH~~	Hours	[522]~~[5212]~~
$EFLH_h$	Equivalent Full Load Hours of operation for the average unit during the heating season	Lookup in Error! Reference source not found.~~Appendix C: Heating and Cooling EFLH~~	Hours	[522]~~[5212]~~
COP_b	Coefficient of performance of the baseline unit	Look up in Error! Reference source not found.~~Appendix E: Code-Compliant Efficiencies~~	N/A	[529]~~[5289]~~[530]~~[529530]~~
1.09	Correction for 9% increase in EER as the entering fluid temperature decreases from 77°F to 68°F	1.09	N/A	[524]~~[5234]~~
1.08	Correction for 8% increase in COP as entering fluid temperature increases from 32°F to 40°F	1.08	N/A	[524]~~[5234]~~
1,000	Conversion from W to kW	1,000	w/kW	
3.412	Conversion factor from kWh to kBtu	3.412	kBtu/kWh	
0.746	Conversion from HP to kW	0.746	kW/hp	
1.4	Conversion from therms to gallons	1.4	Therms/gal	
0.916	Conversion from therms to gallons	0.916	Therms/gal	
LF	Load factor of pump motor	0.75	N/A	[525]~~[5245]~~
DSF_{VFD}	Demand savings factor to account for variable speed pumping in qualifying unit	If variable speed pump: 0.210 If constant speed: 1.0		See section 3.5.17
FLH_{pump}	Annual full-load hours of ground/groundwater loop	Look up in Error! Reference source not found.~~Appendix~~	Hours	

Variable	Description	Value	Units	Ref
	circulating pump motor, approximated as $EFLH_c + EFLH_h$	~~D: HVAC Fan and Pump Operating Hours~~		
CF_c	Cooling coincidence factor	Look up in Table 3-128	N/A	
CF_{pump}	Pump coincidence factor	Look up in Table 3-128	N/A	
PDF	Gas peak day factor	Look up in Table 3-128	N/A	
EUL	Effective useful life	See Measure Life Section	Years	
RUL	Remaining useful life	See Measure Life Section	Years	

Table 3-127 Federal Baseline Motor Efficiencies

Motor HP	Motor Nominal Full-Load Efficiencies (percent)							
	2 Poles		4 poles		6 Poles		8 Poles	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
1	77.0	77.0	85.5	85.5	82.5	82.5	75.5	75.5
1.5	84.0	84.0	86.5	86.5	87.5	86.5	78.5	77.0
2	85.5	85.5	86.5	86.5	88.5	87.5	84.0	86.5
3	86.5	85.5	89.5	89.5	89.5	88.5	85.5	87.5
5	88.5	86.5	89.5	89.5	89.5	89.5	86.5	88.5
7.5	89.5	88.5	91.7	91.0	91.0	90.2	86.5	89.5
10	90.2	89.5	91.7	91.7	91.0	91.7	89.5	90.2
15	91.0	90.2	92.4	93.0	91.7	91.7	89.5	90.2
20	91.0	91.0	93.0	93.0	91.7	92.4	90.2	91.0

Peak Factors

Table 3-128 Peak Factors

Peak Factor	Value	Ref
Cooling coincidence factor (CF_c)	0.5	[526]~~[5256]~~
Pump coincidence factor (CF_{pump})	If unit runs 24/7/365, CF=1.0, else use 0.5	[526]~~[5256]~~
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-129 Measure Life

Equipment	EUL	RUL	Ref
Water source Pump	15	5	[528]~~[5278]~~
Ground source heat pump	25	8.33	[528]~~[5278]~~
Central A/C	15	5	[528]~~[5278]~~
Air source heat pump	15	5	[528]~~[5278]~~
PTAC/PTHP	15	5	[528]~~[5278]~~
Room air conditioner	12	4	[528]~~[5278]~~
Fossil fuel furnace	20	6.7	[528]~~[5278]~~
Electric resistance/electric furnace	20	6.7	[528]~~[5278]~~

References

~~[521]~~[522] Simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

~~[522]~~[523] VEIC estimate. Extrapolation of manufacturer data.

~~[523]~~[524] From NY TRM V11, pg 287-288

~~[524]~~[525] *Determining Electric Motor Load and Efficiency*. (DOE, 2014), pg 1, https://www.energy.gov/sites/prod/files/2014/04/f15/10097517.pdf

~~[525]~~[526] C&I Unitary HVAC Load Shape Project Final Report. August 2011, v.1.1, p. 12, Table O-5. The CF reported here is a center point for NJ chosen between the CF for urban NY and for the Mid-Atlantic region in the PJM peak periods.

~~[526]~~[527] Available at: http://www.neep.org/sites/default/files/resources/NEEP_HVAC_Load_Shape_Report_Final_August2_0.pdf

~~[527]~~[528] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

~~[528]~~[529] ASHRAE Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-5, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

~~[529]~~[530] ASHRAE Standard 90.1-2013, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-5, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

~~[530]~~[531] *§ CFR431.25 Energy conservation standards and effective dates*, (2023) Table 1, https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-431/subpart-B/subject-group-ECFR03b7039d87b7cc6/section-431.25

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

~~[531]~~[532] ASHRAE: Owning and Operating Cost Database, Equipment Life/Maintenance Cost Survey: https://xp20.ashrae.org/publicdatabase/system_service_life.asp?selected_system_type=1

3.5.4 GAS HEAT PUMPS

Market	Commercial
Baseline Condition	NC/TOS/EREP
Baseline	Code/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	March 2024
Changes Since Last Version	~~New measure~~

Description

This measure targets the use of gas heat pumps in commercial applications as further described below. Gas-fired heat pumps are a subset of heat pumps whose primary input drive energy is a gaseous fuel, instead of an electrically-driven compressor. This measure may apply to early replacement of an existing system, replacement on failure, or installation of a new unit in a new or existing commercial building for HVAC applications.

Baseline Case

For whole building new construction, the baseline equipment is a gas-fired hot water boiler, direct expansion cooling system, and a water heater all compliant with ASHRAE 90.1-2019 (see **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~).

For replacement of failed equipment, or end of useful life, the baseline is a minimally code compliant (ASHRAE 90.1-2019) version of the replaced system type and fuel.

For early replacement projects, use dual baselines:

- For the remaining useful life (RUL) of the existing equipment, the baseline is the actual existing equipment. If the site specific efficiency of the existing equipment is unknown, use the equipment efficiency from the ASHRAE 90.1 version in force when the equipment was new (if equipment vintage is unknown, use ASHRAE 90.1 2013 efficiency requirements from **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~).
- For the duration of the measure life after the end of the RUL, the baseline is a minimally code-compliant (ASHRAE 90.1-2019 or current code at end of RUL) version of the replaced equipment.

Efficient Case

A gas heat pump for space heating/cooling and domestic hot water heating that meets program eligibility requirements.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Annual Fuel Savings

$$\Delta Therms = Therms_{Space} + Therms_{DHW}$$

Where,

$$Therms_{space} = EFLH_h \times Cap_h \times \frac{(Eff_q - Eff_b)}{Eff_b \times 100{,}000}$$

$$Therms_{DHW} = (T_{out} - T_{in}) \times GPD \times 365 \times 8.33 \times 1.0 \times \left(\frac{1}{Eff_{b,DHW}} - \frac{1}{Eff_{q,DHW}}\right) \times \frac{1}{100{,}000}$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \mathrm{N/A}$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 1-2 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	

Variable	Description	Value	Units	Ref
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$\Delta Therms_{Space}$	Space Heating Savings	Calculated	Therms/yr	
$\Delta Therms_{DHW}$	Domestic hot water savings	Calculated	Therms/yr	
$EFLH_h$	Equivalent Full Load Hours of operation for the average unit during the heating season	Lookup in **Error! Reference source not found.**~~Appendix C:~~ Heating and Cooling EFLH	Hours	[512]~~[5112]~~
Cap_h	Heating capacity of qualifying unit	Site-specific	Btu/hr	
Eff_b	Efficiency of baseline space heating unit	Site-specific, if unknown look up in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~	N/A	[509]~~[5089]~~[511]~~[5101]~~
Eff_q	Space heating efficiency of gas heat pump	Site-specific	N/A	
T_{out}	Tank temperature	Site-specific, if unknown, use 125	°F	[539]~~[5389]~~
T_{in}	Supply water temperature in water main[121]	60	°F	[538]~~[5378]~~
GPD	Estimated annual hot water consumption	Site-specific , if unknown look up in Table 3-349	Gal/day	
365	Days per year	365	Day/yr	
8.33	Specific weight capacity of water	8.33	lbs/gal	
1.0	Specific heat of water	1.0	Btu/lb°F	
100,000	Conversion from Btu to Therms	100,000	Btu/Therms	
$EEF_{b,DHW}$	Rated efficiency of baseline water heater	TOS/NC: Look up in Appendix E for current code-compliant efficiency EREP: Site-specific, if unknown use code efficiency in force when equipment was new. If vintage is unknown, look up in Appendix E Table 9-8	N/A	[511]~~[5101]~~

[121] Average value across 5 NJ climate zones. Calculated from annual average ambient air temperature + 6°F

Variable	Description	Value	Units	Ref
$EEF_{q,DHW}$	Rated efficiency of the commercial gas heat pump as certified expressed as Uniform Energy Factor (UEF) or Coefficient of Performance	Site-specific COP or calculate UEF with equations in Appendix E Table 9-7	N/A	[511]~~[5101]~~
PDF	Gas peak day factor	Look up in Table 3-120~~Table 3-120~~	N/A	
EUL	Effective useful life	See Measure Life Section	Years	[514]~~[5134]~~
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Peak Factors

Table 3-130 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The effective useful life (EUL) for the gsa heat pump is 15 years [1]. The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

References

~~[532]~~[533] *2024 Illinois Statewide Technical Reference Manual for Energy Efficiency Version 12 Volume 2: Commerical and Industrial Measures* (September 2023), Pg 600, https://icc.illinois.gov/api/web-management/documents/downloads/public/il-trm-12/IL-TRM_Effective_010124_v12.0_Vol_2_C_and_I_09222023_FINAL_clean.pdf

~~[533]~~[534] ENERGY STAR Light Commercial HVAC Version 4.0, https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20LC%20HVAC%20Version%204.0%20Specification%20Rev%20April%202022.pdf?_gl=1*n9oet2*_ga*MTUwMjg5MDYyNC4xNjY0NDc5NDA0*_ga_S0KJTVVLQ6*MTY4MDU0NjcxNi4zNS4xLjE2ODA1NDY5NjAuMC4wLjA

~~[534]~~[535] ASHRAE Standard 90.1-2013, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-5, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

~~[535]~~[536] Simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

Field Code Changed

Field Code Changed

~~[536]~~[537] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

~~[537]~~[538] Burch, Jay and Christensen, Craig, *Towards Development of an Algorithm for Mains Water Temperature*. National Renewable Energy Laboratory. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.515.6885&rep=rep1&type=pdf

~~[538]~~[539] 10 CFR 430 Appendix E to Subpart B of Part 430 Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature, December 2022.

Field Code Changed

Field Code Changed

3.5.5 INFRARED HEATER

Market	Commercial/Multifamily
Baseline Condition	NC/TOS/DI
Baseline	Code/Dual
End Use Subcategory	Gas Space Heating Equipment
Measure Last Reviewed	November 2022
Changes Since Last Version	~~Corrected statewide HDD value~~

Description

This measure outlines the savings for the installation of a gas-fired, low intensity infrared (IR) heating system in place of a unit heater, furnace, or other standard efficiency equipment in commercial and industrial facilities.

Savings are based on the reduced input capacity requirement with the radiant heating of an IR Heater (efficient) as opposed to convective heating of a conventional heating system (baseline). The thermal efficiency is assumed to be equivalent between the baseline and efficient case.

The algorithms do not include potential savings as a result of a few baseline assumptions. For example, if the baseline is assumed to be a furnace, there will be kwh savings associated with reduction in fan energy reduction.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

Code-compliant furnace, unit heater, or other standard efficiency equipment. For new construction, a gas-fired warm unit heater shall be assumed.

Efficient Case

The efficient case condition is a low-intensity, gas-fired infrared heater. The prescribed methodology assumes a reduction of 10°F to maintain occupant comfort. [542]~~[5412]~~

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Annual Fuel Savings

$$\Delta Therms = Cap_{in} * \left(1 - \frac{HDD_{55}/(55 - T_{design})}{HDD_{65}/(65 - T_{design})}\right) * \frac{EFLH_h}{100}$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-131 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
Cap_{in}	Input capacity of qualifying unit	Site-specific	kBtu/hr	
HDD_{55}	Heating degree days: number of degrees the average daily temperature is below 55°F	Look up in Table 3-132	°F-day	[540]~~[539~~540]

Variable	Description	Value	Units	Ref
HDD_{65}	Heating degree days: number of degrees the average daily temperature is below 65°F	Look up in Table 3-132	°F-day	[540]~~[539540]~~
T_{design}	Equipment design temperature	Look up in Table 3-132	°F	[543]~~[5423]~~
$EFLH_h$	Equivalent Full Load Hours of operation for the average unit during the heating season	See **Error! Reference source not found.**~~Appendix C: Heating and Cooling EFLH~~	hour/yr	[541]~~[5401]~~
100	Conversion from kBtu to therms	100	kBtu/therms	
CF	Electric coincidence factor	Look up in Table 3-133	N/A	
PDF	Gas peak day factor	Look up in Table 3-133	N/A	
EUL	Effective useful life	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 3-132 Heating Degree Days and Equipment Design Temperature

Climate Zone	HDD_{65}	HDD_{55}	T_{design}
Northern	6,136	3,759	8.1
Central	5,588	3,331	11.6
Pine Barrens	5,529	3,294	10.5
Southwest	5,658	3,418	13.8
Coastal	4,795	2,573	11.6
Statewide Average	5,553	3,288	11.1

Peak Factors

Table 3-133 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

Table 3-134 Measure Life

Equipment	EUL	RUL	Ref
Infrared Heater	17	5.7	[545]~~[5445]~~

References

~~[539]~~[540] TMY3 data for NJ climate zone representative cities: Northern – Allentown, PA; Central – Trenton, NJ; Pine Barrens – McGuire AFB NJ; Southwest – Philadelphia, PA International Airport; Coastal – Atlantic City, NJ.

~~[540]~~[541] Simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

~~[541]~~[542] 2012 ASHRAE Handbook – HVAC Systems and Equipment, Chapter 16, Infrared Radiant Heating.

~~[542]~~[543] ASHRAE Fundamentals 2021, Chapter 14 Climactic Design Conditions, https://handbook.ashrae.org/Handbook.aspx#. Based on NJ climate zone representative cities: Northern – Allentown, PA; Central – Trenton, NJ; Pine Barrens – McGuire AFB NJ; Southwest – Philadelphia, PA International Airport; Coastal – Atlantic City, NJ.

~~[543]~~[544] GDS Associates, Inc. "Natural Gas Efficiency Potential Study." DTE Energy. July 29, 2016. Available from: https://www.michigan.gov/documents/mpsc/DTE_2016_NG_ee_potential_study_w_appendices_vFINAL_554360_7.pdf

~~[544]~~[545] California Public Utilities Commission EUL Table, version 027 (updated November 12, 2022). Accessed December 30, 2022. https://www.caetrm.com/shared-data/value-table/EUL/

Field Code Changed

3.5.6 ~~FURNACES, UNIT HEATERS~~GAS FORCED AIR AND ~~BOILERS~~HYDRONIC HEATING

Market	Commercial/Multifamily
Baseline Condition	NC/TOS/DI/EREP
Baseline	Code/ISP/Dual
End Use Subcategory	Gas Space Heating Equipment
Measure Last Reviewed	November 2022
Changes Since Last Version	• ~~Corrected capacity parameter nomenclature in~~ • Renamed measure to "gas forced air and hydronic heating" • Updated algorithm to account for equipment oversizing

Description

This measure encourages the installation of high-efficiency, natural gas-fired furnaces, unit heaters and closed loop space heating boilers meeting program eligibility requirements. Equipment sizing assumes compliance with ASHRAE 90.1 - 2019 sizing requirements.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

For NC and TOS programs, , the baseline unit is a code compliant unit of the same type and size as the installed unit with efficiency as required by ASHRAE Std. 90.1 – 2019 and IECC 2021, which are the current codes adopted by the State of New Jersey (see **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~). For New Construction, an Industry Standard Practice baseline which is 15% more efficient than Code applies to furnaces.

For early replacement projects, use dual baselines:

- For the remaining useful life of the existing equipment, the baseline is the actual existing equipment if the site specific efficiency of the existing equipment is unknown, use the ASHRAE 90.1-2013 efficiency for the existing equipment type (see **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~).
- For the duration of the measure life, the baseline is a code-compliant unit of the same type and size of the installed unit with efficiency as required by ASHRAE Std. 90.1 – 2019 and IECC 2021 (see **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~).

Efficient Case

Equipment with an efficiency higher than Code or ISP that meets program eligibility requirements. No size limits on furnaces or unit heaters.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = kWh_b - kWh_q$$

Where,

$$kWh_b = \frac{Cap_{out}}{HSPF_b \times 1{,}000} \times EFLH_h \; (Electric\ Resistance\ Baseline)$$

$$kWh_b = 0 \; (Gas\ Equipment\ Baseline)$$

$$kWh_q = 0$$

Annual Fuel Savings

$$\Delta Therms = Therms_b - Therms_q$$

Where,

$$Therms_b = \cancel{\frac{Cap_{out}}{Eff_{AF} \times Eff_b \times 100{,}000}} \frac{Cap_{out} \times F_{os}}{Eff_{AF} \times Eff_b \times 100{,}000} \times EFLH_h \; (Gas\ Equipment\ Baseline)$$

$$Therms_b = 0 \; (Electric\ Baseline)$$

$$Therms_q = \cancel{\frac{Cap_h}{Eff_q \times 100{,}000}} \frac{Cap_{out}}{Eff_q \times 100{,}000} \times EFLH_h$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-135 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Lifetime}$	Lifetime fuel savings	Calculated	Therms	
Cap_{out}	Output capacity of qualifying unit	Site-specific	Btu/hr	
Eff_q	Equipment Proposed Efficiency	Site-specific	Varies	
$HSPF_b$	Heating seasonal performance factor of baseline electric unit	3.412		
$EFLH_h$	Equivalent Full Load Hours of operation for the average unit during the heating season	Look up in Error! Reference source not found.~~Appendix C: Heating and Cooling EFLH~~	Hrs/yr	[546]~~[5456]~~
Eff_b	Gas equipment baseline efficiency	Look up in Table 3-136	Varies	[547]~~[5467]~~[548]~~[5478]~~
Eff_{AF}	Equipment baseline efficiency ISP adjustment Factor	1.15 (New Construction furnaces only) 1.0 (all others)	N/A	[549]~~[5489]~~
F_{os}	Factor to account for baseline efficiency degradation when equipment is oversized more than the standard assumption	0.9	N/A	[553]
1,000	Conversion factor	1,000	Watts/kW	
100,000	Conversion factor	100,000	Btu/Therm	
CF	Electric coincidence factor	Look up in Table 3-137 Peak Factors	N/A	

Variable	Description	Value	Units	Ref
PDF	Gas peak day factor	Look up in Table 3-137 Peak Factors	N/A	
EUL	Effective useful life	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 3-136 Baseline Efficiencies

Equipment	Type	Size Category (kBtu input)	ASHRAE Standard 90.1-2019 Efficiency
Furnace	Gas Fired	< 225	Nonweatherized 80% AFUE Weatherized 81% AFUE or 80% Et
	Gas Fired	≥ 225	81% Et
	Oil Fired	< 225	Nonweatherized excluding mobile home 83% AFUE Nonweatherized mobile home 75% AFUE Weatherized 78% AFUE
	Oil Fired	≥ 225	82% Et
Unit Heater	Gas Fired, Oil Fired	All Capacities	80% Ec
Hot Water Boiler	Gas Fired	<300	82% AFUE
		≥300 and ≤ 2,500	80% Et
		>2,500	82% Ec
	Oil Fired	<300	84% AFUE
		≥300 and ≤ 2,500	82% Et
		>2,500	84% Ec
Steam Boiler	Gas Fired	<300	82% AFUE
	Gas Fired All Except Natural Draft	≥300 and ≤ 2,500	79% Et
		>2,500	79% Et
	Gas Fired Natural Draft	≥300 and ≤ 2,500	79% Et
		>2,500	79% Et
	Oil Fired	<300	85% AFUE
		≥300 and ≤ 2,500	81% Et
		>2,500	81% Et

Peak Factors

Table 3-137 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-138 Measure Life

Equipment	EUL	RUL	Ref
Furnace	20	6.67	[550]~~[549550]~~
Unit Heater	18	6	[551]~~[5501]~~
Boiler	20	6.67	[550]~~[549550]~~
Electric Resistance Heating	20	6.67	[552]~~[5512]~~

References

~~[545]~~[546] Simulations of prototypical buildings from the NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

~~[546]~~[547] *ASHRAE Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings*. (ASHRAE, 2019), Table 6.8.1-5, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

~~[547]~~[548] *2021 INTERNATIONAL ENERGY CONSERVATION CODE (IECC) | ICC DIGITAL CODES* (IECC 2021), Table C403.3.2(5) https://codes.iccsafe.org/content/IECC2021P2/chapter-4-ce-commercial-energy-efficiency

~~[548]~~[549] *New Jersey Commercial New Construction Industry Standard Practice Analysis.* Prepared for Rutgers University by DNV. June 2022.

~~[549]~~[550] California Database of Energy Efficient Resources (DEER) http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx

~~[550]~~[551] Ecotope, *Natural Gas Efficiency and Conservation Measure Resource Assessment*, 2003, section 5.2.3, https://ecotope-publications-database.ecotope.com/2003_007_NaturalGasEfficiency.pdf

~~[551]~~[552] *Energy Saver 101: Everything you need to know about Home Heating* ~~https://www.energy.gov/sites/prod/files/2014/01/f6/homeHeating.pdf~~https://www.energy.gov/sites/prod/files/2014/01/f6/homeHeating.pdf

[553] Placeholder assumption based on NREL simulation model relationships between efficiency and part load ratio

Field Code Changed

Field Code Changed

Field Code Changed

3.5.7 BOILER CONTROLS

Market	Commercial/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	November 2022

Description

Boiler reset controls automatically adjust the boiler water temperature based on the outdoor air temperature. Boiler cut-out controls use sensors to determine when outside air has reached a specific temperature and turn off the boiler and its connected heating system. Optionally, a timer to control when heating equipment comes on and when it goes off may also be included. These controls are most often installed together using controls that accomplish both functions.

This measure is limited to cut-out controls on non-condensing boilers since boiler reset savings is minimal for non-condensing boilers. Both boiler reset and cut-out controls are applicable to condensing boilers.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

Existing boiler without controls.

Efficient Case

Installation of boiler reset and/or cut-out controls. The system's minimum temperature setpoint must be set no more than 10 degrees above manufacturer's recommended minimum return temperature.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Annual Fuel Savings

$$\Delta Therms = SF \times \frac{EFLH_h \times Cap_{in}}{100}$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = N/A$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EU$$

Calculation Parameters

Table 3-139 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
SF	Savings Factor: estimated percent reduction in heating load due to controls being installed.	Lookup in Table 3-140	%	[554]~~[5524]~~ [555]~~[5535]~~
$EFLH_h$	Equivalent full load hours for heating	Look up in **Error! Reference source not found.**~~Appendix C:~~	hrs	[556]~~[5546]~~
Cap_{in}	Input capacity of boiler	Site-specific	kBtu/hr	
EUL	Effective useful life	See Measure Life Section	yrs	
100	Conversion from kBtu to therm	100	kBtu	

Table 3-140 Savings Percentage

Control Type	Savings	Ref
Boiler Reset	5.0%	[554]~~[5524]~~
Boiler Cut-Out	1.7%	[555]~~[5535]~~
Boiler Reset & Cut-Out	5%	

Peak Factors

Table 3-141 Peak Factors

Peak Factor	Value	Ref
Coincidence Factor (CF)	N/A	
Natural gas peak day factor (PDF)	**Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The effective useful life (EUL) of boiler controls is limited to the smaller of the measure life or the remaining useful life (RUL) of the boiler. If boiler RUL unknown, assume 1/3 of the boiler EUL.

Table 3-142 Measure Life

Equipment	EUL	RUL	Ref
Boiler Controls	Smaller of: boiler RUL or 7.33	N/A	
Boiler (steel water-tube)	22	7.33	[557]~~[5557]~~
Boiler (steel fire-tube)	25	8.33	[557]~~[5557]~~
Boiler (cast iron)	35	11.67	[557]~~[5557]~~

References

~~[552]~~[554] GDS Associates, Inc. Natural Gas Energy Efficiency Potential in Massachusetts, 2009, p. 38 Table 6-4. https://ma-eeac.org/wp-content/uploads/5_Natural-Gas-EE-Potenial-in-MA.pdf

~~[553]~~[555] Arkansas Technical Reference Manual, Version 9.1, Volume 2, page 223 , https://apsc.arkansas.gov/wp-content/uploads/AR_TRM_V9.1_Volume_1_2_and_3_on_8-31-22.pdf

~~[554]~~[556] Simulations of prototypical buildings from the NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022.

~~[555]~~[557] ASHRAE Handbook 2019, HVAC Applications. Chapter 38 *Owning and Operating Costs*, Table 4.

Field Code Changed

3.5.8 BOILER ECONOMIZER

Market	Commercial/Multifamily
Baseline Condition	NC/RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	November 2022

Description

This measure covers the installation of a boiler economizer, also known as stack economizers and feedwater economizers. Boiler economizers are designed to recover heat from hot flue gases which is then used to pre-heat boiler feedwater thereby reducing heating requirements. Condensing and conventional non-condensing economizers are the two principal types of boiler economizers.

Non-condensing or conventional economizers are typically air-to-water heat exchangers and operate above the flue gas dew point to avoid condensation [558]~~[5568]~~.

Condensing economizers allow condensing of the exhaust gas components and reduce the flue gas temperature below its dew point. This results in latent heat being recaptured, thereby improving the effectiveness of waste heat recovery [560]~~[558560]~~.

This measure is applicable to the installation of condensing and non-condensing economizers on boilers serving space heating loads and process loads and is restricted to non-condensing, forced draft burner boilers.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

The baseline condition is a non-condensing, forced draft burner boiler serving space heating or process loads without a boiler economizer.

Efficient Case

The compliance condition is a non-condensing, forced draft burner boiler serving space heating or process loads with a non-condensing or condensing boiler economizer.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Annual Fuel Savings

Economizer for Boilers Serving HVAC Loads:

$$\Delta Therms = Cap_{in} \times \frac{ESF \times EFLH_h}{100}$$

Where,

$$ESF = \frac{T_b - T_q}{40} \times TRE$$

Economizer for Boilers Serving Process Loads:

$$\Delta Therms = Cap_{in} \times \frac{ESF \times 8{,}766 \times UF}{100}$$

Where,

$$ESF = \frac{T_b - T_q}{40} \times TRE$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = N/A$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-143 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	

Variable	Description	Value	Units	Ref
ESF	Energy Savings Factor	Calculated	N/A	[561]~~[559~~561]
Cap_{in}	Input capacity of qualifying unit	Site-specific	kBtu/hr	
T_b	Baseline full-fire boiler flue gas temperature as it exits the stack	Site-specific. If unknown, use the default of 420°F for hot water boilers and 500°F for steam boilers[122]	°F	[562]~~[560~~2]
T_q	Energy efficient full-fire boiler flue gas temperature as it exits the stack	Site-specific. If unknown, look up in Table 3-144	°F	[559]~~[557~~9]
TRE	Temperature Reduction Efficiency; percentage efficiency increases for stack temperature reduction, per 40ºF reduction in net stack temperature	Site-specific. If unknown, use a default of 0.01	N/A	[561]~~[559~~561]
$EFLH_h$	Equivalent Full Load Hours of operation for the average unit during the heating season	Look up in **Error! Reference source not found.**~~Appendix C:~~	Hrs/yr	[562]~~[560~~2]
100	Conversion from kBtu to therms	100	kBtu/Therms	
40	Stepped reduction in net stack temperature, in ºF	40	°F	
8,766	Process load boiler operating hours	8,766	Hrs/yr	[565]~~[563~~5]
UF	Utilization factor	0.419	N/A	[565]~~[563~~5]
PDF	Gas peak day savings factor	Look up in Table 3-145	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-144 Energy Efficient Boiler Flue Gas Temperature

Equipment Type	Conventional Economizer[123,124]	Condensing Economizer[125,126]
Hot Water Boiler	335 °F	247.5 °F
Steam Boiler	375 °F	287.5 °F

[122] Assumes hot water boiler efficiency of 82% and steam boiler efficiency of 80%

[123] As cited in U.S. DOE, Steam Tip Sheet #26A, Consider Installing a Condensing Economizer, the minimum stack temperature for a non-condensing economizer is 250°F. The average temperature drop is assumed to be halfway between the baseline and efficient temperature minimum: (420°F + 250°F) / 2 = 335°F

[124] Ibid, the minimum stack temperature for a non-condensing economizer is 250°F: (500°F + 250°F) / 2 = 375°F

[125] Ibid, the minimum stack temperature for a condensing economizer is 75°F: (420°F + 75°F) / 2 = 247.5°F

[126] Ibid, the minimum stack temperature for a condensing economizer is 75°F: (500°F + 75°F) / 2 = 287.5°F

Peak Factors

Table 3-145 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The effective useful life (EUL) of the boiler economizer is limited to the remaining useful life (RUL) of the boiler. If unknown, assume 1/3 of the boiler EUL.

Table 3-146 Measure Life

Equipment	EUL	RUL	Ref
Boiler	20	6.67	[557]~~[5557]~~

References

~~[556]~~[558] US DOE, "Improving Steam System Performance: A Sourcebook for Industry, Second Edition", 2004. https://www.energy.gov/sites/prod/files/2014/05/f15/steamsourcebook.pdf

~~[557]~~[559] US DOE, "ADVANCED MANUFACTURING OFFICE Energy Tips: STEAM Steam Tip Sheet #26A." n.d. https://www.energy.gov/sites/prod/files/2014/05/f16/steam26a_condensing.pdf

~~[558]~~[560] US DOE, "ADVANCED MANUFACTURING OFFICE Energy Tips: STEAM Steam Tip Sheet #26B." n.d. https://www.energy.gov/sites/prod/files/2014/05/f16/steam26b_condensing.pdf

~~[559]~~[561] US DOE, "ADVANCED MANUFACTURING PROGRAM Energy Tips: STEAM Steam Tip Sheet #3 Use Feedwater Economizers for Waste Heat Recovery." n.d. https://www.energy.gov/sites/prod/files/2014/05/f16/steam3_recovery.pdf

~~[560]~~[562] ECCCNYS 2020 Table C403.3.2(5): Minimum Efficiency Requirements: Gas- And Oil-Fired Boilers & Table C404.2: Minimum Performance of Water Heating Equipment. https://codes.iccsafe.org/content/NYSECC2020P1/chapter-4-ce-commercial-energy-efficiency

~~[561]~~[563] Simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

~~[562]~~[564] California Database of Energy Efficient Resources (DEER). http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

~~[563]~~[565] *2022 Illinois Statewide Technical Reference Manual for Energy Efficiency Version 10.0: Volume 2* (2022), Pg 357. https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010122_v10.0_Vol_2_C_and_I_09242021.pdf

Field Code Changed

3.5.9 GAS CHILLERS

Market	Commercial/Multifamily
Baseline Condition	TOS/NC
Baseline	Code
End Use Subcategory	Equipment
Measure Last Reviewed	January 2023
Changes Since Last Version	~~Corrected EFLHc nomenclature in parameter table~~

Description

This measure describes the energy savings resulting from installing a gas-fueled absorption chiller more efficient than code. The calculation of energy savings for C&I gas fired chillers and in time of sale and new construction applications is based on algorithms with key variables captured on the application form or from manufacturer's data sheets.

Note that this measure applies to only absorption chillers, in keeping with ASHRAE 90.1-2019 efficiency specifications. For other types of gas chillers, or complex cooling systems, consider using a custom analysis approach.

Baseline Case

Minimally code-compliant gas-fueled absorption chiller with a baseline efficiency as defined in ASHRAE 90.1-2019.

Efficient Case

A new efficient gas-fueled absorption chiller, more efficient than code.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Annual Fuel Savings

$$\Delta Therms = Cap \times (\frac{1}{COP_b} - \frac{1}{COP_q}) \times EFLH_c \times 10$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = N/A$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-147 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{winter}$	Annual winter fuel savings	Calculated	Therms/yr	
$Therms_{summer}$	Annual summer fuel usage	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
IR	Input rating	Site-specific	MMBtu/hr	
Cap	Cooling capacity of gas chiller	Site-specific	MMBtu/hr	
COP_b	Coefficient of performance of baseline unit	Site-specific, if unknown look up in Table 3-148	N/A	[567]~~[5657]~~
COP_q	Coefficient of performance of energy efficient unit	Site-specific	N/A	
$EFLH_c$	Equivalent full load hours, cooling	Look up in **Error! Reference source not found.**~~Appendix C:~~		
CF	Electric coincidence factor	Look up in Table 3-149	N/A	
PDF	Gas peak day factor	Look up in Table 3-149	N/A	
10	Unit conversion, Therms/MMBtu	10	Therms/MMBtu	

Variable	Description	Value	Units	Ref
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-148 Minimum Gas Chiller Efficiencies, AHRAE 90.1-2019

Equipment	Minimum COP
Air cooled absorption, single effect	0.6 FL
Water cooled absorption, single effect	0.7 FL
Absorption double effect, indirect fired	1.0 FL 1.05 IPLV
Absorption double effect, direct fired	1.0 FL 1.0 IPLV

Peak Factors

Table 3-149 Peak Factors

Peak Factor	Value
Electric coincidence factor (CF)	N/A
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~

Measure Life

The effective useful life (EUL) is 20 years [566]~~[5646]~~.

References

~~[564]~~[566] DEER 2014
~~[565]~~[567] ASHRAE 90.1 2019 Table 6.8.1-3

3.5.10 ELECTRIC CHILLERS

Market	Commercial/Multifamily
Baseline Condition	TOS/NC/EREP
Baseline	Code/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	December 2022
Changes Since Last Version	~~Updated measure to accommodate EREP baseline condition~~

Description

This prescriptive measure targets the use of electric chillers in all commercial facilities.

This measure applies to new construction, replacement of failed equipment, or end of useful life. The baseline chiller is a minimally code-compliant chiller with an efficiency as required by ASHRAE Std. 90.1 – 2019, which is the current code adopted by the state of New Jersey.

Baseline Case

New Construction/Replacement of Failed Equipment/End of Useful Life: Chiller compliant with ASHRAE Std. 90.1–2019.

Early replacement: Use dual baseline. Baseline is site-specific pre-existing equipment for first baseline period. Baseline is chiller compliant with ASHRAE Std. 90.1-2019 for second baseline period.

Efficient Case

Chiller with an efficiency greater than code.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = Tons \times EFLH_c \times (IPLV_b - IPLV_q)$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = Tons \times CF \times (FLV_b - FLV_q)$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-150 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Tons/Unit	Rated capacity of cooling equipment.	Site-specific	Tons	
$IPLV_b$	Integrated Part Load Value of baseline equipment, the efficiency of the chiller under partial-load conditions	TOS/NC: Look up in Table 3-151 EREP: Site-specific. If unknown, look up in Table 3-151	kW/ton	[569]~~[5679]~~
$IPLV_q$	Integrated Part Load Value of qualifying unit, the efficiency of the chiller under partial-load conditions	Site-specific	kW/ton	

Variable	Description	Value	Units	Ref
FLV_b	Full Load Value of baseline equipment, the efficiency of the chiller under full-load conditions	TOS/NC: Look up in Table 3-151 EREP: Site-specific. If unknown, look up in Table 3-151	kW/ton	[569]~~[5679]~~
FLV_q	Full Load Value of qualifying equipment, the efficiency of the chiller under full-load conditions	Site-specific	kW/ton	
$EFLH_c$	Equivalent Full Load Cooling Hours	Look up in **Error! Reference source not found.**~~Appendix C: Heating and Cooling EFLH~~	hr	[570]~~[568570]~~
CF	Electric coincidence factor	Table 3-152	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-151 Water-Chilling Minimum Efficiency, ASHRAE 90.1–2019 (Table 6.8.1-3)

Equipment Type	Size Category	Path A		Path B	
		FLV (kW/ton)	IPLV (kW/ton)	FLV (kW/ton)	IPLV (kW/ton)
Air Cooled	tons < 150	1.188	0.876	1.237	0.759
	tons > 150	1.188	0.857	1.237	0.745
Water Cooled Positive Displacement (rotary screw and scroll)	tons < 75	0.750	0.600	0.780	0.500
	75 +< tons < 150	0.720	0.560	0.750	0.490
	150 =< tons < 300	0.660	0.540	0.680	0.440
	300 =< tons < 600	0.610	0.520	0.625	0.410
	tons => 600	0.560	0.500	0.585	0.380
Water Cooled Centrifugal	tons < 150	0.610	0.550	0.695	0.440
	150 < tons < 300	0.610	0.550	0.635	0.400
	300 < tons < 400	0.560	0.520	0.595	0.390
	400 < tons < 600	0.560	0.500	0.585	0.380
	tons > 600	0.560	0.500	0.585	0.380

Notes:

1. Path A is generally used with equipment designed to maximize full load efficiency. Either Path A or Path B may be used to demonstrate compliance.
2. Path B is generally used with equipment designed to maximize part-load efficiency. Either Path A or Path B may be used to demonstrate compliance.

3. Typically, constant speed chillers use Path A values whereas variable speed chillers use Path B values.

Peak Factors

Table 3-152 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.67	[568]~~[5668]~~
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 23 years. [571]~~[569571]~~

References

~~[566]~~[568] New Jersey Board of Public Utilities, *New Jersey's Clean Energy Program Protocols to Measure Resource Savings: FY2022 Addendum*. (New Jersey Board of Public Utilities, 2022), pg 27.

~~[567]~~[569] ASHRAE Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-3. https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

~~[568]~~[570] Simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022.

~~[569]~~[571] GDS Associates, Inc. 2007. *Measure Life Report Residential and Commercial/Industrial Lighting and HVAC Measures*. Prepared for the New England State Program Working Group (SPWG).

Field Code Changed

3.5.11 MAKE-UP AIR UNIT

Market	Commercial/Multifamily
Baseline Condition	TOS/NC/DI
Baseline	Code/Dual
End Use	HVAC
Measure Last Reviewed	December 2022

Description

This section provides energy savings algorithms for make-up air systems in commercial applications. These systems utilize an indirect gas-fired process to heat 100% outside air (OA) to provide ventilation or make-up air to commercial and industrial spaces. The unitary package must contain an indirect gas-fired warm air furnace section.

The annual OA heating load per cfm of OA (Q_{OA}) was determined for each New Jersey location by scaling the heating load derived from the Illinois TRM V9.0 using heating degree days for each location.

The IL TRM Q_{OA} Values were determined based on hourly differences between a range of supply air temperatures (SAT) and outside air temperature (OAT) using TMY3 Data. 3 different base temperatures were used to calculate the heating loads, 45 °F, 55 °F, and 65 °F. The loads are then summed for the entire year.

To determine the appropriate value, follow the guidance below to use Table 3-154 through Table 3-166.

First, select the most representative operating schedule for the application from among the four scenarios listed below. Second, select the representative HDD base temperature. If that base temperature is not readily determined, select the TRM default base temperature of 55 °F (HDD55) for heating in C&I settings. Third, select the climate zone. Fourth, select an appropriate heated to supply air (SA) temperature. Use the resulting Q_{OA} value.

The four scenarios available are indicative of the following building applications and operating schedules:

1. 24-hour-a-day and 7-day-a-week (24/7) operation, with HVAC operating schedule of 8,760 hours per year, typical of large retail stores with DOAS, hotel/multifamily buildings with corridor MUAS, and healthcare facilities with DOAS. Use Table 3-155 through Table 3-157.
2. 6:00 AM to 1:00 AM every day operation, with HVAC operating schedule of 7,300 hours per year, typical of full service and quick service restaurants with kitchen MUAS. Use Table 3-158 through Table 3-160.
3. 7:00 AM to 9:00 PM Monday-Friday, 7:00 AM to 10:00 PM Saturday, and 9:00 AM to 7:00 PM Sunday operations, with HVAC operating schedule of 5,266 hours per year, typical of non-24/7 retail stores with DOAS. Use Table 3-161 through Table 3-163.
4. 7:00 AM to 9:00 PM Monday-Friday operation, with HVAC operating schedule of 3,911 hours per year, typical of school buildings with DOAS. Use Table 3-164 through Table 3-166.

Baseline Case

The baseline case is a make-up air unit that contains a non-condensing gas-fired warm air furnace compliant with ASHRAE Std. 90.1 – 2019 and IECC 2021.

Efficient Case

The efficient case is an efficient make-up air unit that contains a condensing gas-fired warm air furnace with a thermal efficiency higher than code.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = \frac{t_{fan} \times CFM \times \Delta P}{Eff_{fan,motor} \times 8{,}520}$$

Annual Fuel Savings

$$\Delta Therms = \frac{Q_{OA} \times CFM \times \left(\frac{1}{Eff_b} - \frac{1}{Eff_q}\right)}{100{,}000}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{t_{fan}} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms:

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-153 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
t_{fan}	Supply air fan runtime	Use one of the 4 scenarios in the description above	Hours	
CFM	Supply fan airflow	Site-specific	ft^3/min	
ΔP	Additional pressure drop of the condensing heat exchanger of warm air furnace section	-0.15	Inch w.g.	[572]~~[5702]~~
$Eff_{fan,motor}$	Combined fan and motor efficiency	0.6	N/A	[572]~~[5702]~~
8,520[127]	Conversion factor	8,520	N/A	
Q_{OA}	Annual outside air heating load per cfm of OA	Look up in Table 3-155 through Table 3-166	Btu/cfm	[572]~~[5702]~~
Eff_b	Baseline non condensing efficiency	Look up in Table 3-154	N/A	[573]~~[5713]~~
Eff_q	Efficient condensing efficiency	Site-specific. Use the same efficiency metric as Eff_b	N/A	
100,000	Conversion from Btu to therm	100,000	Btu/therm	
CF	Electric coincidence factor	Look up in Table 3-167	N/A	
PDF	Gas peak demand factor	Look up in Table 3-167	N/A	
EUL	Effective useful life	See Measure Life ~~Measure Life~~ Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life ~~Measure Life~~ Section	Years	

[127] Fan horsepower (HP) calculation constant of 6,356 for standard air conditions adjusted by 1 HP = 0.746 kW, or (6,356 / 0.746) = 8,520 for this kW calculation.

Table 3-154 Furnace Baseline Efficiencies

Furnace Type	Size Category (kBtu input)	Standard 90.1-2019
Gas Fired	< 225	Nonweatherized 80% AFUE Weatherized 81% AFUE
Gas Fired	≥ 225	81% Et
Oil Fired	< 225	Nonweatherized excluding mobile home 83% AFUE Nonweatherized mobile home 75% AFUE Weatherized 78% AFUE
Oil Fired	≥ 225	82% Et

Table 3-155 8760 Annual Operation Scenario for HDD45

t_{fan} = 8760 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
Northern	138,650	169,078	199,506	229,934
Southwest	123,809	150,980	178,151	205,322
Coastal	76,756	93,601	110,446	127,291
Central	117,464	143,242	169,021	194,800
Pine Barrens	115,338	140,651	165,962	191,275
Statewide Average	115,016	140,258	165,499	190,741

Table 3-156 8760 Hour Annual Operation Scenario for HDD55

t_{fan} = 8760 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
Northern	182,976	227,595	272,214	316,833
Southwest	166,370	206,940	247,510	288,079
Coastal	125,238	155,777	186,317	216,856
Central	162,154	201,695	241,236	280,777
Pine Barrens	160,335	199,433	238,531	277,628
Statewide Average	160,051	199,079	238,108	277,136

Table 3-157 8760 Hour Annual Operation Scenario for HDD65

t_{fan} = 8760 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
Northern	218,007	280,807	343,606	406,405
Southwest	201,016	258,922	316,827	374,732
Coastal	170,353	219,425	268,498	317,570
Central	198,527	255,715	312,904	370,091
Pine Barrens	196,445	253,034	309,623	366,211
Statewide Average	197,376	254,232	311,089	367,945

Table 3-158 7300 Annual Operation Scenario for HDD45

t_{fan} = 7300 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
Northern	111,241	135,739	160,237	184,734
Southwest	99,334	121,210	143,085	164,960
Coastal	61,583	75,145	88,707	102,268
Central	94,243	114,998	135,752	156,506
Pine Barrens	92,538	112,917	133,296	153,674
Statewide Average	92,280	112,602	132,924	153,245

Table 3-159 7300 Annual Operation Scenario for HDD55

t_{fan} = 7300 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
Northern	146,885	182,811	218,738	254,664
Southwest	133,554	166,220	198,886	231,552
Coastal	100,535	125,125	149,715	174,305
Central	130,169	162,007	193,845	225,683
Pine Barrens	128,709	160,190	191,671	223,152
Statewide Average	128,481	159,906	191,331	222,756

Table 3-160 7300 Annual Operation Scenario for HDD65

t_{fan} = 7300 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
Northern	174,841	225,198	275,554	325,911
Southwest	161,214	207,647	254,079	300,512
Coastal	136,622	175,972	215,321	254,671
Central	159,218	205,075	250,932	296,790
Pine Barrens	157,549	202,925	248,301	293,678
Statewide Average	158,295	203,886	249,477	295,069

Table 3-161 5266 Annual Operation Scenario for HDD45

t_{fan} = 5266 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
Northern	76,284	93,254	110,223	127,194
Southwest	68,118	83,272	98,425	113,579
Coastal	42,231	51,625	61,019	70,414
Central	64,627	79,004	93,381	107,758
Pine Barrens	63,458	77,575	91,691	105,808
Statewide Average	63,281	77,358	91,435	105,513

Table 3-162 5266 Annual Operation Scenario for HDD55

t_{fan} = 5266 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
Northern	100,163	124,786	149,408	174,031
Southwest	91,073	113,461	135,848	158,237
Coastal	68,557	85,409	102,262	119,115
Central	88,765	110,585	132,405	154,226
Pine Barrens	87,769	109,345	130,920	152,496
Statewide Average	87,614	109,151	130,688	152,226

Table 3-163 5266 Annual Operation Scenario for HDD65

t_{fan} = 5266 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
Northern	119,326	153,797	188,268	222,738
Southwest	110,026	141,810	173,595	205,378
Coastal	93,242	120,178	147,114	174,049
Central	108,663	140,054	171,445	202,835
Pine Barrens	107,524	138,586	169,647	200,708
Statewide Average	108,033	139,242	170,451	201,659

Table 3-164 3911 Annual Operation Scenario for HDD45

t_{fan} = 3911 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
Northern	54,942	67,170	79,398	91,626
Southwest	49,061	59,980	70,900	81,819
Coastal	30,416	37,185	43,955	50,724
Central	46,546	56,906	67,266	77,625
Pine Barrens	45,704	55,876	66,049	76,221
Statewide Average	45,577	55,720	65,865	76,008

Table 3-165 3911 Annual Operation Scenario for HDD55

t_{fan} = 3911 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
Northern	72,525	90,433	108,340	126,247
Southwest	65,943	82,225	98,507	114,789
Coastal	49,640	61,896	74,153	86,410
Central	64,272	80,141	96,011	111,880
Pine Barrens	63,551	79,242	94,934	110,625
Statewide Average	63,438	79,102	94,766	110,429

Table 3-166 3911 Annual Operation Scenario for HDD65

t_{fan} = 3911 Hours	Q_{oa} (Annual Btu/cfm) At Supply Air Temperature Of			
Climate Zone - Weather Station/City	75°F	85°F	95°F	105°F
Northern	87,018	112,390	137,763	163,136
Southwest	80,236	103,631	127,026	150,422
Coastal	67,996	87,823	107,649	127,476
Central	79,242	102,348	125,453	148,559
Pine Barrens	78,411	101,275	124,138	147,001
Statewide Average	78,782	101,754	124,725	147,697

Peak Factors

Table 3-167 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1	[572]~~[5702]~~
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-168 Measure Life

Equipment	EUL	RUL	Ref
Make-up Air Unit	15	5	[574]~~[5724]~~

References

~~[570]~~[572] *2022 Illinois Statewide Technical Reference Manual for Energy Efficiency V10: Volume 2 Commercial and Industrial Measures*. (2021), Pg 405-412, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010122_v10.0_Vol_2_C_and_I_09242021.pdf.

~~[571]~~[573] ASHRAE Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-5, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards.

~~[572]~~[574] DEER 2014 EUL http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx.

Field Code Changed

Field Code Changed

Field Code Changed

3.5.12 HEAT OR ENERGY RECOVERY VENTILATOR

Market	Commercial/Multifamily
Baseline Condition	NC/RF/TOS
Baseline	Code/Existing
End Use Subcategory	Heat Recovery
Measure Last Reviewed	January 2023

Description

This measure covers the installation of Energy Recovery Ventilators (ERV) and Heat Recovery Ventilators (HRV). ERVs and HRVs reduce heating and cooling loads while maintaining required ventilation rates by facilitating heat transfer between outgoing conditioned air and incoming outdoor air. ERVs and HRVs employ air-to-air heat exchangers to recover energy from exhaust air for the purpose of pre-conditioning outdoor air prior to supplying the conditioned air to the space, either directly or as part of an air-conditioning system. For new construction, this measure only applies in cases where ERV/HRV functionality is not required by federal, state, local or municipal codes or standards. This measure is also applicable to retrofit of existing buildings. For the purposes of this measure, ERVs and HRVs are distinguished as follows:

- Energy Recovery Ventilator (ERV): Transfers both sensible (heat content) and latent (moisture content) heat between supply and exhaust airstreams.
- Heat Recovery Ventilator (HRV): Transfers sensible heat only between supply and exhaust airstreams.

Baseline Case

The baseline condition for this measure is a commercial or multifamily high-rise building with an ASHRAE 62.2-compliant exhaust fan system with no heat or energy recovery.

Efficient Case

The compliance condition for this measure is a commercial or multifamily high-rise building with an ASHRAE 62.2-compliant exhaust fan system equipped with AHRI certified ERV or HRV components.

Annual Energy Savings Algorithms

Note: Conversions from SEER to SEER2, EER to EER2, and HSPF to HSPF2 can be found in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~.

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_c + \Delta kWh_h + \Delta kWh_{fan}$$

Cooling energy savings:

For ERVs:

$$\Delta kWh_c = \frac{4.5 \times CFM \times Eff_{hx,total} \times \left(H_{outdoor,c} - H_{indoor,c}\right)}{1{,}000 \times Eff_{elec,c}} \times hrs_c$$

For HRVs:

$$\Delta kWh_c = \frac{1.08 \times CFM \times Eff_{hx,sens} \times \left(T_{outdoor,c} - T_{indoor,c}\right)}{1{,}000 \times Eff_{elec,c}} \times hrs_c$$

Heating energy savings (both ERVs and HRVs):

$$\Delta kWh_h = \frac{1.08 \times CFM \times Eff_{hx,sens} \times \left(T_{indoor,h} - T_{outdoor,h}\right)}{1{,}000 \times HSPF2} \times F_{ElecHeat} \times hrs_h$$

Fan energy savings:

$$\Delta kWh_{fan} = \left(kW_{fan,b} - kW_{fan,q}\right) \times (hrs_h + hrs_c)$$

Calculate baseline and qualifying fan kW as follows.[128] Use first equation if values are known, otherwise use second equation:

$$kW_{fan} = \sum\left(\frac{CFM \times \Delta P}{33{,}013/5.202 \times Eff_{fan,mech} \times Eff_{fan,motor}} \times 0.746\right)$$

$$kW_{fan} = \sum\left(\frac{HP \times LF}{Eff_{fan,motor}} \times 0.746\right)$$

Annual Fuel Savings

$$\Delta Therms = \frac{1.08 \times CFM \times Eff_{hx,sens} \times \left(T_{indoor,h} - T_{oudoor,h}\right)}{100{,}000 \times Eff_{fuel,h}} \times F_{FuelHeat} \times hrs_h$$

Summer Peak Demand Savings

For ERVs:

$$\Delta kW_{Peak} = \left(\frac{4.5 \times CFM \times Eff_{hx,total} \times (H_{outdoor,c,peak} - H_{indoor,c})}{1{,}000 \times EER2} + (kW_{fan,b} - kW_{fan,q})\right) \times CF$$

For HRVs:

$$\Delta kW_{Peak} = \left(\frac{1.08 \times CFM \times Eff_{hx,sense} \times (T_{outdoor,c,peak} - T_{indoor,c})}{1{,}000 \times EER2} + (kW_{fan,b} - kW_{fan,q})\right) \times CF$$

[128] Represents total electric power of ERV/HRV supply and exhaust fans (kW). Sigma operator included to indicate that this term shall include consideration of all ERV/HRV fans.

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Lif} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-169 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ΔkWh_{c}	Annual electric energy savings during cooling season	Calculated	kWh	
ΔkWh_{h}	Annual electric energy savings during heating season	Calculated	kWh	
ΔkWh_{fan}	Annual electric energy savings due to fan operation	Calculated	kWh	
$kW_{fan,b}$	Total electric power of baseline supply and exhaust fans	Calculated	kW	
$kW_{fan,q}$	Total electric power of efficient supply and exhaust fans	Calculated	kW	
CFM	Volume of supply air	Site-specific	Ft^3/min	
$Eff_{hx,total}$	Total effectiveness of heat exchanger per rating in accordance with AHRI Standard 1060	Site-specific	N/A	[575]~~[5735]~~

Variable	Description	Value	Units	Ref
$Eff_{hx,sens}$	Sensible effectiveness of heat exchanger per rating in accordance with AHRI Standard	Site-specific	N/A	[575]~~[5735]~~
$Eff_{elec,c}$	Seasonal average energy efficiency of electric cooling equipment (SEER or IEER)	Site-specific, if unknown look up in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~ for equipment type and size	Btu/watt-hour	[576]~~[5746]~~
EER2	Energy efficiency ratio of electric cooling equipment[129]	Site-specific, if unknown look up in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~ for equipment type and size	Btu/watt-hour	
HSPF2	Heating seasonal performance factor of electric heating equipment[130]	Site-specific, if unknown look up in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~ for equipment type and size	Btu/watt-hour	
$Eff_{fuel,h}$	Efficiency of fossil fuel heating equipment (AFUE, E_t or E_c)	Site-specific, if unknown look up in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~ for equipment type and size	N/A	
$T_{indoor,h}$	Indoor heating setpoint temperature	Site-specific, if unknown use 70°F	°F	
$T_{indoor,c}$	Indoor cooling setpoint temperature	Site-specific, if unknown use 70°F	°F	
H_{indoor}	Enthalpy of indoor air	Look up in Table 3-170 based on T_{indoor}	Btu/lb	
$Eff_{fan,mech}$	Mechanical efficiency of ERV fans	Site-specific, if unknown use 0.67	N/A	[577]~~[5757]~~
$Eff_{fan,motor}$	Efficiency of ERV fan motors	Site-specific, if unknown use 0.7[131]	N/A	[578]~~[5768]~~
ΔP	Pressure drop at nominal airflow in the ERV as rated in accordance with AHRI Standard 1060	Site-specific	Inches of H_2O	
HP	Total fan horsepower	Site-specific	HP	
LF	Load factor	Site-specific, if unknown use 0.92	N/A	[583]~~[5813]~~

129 If needed, calculate EER as follows:
$EER = (1.12 \times SEER) - (0.02 \times SEER^2)$
130 If needed, convert COP to HSPF as follows:
$HSPF = COP \times 3.412$
131 Based on ¼ hp, 4-pole polyphase motor. 10 CFR 431.446

Variable	Description	Value	Units	Ref
hrs_c	Operating hours in the cooling season	Look up in Table 3-171	hrs	[581]~~[579581]~~
hrs_h	Operating hours in the heating season	Look up in Table 3-171	hrs	[581]~~[579581]~~
$H_{outdoor,c}$	Enthalpy of outside air during cooling	**Look up in Table 3-172** ~~Table 3-172~~	Btu/lb	[582]~~[5802]~~
$H_{outdoor,h}$	Enthalpy of outside air during heating	**Look up in Table 3-172** ~~Table 3-172~~	Btu/lb	[582]~~[5802]~~
$T_{outdoor,c}$	Avg. outdoor temperature during cooling season.	**Look up in Table 3-172** ~~Table 3-172~~	°F	[582]~~[5802]~~
$T_{outdoor,h}$	Avg. outdoor temperature during heating season	**Look up in Table 3-172** ~~Table 3-172~~	°F	[582]~~[5802]~~
$T_{outdoor,c,peak}$	Peak outdoor temperature during cooling season	Look up in Table 3-173	°F	[584]~~[5824]~~
$H_{outdoor,c,peak}$	Peak Enthalpy of outdoor air during cooling season	Look up in Table 3-173	°F	[584]~~[5824]~~
$F_{ElecHeat}$	Electric heating factor, to account for presence of electric heat	Use 1 if electric heat, otherwise use 0	N/A	
$F_{FuelHeat}$	Fuel heating factor, to account for presence of fuel heat	Use 1 if fuel heat, otherwise use 0	N/A	
1.08	Specific heat of air × density of inlet air @ 70°F × 60 min/hr	1.08	BTU/h.°F.CFM	
4.5	Density of inlet air at 70 °F x 60 min/hr	4.5	Lb.min/ft^3.hr	
60	Minutes per hour	60	Min/hr	
1,000	Conversion factor, one kW equals 1,000 Watts	1,000	kW/W	
100,000	Conversion from Btu to therms	100,000	Btu/therm	
0.746	Conversion from horsepower to kW	0.746	kW/HP	
33,013	Conversion factor from horsepower to ft.lb/min	33,013	(ft.lb/min)/ hp	

Variable	Description	Value	Units	Ref
5.202	Conversion factor from inches of water to pounds per square ft	5.202	lb/ft^2)/ inH_2O	
CF	Electric coincidence factor	Look up in Table 3-174	N/A	
PDF	Gas peak day factor	Look up in Table 3-174	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-170 Indoor Enthalpy

Temperature, T_{indoor} (°F)	Enthalpy, H_{indoor} at 50% Relative Humidity (Btu/lb)
65	22.7
66	23.2
67	23.7
68	24.2
69	24.8
70	25.3
71	25.8
72	26.4
73	27.0
74	27.5
75	28.1
76	28.7
77	29.3
78	29.9

Table 3-171 Heating and Cooling Hours[132]

NJ Climate Region	Heating Hours, hrs_h	Cooling Hours, hrs_c
Northern	4,970	1,670

[132] Calculated from TMY3 data for representative weather stations for each NJ climate zone. Cooling hours are defined as any hour when outdoor air temperature is above 65°F for the months of June through August and heating hours are defined as any hour when outdoor air temperature is below 65°F for the months of October through April. The heating and cooling hours above represent the count of each in a typical meteorological year. Note: these values may over-estimate hours for buildings with limited operating hours such as offices, schools, etc. Site-specific estimate should be used when possible.

NJ Climate Region	Heating Hours, hrs_h	Cooling Hours, hrs_c
Southwest	4,896	1,783
Coastal	4,981	1,954
Central	4,969	1,810
Pine Zones	4,899	1,828
Statewide Average	4,953	1,820

Table 3-172 Outdoor Air Temperature and Enthalpy[133]

NJ Climate Region	Relative Humidity[134] (%)	Avg. outdoor temperature[135] during cooling season, $T_{outdoor,c}$ (°F)	Avg. outdoor temperature[135]~~[1331]~~~~[34]~~ during heating season, $T_{outdoor,h}$ (°F)	Avg enthalpy[136] of outdoor air at duing cooling season, $H_{outdoor,c}$ (Btu/lb)	Avg enthalpy[136]~~[134135]~~ of outdoor air at duing cooling season, $H_{outdoor,c}$ (Btu/lb)
Northern	69.77	74.60	42.10	32.05	14.39
Southwest	67.39	74.50	42.70	31.51	14.49
Coastal	74.63	73.00	46.20	31.87	16.47
Central	75.77	74.30	43.20	33.09	15.23
Pine Barrens	74.34	73.70	43.40	32.33	15.22
Statewide Average	72.61	73.91	43.82	32.14	15.31

Table 3-173 Peak Outdoor Air Temperature and Enthalpy

NJ Climate Region	Peak outdoor temperature during cooling season, $T_{outdoor,c,peak}$ (°F)	Peak Enthalpy of outdoor air at duing cooling season, $H_{outdoor,c,peak}$ (Btu/lb)
Northern	89	40.24
Southwest	93	42.28
Coastal	90	41.26
Central	93	42.28

[134] Average of NOAA hourly relative humidity from January 2020 – December 2022 for each climate zone representative weather station (Northern = Allentown, PA; Southern = Philadelphia, PA; Coastal = Atlantic City, NJ; Central = Trenton, NJ; Pine Barrens = McGruire Air Force Base, NJ)

[135] Calculated from TMY3 data for representative weather stations for each NJ climate zone. Cooling hours are defined as any hour when outdoor air temperature is above 65°F for the months of June through August and heating hours are defined as any hour when outdoor air temperature is below 65°F for the months of October through April. The average heating and cooling temperatures are the average temperature of these hours for the typical meteorological year.

[136] Calculated via ASHRAE Dayton's online psychometric tool, using the average NJ elevation of 228 ft above sea level. https://daytonashrae.org/psychrometrics/psychrometrics_imp.html#start

Field Code Changed

NJ Climate Region	Peak outdoor temperature during cooling season, $T_{outdoor,c,peak}$ (°F)	Peak Enthalpy of outdoor air at duing cooling season, $H_{outdoor,c,peak}$ (Btu/lb)
Pine Barrens	94	41.22
Statewide Average	91	41.32

Peak Factors

Table 3-174 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.69	[579]~~[5779]~~
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The effective useful life (EUL) is 14 years[580]~~[5780]~~.

References

~~[573]~~[575] *Performance Rating of air-to-air exchanges for Energy Recovery Ventilation Equipment*, (AHRI, 2018). https://www.ahrinet.org/sites/default/files/2022-06/AHRI_Standard_1061_SI_2018.pdf

~~[574]~~[576] 10 CFR 430.32 (c)(1) , December 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430

~~[575]~~[577] ASHRAE 90.1 2013, Section 6.5.3.1.3, June 2014. http://arkanarzesh.com/wp-content/uploads/2016/09/ASHRAE%2090.1-2013%20%20-IP.pdf

~~[576]~~[578] 10 CFR 431.446 , December 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-431

~~[577]~~[579] Based on BG&E 'Development of Residential Load Profile for Central Air Conditioners and Heat Pumps' research, the Maryland Peak Definition coincidence factor is 0.69. This study is not publicly available, but is referenced by M. M. Straub, Using Available Information for Efficient Evaluation of Demand-Side Management Programs, Electricity Journal, and supported by research conducted by Cadmus on behalf of the RM Management Committee, September 2011.

~~[578]~~[580] PA Consulting Group Inc., Focus on Energy Evaluation Business Programs: Measure Life Study, final report, August 2009 https://focusonenergy.com/sites/default/files/bpmeasurelifestudyfinal_evaluationreport.pdf

~~[579]~~[581] ONJSC: Monthly/Annual Temperature Normals (1991-2020), December 2022 http://climate.rutgers.edu/stateclim_v1/norms/monthly/index.html.

~~[580]~~[582] NSRDB, TMY3 data, December 2022. https://nsrdb.nrel.gov/data-sets/tmy

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

~~[581]~~[583] *Proposed Standard Savings Estimation Protocol for Ultra-Premium Efficiency Motors*, Cascade Energy, November 5, 2012. Table 6: Load Factor by Nameplate hp and End Use. November 5, 2012

~~[582]~~[584] ASHRAE Fundamentals 2021 - Chapter 14 Climactic Design Conditions - https://handbook.ashrae.org/Handbook.aspx#

Field Code Changed

3.5.13 DEMAND CONTROLLED VENTILATION

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	February 2024
Changes Since Last Version	~~Removed references to DI Baseline Condition and dual baseline~~

Description

Maintaining acceptable air quality requires standard ventilation systems designers to determine ventilation rates based on maximum estimated occupancy levels and published CFM/occupant requirements. During low occupancy periods, this approach results in higher ventilation rates than are required to maintain acceptable levels of air quality. This excess ventilation air must be conditioned and therefore results in wasted energy.

Building occupants exhale CO_2, and the CO_2 concentration in the air increases in proportion to the number of occupants. The CO_2 concentration provides a good indicator of overall air quality. Demand control ventilation (DCV) systems monitor indoor air CO_2 concentrations and use this data to automatically modulate dampers and regulate the amount of outdoor air that is supplied for ventilation. DCV is most suited for facilities where occupancy levels are known to fluctuate considerably.

Saving factors were calculated based on IL TRM values for Chicago, adjusted by ratio of Degree Days for each listed NJ Climate Zone and Chicago, based on TMY 3 Data using base 65 F balance point. See the 'Demand Controlled Ventilation' Section of the Illinois Statewide Technical Reference Manual V11 for further explanation [585]~~[5835]~~.

Baseline Case

The baseline system is an existing cooling and heating systems with no demand control ventilation or ventilation heat recovery equipment installed.

Efficient Case

The compliance condition is a DCV system added to the return air system to supply air based on occupancy demands.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{A}{1,000} \times SF_{ElecCool} + \frac{A}{1,000} \times SF_{ElecHeat} \times F_{ElecHeat}$$

Annual Fuel Savings

$$\Delta Therms = \frac{A}{1{,}000} \times SF_{fuel} \times F_{FuelHeat}$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-175 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
A	Total area square footage of the conditioned space impacted by the measure	Site-specific	Ft^2	
$SF_{ElecCool}$	DCV energy savings factor for cooling	Look up in Table 3-176	kWh/1,000 ft^2	[585]~~[5835]~~
$SF_{ElecHeat}$	DCV energy savings factor for electric heating	Look up in Table 3-177, Table 3-178	kWh/1,000 ft^2	[585]~~[5835]~~
$F_{elecHeat}$	Electric heating factor, used to account for the presence or absence of an electric heating system	1 (if electric heat) 0 (otherwise)	N/A	
SF_{Fuel}	DCV fuel savings factor for heating	Look up in Table 3-179	Therms/1,000 ft^2	[585]~~[5835]~~

Variable	Description	Value	Units	Ref
$F_{FuelHeat}$	Fuel heating factor, used to account for the presence or absence of a fossil fuel heating system	1 (if fossil fuel heat) 0 (otherwise)	N/A	
CF	Electric coincidence factor	Look up in Table 3-180	N/A	
PDF	Gas peak day factor	Look up in Table 3-180	N/A	
10	Unit conversion, Therm/MMBtu	10	Therm/MMBtu	
EUL	Effective useful life	See Measure Life Section	Years	[586]~~[5846]~~

Table 3-176 Energy Savings Factor for Cooling (kWh/1,000 ft^2)

Building Type	North	Coastal	Central	Pine Barrens	Southwest	Statewide Average[137]
Office - Low-rise (1 to 3 Stories)	267	362	368	366	359	334
Office - Mid-rise (4 to 11 Stories)	211	286	291	289	283	264
Office - High-rise (12+ Stories)	250	340	345	344	337	314
Religious Building	720	978	994	989	970	903
Restaurant	471	640	650	647	634	590
Retail - Department Store	363	493	501	498	489	455
Retail - Strip Mall	251	341	347	345	338	315
Convenience Store	330	448	455	453	444	413
Elementary School	339	460	468	465	456	425
High School	332	450	457	455	446	415
College/ University	393	534	543	540	530	493
Healthcare Clinic	327	444	451	449	440	410
Lodging (Hotel/Motel)	378	513	521	518	508	473
Manufacturing	163	222	226	224	220	205
Special Assembly Auditorium	537	729	740	737	722	672
Other	356	483	491	488	479	446
Enclosed Parking Garage	854	1,160	1,179	1,173	1,150	1070

[137] Weighted average based on NJ climate zone distribution.

Table 3-177 Electric Heating Savings with Heat Pump (kWh/1,000 ft^2)

Building Type	North	Coastal	Central	Pine Barrens	Southwest	Statewide Average[137]~~135~~[136]
Office - Low-rise (1 to 3 Stories)	185	149	163	158	163	167
Office - Mid-rise (4 to 11 Stories)	125	100	110	106	109	112
Office - High-rise (12+ Stories)	167	135	147	143	147	151
Religious Building	1,206	970	1,062	1,028	1,057	1,087
Restaurant	870	700	767	742	763	785
Retail - Department Store	298	239	262	254	261	268
Retail - Strip Mall	194	156	171	166	171	175
Convenience Store	147	119	130	126	129	133
Elementary School	517	416	456	441	454	467
High School	505	406	445	430	443	455
College/ University	1007	811	888	859	884	909
Healthcare Clinic	358	288	316	305	314	323
Lodging (Hotel/Motel)	166	134	147	142	146	150
Manufacturing	103	83	91	88	90	93
Special Assembly Auditorium	1,414	1,138	1,246	1,207	1,241	1,276
Other	484	389	426	413	424	436
Enclosed Parking Garage	185	149	163	158	163	167

Table 3-178 Electric Heating Savings with Electrical Resistance (kWh/1,000 ft^2)

Building Type	North	Coastal	Central	Pine Barrens	Southwest	Statewide Average
Office - Low-rise (1 to 3 Stories)	556	448	490	474	488	493
Office - Mid-rise (4 to 11 Stories)	374	301	329	319	328	331
Office - High-rise (12+ Stories)	501	403	441	427	439	443
Religious Building	3617	2910	3186	3085	3172	3202
Restaurant	2610	2100	2300	2226	2289	2311
Retail - Department Store	893	718	786	761	783	790
Retail - Strip Mall	584	470	515	498	512	517

Building Type	North	Coastal	Central	Pine Barrens	Southwest	Statewide Average
Convenience Store	441	355	389	376	387	391
Elementary School	1551	1248	1367	1323	1360	1374
High School	1513	1218	1333	1291	1327	1340
College/ University	3022	2432	2662	2577	2650	2676
Healthcare Clinic	1074	865	947	916	942	952
Lodging (Hotel/Motel)	498	401	439	425	437	441
Manufacturing	310	250	273	265	272	275
Special Assembly Auditorium	4242	3414	3738	3619	3721	3757
Other	1452	1169	1280	1239	1274	1286

Table 3-179 Fuel Heating Savings (therms/1000 SF)

Building Type	North	Coastal	Central	Pine Barrens	Southwest	Statewide Average
Office - Low-rise (1 to 3 Stories)	24	19	21	20	21	21
Office - Mid-rise (4 to 11 Stories)	16	13	14	14	14	14
Office - High-rise (12+ Stories)	22	17	19	19	19	19
Religious Building	155	124	136	132	136	137
Restaurant	111	90	98	95	98	99
Retail - Department Store	38	31	33	32	33	33
Retail - Strip Mall	25	20	22	22	22	22
Convenience Store	19	15	17	16	17	17
Elementary School	66	53	58	56	58	58
High School	64	52	57	55	56	57
College/ University	129	104	114	110	113	114
Healthcare Clinic	46	37	41	39	40	41
Lodging (Hotel/Motel)	21	17	18	18	18	18
Manufacturing	14	11	12	12	12	12
Special Assembly Auditorium	181	146	159	154	159	160
Other	61	49	54	52	54	54

Peak Factors

Table 3-180 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

Use the smaller of the measure life (10 yr) or the remaining useful life (RUL) of host equipment [586]~~[5846]~~. If applied to a packaged HVAC system, the RUL of the host equipment is 5 years.

References

~~[583]~~[585] *2023 Illinois Statewide Technical Reference Manual for Energy Efficiency Version 11 Volume 2: Commerical and Industrial Measures* (September 2022), Pg 357, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010123_v11.0_Vol_2_C_and_I_092222_FINAL.pdf

~~[584]~~[586] ERS (2005). *Measure Life Study prepared for The Massachusetts Joint Utilities*.

Field Code Changed

3.5.14 DEMAND CONTROLLED KITCHEN VENTILATION

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	January 2023

Description

Installation of variable speed drives (VSD) on commercial kitchen exhaust fans and make-up air fans allows the variation of ventilation based on cooking load and/or time of day. This measure is targeted to non-residential customers whose kitchen exhaust fans and make-up air fans are equipped with a VSD that varies the exhaust rate of kitchen ventilation based on the energy and effluent output from the cooking appliances (i.e., the more heat and smoke/vapors generated, the more ventilation needed). This involves installing a temperature sensor in the hood exhaust collar and/or an optic sensor on the end of the hood that sense cooking conditions which allows the system to automatically vary the rate of exhaust to what is needed by adjusting the fan speed.

Baseline Case

The baseline equipment is a constant speed commercial kitchen ventilation system.

Efficient Case

The energy efficient condition is a commercial kitchen ventilation system equipped with a VSD and demand ventilation controls and sensors.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{fan} + \Delta kWh_{cooling}$$

$$\Delta kWh_{fan} = \left(\frac{CFM}{1400}\right) \times Hours \times Days \times Weeks \times \sum_{0\%}^{100\%} \%FF \times PLR$$

$$\Delta kWh_{cooling} = SF_{cool} \times \%MUA_{cool} \times \Delta kWh_{fan}$$

Annual Fuel Savings

$$\Delta Therms = SF_{heat} \times \Delta kWh_{fan} \times 10$$

Peak Demand Savings

$$\Delta kW_{Peak} = \left(\frac{\Delta kWh}{Hours \times Days \times Weeks}\right) \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Lif} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-181 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
CFM	Uncontrolled design hood exhaust flow in cubic feet per minute.	Site-specific If actual flow is unknown, estimate flow from hood dimensions. For unlisted hoods estimate 100 CFM per square foot of plan area. For UL listed hoods estimate 250 CFM per length of hood in feet.	cfm	[590]~~[588590]~~
1,400	Estimation of CFM delivered per kW consumed from both exhaust and make-up air fan motor	1,400	Cfm/kW	[588]~~[5868]~~
Hours	Hours per day hood is operated	Site-specific, if actual hours are unknown assume 5 hours per meal served.	hrs	[590]~~[588590]~~

Variable	Description	Value	Units	Ref
Days	Number of days kitchen is in operation per week	Site-specific	Days	
Weeks	Number of weeks kitchen is in operation	Site-specific, if actual weeks are unknown assume 50 weeks per year.	Weeks	[590]~~[588~~590~~]~~
%FF	Percentage of run-time spent within a given flow fraction range	Site-specific, if actual values unknown assume 30% of time at full flow, 30% of time at 75% flow, and 40% of time at 50% flow	N/A	[590]~~[588~~590~~]~~
PLR	Part load ratio for a given flow fraction range	Look up Table 3-182	N/A	[590]~~[588~~590~~]~~
SF_{cool}	Cooling savings factor	0.471	N/A	[589]~~[587~~9~~]~~
$\%MUA_{cool}$	During the cooling season, the percentage of make-up air that is conditioned	If kitchen is cooled, then %MUA = 1.0. If kitchen is not cooled, then must calculate the percentage of make-up air that is being pulled from the dining room or other conditioned space. = If actual value is unknown, then assume 30%, or 0.3.	N/A	[590]~~[588~~590~~]~~
SF_{heat}	Heating savings factor	Lookup Table 3-183. If percent of make-up air from dining room is unknown, assume 30% from dining room	MMBtu/kWh	[589]~~[587~~9~~]~~ [590]~~[588~~590~~]~~
CF	Electric coincidence factor	Look up in Table 3-184	N/A	
PDF	Gas peak day factor	Look up in Table 3-184	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-182 Part Load Ratios by Control and Fan Type and Flow Fraction (PLR)

Control Type	Flow Fraction									
	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
VFD	0.09	0.10	0.11	0.15	0.20	0.28	0.41	0.57	0.77	1.00

Table 3-183 Heating Savings Factor (SF_{Heat})

Percent of Make-up Air from Nearby Conditioned Space (Dining Room)	Make-up Air Directly Supplied to Kitchen is NOT Heated	Make-up Air Directly Supplied to Kitchen is Heated
0%	0	0.0088
10%	0.0013	0.0093
20%	0.0026	0.0097

Percent of Make-up Air from Nearby Conditioned Space (Dining Room)	Make-up Air Directly Supplied to Kitchen is NOT Heated	Make-up Air Directly Supplied to Kitchen is Heated
30%	0.0039	0.0101
40%	0.0042	0.0105
50%	0.0065	0.0109
60%	0.0078	0.0113
70%	0.0091	0.0118
80%	0.0104	0.0122
90%	0.0117	0.0126
100%	0.0130	0.0130

Peak Factors

Table 3-184 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1.0 if kitchen operates during dinner 0.0 if the kitchen does not operate during dinner	
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The effective useful life (EUL) is 15 years. [587]~~[5857]~~

References

~~[585]~~[587] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx.

~~[586]~~[588] Estimation of CFM delivered per kW consumed from both exhaust and make-up air fan motor. Derived from proprietary Navigant DCKW tool.

~~[587]~~[589] Savings factor calculated from proprietary Navigant DCKW tool using TMY3 temperature data from Baltimore, MD. The tool does a bin hour calculation of the cooling energy required to condition make-up air.

~~[588]~~[590] *Mid-Atlantic Technical Reference Manual: Version 10* (May 2020), https://neep.org/mid-atlantic-technical-reference-manual-trm-v10, Pg 404

Field Code Changed

3.5.15 DESTRATIFICATION FAN

Market	Commercial
Baseline Condition	NC/RF
Baseline	ISP/Existing
End Use Subcategory	HVAC
Measure Last Reviewed	September 2024
Changes Since Last Version	~~Corrected parameter nomenclature in algorithms and corresponding definitions~~

Description

This measure applies to buildings with high bay ceiling construction without fans currently installed for the purpose of destratifying air. Air stratification leads to higher temperatures at the ceiling and lower temperatures at the ground. During the heating season, destratification fans improve air temperature distribution in a space by circulating warmer air from the ceiling back down to the floor level, thereby enhancing comfort and saving energy. Energy savings are realized by a reduction of heat loss through the roof-deck and walls as a result of a smaller temperature differential between indoor temperature and outdoor air. This measure does not attempt to quantify savings from shorter heating system runtimes due to air mixing.

Limitations

- For use in conditioned, high bay structures. Recommended minimum ceiling height of 20 ft.
- This measure should only be applied to spaces in which the ceiling is subject to heat loss to outdoor air (i.e., single story or top floor spaces) and where there is sufficient space to allow for appropriate spacing of the fans. Other applications require custom analysis.
- Installation must follow manufacturer recommendations sufficient to effectively destratify the entire space.
- Measure does not currently support facilities with night setbacks on heating equipment. Custom analysis is needed in this case.
- Certain heating systems may not be a good fit for destratification fans, such as locations with: high velocity vertical throw unit heaters, radiant heaters, and centralized forced air systems. In these cases, measured evidence of stratification should be confirmed, and custom analysis may be necessary.

Baseline Case

No destratification fans or other means to effectively mix indoor air.

Efficient Case

High Volume, Low Speed (HVLS) fans with a minimum diameter of 14 ft with Variable Speed Drive (VSD) installed.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_h - kWh_{fan}$$

In all cases:

$$kWh_{fan} = W_{fan} \times hrs_{fan}$$

If building is electricially heated:

$$\Delta kWh_h = \frac{(\Delta Q_r + \Delta Q_w) \times hrs_{heat} \times 29.31}{100{,}000 \times COP}$$

Where,

$$\Delta Q_r = \frac{1}{R_r} \times A_r \times \left(T_{r,s} - T_{r,d}\right)$$

$$\Delta Q_w = \frac{1}{R_w} \times A_w \times (T_{w,s} - T_{w,d})$$

$$T_{r,s} = m_s \times h_r + (T_{stat} - m_s \times h_{stat})$$

$$T_{r,d} = T_{stat} + 1$$

$$T_{w,s} = m_s \times \frac{h_r}{2} + (T_{stat} - m_s \times h_{stat})$$

$$T_{w,d} = T_{stat} + 0.5$$

If building is not electricially heated:

$$\Delta kWh_h = 0$$

Annual Fuel Savings

$$\Delta Therms = \frac{(\Delta Q_r + \Delta Q_w) \times hrs_{heat}}{100{,}000 \times Eff}$$

Annual Peak Demand Savings

$$\Delta kWh_{peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-185 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ΔkWh_h	Savings due to reduced heat loss from air destratification (if building is electrically heated)	Calculated	kWh	
kWh_{fan}	Annual electric consumption of fan	Calculated	kWh	
ΔQ_r	Heat loss reduction through the roof due to the destratification fan	Calculated	Btu/hr	
ΔQ_w	Heat loss reduction through the exterior walls due to destratification fan	Calculated	Btu/hr	
$T_{w,s}$	Average indoor air temperature for wall heat loss, stratified case	Calculated	°F	[591]~~[5891]~~
$T_{w,d}$	Average indoor air temperature for wall heat loss, destratified case	Calculated	°F	[591]~~[5891]~~
W_{fan}	Rated fan wattage	Site-specific	W	
hr_{fan}	Annual fan operating hours	Site-specific, if unknown look up in **Error! Reference source not found.**~~Appendix D: HVAC Fan and Pump Operating Hours~~		
$T_{r,s}$	Indoor temperature at roof deck, stratified case	Site-specific or calculated	°F	[591]~~[5891]~~

Variable	Description	Value	Units	Ref
$T_{r,d}$	Indoor temperature at roof deck, destratified case	Site-specific or calculated	°F	[591]~~[5891]~~
COP	Heating efficiency of electric heating system	Site-specific, calculate if needed: COP = HSPF/3.413	N/A	[591]~~[5891]~~
Eff	Fuel heating system efficiency	Site-specific	N/A	[591]~~[5891]~~
R_r	Overall thermal resistance through the roof	**Site-specific, if unknown look up in** **Table 3-186** ~~Table 3-186~~	Hr*ft2*F/Btu	[591]~~[5891]~~
A_r	Roof area	Site-specific	Ft2	[591]~~[5891]~~
R_w	Overall thermal resistance through the exterior walls	**Site-specific, if unknown look up in** **Table 3-186** ~~Table 3-186~~	Hr*ft2*F/Btu	[591]~~[5891]~~
A_w	Area of exterior walls	Site-specific	Ft^2	[591]~~[5891]~~
h_r	Ceiling height/roof deck	Site-specific	ft	[591]~~[5891]~~
T_{stat}	Temperature set point at the thermostat	Site-specific	°F	[591]~~[5891]~~
h_{stat}	Vertical distance between the floor and the thermostat	Site-specific, if unknown use 5	Ft	[591]~~[5891]~~
m_s	Estimated heat gain per foot elevation, stratified case	0.8	F/ft	[591]~~[5891]~~
Hrs_{heat}	Total annual heating hours	Site-specific, if unknown look up in Table 3-187	Hours	[591]~~[5891]~~
29.31	Conversion factor	29.31	kWh/therm	[591]~~[5891]~~
100,000	Conversion factor	100,000	Btu/therm	[591]~~[5891]~~
PDF	Peak day factor	Look up in Table 3-152	N/A	
EUL	Effective useful life	See Measure Life section	Years	[591]~~[5891]~~

Table 3-186 Thermal Resistance Factors

Location	Retrofit	New Construction
Roof (Rr)	15.0	30.0
Wall (Rw)	6.5	13.0

Table 3-187 Annual Heating Hours by Climate Zone

Climate Zone	Annual Heating Hours[138]
Northern	4,970
Southwest	4,896
Coastal	4,981
Central	4,969
Pine Barrens	4,899
Statewide Average	**4,955**

Peak Factors

Table 3-188 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A: No peak demand savings because no savings from cooling	[591]~~[5891]~~
Natural gas peak day factor (PDF)	Look up in **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The effective useful life (EUL) is 10 years [591]~~[5891]~~.

References

~~[589]~~[591] Illinois TRM v11, Destratification Fan, pg. 424. https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010123_v11.0_Vol_2_C_and_I_092222_FINAL.pdf

Field Code Changed

[138] Annual heating hours calculated as the total number of hours colder than 65°F for each climate zone, using representative climate stations and TMY3 weather data.

3.5.16 DUCT SEALING AND DUCT INSULATION

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Category	HVAC
Measure Last Reviewed	January 2023
Changes Since Last Version	~~Removed references to DI Baseline Condition and dual baseline~~

Description

This measure describes evaluating the savings associated with performing duct sealing using mastic sealant, metal tape or aerosol sealant to the distribution systems of small commercial buildings with duct systems in unconditioned and semi-conditioned spaces. The application of the measure is limited to residential sized systems less than 65,000 Btu/hr of cooling capacity applied to small commercial buildings. Savings calculations are based on test in / test out duct leakage measurements.

Baseline Case

The baseline condition is existing leaky duct work within an unconditioned or semi-conditioned space in the building.

Efficient Case

The efficient condition is sealed duct work within an unconditioned or semi-conditioned space in the building.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{cooling} + \Delta kWh_{heating}$$

Where,

$$\Delta kWh_{cooling} = \frac{CFM_{25B} - CFM_{25Q}}{400 \times Cap_{cool}} \times Cap_{cool} \times EFLH_{cool} \times TRF_{cool} \frac{12}{DE_{pre} \times SEER}$$

$$\Delta kWh_{heating} = \frac{CFM_{25B} - CFM_{25Q}}{17 \times Cap_{heat}} \times Cap_{heat} \times EFLH_{heat} \times TRF_{heat} \times \frac{1}{DE_{pre} \times HSPF}$$

Annual Fuel Savings

$$\Delta Therms = \frac{CFM_{25B} - CFM_{25Q}}{17 \times Cap_{heat}} \times Cap_{heat} \times EFLH_{heat} \times TRF_{heat} \times \frac{1}{DE_{pre} \times AFUE\ x\ 100}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh_{cooling}}{EFLH_{cool}} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-189 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
$\Delta kWh_{cooling}$	Annual electric energy savings, cooling	Calculated	kWh/yr	
$\Delta kWh_{heating}$	Annual electric energy savings, heating	Calculated	kWh/yr	
$\Delta Therms$	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
Cap_{cool}	Capacity of air cooling system	Site-specific	ton	
Cap_{heat}	Output capacity of air heating system	Site-specific	kBtu/hr	
CFM_{25B}	Standard duct leakage test result at 25 Pascal pressure differential of the duct system prior to sealing	Site-specific	CFM	
CFM_{25Q}	Standard duct leakage test result at 25 Pascal pressure differential of the duct system after sealing	Site-specific	CFM	
SEER	Seasonal energy efficiency ratio	Site-specific, if unknown look up in Table 2-95	Btu/W·hr	[127]~~[1267]~~

Variable	Description	Value	Units	Ref
HSPF	Heating seasonal performance factor	Site-specific, if unknown look up in Table 2-95	Btu/W·hr	[127]~~[1267]~~
DE_{pre}	Distribution efficiency before duct sealing and insulation	0.89	N/A	[594]~~[5924]~~
AFUE	Annual fuel utilization efficiency	Look up in Table **2-96** ~~Table **2-96**~~xx	N/A	[127]~~[1267]~~
$EFLH_{cool}$	Cooling equivalent full load hours	See Appendix C	Hrs	
$EFLH_{heat}$	Heating equivalent full load hours	See Appendix C	Hrs	
400	Rule of Thumb, CFM/ton	Site-specific, if unknown use 400	CFM/ton	
TRF_{cool}	Cooling thermal regain factor based on duct location	Semi-conditioned space: 0.0 Unconditioned space or outdoors: 1.0	N/A	[594]~~[5924]~~
TRF_{heat}	Heating thermal regain factor based on duct location	Semi-conditioned space: 0.4 Unconditioned space or outdoors: 1.0	N/A	[594]~~[5924]~~
12	Unit conversion, kBtu/hr·ton	12	kBtu/ hr·ton	
100	Unit conversion, kBtu/therm	100	kBtu/therm	
CF	Electric coincidence factor	Look up in Table 2-97	N/A	
PDF	Gas peak day factor	Look up in Table 2-97	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-190 SEER and HSPF Values

Product Class	SEER	HSPF
Split systems – air conditioners	13	-
Split systems – heat pumps	14	8.2
Single package units – air conditioners	14	-
Single package units – heat pumps	14	8.0

Table 3-191 AFUE Values

Product Class	AFUE
Non-weatherized gas furnaces	0.80
Weatherized gas furnaces	0.81

Peak Factors

Table 3-192 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.69	[594]~~[5924]~~
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix H: Net-to-Gross Factors~~	

Measure Life

Table 3-193 Measure Life

Equipment	EUL	Ref
Duct Sealing	15	[131]~~[1301]~~

References

~~[590]~~[592] 10 CFR Subpart C of Part 430, https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32

~~[591]~~[593] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

~~[592]~~[594] Home Energy Services Impact Evaluation, prepared for the Massachusetts Residential Retrofit and Low Income Program Area Evaluation, Cadmus Group, Inc., August 2012.

Field Code Changed

Field Code Changed

3.5.17 EC MOTORS

Market	Commercial/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Motor
Measure Last Reviewed	December 2022

Description

This measure covers the retrofit installation of an Electronically Commuted (EC) motor to replace an existing HVAC supply fan motor or hydronic circulator pump motor.

This measure is not applicable to exhaust fan motors. New construction and replace-on-burnout scenarios are not eligible because ECM technology is required in new equipment by federal efficiency standards [595]~~[5935]~~.

Interactive factors should be applied for motors that supply cooling or heating to account for the reduced cooling load, or increased heating load, associated with the lower wattage ECM motor. Interactive factors do not apply if the motor is located outside of the conditioned air or hydronic pathway.

Baseline Case

An existing HVAC fan or pump with a single-speed, shaded-pole (SP) or permanent-split capacitor (PSC) motor. Baseline wattage should be derived from the nameplate rating of the existing motor.

Efficient Case

HVAC fan or pump with an Electronically Commuted (EC) Motor

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_h + \Delta kWh_c$$

For blower fans:

$$\Delta kWh_h = \frac{(W_b \times ESF_h)}{1{,}000} \times LF \times Hrs_h \times (1 - HVAC_e)$$

$$\Delta kWh_c = \frac{(W_b \times ESF_c)}{1{,}000} \times LF \times Hrs_c \times (1 + HVAC_e)$$

For circulator pumps:

$$\Delta kWh_h = \frac{(W_b - W_q)}{1{,}000} \times Hrs_h \times (1 - HVAC_e)$$

$$\Delta kWh_c = \frac{(W_b - W_q)}{1{,}000} \times Hrs_c \times (1 + HVAC_e)$$

If motor wattage is unknown, estimate as:

$$W = \frac{0.746 \times HP}{Eff_{motor}}$$

Annual Fuel Savings

$$\Delta herms = \frac{W_b \times ESF_h}{1{,}000} \times LF \times Hrs_h \times HVAC_{ff}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{(W_b \times ESF_c)}{1{,}000} \times LF \times (1 + HVAC_d) \times CF$$

Peak Daily Fuel Savings:

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-194 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkWh_h	Annual electric heating savings	Calculated	kWh/yr	
ΔkWh_c	Annual electric cooling savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
W_b	Wattage of baseline motor	Site-specific, if unknown calculate from HP	Watts	
W_q	Wattage of efficient motor	Site-specific	Watts	

Variable	Description	Value	Units	Ref
Eff_{motor}	Motor efficiency	Site-specific, if unknown look up in Table 3-195	N/A	[598]~~[5968]~~
Hrs_h	Motor operating hours, heating	Site-specific, if unknown see **Error! Reference source not found.**~~Appendix D: HVAC Fan and Pump Operating Hours~~	Hrs	
Hrs_c	Motor operating hours, cooling	Site-specific, if unknown see **Error! Reference source not found.**~~Appendix D: HVAC Fan and Pump Operating Hours~~	Hrs	
ESF_h	Energy savings factor, heating	0.23	N/A	[597]~~[5957]~~
ESF_c	Energy savings factor, cooling	0.38		[597]~~[5957]~~
LF	Motor load factor	0.9	N/A	[597]~~[5957]~~
$HVAC_e$	HVAC interactivity factor, electric	See **Error! Reference source not found.**~~Appendix F: HVAC Interactivity Factors~~	N/A	
$HVAC_d$	HVAC interactivity factor, demand	See **Error! Reference source not found.**~~Appendix F: HVAC Interactivity Factors~~	N/A	
$HVAC_{ff}$	HVAC interactivity factor, fossil fuel	See **Error! Reference source not found.**~~Appendix F: HVAC Interactivity Factors~~	N/A	
CF	Coincidence factor	Look up in Table 3-196	N/A	
PDF	Gas peak demand factor	Look up in Table 3-196	N/A	
0.746	Conversion factor	0.746	kWh/HP	
1,000	Conversion factor	1,000	Watts/kW	
100	Conversion factor	100	kBtu/Therms	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-195 Default Motor Efficiency by Motor Type

Motor Type	Assumed Efficiency
Shaded Pole (SP)	0.40
Permanent Split Capacitor (PSC)	0.50
ECM	0.70

Peak Factors

Table 3-196 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.8	[596]~~[5946]~~
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The remaining useful life (RUL) for retrofit projects is assumed to equal to the smaller or the motor EUL or the RUL of the host equipment. Default RUL of the host equipment is 1/3 of the EUL.

References

~~[593]~~[595] Federal standards: U.S. Department of Energy, *Federal Register. 164th ed. Vol. 79*, July 3, 2014. https://www.govinfo.gov/content/pkg/FR-2014-07-03/pdf/FR-2014-07-03.pdf

~~[594]~~[596] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – Residential Multifamily, and Commercial/Industrial Measures. Version 6. April 16, 2018.

~~[595]~~[597] US DOE, *Evaluation of Retrofit Variable-Speed Furnace Fan Motors*, January 2014. https://www.nrel.gov/docs/fy14osti/60760.pdf

~~[596]~~[598] DOE Building Technologies Office. Energy Savings Potential and Opportunities for High-Efficiency Electric Motors in Residential and Commercial Equipment. https://www.energy.gov/sites/prod/files/2014/02/f8/Motor%20Energy%20Savings%20Potential%20Report%202013-12-4.pdf. Accessed December 2022.

Field Code Changed

Field Code Changed

Field Code Changed

3.5.18 ECONOMIZER CONTROLS

Market	Commercial/Multifamily
Baseline Condition	NC/RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	February 2024
Changes Since Last Version	~~Removed references to DI Baseline Condition and dual baseline~~

Description

This measure involves the installation of a dual enthalpy economizer to provide free cooling during the appropriate ambient conditions. Enthalpy refers to the total heat content of the air. A dual enthalpy economizer uses two sensors — one measuring return air enthalpy and one measuring outdoor air enthalpy. Dampers are modulated for optimum and lowest enthalpy to be used for cooling. Retrofit installations are only eligible for savings if the existing HVAC system does not have a functioning economizer.

New construction installations are only eligible for savings when economizers are not already required by the IECC 2021 Energy Code, Section C403.5.

Baseline Case

RF: The baseline condition is the site-specific HVAC unit with fixed outside air (no economizer). Use site-specific tonnage for calculation.

NC: New construction installations only eligible if economizer not required by code. The NC baseline is the site-specific and code-compliant HVAC unit with fixed outside air. Use site-specific tonnage for calculation.

Efficient Case

The efficiency condition is assumed to be an enthalpy economizer equipped with sensors that monitor the enthalpy of outside air and return air and modulate the outside air damper to optimize energy performance.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = Tons\ x\ \left(\frac{kWh}{ton}\right)_{Econ}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = 0$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therm_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-197 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Tons	Rated capacity of the cooling system retrofitted with an economizer	Site specific	Tons	
$(kWh/ton)_{Econ}$	Annual electric energy savings per ton of cooling	Look up in Table 3-198	Hrs/yr	[599]~~[5979]~~
CF	Electric coincidence factor	Look up in Table 3-199	N/A	
PDF	Gas peak demand factor	Look up in Table 3-199	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-198 Economizer savings kWh per Cooling Ton

Building Type	$(kWh/ton)_{Econ}$
Assembly	27
Big Box Retail	152
Fast Food Restaurant	39
Full Service Sertaurant	31

Building Type	$(kWh/ton)_{Econ}$
Light Industrial	25
Elementary School	42
Small Office	186
Small Retail	95
Religious	6
Warehouse	2
Other	61

Peak Factors

Table 3-199 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0	
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The effective useful life (EUL) is 10 years [600]~~[598600]~~.

References

~~[597]~~[599] *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – Version 10*. (New York State Joint Utilities, 2022), Appendix J Pg 1289-1290 https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V10.pdf

~~[598]~~[600] California Public Utilities Commission EUL Table, version 027 (updated November 12, 2022). Accessed December 30, 2022. https://www.caetrm.com/shared-data/value-table/EUL/

Field Code Changed

Field Code Changed

~~3.5.19 ELECTRONIC FUEL-USE ECONOMIZER~~

3.5.1 MICROPROCESSOR-BASED CONTROLS

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	HVAC
Measure Last Reviewed	~~March 2024~~February 2025
Changes Since Last Version	• ~~New Measure~~Renamed to "Microprocessor-Based Controls" from "Electronic Fuel-Use Economizer" • Added electric savings for AC applications

Description

These devices ~~are~~provide intelligent microprocessor-based ~~fuel-saving controls~~control logic for commercial steam and hydronic heating systems~~.~~ and commercial air conditioning systems. They optimize energy consumption by adjusting burner or compressor run patterns to match the system's load. They can be used to control gas or oil consumption for any type of boiler or forced air furnace system.

Baseline Case

~~Any boiler~~A heating or ~~furnace~~cooling system system without an ~~electronic~~ intelligent microprocessor control fuel use economizer.

Efficient Case

~~Any boiler~~A heating or ~~furnace~~cooling system system with an ~~electric fuel use economizer~~intelligent microprocessor control.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \cancel{N/A} kWh_{Annual} \times F_{svg,c}$$

Where,

$$kWh_{Annual} = \frac{Cap_c}{Eff_c \times 1{,}000} \times EFLH_c$$

Annual Fuel Savings

$$\Delta Therms = Therms_{Annual} \times \cancel{0.127} F_{svg,h}$$

Where,

$$Therms_{Annual} = \frac{Cap}{Eff \times 100{,}000} \times EFLH_h$$

To calculate savings in gallons of delivered fuel, use Table 3-200.

Table 3-200 Fuel Savings in Gallons

Delivered Fuel	Fuel savings (gallons)
Oil	$\Delta Gal_{Oil} = \frac{\Delta Therms}{1.4}$
Propane	$\Delta Gal_{Propane} = \frac{\Delta Therms}{0.916}$

Annual Peak Demand Savings

$$\Delta k\cancel{_{Peak}}W_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \cancel{N/A}\Delta \mathrm{kWh} \times \mathrm{EUL}$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-201 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak electric savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric savings	Calculated	kWh	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	

Variable	Description	Value	Units	Ref
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$Therms_{Annual}$	Annual consumption of uncontrolled boiler or furnace	Calculated	Therms/yr	
Cap	Heating capacity of uncontrolled boiler or furnace	Site-specific	Btu/h	
Eff	Heating efficiency of uncontrolled boiler or furnace	Site-specific	N/A	
$EFLH_h$	Effective full-load hours, heating	Look up in ~~Appendix E~~Error! Reference source not found.~~Appendix C: Heating and Cooling EFLH~~	Hr/yr	
$EFLH_c$	Effective full-load hours, cooling	Look up in Error! Reference source not found.~~Appendix C: Heating and Cooling EFLH~~	Hr/yr	
~~0.127~~$F_{svg,c}$	Approximate energy savings factor ~~related to installation of fuel use economizers~~, cooling	0.~~127~~144	N/A	[602]~~[6002]~~
$F_{svg,h}$	Approximate energy savings factor, heating	0.128	N/A	[602]
100,000	Conversion from Btu to therm	100,000	Therm/Btu	
1.4	Conversion from therms to gallons of oil	1.4	Therms/gal	0
0.916	Conversion from therms to gallons of propane	0.916	Therms/gal	0
PDF	Gas peak day factor	Lookup in Table 3-152	N/A	
EUL	Effective useful life	See Measure Life ~~Measure Life~~	Years	

Peak Factors

Table 3-202 Peak Factors

Peak Factor	Value	Ref
Natural gas peak day factor (PDF)	Look up in Appendix G	

Measure Life

The effective useful life (EUL) is the smaller of the economizer EUL of 15 years or the RUL of the host equipment [601]~~[599601]~~.

References

~~[599]~~[601] New Jersey Board of Public Utilities, New Jersey's Clean Energy Program™ Protocols to Measure Resource Savings, FY2021 Addendum, Appendix A Measure Lives

~~[600]~~[602] Intellidyne LLC & Brookhaven National Laboratories, *NYSERDA: A Technology Demonstration and Validation Project for Intellidyne Energy Saving Control*, March 2007, Page 3, Table 2, Average of the Four Degree Day Adjusted Heating Sites http://smartbuildingproducts.com/casestudies/files/NYSERDA%20final%20report%203-23-07.pdf

Oak Ridge National Laboratory, *Fuel Conversions Needed in the Weatherization Assistant*, https://weatherization.ornl.gov/wp-content/uploads/2018/05/FuelConversions.pdf

Field Code Changed

Field Code Changed

~~3.5.20~~3.5.2 GUEST ROOM EMS

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	HVAC controls
Measure Last Reviewed	November 2022

Description

This measure covers the installation of an Energy Management System (EMS) in hotel/motel guest rooms or dormitories which automatically adjust the temperature setback during unoccupied periods. Network controlled systems must also include occupancy sensors in guest rooms. Room occupancy is typically detected by occupancy sensors, infrared sensors or key cards. During unoccupied periods the default setting for controlled units should differ by at least 5 degrees from the operating setpoint. Savings are based on the EMS system's ability to automatically adjust the temperature setpoint of the guest room for various occupancy modes reducing the consumption of electricity and/or gas by requiring less heating and/or cooling when a room or a facility is vacant or unoccupied. Measure applicable to Motel, Hotel and Dormitory building types only.

Baseline Case

Hotel/motel rooms or dormitories with manual heating/cooling temperature set-points and on/off controls.

Efficient Case

Hotel/motel guest room or dormitory with an EMS that automatically adjusts room temperature based on room occupancy during unoccupied periods.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

If electric heat:

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

If fuel heat:

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

Where,

$$\Delta kWh_{cool} = \left(\frac{T_c \times (Hrs_{wk} + 7) + S_c \times (168 - (Hrs_{wk} + 7)}{168} - T_c\right) \times \frac{P_c \times Cap_c \times 12 \times EFLH_c}{EER}$$

$$\Delta kWh_{heat} = \left(T_h - \frac{T_h \times (Hrs_{wk} + 7) + S_h \times (168 - (Hrs_{wk} + 7))}{168}\right) \times \frac{P_h \times Cap_h \times EFLH_h}{COP \times 3{,}412}$$

Annual Fuel Savings

If fuel heat:

$$\Delta Therms = \left(T_h - \frac{T_h \times (Hrs_{wk} + 7) + S_h \times (168 - (Hrs_{wk} + 7))}{168}\right) \times \frac{P_h \times ap_h \times EFLH_h}{AFUE \times 100{,}000}$$

Peak Demand Savings

$$\Delta kWh_{Peak} = \frac{\Delta kWh_{cool}}{EFLH_c} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \ \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-203 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkWh_{cool}	Annual cooling electric energy savings	Calculated	kWh/yr	
ΔkWh_{heat}	Annual heating electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
Cap_h	Heating Capacity	Site-specific	Btu/hr	

Variable	Description	Value	Units	Ref
Cap_c	Cooling capacity	Site-specific	Tons	
T_h	Occupied heating setpoint temperature	Site-specific	°F	
T_c	Occupied cooling setpoint temperature	Site-specific	°F	
COP	Electric heating system coefficient of performance	Site-specific; use 1.0 for electric resistance heat	N/A	
AFUE	Heating Annual Fuel Utilization Efficiency	Site-specific. If unknown, use code compliant efficiency when the equipment was new. If equipment age unknown, use vintage efficiency for site-specific equipment type in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~	N/A	
EER	Cooling Energy Efficiency Ratio	Site-specific. If unknown, use code compliant efficiency when the equipment was new. If equipment age unknown, use vintage efficiency for site-specific equipment type in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~	Btu/hr-W	
Hrs_{wk}	Weekly occupied hours[139]	Site-specific; default to 84	Hr/wk	
S_h	Heating setback temperature	Site-specific; default to $T_h - 5$	°F	
S_c	Cooling setback temperature	Site-specific; default to $T_c + 5$	°F	
P_h	Heating savings fraction per degree of setback	0.03	N/A	[603]~~[6013]~~
P_c	Cooling savings fraction per degree of setback	0.06	N/A	[603]~~[6013]~~
$EFLH_h$	Heating Equivalent Full Load Hours. Measure applicable to Motel, Hotel and Dormitory building types only.	Look up in **Error! Reference source not found.**~~Appendix C:~~	Hr	[604]~~[6024]~~

[139] Default value assumes operating hours is 12 hours a day, 7 days a week.

Variable	Description	Value	Units	Ref
$EFLH_c$	Cooling Equivalent Full Load Hours. Measure applicable to Motel, Hotel and Dormitory building types only.	Look up in **Error! Reference source not found.**~~Appendix C:~~	Hr	[604]~~[6024]~~
12	Conversion from tons to kBtu/hr	12	kBtu/h/ton	
168	Hours per week	168	Hr/wk	
7	Weekly hours for setback/setup adjustment based on 1 setback/setup per day, 7 days per week	7	Hr/wk	
3,412	Conversion from Btu to kWh	3,412	Btu/kWh	
100,000	Conversion from Btu to therms	100,000	Btu/therm	
CF	Coincidence factor	Look up in Table 3-204	kW/kWh	
PDF	Peak day factor	Look up in Table 3-204		
EUL	Effective useful life	See Measure Life Section	Years	

Peak Factors

Table 3-204 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.65	[605]~~[6035]~~
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The effective useful life (EUL) for add-on equipment is limited to the remaining useful life (RUL) of the underlying system. If unknown, assume 1/3 of the EUL of the base HVAC equipment (look up in relevant HVAC measure).

References

~~[601]~~[603] ENERGY STAR Programmable Thermostat Calculator. Savings assumptions per 2004 Industry Data.

~~[602]~~[604] Simulations of prototypical buildings from the NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022.

~~[603]~~[605] Average of Massachusetts Utilities summer coincidence factors. Massachusetts eTRM, 2020 update, measure code COM-HVAC-HOS. Available online: https://www.masssavedata.com/Public/TechnicalReferenceLibrary

Field Code Changed

~~3.5.21~~3.5.3 SMART THERMOSTATS

Market	Commercial/Multifamily
Baseline Condition	TOS/NC/RF
Baseline	Code/ISP/Existing
End Use Subcategory	HVAC Control
Measure Last Reviewed	February 2024
Changes Since Last Version	~~Removed references to DI Baseline Condition and dual baseline~~

Description

The smart thermostat measure involves the replacement of a manually operated or conventional programmable thermostat with a "smart" thermostat (defined below). This measure only applies to thermostats that control central A/C, heat pump, furnace, or rooftop units (RTUs) with capacity up to 300,000 Btu/h that serve normal conditioned spaces, not semi-conditioned spaces or spaces with large, frequently open doors (e.g., loading docks and car repair shops). Thermostats for larger systems should be treated as custom measures. This measure may be a time of sale, retrofit, direct install, or new construction measure.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

Retrofit and DI: As a retrofit measure, the baseline equipment is the in-situ manually operated or properly programmed thermostat that was replaced. If a manually operated non-programmable thermostat baseline is claimed, supporting photographic documentation should be collected.

Time of Sale or New Construction: The baseline condition is a programmable thermostat meeting minimum efficiency standards as presented in the 2021 International Energy Conservation Code (IECC 2021).

Efficient Case

The efficient condition is a smart thermostat that has earned ENERGY STAR certification [607]~~[6057]~~ or has followed the ENERGY STAR product requirements[608]~~[6068]~~.

Annual Energy Savings Algorithms

As smart thermostats are control technologies, when possible, heating and cooling savings should be calculated based on data from installed thermostats [609]~~[6079]~~. Otherwise, cooling savings should only be claimed for buildings with central air conditioning. Heating savings may be claimed for buildings with electric resistance, heat pump, or non-electric heating.

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{\mathrm{c}} + \Delta kWh_{\mathrm{h}}$$

Where,

$$\Delta kWh_{c} = CCAP \times EFLH_{cool} \times \frac{1}{Eff_{cool}} \times SF_{elec,c}$$

$$\Delta kWh_{h} = HCAP_{elec} \times EFLH_{heat} \times \frac{1}{HSPF} \times SF_{elec,h}$$

Annual Fuel Savings

$$\Delta Therms = HCAP_{fuel} \times EFLH_{heat} \times \frac{1}{AFUE} \times SF_{fuel}$$

Peak Demand Savings[140]

$$\Delta kW_{Peak} = 0$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-205 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	

[140] The smart thermostat measure as defined here (i.e., without a corresponding demand reduction program) is assumed to have no demand savings. Smart thermostats with a demand response program added on top may generate demand savings.

Variable	Description	Value	Units	Ref
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
CCAP	Cooling capacity of existing AC unit	Site-specific	kBtu/hr	
Eff_{cool}	Cooling efficiency of controlled unit (SEER, SEER2, or IEER). For GSHP, use EER.	Site-specific, if unknown look up in Appendix	Btu/W-h	
$HCAP_{fuel}$	Heating capacity of existing furnace unit	Site-specific	MMBtu/hr	
AFUE	Annual Fuel Utilization Efficiency	Site-specific, if unknown look up in Appendix	N/A	
$HCAP_{elec}$	Heating capacity of existing heat pump or electric resistance unit	Site-specific	kBtu/hr	
HSPF	Heating seasonal performance factor of controlled unit	Site-specific, if unknown look up in Appendix. For electric resistance heat, use 3.412	Btu/W-h	
$SF_{elec,c}$	Electrical cooling percent savings from thermostat relative to baseline control	Look up in Table 3-206	%	[611]~~[609611]~~[612]~~[6102]~~
$SF_{elec,h}$	Electrical heating percent savings from thermostat relative to baseline control	Look up in Table 3-206	%	[611]~~[609611]~~[612]~~[6102]~~
SF_{fuel}	Heating fuel percent savings from thermostat relative to baseline control.	Look up in Table 3-206	%	[611]~~[609611]~~[612]~~[6102]~~
$EFLH_c$	Full load hours for cooling equipment	Look up in Appendix	Hrs/yr	[606]~~[6046]~~
$EFLH_h$	Full load hours for heating equipment	Look up in Appendix	Hrs/yr	[606]~~[6046]~~
CF	Electric coincidence factor	Look up in Table 3-207	N/A	
PDF	Gas peak day factor	Look up in Table 3-207	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-206 Saving Factors for Smart Thermostats by Baseline Technology

Fuel and Function	Baseline Technology		
	Manual Thermostat	Programmable Thermostat	Unknown
Savings factor for electric cooling, $SF_{elec,c}$	5%	3%	3%

Fuel and Function	Baseline Technology		
	Manual Thermostat	Programmable Thermostat	Unknown
Savings factor for electric heating, $SF_{elec,h}$	4%	2%	2%
Savings factor for fuel heating, SF_{fuel}	5%	2%	2%

Peak Factors

Table 3-207 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The effective useful life (EUL) IS 7.5 years [610]~~[6108]~~.

References

~~[604]~~[606] Simulations of prototypical buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022.

~~[605]~~[607] ENERGY STAR's qualified products list for smart thermostats: https://data.energystar.gov/dataset/ENERGY-STAR-Certified-Connected-Thermostats/7p2p-wkbf

~~[606]~~[608] ENERGY STAR Smart Thermostat Specification, from which most requirements based: https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Program%20Requirements%20for%20Connected%20Thermostats%20Version%201.0.pdf

~~[607]~~[609] NEEP has developed a Guidance Document detailing methodology to claim savings from smart thermostats, available here: https://neep.org/sites/default/files/resources/ClaimingSavingsfromSmartThermostatsGuidanceDocumentFinal.pdf. This guidance uses the metric developed for the ENERGY STAR certification to develop geographically and temporally specific savings averages for program claims. These calculated savings numbers are expected to be more accurate and potentially yield higher level of savings than the estimates provided in the TRM.

~~[608]~~[610] Based on professional judgment of TRM technical team. EULs observed for residential applications include: 11 years in AR TRM and 10 years in IL TRM, both of which are based on programmable thermostat EULs. CA workpapers conclude 3-year EUL using persistence modeling. RTF concludes a 5-year EUL based on CA workpapers and concerns that there is little basis for assuming long-time persistence of savings, considering past challenges with manual overrides and "know-how" needed to use wifi-connected devices, including communicating hardware and software downloading. For discussion, see Northwest Regional Technical Forum April 2017. https://nwcouncil.box.com/v/ResConnectedTstatsv1-2

~~[609]~~[611] The savings percentages claimed for manual thermostats include the savings associated with upgrading from manual thermostats to programmable thermostats, which a 2015 MEMD study reported as about 3%

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

savings for gas customers and 2% savings for electric customers. http://www.michigan.gov/documents/mpsc/CI_Programmable_TStats_MEMD_6_15_15_491808_7.pdf

Field Code Changed

~~[610]~~[612] Relative to a programmable thermostat, smart thermostats have savings opportunities available from a "smart recovery" function, which enables users to set the time they would like the building to reach a temperature as opposed to setting a time that the unit should start operating. Savings are also available from improved error detection and from locking out building occupants' ability to override programmed schedules. Individual case studies have demonstrated savings in a variety of small commercial applications, but large-scale evaluations of smart thermostat savings have so far been limited to thermostats installed in residential applications. CLEAResult's "Guide to Smart Thermostats" reports the ranges of savings measured in recent *residential* evaluations, relative to a baseline that blended programmable and manual thermostats: 10–13% for gas savings; 14–18% for electric cooling savings; and 6–13% for electric heating savings. https://www.clearesult.com/insights/whitepapers/guide-to-smart-thermostats/

Field Code Changed

~~[611]~~[613] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

Field Code Changed

~~3.5.22~~3.5.4 STEAM TRAP REPAIR/REPLACE

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Controls
Measure Last Reviewed	May 2023

Description

This measure covers the repair or replacement of leaking or blow-through steam traps in existing commercial steam systems served by fossil fuel-fired boilers. Steam traps that fail open allow excess steam to escape, thus increasing the amount of steam that must be generated to meet end-use requirements. This measure is intended for the repair or replacement of steam traps failed open only and requires the completion of a steam trap assessment to ensure the number of failed open steam traps are properly quantified. This measure does not apply to municipal steam systems. Energy savings from the installation of a stream trap monitoring system may not be claimed in conjunction with the saving presented in this measure.

The savings in this measure are per-steam trap. Savings should be multiplied by the total number of steam traps replaced. This measure is applicable to low pressure (≤15 psig) and high pressure (>15 psig) steam traps.

Baseline Case

The baseline case is the existing leaking or blow-through steam traps.

Efficient Case

The efficient case is the repaired or replaced steam traps.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Annual Fuel Savings

$$\Delta Therms = Loss_{steam} \times \frac{\Delta H_{vap}}{Eff} \times \frac{hrs}{1{,}000{,}000} \times F_{hrs} \times F_{CR}$$

Where,

$$Loss_{steam} = 60 \times \frac{\pi}{4} \times ID^2 \times psia^{0.97} \times F_{discharge} \times F_{loss}$$

$$psia = psig + p_{atm}$$

Annual Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times N/A$$

Lifetime Fuel Savings

$$\Delta herms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-208 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$Loss_{steam}$	Hourly steam loss per failed trap	Calculated	Lb/hr	
psia	Absolute steam pressure	Calculated	psi	
psig	Steam gauge pressure	Site-specific, if unknown look up in Table 3-210	psi	[614]~~[6124]~~
Eff	Thermal efficiency of boiler	Site-specific, if unknown look up in Table 3-210	Et or AFUE	[614]~~[6124]~~
Hrs	Annual hours trap pressurized	Site-specific, if unknown look up in Table 3-210	Hours	[614]~~[6124]~~
ID	Internial diameter of steam trap orifice	Site-specific, if unknown look up in Table 3-210	Inches	
F_{CR}	Condensate return factor, used to account for the proportion of energy lost that is returned to the system via condensate line	If no condensate return: 1.00	N/A	[614]~~[6124]~~

Variable	Description	Value	Units	Ref
		Otherwise, look up in Table 3-210		
ΔH_{vap}	Heat of vaporization (latent heat) at system operating pressure	Look up in Table 3-209	Btu/lb	
$F_{discharge}$	Discharge coefficient	Look up in Table 3-210	N/A	[614]~~[6124]~~
F_{loss}	Steam loss adjustment factor	Look up in Table 3-210	N/A	[614]~~[6124]~~
p_{atm}	Atmospheric pressure	14.7	psi	
60	Empirically derived constant in Grashof's equation	60	lbm/ $in^{0.06}$-$lb^{0.97}$-hr	[615]~~[6135]~~
π/4	Orifice area development factor	π/4	N/A	
0.97	Empirically derived constant in Grashof's equation	0.97	N/A	[615]~~[6135]~~
100,000	Conversion factor	100,000	Btu/therm	
PDF	Gas peak day factor	Lookup in Table 3-152	N/A	
EUL	Effective useful life	See Measure Life section	Years	

Table 3-209 Heat of Vaporization

Gauge Pressure (psig)	Heat of Vaporization (Btu/lb)	Gauge Pressure (psig)	Heat of Vaporization (Btu/lb)
0	970	80	892
1	968	90	886
2	966	100	880
5	960	110	875
10	952	120	871
15	945	125	868
20	939	130	866
25	934	140	861
30	929	150	857
40	920	160	853
50	912	180	845
60	905	200	837
70	898	225	829

Gauge Pressure (psig)	Heat of Vaporization (Btu/lb)
250	820

Table 3-210 Default Steam Trap Parameters

Parameter	Low Pressure (≤15 psig)	High Pressure (>15psig)
Guage pressure (psig)	7.2	86.7
Orifice size (ID)	0.25	0.156
Annual hours	2,525	6,558
Boiler efficiency	0.80	0.80
Steam loss adjustment factor (F_{loss})	0.369	0.369
Discharge coefficient ($F_{discharge}$)	0.70	0.70
Condensate return factor (F_{CR})	0.363	0.363

Peak Factors

Table 3-211 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	Look up in **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The effective useful life (EUL) is 6 years [615]~~[6135]~~.

References

~~[612]~~[614] ERS, "Two-Tier Steam Trap Savings Study", April 26, 2018. pg 5.

~~[613]~~[615] Massachusetts Program Administrators and Energy Efficiency Advisory Council, "Steam Trap Evaluation Phase 2" March 8, 2017. Pg. 6.

~~3.5.23~~3.5.5 MAINTENANCE

Market	Commercial/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Maintenance
Measure Last Reviewed	December 2022
Changes Since Last Version	~~Removed references to DI Baseline Condition and dual baseline~~

Description

This section provides energy savings algorithms for existing HVAC tune ups in commercial applications. Efficiency of various HVAC Units degrades with age and a “tune-up” or preventative maintenance can help restore some of the lost efficiency.

For gas applications, a tune-up of non-residential fossil space heating boilers or furnaces involves cleaning and inspection, adjusting air flow, reduce stack temperatures (for boilers), and adjust burner input among other steps.

Electric Units such as Central A/C and heat pumps also benefit greatly from tune ups. A tune up typically includes air filter replacement, cleaning of coils and fans, repair of case insulation,refrigerant charge adjustments, and air flow adjustments. This measure only applies to central AC Systems or heat pumps of 20 tons (65,000 BTU/h) or less.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

Gas: Commercial fossil space heating boiler or furnace that has not received a tune-up in 3 years or more.

Electric: An existing pre tune-up central A/C or heat pumpthat has not received a tune-up in 3 years or more.

Efficient Case

Gas: Commercial space heating boiler or furnace that has undergone a tune-up in accordance with the program requirements.

Electric: Central A/C System or heat pump after receiving tune up.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

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

Where,

$$\Delta kWh_{Cool} = Cap_c \times EFLH_c \times \frac{1}{SEER_b} \times F_{improv}$$

$$\Delta kWh_{Heat} = Cap_h \times EFLH_h \times \frac{1}{HSPF_b} \times F_{Improv}$$

$$F_{improv} = \frac{Eff_{improv,q} - Eff_{improv,b}}{Eff_{improv,q}}$$

Annual Fuel Savings

For boilers,

$$\Delta Therms = \frac{Cap_{in}}{100} \times \left(1 - \frac{Eff_{c,b}}{Eff_{c,q}}\right) \times EFLH_h$$

For furnaces,

$$\Delta Therms = \frac{F_{furnace} \times Cap_{in} \times EFLH_h}{100}$$

Where,

$$F_{furnace} = \frac{Eff_{f,b} + \Delta Eff_{f,q}}{Eff_{f,b}} - 1$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{1}{EER_b} \times F_{improv} \times CF \times Cap_{in}$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-212 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	

Variable	Description	Value	Units	Ref
ΔkWh_{cool}	Annual cooling energy savings	Calculated	kWh/yr	
ΔkWh_{heat}	Annual heating energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
F_{improv}	Percent improvement in EER/HSPF[141]	Calculated; if EER unknown look up in Table 3-213[142]	N/A	[616]~~[6146]~~[620]~~[618620]~~
$Eff_{improv,b}$	EER/EER2 of existing AC Unit or HSPF of existing Heat pumps	Site-specific	EER: BTU/watts HSPF: BTU/watt-hr	
$Eff_{improv,q}$	EER/EER2 of efficient AC Unit or HSPF of efficient Heat pumps	Site-specific	EER: BTU/watts HSPF: BTU/watt-hr	
EER_b	EER or EER2 of existing AC Unit	Site-specific	BTU/watts	
Cap_c	Cooling Capacity of existing AC Unit	Site-specific	kBTU/hr	
Cap_h	Heating Capacity of existing Heat Pumps	Site-specific	kBTU/hr	
Cap_{in}	Fuel input rating per boiler/furnace	Site-specific	kBTU/hr	
$Eff_{c,b}$	Baseline combustion efficiency as determined via flue gas analysis	Site-specific	N/A	
$Eff_{c,q}$	Post-implementation boiler combustion efficiency as determined via flue gas analysis	Site-specific	N/A	
$Eff_{f,b}$	Actual combustion efficiency of the furnace before tune-up, based on flue gas analysis	Site-specific	N/A	

[141] For heat pumps: HSPF = COP x 3.413, where COP is coefficient of performance
[142] IL TRM derives savings estimates by applying the findings from DNV-GL "Impact Evaluation of 2013-2014 HVAC3 Commercial Quality Maintenance Programs", April 2016, to simulate the inefficient condition within select eQuest models and across climate zones. The percent savings were consistent enough across building types and climate zones that it was determined appropriate to apply a single set of assumptions for all. See 'eQuest C&I Tune up Analysis.xlsx' for more information.

Variable	Description	Value	Units	Ref
$Eff_{f,q}$	Post-implementation furnace combustion efficiency as determined via flue gas analysis	Site-specific	N/A	
$EFLH_c$	Equivalent Full Load Hours of operation for the average unit during the cooling season	See **Error! Reference source not found.**~~Appendix C:~~	Hours	[617]~~[6157]~~
$EFLH_h$	Equivalent Full Load Hours of operation for the average unit during the heating season	See **Error! Reference source not found.**~~Appendix C:~~	Hours	[617]~~[6157]~~
$SEER_b$	SEER or SEER2 of actual unit, before the tune-up	Site-specific, if unknown look up in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~	Btu/W-h	
100	Conversion from kBtu to therms	100	kBtu/Therms	
$F_{furnace}$	Energy Savings Factor furnace	For Large Commercial - Calculated; For Small Commercial (<225 MBH) = 0.05	N/A	[618]~~[6168]~~
CF	Electric coincidence factor (CF)	Look up in Table 3-214	N/A	[620]~~[618620]~~
PDF	Gas peak demand factor	Look up in Table 3-214	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-213 Percent Improvement in EER (F_{improv})

Maintenance or Tune-Up Component	% Savings
Condenser Cleaning	6.10
Evaporator Cleaning	0.22
Refrigeration Charge Offset <=20%	0.68
Refrigeration Charge Offset >20%	8.44

Peak Factors

Table 3-214 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.478	[620]~~[618620]~~

Peak Factor	Value	Ref
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

Measure Life for HVAC tune-up /maintenance measures is 3 yrs [619]~~[6179]~~.

References

~~[614]~~[616] Energy Center of Wisconsin, *Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research* (May 2008)

~~[615]~~[617] Simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

~~[616]~~[618] Washington State University Energy Program, Building Tune-Up and Operations Program Evaluation (March 2007), Pg 5

~~[617]~~[619] DEER 2014 EUL http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx

~~[618]~~[620] *2022 Illinois Statewide Technical Reference Manual for Energy Efficiency Version 10.0 Volume 2: Commercial and Industrial Measures* (2022), Pg 221-223 https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010122_v10.0_Vol_2_C_and_I_09242021.pdf

Field Code Changed

~~3.5.24~~3.5.6 ADVANCED ROOFTOP CONTROLS

Market	Commercial/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Controls
Measure Last Reviewed	February 2024
Changes Since Last Version	~~Removed references to DI baseline condition and dual baseline~~

Description

This measure covers the installation of advanced rooftop unit control (ARC) on a constant volume rooftop HVAC unit with a single-speed supply fan. This involves the following 3 components, adding demand-controlled ventilation (DCV), Dual enthalpy economizers, and a supply fan with a variable frequency drive (VFD). DCV systems monitor the CO_2 levels and accordingly vary the supply outdoor air as needed, resulting in the reduction of heating and cooling loads. Dual enthalpy economizers reduce cooling loads by supplying outside air to the space when the outside air is deemed suitable for cooling. Multi/variable-speed fan motors reduce the fan speed for first stage cooling and ventilation.

Saving factors were calculated based on IL TRM values for Chicago, adjusted by ratio of Degree Days for each listed NJ Climate Zone and Chicago, based on TMYx Data using base 65 F balance point. See the 'Demand Controlled Ventilation' Section of the Illinois Statewide Technical Reference Manual V11 for further explanation [623]~~[6213]~~.

It is important to note that only those components that are not required by code are eligible for savings. See ASHRAE 90.1-2019 section 6.4.3.

Baseline Case

Constant volume rooftop HVAC unit with a single-speed supply fan and no occupancy-based ventilation or functioning airside economizer

Efficient Case

Rooftop HVAC Unit with an advanced rooftop unit controller added providing DCV, VFD fan speed controls, and dual enthalpy air-side economizer control

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{fan} + \Delta kWh_{DCV} + \Delta kWh_{Econ}$$

Where

$$\Delta kWh_{fan} = hp \times ESF_{fan} \times hrs$$

$$\Delta kWh_{DCV} = \frac{A}{1{,}000} \times SF_{ElecCool} + \frac{A}{1{,}000} \times SF_{ElecHeat} \times F_{ElecHeat}$$

$$\Delta kWh_{Econ} = tons \times SF_{Econ}$$

Annual Fuel Savings

$$\Delta Therms = \frac{A}{1{,}000} \times SF_{fuel} \times F_{FuelHat}$$

Peak Demand Savings

$$\Delta kW_{Peak} = hp \times ESF_{fan} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therm \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-215 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{life}$	Lifetime fuel savings	Calculated	Therms	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{fan}	Annual electricity energy savings resulting from supply fan control	Calculated	kWh/yr	
ΔkWh_{DCV}	Annual electricity energy savings resulting from DCV	Calculated	kWh/yr	
ΔkWh_{Econ}	Annual electricity energy savings resulting from economizer	Calculated	kWh/yr	

Variable	Description	Value	Units	Ref
hp	Horsepower of RTU supply fan	Site-specific	hp	
ESF_{fan}	Energy savings factor for supply fan control[143]	0.580	kWh/hp/hr	[621] ~~[6219]~~
hrs	Annual operating hours of RTU supply fan	Site-specific if unknown use default values in Table 3-216	Hrs/yr	[622] ~~[6202]~~
A	Total area square footage of the conditioned space impacted by the measure	Site-specific	Ft^2	
$SF_{ElecCool}$	DCV energy savings factor for cooling	Look up in Table 3-217	kWh/1,000 ft^2	[623] ~~[6213]~~
$SF_{ElecHeat}$	DCV energy savings factor for electric heating	Look up in Table 3-218, Table 3-219	kWh/1,000 ft^2	[623] ~~[6213]~~
$F_{elecHeat}$	Electric heating factor, used to account for the presence or absence of an electric heating system	1 (if electric heat) 0 (otherwise)	N/A	
tons	Tons of air conditioning supplied by RTU, based on nameplate data	Site-specific	tons	
SF_{econ}	Annual electric energy savings per ton of cooling resulting from economizer	Look up in Table 3-221	kWh/ton	[624] ~~[6224]~~
SF_{Fuel}	DCV fuel savings factor for heating	Look up in Table 3-220	therms/1,000 ft^2	[623] ~~[6213]~~
$F_{FuelHeat}$	Fuel heating factor, used to account for the presence or absence of a fossil fuel heating system	1 (if fossil fuel heat) 0 (otherwise)	N/A	
CF	Electric coincidence factor	Look up in Table 3-222	N/A	[625] ~~[6235]~~
PDF	Gas peak day factor	Look up in Table 3-222	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

[143] Unweighted average of kWh/hp/hour fan savings across all test cases in Advanced Rooftop Control (ARC) Retrofit: Field-Test Results, PNNL22656, Table 10: TMY weather normalized annual savings for all units. Fan Energy Savings (kWh) is divided by RTU Fan Power (hp) and Annual RTU Running Time (hr) to determine Energy Savings Factor for supply fan controls (kWh/hp/hr)

Table 3-216 Hours of Use Based on Building Type

Building Type	Hours
Office – Small Commercial	2,950
Office – Large Commercial	2,969
Religious Building	4,573
Restaurant	4,573
Retail - Department Store	4,920
Retail – Strip Mall	4,926
Grocery	7,134
School	2,575
Healthcare Clinic	3,909
Hospital	8,760
Lodging (Hotel/Motel)	4,573
Multifamily – Common Areas	5,950
Multifamily – In-Unit	679
Warehouse – Small Commercial	3,799
Warehouse – Large Commercial/Industrial	4,116
Other	4,573
Enclosed Parking Garage	3,338

Table 3-217 Energy Savings Factor for Cooling Associated with DCV (kWh/1,000 SF)

Building Type	North	Coastal	Central	Pine Barrens	Southwest	Statewide Average
Office - Low-rise (1 to 3 Stories)	267	362	368	366	359	334
Office - Mid-rise (4 to 11 Stories)	211	286	291	289	283	264
Office - High-rise (12+ Stories)	250	340	345	344	337	314
Religious Building	720	978	994	989	970	903
Restaurant	471	640	650	647	634	590
Retail - Department Store	363	493	501	498	489	455
Retail - Strip Mall	251	341	347	345	338	315
Convenience Store	330	448	455	453	444	413

Building Type	North	Coastal	Central	Pine Barrens	Southwest	Statewide Average
Elementary School	339	460	468	465	456	425
High School	332	450	457	455	446	415
College/ University	393	534	543	540	530	493
Healthcare Clinic	327	444	451	449	440	410
Lodging (Hotel/Motel)	378	513	521	518	508	473
Manufacturing	163	222	226	224	220	205
Special Assembly Auditorium	537	729	740	737	722	672
Other	356	483	491	488	479	446
Enclosed Parking Garage	854	1,160	1,179	1,173	1,150	1,070

Table 3-218 Electric Heating Savings with Heat Pump Associated with DCV (kWh/1,000 SF)

Building Type	North	Coastal	Central	Pine Barrens	Southwest	Statewide Average
Office - Low-rise (1 to 3 Stories)	185	149	163	158	163	167
Office - Mid-rise (4 to 11 Stories)	125	100	110	106	109	112
Office - High-rise (12+ Stories)	167	135	147	143	147	151
Religious Building	1206	970	1062	1028	1057	1087
Restaurant	870	700	767	742	763	785
Retail - Department Store	298	239	262	254	261	268
Retail - Strip Mall	194	156	171	166	171	175
Convenience Store	147	119	130	126	129	133
Elementary School	517	416	456	441	454	467
High School	505	406	445	430	443	455
College/ University	1007	811	888	859	884	909
Healthcare Clinic	358	288	316	305	314	323
Lodging (Hotel/Motel)	166	134	147	142	146	150
Manufacturing	103	83	91	88	90	93
Special Assembly Auditorium	1414	1138	1246	1207	1241	1276
Other	484	389	426	413	424	436
Enclosed Parking Garage	185	149	163	158	163	167

Table 3-219 Electric Heating Savings with Electrical Resistance Associated with DCV (kWh/1,000 SF)

Building Type	North	Coastal	Central	Pine Barrens	Southwest	Statewide Average
Office - Low-rise (1 to 3 Stories)	556	448	490	474	488	493
Office - Mid-rise (4 to 11 Stories)	374	301	329	319	328	331
Office - High-rise (12+ Stories)	501	403	441	427	439	443
Religious Building	3617	2910	3186	3085	3172	3202
Restaurant	2610	2100	2300	2226	2289	2311
Retail - Department Store	893	718	786	761	783	790
Retail - Strip Mall	584	470	515	498	512	517
Convenience Store	441	355	389	376	387	391
Elementary School	1551	1248	1367	1323	1360	1374
High School	1513	1218	1333	1291	1327	1340
College/ University	3022	2432	2662	2577	2650	2676
Healthcare Clinic	1074	865	947	916	942	952
Lodging (Hotel/Motel)	498	401	439	425	437	441
Manufacturing	310	250	273	265	272	275
Special Assembly Auditorium	4242	3414	3738	3619	3721	3757
Other	1452	1169	1280	1239	1274	1286

Table 3-220 Fuel Heating Savings Associated with DCV (therm/1,000 SF)

Building Type	North	Coastal	Central	Pine Barrens	Southwest	Statewide Average
Office - Low-rise (1 to 3 Stories)	24	19	21	20	21	21
Office - Mid-rise (4 to 11 Stories)	16	13	14	14	14	14
Office - High-rise (12+ Stories)	22	17	19	19	19	19
Religious Building	155	124	136	132	136	137
Restaurant	111	90	98	95	98	99
Retail - Department Store	38	31	33	32	33	33
Retail - Strip Mall	25	20	22	22	22	22
Convenience Store	19	15	17	16	17	17
Elementary School	66	53	58	56	58	58
High School	64	52	57	55	56	57
College/ University	129	104	114	110	113	114

Building Type	North	Coastal	Central	Pine Barrens	Southwest	Statewide Average
Healthcare Clinic	46	37	41	39	40	41
Lodging (Hotel/Motel)	21	17	18	18	18	18
Manufacturing	14	11	12	12	12	12
Special Assembly Auditorium	181	146	159	154	159	160
Other	61	49	54	52	54	54

Table 3-221 Economizer Savings kWh Per Cooling Ton

Building Type	$(kWh/ton)_{Econ}$
Office	186
Religious Building	6
Restaurant – Full-Service	31
Restaurant – Fast Food	39
Retail - Department Store	152
Retail – Strip Mall	95
Convenience Store	95
Elementary School	42
High School	61
College/University	61
Healthcare Clinic	61
Lodging (Hotel/Motel)	61
Manufacturing	25
Special Assembly Auditorium	27
Warehouse	2
Other	61

Peak Factors

Table 3-222 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.8	[625]~~[6235]~~

Peak Factor	Value	Ref
Natural gas peak day factor (PDF)	See Error! Reference source not found.~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The effective useful life (EUL) is 5 years [626]~~[6246]~~

References

~~[619]~~[621] *Advanced Rooftop Control (ARC) Retrofit: Field-Test Results.* (US DOE 2013) Table 10, https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22656.pdf

~~[620]~~[622] Navigant, *EmPOWER Maryland DRAFT Final Impact Evaluation Deemed Savings (June 1,2017 – May 31, 2018) Commercial & Industrial Prescriptive, Small Business, and Direct Install Programs*, (2018)

~~[621]~~[623] Saving factors were calculated based on IL TRM values for Chicago, adjusted by ratio of Degree Days for each listed NJ Climate Zone and Chicago, based on TMY 3 Data using base 65 F balance point. *2023 Illinois Statewide Technical Reference Manual for Energy Efficiency Version 11 Volume 2: Commercial and Industrial Measures* (September 2022), Pg 357, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010123_v11.0_Vol_2_C_and_I_092222_FINAL.pdf

~~[622]~~[624] *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – Version 10*. (New York State Joint Utilities, 2023), Appendix J Pg 1279-1280 https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V10.pdf

~~[623]~~[625] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – Version 10. (New York State Joint Utilities, 2023), Pg 818 https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V10.pdf

~~[624]~~[626] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – Version 10. (New York State Joint Utilities, 2023), Pg 1366 https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V10.pdf

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

3.6 SHELL

3.6.1 HIGH-RISE MULTIFAMILY AIR SEALING

Market	Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Shell
Measure Last Reviewed	January 2023

Description

This section provides energy savings algorithms for the sealing air leakage paths to reduce the natural air infiltration rate through the installation of products and repairs to the building envelope. It is assumed that air sealing is the first priority among candidate space conditioning measures. Expected percentage savings is based on previous experiences with measured savings from similar programs.

The method below only applies to high-rise multifamily applications where blower door testing is not conducted.

Baseline Case

The baseline case is a building envelope with natural air infiltration through air leakage paths.

Efficient Case

The exterior envelope, as well as interior walls/partitions between conditioned and unconditioned spaces should be inspected and all gaps sealed. At a minimum, the following items shall be inspected, and sealing measures may be implemented based upon inspection results:

- Caulk and weather strip doors and windows that leak air
- Repair or replace doors leading from conditioned to unconditioned space
- Seal air leaks between unconditioned (including unconditioned basement and attics) and conditioned spaces to include, but not limited to, plumbing, ducting, electrical wiring, wall top plates, chimneys, flues, and dropped soffits
- Use foam sealant on larger gaps around windows, baseboards, and other places where air leakage, either infiltration or exfiltration may occur

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{SF}{1{,}000} \times \left(\frac{\Delta kWh}{1{,}000\ ft^2}\right)$$

ΔAnnual Fuel Savings

$$\Delta Therms = \frac{SF}{1{,}000} \times \left(\frac{\Delta Therms}{1{,}000\ ft^2}\right)$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{SF}{1{,}000} \times \left(\frac{\Delta kW}{1{,}000\ ft^2}\right) \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-223 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
SF	Building square feet of conditioned floor area affected by installation	Site-specific	ft^2	
$\frac{\Delta kWh}{1{,}000\ ft^2}$	Annual electric energy savings per thousand square feet	Lookup Table 3-224	kWh/ft^2	[628]~~[6268]~~
$\frac{\Delta kW}{1{,}000\ ft^2}$	Peak coincident demand electric savings per thousand square feet	Lookup Table 3-224	kWh/ft^2	[628]~~[6268]~~
$\frac{\Delta Therms}{1{,}000\ ft^2}$	Annual gas energy savings per thousand square feet	Lookup Table 3-224	Therms/ ft^2	[628]~~[6268]~~
1,000	Conversion Factor from square feet (SF) to 1,000 square feet (kSF)	1000	N?A	

Variable	Description	Value	Units	Ref
CF	Coincidence factor	Lookup in Table 3-225	N/A	
PDF	Gas peak day factor	Lookup in Table 3-225	N/A	
EUL	Effective useful life	See Measure Life section	Years	

Table 3-224 Impact per thousand square feet[144]

Vintage	$\frac{\Delta kWh}{1,000\ ft^2}$	$\frac{\Delta kW}{1,000\ ft^2}$	$\frac{\Delta Therms}{1,000\ ft^2}$
Old	118	0.119	29
Average	56	0.098	17

Peak Factors

Table 3-225 Peak Factors

Peak Factor	Value	Ref
Coincidence factor	0.69	[629]~~[6279]~~
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The effective useful life (EUL) is 15 years [627]~~[6257]~~.

References

~~[625]~~[627] GDS Associates, Inc. Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures. 2007. https://library.cee1.org/sites/default/files/library/8842/CEE_Eval_MeasureLifeStudyLights&HVACGDS_1Jun2007.pdf

~~[626]~~[628] New York State Joint Utilities, New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs, V10, pg. 1222, January 2023.

Field Code Changed

[144] The baseline infiltration rate for old building is 1.0 ACH and average building is 0.5 ACH. The energy savings are based on a 15% reduction.

~~[627]~~[629] Based on BG&E 'Development of Residential Load Profile for Central Air Conditioners and Heat Pumps' research, the Maryland Peak Definition coincidence factor is 0.69. This study is not publicly available, but is referenced by M. M. Straub, Using Available Information for Efficient Evaluation of Demand-Side Management Programs, Electricity Journal, September 2011 and supported by research conducted by Cadmus on behalf of the RM Management Committee.

3.6.2 COMMERCIAL AND INDUSTRIAL AIR SEALING

Market	Commercial and Industrial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Shell
Measure Last Reviewed	February 2025
Changes Since Last Version	• New Measure

Description

This measure covers methods of sealing air leakage paths to reduce the natural air infiltration rate of a building through the installation of products and repairs to the building envelope, including, but not limited to, caulking, gasketing, and weather stripping. Sealing the thermal envelope reduces passive convective heat transfer between conditioned and unconditioned spaces or outside air, thereby reducing heating and cooling loads and improving occupant comfort. This measure is only applicable as a retrofit in existing buildings. This measure is not applicable to gut rehab/major renovation projects, which entail whole-building envelope alterations that trigger more stringent code provisions, limiting potential incremental savings.

In cases where blower door testing is conducted before and after implementation of air sealing treatments, those measurements shall be utilized in the estimation of energy impacts via the method below. A blower door test is performed to measure the leakage rate by depressurizing the building to a standard pressure difference of 75 Pascals or 0.3 inches of water. The flowrate indicates the leakage rate, or infiltration and exfiltration rate, of the building shell.

Baseline Case

Existing building envelope with natural air infiltration.

Efficient Case

The exterior envelope, as well as interior walls/partitions between conditioned and unconditioned spaces should be inspected and all gaps sealed. At a minimum, the following items shall be inspected, and sealing measures may be implemented based upon inspection results:

- Caulk and weather strip doors and windows that leak air

- Repair or replace doors leading from conditioned to unconditioned space
- Seal air leaks between unconditioned (including unconditioned basement and attics) and conditioned spaces, to include, but not limited to, plumbing, ducting, electrical wiring, wall top plates, chimneys, flues, and dropped soffits.
- Use foam sealant on larger gaps around windows, baseboards, and other places where air leakage, either infiltration or exfiltration may occur.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{cooling} + \Delta kWh_{heating}$$

$$\Delta kWh_{cooling} = \frac{\left[\frac{(CFM_{75}/SF)_{baseline} - (CFM_{75}/SF)_{ee}}{F_{n,cooling} \times F_h}\right] \times SF \times LM \times 1.08 \times CDD \times 24}{Eff_{ElecCool} \times 1{,}000}$$

$$\Delta kWh_{heating} = \frac{\left[\frac{(CFM_{75}/SF)_{baseline} - (CFM_{75}/SF)_{ee}}{F_{n,heating} \times F_h}\right] \times SF \times 1.08 \times HDD \times 24 \times F_{ElecHeat}}{HSPF \times 1{,}000}$$

Annual Fuel Savings

$$\Delta Therms = \frac{\left[\frac{(CFM_{75}/SF)_{baseline} - (CFM_{75}/SF)_{ee}}{F_{n,heating} \times F_h}\right] \times SF \times 1.08 \times HDD \times 24 \times F_{FuelHeat} \times 10}{Eff_{FuelHeat} \times 1{,}000{,}000}$$

Peak Demand Savings

$$\Delta kW = \frac{\left[\frac{(CFM_{75}/SF)_{baseline} - (CFM_{75}/SF)_{ee}}{F_{n,cooling} \times F_h}\right] \times SF \times LM \times 1.08}{EER \times 1{,}000} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-226 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$(CFM_{75}/SF)_{baseline}$	Baseline infiltration rate (cubic foot per minute per building square foot) at a negative pressure differential of 75 Pa or 0.3 inches of water	Site-specific, results from blower door test. If pre-implementation blower door test results are unavailable, use 0.40 CFM75/SF as default.[145]	ft^3/min	
$(CFM_{75}/SF)_{ee}$	Efficient infiltration rate (cubic foot per minute per building square foot) at a negative pressure differential of 75 Pa or 0.3 inches of water	Site-specific, results from blower door test. If post - implementation blower door test results are unavailable, use 0.25 CFM75/SF as default.[146,147,148]	ft^3/min	
SF	SF= Square footage of the above- and below-grade building envelope	Site-specific	ft^2	
F_n	Infiltration-Leakage Ratio, used to convert pressurized blower door testing results to natural infiltration rates, climate zone factor	19	N/A	[634]
F_h	Infiltration-Leakage Ratio, used to convert pressurized blower door testing results to natural infiltration rates, building height factor. Based on the number of conditioned stories in the building, from application[149]. The selected value should reflect the number of stories located inside the conditioned envelope of the building.	$= N_{stories}{}^{-0.3}$	N/A	[634]

[145] ASHRAE 90.1 2019, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards
[146] ECCCNYS 2020 C406.9 Reduced air infiltration.
[147] U.S. Army Corps of Engineers Air Leakage Test Protocol for Building Envelopes, Version 3, May 11, 2012, p. 7
[148] NIST, Analysis of U.S. Commercial Building Envelope Air Leakage Database to Support Sustainable Building Design. Analysis of air sealing in commercial buildings demonstrates buildings exceeding ECCCNYS Additional Efficiency Packages requirements.
[149] LBL, Exegesis of Proposed ASHRAE Standard 119: Air Leakage Performance For Detached Single-Family Residential Buildings, M.Sherman, July 1986, pg. 12.

Variable	Description	Value	Units	Ref
	Unconditioned basements and attics should not be included. Upper levels without full height perimeter walls shall be considered as half-stories (0.5).			
LM	Latent Multiplier, converts the sensible cooling load savings captured in the savings equation to a savings capturing both latent and sensible load savings.[150]	Look up in Table 3-228	N/A	
CDD	Cooling Degree Day	Look up in **Error! Reference source not found.**	F-day/yr	[638]
HDD	Heating Degree Day	Look up in **Error! Reference source not found.**	F-day/yr	[638]
$Eff_{elec,c}$	Seasonal average energy efficiency of electric cooling equipment (SEER or IEER)	Site-specific, if unknown look up in Appendix E: Code-Compliant Efficiencies for equipment type and size	Btu/watt-hour	[635]
HSPF	Heating seasonal performance factor of electric heating equipment[151]	Site-specific, if unknown look up in Appendix E: Code-Compliant Efficiencies for equipment type and size	Btu/watt-hour	[635]
EER/EER2	Efficiency in EER of Air Conditioning equipment	Site-specific. If unknown, see Appendix E: Code-Compliant Efficiencies	Btu/W-h	[635]
$Eff_{FuelHeat}$	Efficiency of fossil fuel heating equipment (AFUE, Et or Ec)	Site-specific, if unknown look up in Appendix E: Code-Compliant Efficiencies for equipment type and size		[635]
$F_{ElecHeat}$ -	Electric heating factor, to account for presence of electric heat	Use 1 if electric heat, otherwise use 0	N/A	-
$F_{FuelHeat}$	Fuel heating factor, to account for presence of fuel heat	Use 1 if fuel heat, otherwise use 0	N/A	

[150] The multiplier accommodates for the energy savings impacts associated with decreased humidity influx in a building with improved air sealing. During the cooling season, humidity poses an additional load on the cooling system. The Latent Multiplier is the ratio of total heat load (latent and sensible) to sensible heat load. Set indoor conditions are taken as 75ºF and 50% rh.

[151] If needed, convert COP to HSPF as follows: HSPF = COP × 3.412

Variable	Description	Value	Units	Ref
CF	Coincidence factor	Look up in Error! Reference source not found.	N/A	
1.08	Specific heat of air x density of inlet air at 70ºF x 60 min/hr, in BTU/h-ºF-CFM	1.08	BTU/h.°F.CFM	
24	Hours in a day	24	hrs	
1,000	Conversion factor	1,000	Watts/kW	
1,000,000	Conversion factor	1,000,000	Btu/MMBtu	
10	Conversion factor	10	Therm/Btu	

Table 3-227 Heating and Cooling Degree Days (65°F set point)

City	HDD	CDD
North	5,734	778
Coastal	4,614	1,056
Central	5,051	1,073
Pine barrens	4,891	1,067
Southwest	5,028	1,046

Table 3-228 Latent Multiplier

Location	Latent Load	Sensible Load	Latent Multiplier (LM) [152]
Atlantic City	4.1	0.6	7.8
Newark	3.1	0.6	6.2

Peak Factors

Table 3-229 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.5	[13]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

[152] ASHRAE Journal, Dehumidification and Cooling Loads From Ventilation Air, Lewis Harriman, November 1997.

Measure Life

The effective useful life (EUL) is 15 years. [643]

References

[630] ECCCNYS 2020 Section C402.5 Air leakage – thermal envelope (Mandatory). Available from: https://codes.iccsafe.org/content/NYSECC2020P1/chapter-4-ce-commercial-energy-efficiency#NYSECC2020P1_CE_Ch04_SecC402

[631] ECCCNYS 2020 Section C406.9 Reduced air infiltration. Available from: https://codes.iccsafe.org/content/NYSECC2020P1/chapter-4-ce-commercial-energy-efficiency#NYSECC2020P1_CE_Ch04_SecC406

[632] US Army Corps of Engineers Air Leakage Test Protocol for Building Envelopes, Version 3, May 11, 2012. Available from: https://www.wbdg.org/FFC/ARMYCOE/usace_airleakagetestprotocol.pdf

[633] National Institute of Standards and Technology, Analysis of U.S. Commercial Building Envelope Air Leakage Database to Support Sustainable Building Design. Available from: https://tsapps.nist.gov/publication/get_pdf.cfm?pub_id=914293

[634] Lawrence Berkley Laboratory, University of California, Exegesis of Proposed ASHRAE Standard 119: Air Leakage Performance for Detached Single-Family Residential Buildings, M. Sherman, July 1986. Available from: https://escholarship.org/uc/item/4268v5z5

[635] 10 CFR 430.32 (c)(1), December 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430

[636] Building America House Simulation Protocols, Robert Hendron and Cheryn Engebrecht, National Renewable Energy Laboratory, October 2010. Available from: https://www1.eere.energy.gov/buildings/publications/pdfs/building_america/house_simulation_revised.pdf

[637] 2017 ASHRAE Handbook – Fundamentals, Chapter 16: Ventilation and Infiltration

[638] ONJSC: Monthly/Annual Temperature Normals (1991-2020), http://climate.rutgers.edu/stateclim_v1/norms/monthly/index.html.

[639] Air Conditioning Contractors of America, Technical Reference Note, Computing Manual J Infiltration Loads Based Upon a Target Envelope Leakage Requirement, Note 2016-1, October 2016. Available from: https://higherlogicdownload.s3.amazonaws.com/ACCA/c6b38bda-2e04-4f93-bd51-7a80525ad936/UploadedImages/Infiltration%20per%20Blower%20Door%20Test%20Oct2016.pdf

[640] Infiltration Factor Calculation Methodology, Bruce Harley, Senior Manager, Applied Building Science, CLEAResult. As captured in Appendix A of the Illinois Technical Advisory Committee's Memorandum, TRM Version 5 Draft 1 Review – Second Measure Group, November 25, 2015. Available from: https://www.ilsag.info/wp-content/uploads/SAG_files/Technical_Reference_Manual/Version_5/IL_TAC_Second_ Measure_Group_Draft_Memo_11-25-2015.pdf

[641] ASHRAE Journal, Dehumidification and Cooling Loads From Ventilation Air, Lewis Harriman, November 1997.

[642] C&I Unitary HVAC Load Shape Project Final Report. August 2011, v.1.1, p. 12, Table O-5. The CF reported here is a center point for NJ chosen between the CF for urban NY and for the Mid-Atlantic region in the PJM peak periods. Available from: http://www.neep.org/sites/default/files/resources/NEEP_HVAC_Load_Shape_Report _Final_August2_0.pdf.

[643] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007, Table 1 – Residential Measures

3.6.3 DOCK DOOR SEALS AND SHELTER

Market	Commercial and Industrial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	N/A
Measure Last Reviewed	February 2025
Changes Since Last Version	• New Measure

Description

This measure applies to buildings with exterior doors that serve as loading docks.

Overhead dock doors allow for loading and unloading of trucks. When the truck backs into the dock bumpers, a gap is created between the truck and the dock door that allows the infiltration or exfiltration of air in the upper, lower, and side portions. The infiltration/exfiltration of cold and warm air during the heating and cooling seasons increases the energy load of the building. Dock door seals are foam panels that are mounted outside of the dock door. Dock shelters are structures that form an enclosure around the perimeter of the trailer and are mounted outside of the dock door. The addition of dock door seals and shelters forms a tight seal between the truck and the door that prevents air infiltration/exfiltration and results in energy savings and enhanced personal comfort. Dock door seals and shelters also prevent the passing of rain droplets, snow, dust, insects, and other airborne particles.

This measure was developed to be applicable to the following program types: RF. If applied to other program types, the measure savings should be verified.

Baseline Case

Dock doors with no seals or shelters installed to effectively reduce heat loss and air during truck loading and unloading.

Efficient Case

Dock doors with compression seals or shelters forming a tight seal around the top, bottom, and sides of the truck and installed following manufacturer guidelines to effectively reduce heat loss and air during truck loading and unloading.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{cooling} + \Delta kWh_{heating}$$

Where,

$$\Delta kWh_{cooling} = \frac{Q}{EER} * \mathrm{t_{open}} * CD$$

$$\Delta kWh_{heating} = \frac{Q}{HSPF} * \mathrm{t_{open}} * HD$$

Heat Transfer Through Open Dock Door Without Dock Door Seal or Shelter (during Cooling Season)

$$Qtbs = 4.5 * CFMtot * (hoc - hic) / (1{,}000\ Btu/kBtu)$$

The total airflow through the gaps, CFM_{tot}, includes both infiltration due to wind as well as thermal forces, as follows:

$$CFM_{tot} = \sqrt{(CFM_w^2 + CFM_t^2)}$$

The infiltration due to the wind is calculated as follows:

$$CFM_w = (v_{wc} * C_{wc}) * C_v * A_d * (88\ fpm/mph)$$

The infiltration due to thermal forces is calculated as follows:

$$CFM_t = A_d * C_{dc} * (60\ sec/min) * \sqrt{2 * g * \frac{H_d}{2} * (T_{oc} - T_{ic})/(459.7 + T_{oc})}$$

$$C_{dc} = 0.4 + 0.0025 * |T_{ic} - T_{oc}|$$

Note, values for C_{dc} show little variation due to balance point temperature, indoor air temperature, and climate zone. As such, if estimating results, the NJ average value of 0.39 at indoor air temp of 70˚F may be used as a simplification.

Annual Fuel Savings

$$\Delta Therms = Q * t_{open} * \frac{HD}{\eta}$$

Heat Transfer Through Open Entryway (Heating Season)

$$Q = 1.08 * CFM_{tot} * \frac{T_{ih} - T_{oh}}{100000\ Btu/therm}$$

The total airflow through the entryway, CFM_{tot}, includes both infiltration due to wind as well as thermal forces, as follows:

$$CFM_{tot} = \sqrt{(CFM_w^2 + CFM_t^2)}$$

The infiltration due to the wind is calculated as follows:

$$CFM_w = (v_{wh} * C_{wh}) * C_v * A_d * (88\ fpm/mph)$$

The infiltration due to thermal forces is calculated as follows:

$$CFM_t = A_d * C_{dh} * (60\ sec/min) * \sqrt{2 * g * \frac{H_d}{2} * (T_{ih} - T_{oh})/(459.7 + T_{ih})}$$

Where,

$$C_{dh} = 0.4 + 0.0025 * |T_{ih} - T_{oh}|$$

Note, values for C_{dh} show little variation due to balance point temperature, indoor air temperature, and climate zone. As such, if estimating results, the NJ average value of 0.46 at indoor air temp of 70˚F may be used as a simplification.

Peak Demand Savings

$$\Delta kW = \left(\frac{\Delta kWh_{cooling}}{CD * 24}\right) * CF$$

Daily Peak Fuel Savings

$$\Delta ThermsPeak = \Delta Therms \text{ X PDF}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-230 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$\Delta kWh_{cooling}$	Annual electric cooling energy savings	Calculated	kWh/yr	
$\Delta kWh_{heating}$	Annual electric heating energy savings	Calculated	kWh/yr	
Q_{tbs}	Rate of total heat transfer through the gap before dock door seal or shelter	Calculated	kBtu/hr	
CFM_w	Infiltration due to the wind	Calculated	Cfm	
CFM_t	Infiltration due to thermal forces	Calculated	Cfm	

Variable	Description	Value	Units	Ref
CFM_{tot}	Total air flow through gaps	Calculated	cfm	
H	Dock door height	Site-specific		
L_A	Leakage Area (gap) between doorway and truck[153]	Site-specific, or assume 16.8	ft^2	[648]
T_{ic}	Average indoor air temperature during cooling season	Site-specific, if unknown use 70°F	˚F	[648]
η	Efficiency of heating equipment	Site specific, if unknown, assume 0.8	AFUE	[646]
T_{ih}	Average indoor air temperature during heating season	Site-specific, if unknown use 70°F	˚F	[648]
EER	Energy efficiency ratio of electric cooling equipment[154]	Site-specific, if unknown look up in Appendix E for equipment type and size	Btu/watt-hour	[646]
HSPF	Heating seasonal performance factor of electric heating equipment[155]	Site-specific, if unknown look up in Appendix E for equipment type and size	Btu/watt-hour	[646]
t_{open}	Average hours per day that a truck is in the loading position and the truck dock door is open[156]	8.39	hr/day	[645]
CD	Operating days in the cooling season	Look up in Table 3-232	Days	
HD	Operating days in the heating season	Look up in Table 3-232	days	
4.5	Unit conversion factor with density of air: 60 min/hr * 0.075 lbm/ft³	4.5	Lb-min/ft³-hr	
h_{oc}	Average outdoor enthalpy during cooling season	Look up in Table 3-231	Btu/lb	
h_{ic}	Average enthalpy of indoor air, cooling season	Look up in Table 3-233~~Table 3-233~~	Btu/lb	
V_{wc}	Average wind speed during the cooling season based on entryway orientation[157]	Look up in Table 3-234	Mph	[647]

[153] Estimated 16.8 square feet of gap area. The leakage area is comprised of gaps on top, bottom and on the sides of the dock door. Common dock door dimensions are 8'0" in width with 8 ft, 9 ft or 10 ft heights. The maximum trailer size limits are 8'6" wide x 13'6" high (varies by state). Most trucks require a dock height of between 46 and 52 in. For the purposes of this calculation a 48" dock height and 9'0" wide x 10'0" high door was use, to cover the full range of truck types.

[154] For equipment rated in EER2, use EER2. If unknown, calculate EER as follows:

$$EER = (1.12 \times SEER) - (0.02 \times SEER^2)$$

[155] If needed, convert COP to HSPF as follows: $HSPF = COP \times 3.412$

[156] Assumes 23-hour per day operation 5 days per week, with an average loading time of 45 minutes (including truck arrival and departure time). Average time between trucks estimated at 90 minutes taken from customer interviews. 5 day/7 days * 23 hr/day / 90 minutes per truck event x 45 minutes door open time per truck event = 8.39 average hr/day, 7 days/week.

[157] Average wind speeds are calculated based on the TMY3 wind speed data

Variable	Description	Value	Units	Ref
C_{wc}	Wind speed correction factor due to wind direction in cooling season[158] (%)	Look up in Table 3-236		[647]
C_v	Effectiveness of openings, assumes diagonal wind[159]	0.3		[647]
C_{dc}	Eischarge coefficient during cooling season[160,161]	0.42		[647]
T_{oc}	Average outdoor temperature during cooling season	Look up in Table 3-231	˚F	
C_{wh}	Wind speed correction factor due to wind direction in heating season,	Look up in		[647]
V_{wh}	Average wind speed during heating season	Look up in Table 3-235	(mph)	[647]
C_{dh}	Discharge coefficient during heating season	0.46		[647]
g	Acceleration due to gravity	32.2	ft/sec^2	
459.7	Conversion factor from ˚F to ˚R[162]	459.7	N/A	
1.08	Sensible heat transfer coefficient: specific heat of air and unit conversions,	1.08	BTU/h.°F.CFM	
T_{oh}	Average outdoor temp during heating season	Look up in Table 3-231	˚F	

[158] Because wind direction is not constant, a wind speed correction factor is used to adjust for the amount of time during the cooling season that prevailing winds can be expected to impact the entryway.
[159] ASHRAE, "Ventilation and Infiltration," in 2013 ASHRAE Handbook – Fundamentals (2013): p 16.13
[160] ASHRAE, "Ventilation and Infiltration," in 2013 ASHRAE Handbook – Fundamentals (2013): p 16.13
[161] A single entrance is assumed for simplicity. Effects of indoor and outdoor temperature differential are expected to have negligible impact on this factor and are therefore ignored.
[162] Calculation requires absolute temperature for values not calculated as a difference of temperatures

Table 3-231 Outdoor Air Temperature and Enthalpy

NJ Climate Region	Relative Humidity[163] (%)	Avg. outdoor temperature[164] during cooling season, $T_{outdoor,c}$ (°F)	Avg. outdoor temperature[135]~~[134]~~ during heating season, $T_{outdoor,h}$ (°F)	Avg enthalpy[165] of outdoor air at during cooling season, $H_{outdoor,c}$ (Btu/lb)	Avg enthalpy[136]~~[135]~~ of outdoor air at during heating season, $H_{outdoor,c}$ (Btu/lb)
Northern	69.77	74.60	42.10	32.05	14.39
Southern	67.39	74.50	42.70	31.51	14.49
Coastal	74.63	73.00	46.20	31.87	16.47
Central	75.77	74.30	43.20	33.09	15.23
Pine Barrens	74.34	73.70	43.40	32.33	15.22
Statewide Average	72.61	73.91	43.82	32.14	15.31

Table 3-232 Cooling days per year and heating days per year[166]

NJ Climate Region	Heating days	Cooling days
Northern	207	70
Southern	204	74
Coastal	208	81
Central	207	75
Pine Barrens	204	76

[163] Average of NOAA hourly relative humidity from January 2020 – December 2022 for each climate zone representative weather station (Northern = Allentown, PA; Southern = Philadelphia, PA; Coastal = Atlantic City, NJ; Central = Trenton, NJ; Pine Barrens = McGruire Air Force Base, NJ)

[164] Calculated from TMY3 data for representative weather stations for each NJ climate zone. Cooling hours are defined as any hour when outdoor air temperature is above 65°F for the months of June through August and heating hours are defined as any hour when outdoor air temperature is below 65°F for the months of October through April. The average heating and cooling temperatures are the average temperature of these hours for the typical meteorological year.

[165] Calculated via ASHRAE Dayton's online psychometric tool, using the average NJ elevation of 228 ft above sea level. https://daytonashrae.org/psychrometrics/psychrometrics_imp.html#start

[166] Calculated from TMY3 data for representative weather stations for each NJ climate zone. Cooling days are defined as any day when outdoor air temperature is above 65°F for the months of June through August and heating day are defined as any day when outdoor air temperature is below 65°F for the months of October through April. The heating and cooling days above represent the count of each in a typical meteorological year. Note: these values may over-estimate days for buildings with limited operating hours such as offices, schools, etc. Site-specific estimate should be used when possible.

Table 3-233 Indoor Enthalpy

Temperature, T_{indoor} (°F)	Enthalpy, H_{indoor} at 50% Relative Humidity (Btu/lb)
65	22.7
66	23.2
67	23.7
68	24.2
69	24.8
70	25.3
71	25.8
72	26.4
73	27.0
74	27.5
75	28.1
76	28.7
77	29.3
78	29.9

Table 3-234 Average wind speed during the cooling season based on entryway orientation

NJ Climate Region	N	E	S	W	Unknown (average)
Northern	3.8	4.3	4.6	6.2	5.2
Central	3.5	3.4	3.7	4.2	3.8
Pine Barrens	4.6	3.1	3.8	4.7	4.2
Southwest	4.3	3.4	3.8	4.5	4.1
Coastal	4.5	4.8	5.6	5.4	5.2

Table 3-235 Average wind speed during the heating season based on entryway orientation

NJ Climate Region	N	E	S	W	Unknown (average)
Northern	3.5	3.4	4.0	4.1	3.8
Central	3.1	3.2	3.0	3.0	3.1
Pine Barrens	3.5	2.3	2.7	2.9	3.0
Southwest	3.4	3.6	2.7	3.9	3.5
Coastal	2.9	3.8	4.5	3.9	3.9

Table 3-236 Wind speed correction factor due to wind direction in cooling season (%)

NJ Climate Region	N	E	S	W	Unknown (average)
Northern	0.16	0.11	0.18	0.20	0.16
Central	0.13	0.10	0.20	0.08	0.13
Pine Barrens	0.13	0.05	0.14	0.15	0.12
Southwest	0.11	0.05	0.11	0.20	0.12
Coastal	0.09	0.11	0.29	0.09	0.15

Table 3-237 Wind speed correction factor due to wind direction in heating season (%)

NJ Climate Region	N	E	S	W	Unknown (average)
Northern	0.11	0.14	0.09	0.32	0.17
Central	0.13	0.07	0.15	0.20	0.14
Pine Barrens	0.17	0.13	0.23	0.39	0.23
Southwest	0.24	0.06	0.11	0.16	0.14
Coastal	0.12	0.10	0.15	0.33	0.18

Peak Factors

Table 3-238 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.50	[648]
Natural gas peak day factor (PDF)	See Appendix G: Natural Gas Peak Day Factors	

Measure Life

The effective useful life (EUL) is 15 years.

References

[644] ASHRAE, "Ventilation and Infiltration," in 2013 ASHRAE Handbook – Fundamentals (2013): Ch 16.1 - 16.37.

[645] https://www.novalocks.com/wp-content/uploads/Dock-Planning-Standards-Guide.pdf

[646] N. J. B. o. Utilities, "New Jersey 2023 Triennial Technical Reference Manual, APPENDIX E: CODE-COMPLIANT EFFICIENCIES, Section 8.2," 2023.

[647] ASHRAE, "Ventilation and Infiltration," ASHRAE Handbook – Fundamentals, p. 16.13, 2013

[648] C&I Unitary HVAC Load Shape Project Final Report. August 2011, v.1.1, p. 12, Table O-5. The CF reported here is a center point for NJ chosen between the CF for urban NY and for the Mid-Atlantic region in the PJM peak periods.

3.7 LIGHTING

3.7.1 LIGHTING FIXTURES

Market	Commercial/Multifamily
Baseline Condition	TOS/NC/EREP/DI
Baseline	Code/Existing
End Use Subcategory	Lighting Fixtures
Measure Last Reviewed	February 2024
Changes Since Last Version	• ~~Removed dual baseline references, use AML instead~~ • ~~Updated headings in Table 3-235 to reflect AML~~ • ~~Updated measure lives in Table 3-235 to round to nearest integer~~Updated HVAC interactivity factors lookup

Description

This section provides energy savings algorithms for qualifying lighting improvements implemented in commercial and industrial settings. This measure includes both retrofit of existing lamps and new construction projects. For in-unit lamps and lamps installed in common areas of multifamily low-rise buildings, refer to the Residential Section. For lamps/fixtures installed in common areas of multifamily high-rise buildings, use the algorithms below.

Replacement programs includes fixture replacements for existing commercial and industrial customers. It is targeted for facilities performing efficiency upgrades to their lighting systems. New fixtures and technologies available after publication will be periodically updated. Baselines will be established based on the guidelines noted below.

For new construction and entire facility rehabilitation projects, savings are calculated by comparing the lighting power density (LPD) of fixtures being installed to the baseline LPD, or "lighting power allowance," from the building code. For the state of New Jersey, the applicable building code is IECC 2021 [650]~~[629~~650].

For interior lighting power allowance, ASHRAE 90.1 allows either a space by space method or a building area method to calculate the overall lighting power allowance. The space by space method involves applying a different LPD for each space using values from Table 3-241~~Table 3-228~~241 whereas the building area method involves applies applying a uniform LPD to the entire building using values from Table 3-240~~Table 3-227~~240.

The exterior lighting power allowance is calculated as follows.

1. Determine the lighting zone from Table 3-242~~Table 3-229~~242.
2. Determine the applicable category and space type from Table 3-243~~Table 3-230~~243

3. Based on lighting zone, category, and space type, determine the applicable exterior LPD.
4. The LPD is multiplied with the appropriate unit to get lighting power allowance.

There are 2 types of surfaces in Table 3-243~~Table 3-230243~~, tradable and non tradable surfaces. Tradable surfaces are surfaces where if you don't use all the lighting allowed on one of the surfaces you can use the left over on another one of the tradable surfaces. Non-tradable surfaces are allowed a certain amount of lighting and you cannot use the excess somewhere else nor can you use excess from somewhere else on these surfaces.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

New Construction Interior Lighting: Baseline lighting LPD based on the IECC 2021 Code [650]~~[629650]~~ with adjustments for standard practice [7].

New Construction Exterior Lighting: Baseline lighting LPA based on the IECC 2021 Code [650]~~[629650]~~ with adjustments for standard practice [7].

Replacement: Actual existing fixture/lamp wattage. If unknown, use wattage from **Error! Reference source not found.**~~Appendix L: Lighting Wattages~~ Table 15.2 [649]~~[628649]~~.

Mid-Stream Lighting: Lookup in **Error! Reference source not found.**~~Appendix L: Lighting Wattages~~ Table 15.1

Efficient Case

New Construction Interior Lighting: LPD of qualified fixtures, equal to the sum of installed fixture wattage divided by floor area of the space where the fixtures are installed.

New Construction Exterior Lighting: LPA of qualified fixtures, equal to the sum of installed fixture wattage

Retrofit: Wattage of new fixture.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

New Construction Interior Lighting:

$$\Delta kWh = \frac{LPD_b \times LPD_{AF} - LPD_q}{1{,}000} \times A \times Hrs \times (1 + HVAC_c)$$

New Construction Exterior Lighting:

$$\Delta kWh = \frac{\left(LPA_b \times LPA_{AF} - LPA_q\right)}{1{,}000} \times AL \times Hrs$$

Replacement/Midstream Interior Lighting:

$$\Delta kWh = \frac{Qty_b \times W_b - Qty_q \times W_q}{1{,}000} \times Hrs \times (1 + HVAC_c)$$

Replacement/Midstream Exterior Lighting:

$$\Delta kWh = \frac{Qty_b \times W_b - Qty_q \times W_q}{1{,}000} \times Hrs$$

Annual Fuel Savings

Replacement/Midstream Interior Lighting:

$$\Delta Therms = \frac{\left(Qty_b \times W_b - Qty_q \times W_q\right)}{1{,}000} \times Hrs \times HVAC_{ff} \times 10$$

New Construction Interior Lighting:

$$\Delta Therms = \frac{LPD_b \times LPD_{AF} - LPD_q}{1{,}000} \times A \times Hrs \times HVAC_{ff} \times 10$$

Note: *No fuel impacts are claimed in exterior lighting installation.*

Peak Demand Savings

Retrofit Interior Lighting:

$$\Delta kW_{Peak} = \frac{Qty_b \times W_b - Qty_q \times W_q}{1{,}000} \times CF \times (1 + HVAC_d)$$

Retrofit Exterior Lighting:

$$\Delta kW_{Peak} = \frac{Qty_b \times W_b - Qty_q \times W_q}{1{,}000} \times CF$$

New Construction Interior Lighting:

$$\Delta kW_{Peak} = \frac{LPD_b \times LPD_{AF} - LPD_q}{1{,}000} \times A \times CF \times (1 + HVAC_d) \times (1 + SVG_b)$$

New Construction Exterior Lighting

$$\Delta kW_{peak} = \frac{\left(LPA_b \times LPA_{AF} - LPA_q\right)}{1{,}000} \times AL \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms * PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

For NC/TOS:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

For EREP/DI:

$$\Delta kWh_{Life} = \Delta kWh \times AML$$

Lifetime Fuel Energy Savings

For NC/TOS:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

For EREP/DI:

$$\Delta Therms_{Life} = \Delta Therms \times AML$$

Calculation Parameters

Table 3-239 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	

~~226 Calculation Parameters~~

~~Variable~~	~~Description~~	~~Value~~	~~Units~~	~~Ref~~
~~ΔkWh~~	~~Annual electric energy savings~~	~~Calculated~~	~~kWh/yr~~	
~~ΔTherms~~	~~Annual fuel savings~~	~~Calculated~~	~~Therms/yr~~	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
Qty_b	Quantity of replaced fixtures	Site-specific	N/A	
Qty_q	Quantity of qualifying fixtures	Site-specific	N/A	
W_b	Wattage of baseline fixture	Site-specific, if unknown see **Error! Reference source not found.**~~Appendix L: Lighting Wattages~~	W	[649]~~[628~~649]
W_q	Wattage of qualifying fixture (per DLC or ENERGY STAR certification,	Site-specific	W	

~~Variable~~	~~Description~~	~~Value~~	~~Units~~	~~Ref~~
	or manufacturer's cutsheet if certification not required by program)			
LPD_q	Installed lighting power density	Site-specifiic	W/Sq Ft	
LPD_b	Baseline lighting power density	Site-specific, if unknown look up in Table 3-240~~Table 3-227~~240, Table 3-241~~Table 3-228~~241, Table 3-243~~Table 3-230~~243	W/Sq Ft	
LPA_b	Baseline lighting power allowance	Site-specific, if unknown look up in Table 3-243~~Table 3-230~~243	W/Sq Ft or W/ Linear Ft	[650]~~[629~~650]
LPA_q	Installed lighting power allowance	Site-specific, if unknown look up in Table 3-243~~Table 3-230~~243	W/Sq Ft or W/ Linear Ft	[650]~~[629~~650]
AL	If LPA unit is W/Sq Ft: AL is Area If LPA Unit is W/linear ft: AL is linear ft	Site-specific	Sq Ft or Linear Ft	
A	Area in Square Feet	Site-Specific	Square Foot	
Hrs	Annual Hours of Operation	Site-specific, if unknown use Table 3-244~~Table 3-231~~244	Hrs/yr	[622]~~[620~~2]
LPD_{AF} (interior)	Interior Lighting LPD adjustment factor (25% better)	0.75	N/A	[655]~~[634~~655]
LPA_{AF} (exterior)	Exterior Lighting LPA adjustment factor (35% better)	0.65	N/A	[655]~~[634~~655]
$HVAC_c$	HVAC Interactive Factor for Annual Energy Savings	Look up in ~~Table 3-232~~**Error! Reference source not found.**~~Appendix F: HVAC Interactivity Factors~~	N/A	[672]~~[651~~672][674]~~[653~~674]
$HVAC_{ff}$	HVAC Interactive Factor for Annual Fossil Fuel Savings	Look up in **Error! Reference source not found.**~~Appendix F: HVAC Interactivity Factors~~	MMBtu/kWh	[659]~~[638~~659]

~~Variable~~	~~Description~~	~~Value~~	~~Units~~	~~Ref~~
$HVAC_d$	HVAC Interactive Factor for Peak Demand Savings	Look up in Table 3-245~~Table 3-232~~245	N/A	[672]~~[651~~672][674]~~[653~~674]
CF	Coincidence Factor	Look up in Table 3-244~~Table 3-231~~244	N/A	[622]~~[620~~2]
SVG_b	Savings control factor	Look up in Table **3-245** ~~Table 3-233~~246		[658]~~[637~~658]
PDF	Gas peak day factor	Look up in Table 3-246~~Table 3-234~~247		
AML	Adjusted measure life for EREP/DI	See Measure Life Section	Years	
EUL	Effective useful life for NC/TOS	See Measure Life Section	Years	
1,000	Conversion from watts to kW	1,000	W/kW	
10	Conversion from MMBtu to therms	10	Therms/MMBtu	

Table 3-240~~227~~240 Baseline Lighting Power Density (Building Area Method) – IECC 2021 Standard Section C405.3.2(1) [650]~~[629~~650]

Building Area Type	LPD (Watts/ft²)	Building Area Type	LPD (Watts/ft²)
Automotive facility	0.75	Multifamily	0.45
Convention center	0.64	Museum	0.55
Court house	0.79	Office	0.64
Dining: bar lounge/leisure	0.80	Parking garage	0.18
Dining: cafeteria/fast food	0.76	Penitentiary	0.69
Dining: family	0.71	Performing arts theatre	0.84
Dormitory	0.53	Police/fire station	0.66
Exercise center	0.72	Post office	0.65
Fire station	0.56	Religious building	0.67
Gymnasium	0.76	Retail	0.84
Health care clinic	0.81	School/university	0.72
Hospital	0.96	Sports arena	0.76
Hotel/motel	0.56	Town hall	0.69
Library	0.83	Transportation	0.50
Manufacturing facility	0.82	Warehouse	0.45

Building Area Type	LPD (Watts/ft²)
Motion picture theatre	0.44
Workshop	0.91

Table 3-241~~228~~241 Baseline Lighting Power Density (Space by Space Method) 2021 IECC section C405.3.2(2) [2]

Space Types	LPD (watts/ft²)
Atrium	
Less than 40 feet in height	0.48
Greater than 40 feet in height	0.6
Audience seating area	
In an auditorium	0.61
In a gymnasium	0.23
In a motion picture theater	0.27
In a penitentiary	0.67
In a performing arts theater	1.16
In a religious building	0.72
In a sports arena	0.33
Otherwise	0.33
Automotive (see Vehicular maintenance area)	
Banking activity area	0.61
Breakroom (See Lounge/breakroom)	
Classroom/lecture hall/training room	
In a penitentiary	0.89
Otherwise	0.71
Computer room, data center	0.94
Conference/meeting/multipurpose room	0.97
Convention Center—exhibit space	0.61
Copy/print room	0.31
Corridor	
In a facility for the visually impaired (and not used primarily by the staff)[b]	0.71
In a hospital	0.71
Otherwise	0.41
Courtroom	1.2
Dining area	
In bar/lounge or leisure dining	0.86
In cafeteria or fast food dining	0.4
Laundry/washing area	0.53
Library	
In a reading area	0.96
In the stacks	1.18
Loading dock, interior	0.88
Lobby	
For an elevator	0.65
In a facility for the visually impaired (and not used primarily by the staff)[b]	1.69
In a hotel	0.51
In a motion picture theater	0.23
In a performing arts theater	1.25
Otherwise	0.84
Locker room	0.52
Lounge/breakroom	
In a healthcare facility	0.42
Otherwise	0.59
Manufacturing facility	
In a detailed manufacturing area	0.8
In an equipment room	0.76
In an extra-high-bay area (greater than 50 feet floor-to-ceiling height)	1.42
In a high-bay area (25–50 feet floor-to-ceiling height)	1.24
In a low-bay area (less than 25 feet floor-to-ceiling height)	0.86
Museum	
In a general exhibition area	0.31
In a restoration room	1.1
Office	
Enclosed	0.74
Open plan	0.61
Parking area, interior	0.15
Pharmacy area	1.66

Space Types	LPD (watts/ft²)
In a facility for the visually impaired (and not used primarily by the staff)[b]	1.27
In family dining	0.6
In a penitentiary	0.42
Otherwise	0.43
Dormitory—living quarters[c, d]	0.5
Electrical/mechanical room	0.43
Emergency vehicle garage	0.52
Facility for the visually impaired[b]	
In a chapel (and not used primarily by the staff)	0.7
In a recreation room (and not used primarily by the staff)	1.77
Fire Station—sleeping quarters[c]	0.23
Food preparation area	1.09
Guestroom[c, d]	0.41
Gymnasium/fitness center	
In an exercise area	0.9
In a playing area	0.85
Healthcare facility	
In an exam/treatment room	1.4
In an imaging room	0.94
In a medical supply room	0.62
In a nursery	0.92
In a nurse's station	1.17
In an operating room	2.26
In a patient room[c]	0.68
In a physical therapy room	0.91
In a recovery room	1.25
Laboratory	
In or as a classroom	1.11
Otherwise	1.33

Space Types	LPD (watts/ft²)
Performing arts theater—dressing room	0.41
Post office—sorting area	0.76
Religious buildings	
In a fellowship hall	0.54
In a worship/pulpit/choir area	0.85
Restroom	
In a facility for the visually impaired (and not used primarily by the staff[b]	1.26
Otherwise	0.63
Retail facilities	
In a dressing/fitting room	0.51
In a mall concourse	0.82
Sales area	1.05
Seating area, general	0.23
Stairwell	0.49
Sports arena—playing area	
For a Class I facility[e]	2.94
For a Class II facility[f]	2.01
For a Class III facility[g]	1.3
For a Class IV facility[h]	0.86
Storage room	0.38
Transportation facility	
At a terminal ticket counter	0.51
In a baggage/carousel area	0.39
In an airport concourse	0.25
Vehicular maintenance area	0.6
Warehouse—storage area	
For medium to bulky, palletized items	0.33
For smaller, hand-carried items	0.69
Workshop	1.26

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

b. A 'Facility for the Visually Impaired' is a facility that is licensed or will be licensed by local or state authorities for senior long-term care, adult daycare, senior support or people with special visual needs.

c. Where sleeping units are excluded from lighting power calculations by application of Section R404.1, neither the area of the sleeping units nor the wattage of lighting in the sleeping units is counted.

d. Where dwelling units are excluded from lighting power calculations by application of Section R404.1, neither the area of the dwelling units nor the wattage of lighting in the dwelling units is counted.

e. Class I facilities consist of professional facilities; and semiprofessional, collegiate, or club facilities with seating for 5,000 or more spectators.

f. Class II facilities consist of collegiate and semiprofessional facilities with seating for fewer than 5,000 spectators; club facilities with seating for between 2,000 and 5,000 spectators; and amateur league and high school facilities with seating for more than 2,000 spectators.

g. Class III facilities consist of club, amateur league and high school facilities with seating for 2,000 or fewer spectators.

h. Class IV facilities consist of elementary school and recreational facilities; and amateur league and high school facilities without provision for spectators.

Table 3-242~~229~~242 Exterior Lighting Zones - 2021 IECC section C405.5.2 (1)

Lighting Zone	Description
1	Developed areas of national parks, state parks, forest land, and rural areas
2	Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited nighttime use, and residential mixed-use areas
3	All other areas not classified as Lighting Zone 1, 2, or 4
4	High-activity commercial districts in major metropolitan areas as designated by the local land use planning authority

Table 3-~~243~~230243 Exterior Lighting Power Allowances – 2021 IECC Standard Section C405.5.2(2) and Section C405.5.2(3)

Category		Space	Units	Zone 1	Zone 2	Zone 3	Zone 4
Base Site Allowance			W	350	400	500	900
Tradable Surfaces	Uncovered Parking Areas	Parking areas and drives	W/ft²	0.03	0.04	0.06	0.08
	Building Grounds	Walkways and ramps less than 10 feet wide	W/Linear Foot	0.50	0.50	0.60	0.70
	Building Grounds	Walkways and ramps 10 feet wide or greater, plaza areas	W/ft²	0.10	0.10	0.11	0.14
	Building Grounds	Dining areas	W/ft²	0.65	0.65	0.75	0.95
	Building Grounds	Stairways	W/ft²	0.60	0.70	0.70	0.70
	Building Grounds	Pedestrian tunnels	W/ft²	0.12	0.12	0.14	0.21
	Building Grounds	Landscaping	W/ft²	0.03	0.04	0.04	0.04
	Building Entrances and Exits	Pedestrian and vehicular entrances and exits	W/Linear Foot of opening	14	14	21	21
	Building Entrances and Exits	Entry canopies	W/ft²	0.20	0.25	0.40	0.40
	Building Entrances and Exits	Loading docks	W/ft²	0.35	0.35	0.35	0.35
	Sales Canopies	Canopies (free-standing and attached)	W/ft²	0.40	0.40	0.6	0.7
	Outdoor Sales	Open areas (including vehicle sales lots)	W/ft²	0.20	0.20	0.35	0.50
	Outdoor Sales	Street frontage for vehicle sales lots in addition to "Open Area" allowance	W/Linear Foot	-	7	7	21
Non-	Building facades		W/ft² of gross above-grade wall area	-	0.075	0.113	0.15
	Automated teller machines (ATMs) and night depositories		W per location	135 plus 45 per	135 plus 45 per	135 plus 45 per	135 plus 45 per

Category	Space	Units	Zone 1	Zone 2	Zone 3	Zone 4
			additional ATM	additional ATM	additional ATM	additional ATM
	Uncovered entrances and gatehouse inspection stations at guarded facilities	W/ft²	0.5	0.5	0.5	0.5
	Uncovered loading areas for law enforcement, fire, ambulance, and other emergency vehicles	W/ft²	0.35	0.35	0.35	0.35
	Drive-up windows and doors	W/drive-through	200	200	200	200
	Parking near 24-hour retail entrances	W/main entry	400	400	400	400

Table 3-244~~231~~244 Hours of Use and Coincidence Factor by Building Type

Building Type	Sector	CF	Hours
Grocery	Large Commercial/Industrial & Small Commercial	~~0.96~~.99	~~7,134~~7580
Medical – Clinic	Large Commercial/Industrial & Small Commercial	1.0~~.8~~	3,909
Medical - Hospital	Large Commercial/Industrial & Small Commercial	1	8,760[167]
Office	Large Commercial/Industrial	0.7	2,969
	Small Commercial	0.67	2,950
Other	Large Commercial/Industrial & Small Commercial	0.66	4,573
Retail	Large Commercial/Industrial	0.~~96~~92	~~4,920~~5593
	Small Commercial	0.86	4,926
School	Large Commercial/Industrial & Small Commercial	0.50	2,575
Warehouse/ Industrial	Large Commercial/Industrial	0.~~7~~79	4,116
	Small Commercial	0.~~68~~65	~~3,799~~2422
Outside/Outdoor Area	All	0.~~11~~0	~~3,604~~4305 (Parking) 4380 (Other)
Parking Garage	All	0.98	8,678
Multifamily – Common Areas[168]	Multifamily	1.0~~.86~~	~~5,950~~8760
Multifamily – In-Unit	Multifamily	0.06	679
Multifamily –Exterior	Multifamily	0.00	3,338

[167] Assumes hospital operations are year round.
[168] NEEP Mid-Atlantic TRM V9, p. 24.

Building Type	Sector	CF	Hours
College/University - Cafeteria[169]	All	0.79	2,713
College/University – Classes[3]	All	0.54	2,586
College/University - Dormitory[3]	All	0.92	3,066
Religious Building[3]	All	0.89	1,955
Nursing Home[3]	All	0.92	5,840
Restaurant - Dine-In[169~~145~~168]	All	0.79	4,182
Restaurant - Fast food[169~~145~~168]	All	0.79	6,456
Museum[169~~145~~168]	All	0.89	3,748

Table 3-245~~232~~246 ~~HVAC Interactive Effects~~[~~170~~]

~~Building Type~~	~~HVAC Interactive Factor for Peak Demand Savings ($HVAC_d$)~~		~~HVAC Interactive Factor for Annual Energy Savings ($HVAC_e$)~~			
	~~AC (Utility)~~	~~AC (PJM)~~	~~AC/NonElec~~	~~AC/ElecRes~~	~~Heat Pump~~	~~NoAC/ElecRes~~
~~Office~~	~~0.35~~	~~0.32~~	~~0.10~~	~~-0.15~~	~~-0.06~~	~~-0.25~~
~~Retail~~	~~0.27~~	~~0.26~~	~~0.06~~	~~-0.17~~	~~-0.05~~	~~-0.23~~
~~Education~~	~~0.44~~	~~0.44~~	~~0.10~~	~~-0.19~~	~~-0.04~~	~~-0.29~~
~~Warehouse~~	~~0.22~~	~~0.23~~	~~0.02~~	~~-0.25~~	~~-0.11~~	~~-0.27~~
~~Mid-Stream/Other~~[~~171~~]	~~0.34~~	~~0.32~~	~~0.08~~	~~-0.18~~	~~-0.07~~	~~-0.26~~

~~Table 3-233~~ Baseline SVG Values

Building Type	SVGbase
Education	17%
Exterior	0%
Grocery	5%

[169] From NY TRM V10, Pg 862

~~[170] These values only apply for conditioned spaces. For unconditioned spaces, the ineractive factors are equal to zero.~~

~~[171] The 'Other' building type should be used when the building type is known but not explicitly listed above. A description of the actual building type should be recorded in the project documentation. For multifamily high-rise building common areas, use this type. For in unit lamps/fixtures and multifamily low-rise building common areas refer to the Residential Section.~~

Health	8%
Industrial/Manufacturing – 1 Shift	0%
Industrial/Manufacturing – 2 Shift	0%
Industrial/Manufacturing – 3 Shift	0%
Institutional/Public Service	12%
Lodging	15%
Miscellaneous/Other	6%
Office	15%
Parking Garage	0%
Restaurant	5%
Retail	5%
Warehouse	14%
Custom	Based on Code

Peak Factors

Table 3-246~~234~~247 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	Look up in Table 3-244~~Table 3-231~~244	[622]~~[620~~2]
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

Table 3-247~~235~~248 Measure Life

Equipment Type	AML (for EREP/DI)	EUL (for NC/TOS)	Ref
LED Fixture	5	Fixture rated life in hours ÷ operating hours from Table 3-244~~Table 3-231~~244. Not to exceed 15 yr.	[656]~~[635~~6]
LED Fixture with Controls	7	Fixture rated life in hours ÷ operating hours from Table 3-244~~Table 3-231~~244. Not to exceed 15 yr.	[656]~~[635~~6]
TLED	5	N/A	[656]~~[635~~6]
High Bay/Low Bay LED Fixture	7	Fixture rated life in hours ÷ operating hours from Table 3-244~~Table 3-231~~244. Not to exceed 15 yr.	[656]~~[635~~6]

Equipment Type	AML (for EREP/DI)	EUL (for NC/TOS)	Ref
High Bay/Low Bay LED Fixture with Controls	8	Fixture rated life in hours ÷ operating hours from Table 3-244~~Table 3-231~~244. Not to exceed 15 yr.	[656]~~[635~~6~~]~~
High Bay/Low Bay TLED	6	N/A	[656]~~[635~~6~~]~~
Exterior/Outdoor LED Fixture	7	Fixture rated life in hours ÷ operating hours from Table 3-244~~Table 3-231~~244. Not to exceed 15 yr.	[656]~~[635~~6~~]~~
Exterior/Outdoor LED Fixture with Controls	8	Fixture rated life in hours ÷ operating hours from Table 3-244~~Table 3-231~~244. Not to exceed 15 yr.	[656]~~[635~~6~~]~~
Exterior/Outdoor TLED	6	N/A	[656]~~[635~~6~~]~~
Screw-in LEDs	1	N/A	[657]~~[636~~657~~]~~

References

~~[628]~~[649] Review of Device Codes and Rated Lighting System Wattage Table Retrofit Program. 2015. National Grid. January 13, 2015. https://www.nationalgridus.com/non_html/2010_Retrofit_Lighting_DeviceCodes_RI.pdf

~~[629]~~[650] “2021 INTERNATIONAL ENERGY CONSERVATION CODE (IECC) | ICC DIGITAL CODES.” n.d. Codes.iccsafe.org. Accessed November 16, 2022. https://codes.iccsafe.org/content/IECC2021P2/chapter-4-ce-commercial-energy-efficiency.

~~[630]~~[651] Navigant, *EmPOWER Maryland DRAFT Final Impact Evaluation Deemed Savings (June 1,2017 – May 31, 2018) Commercial & Industrial Prescriptive, Small Business, and Direct Install Programs*, (2018)

~~[631]~~[652] Navigant, *EmPOWER Maryland DRAFT Final Impact Evaluation Report Evaluation Year 4 (June 1, 2012 – May 31, 2013) Commercial & Industrial Prescriptive & Small Business Programs*, (2013)

~~[632]~~[653] DNV KEMA (2013). *Impact Evaluation of 2010 Prescriptive Lighting Installations. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory*

~~[633]~~[654] Northeast Energy Efficiency Partnerships & KEMA, *C&I Lighting Load Shape Project FINAL Report - Prepared for the Regional Evaluation, Measurement and Verification Forum.* (2011).

~~[634]~~[655] DNV, *New Jersey Commercial New Construction Industry Standard Practice Analysis. Prepared for Rutgers University and the NJ Board of Public Utilities.* (2022).

~~[635]~~[656] DNV, *New Jersey Non-Residential Lighting Market Characterization. Prepared for Rutgers University and the NJ Board of Public Utilities.* (2022).

~~[636]~~[657] Engineering judgement based on expected existing incandescent or halogen lamp remaining life. Once the existing lamp has burned out, replacement with an EISA-compliant lamp is assumed to be the only option.

~~[637]~~[658] *Technical Reference Manual Volume 3: Commercial and Industrial Measures* (August 2019) Pg 21 https://www.puc.pa.gov/filing-resources/issues-laws-regulations/act-129/technical-reference-manual/

~~[638]~~[659] *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs: Version 10* (2023) Appendix D, Pg 1162

Field Code Changed

3.7.2 LIGHTING CONTROLS

Market	Commercial/Multifamily
Baseline Condition	NC/RF
Baseline	ISP/Existing
End Use Subcategory	Control
Measure Last Reviewed	February 2024
Changes Since Last Version	~~Removed references to DI Baseline Condition and dual baseline~~

Description

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

- **Normal Lighting Controls:** Normal lighting controls include occupancy sensors, daylight dimmer systems, and occupancy controlled hi-low controls for fluorescent, LED, and HID fixtures.
- **Networked Lighting Controls:** This measure defines the savings associated with installing a network controlled lighting system. The control system must include luminaire-level lighting control (LLLC) that can switch lights on and off based on occupancy and is capable of full-range dimming based on local light levels. Note: Because networked lighting controls are required to include occupancy sensors and daylight harvesting, savings from occupancy sensors and daylight dimming control cannot be claimed separately. Additional savings may be achieved at no additional hardware cost on a site-specific basis by implementing high-end trimming, personalized local controls, and customized scheduling with no need for additional equipment or software.
- **Bi-level Lighting Controls:** This measure addresses bi-level occupancy control of lighting in stairwells, corridors, parking garages and parking lots via the installation of controls on existing fixtures or installation of luminaires with integrated bi-level occupancy control. Bi-level occupancy control allows for the continuous lighting of spaces at code-mandated minimum illumination levels when the space is unoccupied and at higher light levels when occupied. This measure is only applicable as a retrofit or replacement in existing buildings because multi-level switching at defined lighting power densities and percentages of full connected load is mandated in many space types by federal, state, local, and municipal codes and standards. This measure is restricted to lighting in parking lots and in spaces that are required by fire and safety code to be illuminated continuously. The post-implementation case must comply with all provisions of applicable fire, safety and construction code.

Baseline Case

Retrofit (RF): The baseline condition is the existing lighting system which includes controls such as continuous operation or manual on/off controls

New Construction (NC): The baseline condition is a control system that meets ASHRAE 90.1-2019 or industry standard practice in new construction.

Efficient Case

Retrofit (RF): The efficient condition is the existing lighting system retrofitted with more efficient controls.

New Construction (NC): The efficient condition is the baseline system that meets ASHRAE 90.1-2019 or industry standard practice in new construction with additional controls.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

Normal or Networked Lighting

$$\Delta kWh = kW_c \times Hrs \times (SVG_b - SVG_q) \times (1 + HVAC_c)$$

Bi-level Lighting

$$\Delta kWh = \left[\frac{W_b \times Qty_b}{1{,}000} - \left(\frac{W_q \times Qty_q}{1{,}000} \times (1 - SVG_{bl})\right)\right] \times Hrs$$

Where,

$$SVG_{bl} = F_{low} \times \left(1 - \frac{W_{low}}{W_q}\right)$$

Annual Fuel Savings

Normal or Networked Lighting

$$\Delta Therms = kW_c \times Hrs \times (SVG_b - SVG_q) \times HVAC_{ff} \times 10$$

Bi-level Lighting

$$\Delta Therms = N/A$$

Peak Demand Savings

Normal or Networked Lighting

$$\Delta kW_{Peak} = kW_c \times (SVG_b - SVG_q) \times CF \times (1 + HVAC_d)$$

Bi-level Lighting

$$\Delta kW_{Peak} = \left[\frac{W_b \times Qty_b}{1{,}000} - \left(\frac{W_q \times Qty_q}{1{,}000} \times (1 - SVG_{bl,demand})\right)\right] \times CF$$

Where,

$$SVG_{bl,demand} = F_{low} \times \left(1 - \frac{W_{low}}{W_q}\right)$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-248~~236~~249 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
$\Delta Therms$	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ESF	Energy savings factor	Calculated	N/A	
SVG_{bl}	Percent of annual lighting energy saved by the bi-level lighting control	Calculated	N/A	
$SVG_{bl,demand}$	Percent of annual lighting demand energy saved by the bi-level lighting control	Calculated	N/A	

Variable	Description	Value	Units	Ref
kW_c	Lighting load connected to control	Site-specific	kW	
Qty_b	Quantity of existing fixture	Site-specific	N/A	
Qty_q	Quantity of efficient fixture	Site-specific	N/A	
W_b	Wattage of existing fixture	Site-specific	W	
W_q	Wattage of efficient fixture at full light output	Site-specific	W	
W_{low}	Wattage of the efficient fixture in low-power mode	Site-specific	W	
F_{low}	Percentage of annual operating hours that the fixture operated in low-power mode	Site-specific, if unknown lookup in Table 3-250~~Table 3-238~~251	N/A	[663]~~[642~~663][664]~~[6~~6~~43]~~[665]~~[644~~665][666]~~[645~~666]
SVG_b	Percent of annual lighting energy saved by the baseline lighting control	Lookup in Table 3-249~~Table 3-237~~250	N/A	[662]~~[641~~662]
SVG_q	Percent of annual lighting energy saved by the efficient lighting control	Lookup in Table 3-249~~Table 3-237~~250	N/A	[662]~~[641~~662]
$HVAC_d$	Secondary demand in reduced HVAC consumption resulting from decreased indoor lighting wattage	Look up in **Error! Reference source not found.**~~Appendix F: HVAC Interactivity Factors~~	N/A	[660]~~[639~~660]

Variable	Description	Value	Units	Ref
$HVAC_c$	Secondary energy savings in reduced HVAC consumption resulting from decreased indoor lighting wattage	Look up in **Error! Reference source not found.**~~Appendix F: HVAC Interactivity Factors~~	N/A	[660]~~[639660]~~
$HVAC_{ff}$	Secondary energy savings in reduced HVAC consumption resulting from decreased indoor lighting wattage	Lookup in **Error! Reference source not found.**~~Appendix F: HVAC Interactivity Factors~~	MMBtu/kWh	[669]~~[648669]~~
Hrs	Annual hours of operation prior to installation of controls	Site-specific, if unknown use Table 3-244~~Table 3-231~~244 (in Section 3.7.1)	Hours	[670]~~[649670]~~
ISR	In-service rate	Look up by program in **Error! Reference source not found.**~~Appendix J: In-Service Rates~~, or use default value = 1	N/A	
1,000	Conversion factor	1,000	kW/W	
10	Conversion factor	10	Therms/MMBtu	
CF	Electric coincidence factor	Lookup in Table 3-251~~Table 3-239~~252	N/A	[670]~~[649670]~~
PDF	Gas peak day factor	Lookup in Table 3-251~~Table 3-239~~252	N/A	

Variable	Description	Value	Units	Ref
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-249~~237~~250 SVG

Lighting Control Type	SVG
Networked lighting controls (NLC)	0.49
Luminaire-level lighting controls (LLLC) – Networked & Commissioned	0.49
Integrated fixture with room-based controls[172]	0.38
Dual occupancy and daylight sensors	0.38
Combination of high-end trim and daylight dimming	0.35
Combination of high-end trim and occupancy sensors	0.33
Daylight dimming	0.28
Occupancy sensors	0.24
No lighting controls	0.00

Table 3-250~~238~~251 Low-Power Mode Factor

Space Type	F_{low}
Stairwell	0.73
Corridor	0.75
Parking Garage	0.56
Parking Lot	0.45

Peak Factors

Table 3-251~~239~~252 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	Look up in Table 3-244~~Table 3-231~~244 (in Section 3.7.1)	[667]~~[6467]~~
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

172 38% is highest savings factor associated with a non-networked fixture with integrated controls. This was determined to be a reasonable assumption for a fixture with three integrated controls that is not networked or verified/commissioned.

Measure Life

The effective useful life (EUL) is 8 years [572].

References

~~[639]~~[660] Average HVAC interactive effects by building type derived from the NEEP Mid-Atlantic TRM 2017, NEEP, *Mid-Atlantic Technical Reference Manual*, V10, Appendix E.

~~[640]~~[661] Massachusetts TRM, 2016-2018 Program Years, October 2015. Original source: DNV KEMA (2013). Impact Evaluation of 2010 Prescriptive Lighting Installations. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council

~~[641]~~[662] DNV. 2022. "X1931-4 ALC PSD Phase 2 Memo." Connecticut Energy Efficiency Board (EEB) and Evaluation Administrators.

~~[642]~~[663] California Energy Commission, Lighting Research Program, Project 5.1 Bi-level Stairwell Fixture Performance Final Report, October 2005 – Average of "Time Dimmed" across the four test sites during weekday operation (Table 2. Weekday daily average energy usage and savings, pg. 22).

~~[643]~~[664] CA State Partnership for Energy Efficiency Demonstrations, Interior Lighting Case Study: Adaptive Corridor Lighting, April 2014, pg. 2. https://cltc.ucdavis.edu/sites/default/files/files/publication/CASE_STUDY_UCSF_Adaptive_Corridors_140602.pdf

~~[644]~~[665] California Energy Commission Public Interest Energy Research Program, Case Study: Bi-Level LED Parking Garage Luminaires – Average of unoccupied hours across the three test sites. https://cltc.ucdavis.edu/sites/default/files/files/publication/case-study-bi-level-led-garage-luminaires.pdf

~~[645]~~[666] Pacific Gas & Electric, Application Assessment of Bi-Level LED Parking Lot Lighting, February 2009, pg. 1. https://www.osti.gov/biblio/1218189

~~[646]~~[667] NEEP Mid-Atlantic TRM 2018, NEEP, Mid-Atlantic Technical Reference Manual, V8. May 2018, pp. 462-463.

~~[647]~~[668] California Public Utilities Commission EUL Table, version 027 (updated November 12, 2022). Accessed December 30, 2022. https://www.caetrm.com/shared-data/value-table/EUL/

~~[648]~~[669] *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs: Version 10* (2023) Appendix D, Pg 1162

~~[649]~~[670] Navigant, *EmPOWER Maryland DRAFT Final Impact Evaluation Deemed Savings (June 1,2017 – May 31, 2018) Commercial & Industrial Prescriptive, Small Business, and Direct Install Programs*, (2018)

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

3.7.3 DELAMPING

Market	Commerical/Multifamily
Baseline Condition	ERET/DI
Baseline	Existing/Dual
End Use Subcategory	Lighting
Measure Last Reviewed	September 2024
Changes Since Last Version	• ~~Clarified efficient case definition~~ • ~~Moved HVAC interactive effect look-up to appendix~~

Description

This measure relates to the permanent removal of a lamp and the associated electrical sockets (or “tombstones”) from a fixture.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

The baseline conditions will vary dependent upon the characteristics of the existing fixture.

Efficient Case

The efficient condition will vary depending on the existing fixture and the number of lamps removed.

- Total delamping (all lamps removed): efficient wattage = 0
- Parital delamping (not all lamps removed): efficient wattage = pre-existing wattage minus wattage of removed lamps. For replacement with efficient lamps see Section 3.7.1.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{Watts_b - Watts_q}{1{,}000} \times Hrs \times (1 + HVAC_c)$$

Annual Fuel Savings

$$\Delta Therms = \frac{Watts_b - Watts_q}{1{,}000} \times Hrs \times HVAC_{ff}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{Watts_b - Watts_q}{1{,}000} \times (1 + HVAC_d) \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-252~~240~~253 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$Watts_b$	Total Connected load of baseline fixture	Site-specific	Watts	
$Watts_q$	Total Connected load of delamped fixture (equal to baseline watts minus wattage of removed lamps – for replacement with efficient lamps see Section 3.7.1)	Site-specific	Watts	

Variable	Description	Value	Units	Ref
Hrs	Deemed average hours of use per year	Look up in Table 3-244~~Table 3-231~~244 (in Section 3.7.1)	Hrs/yr	[671]~~[650~~671~~]~~
$HVAC_c$	HVAC Interactive Factor for Annual Energy Savings	Look up in **Error! Reference source not found.**~~Appendix F: HVAC Interactivity Factors~~	N/A	[672]~~[651~~672~~]~~[674]~~[653~~674~~]~~
$HVAC_{ff}$	HVAC Interactive Factor for Annual Fuel Savings	Look up in **Error! Reference source not found.**~~Appendix F: HVAC Interactivity Factors~~	N/A	[676]~~[655~~676~~]~~
$HVAC_d$	HVAC Interactive Factor for Annual Demand Savings	Look up in **Error! Reference source not found.**~~Appendix F: HVAC Interactivity Factors~~	N/A	[672]~~[651~~672~~]~~[674]~~[653~~674~~]~~
CF	Electric coincidence factor	Look up in Table 3-244~~Table 3-231~~244 (in Section 3.7.1)	N/A	[671]~~[650~~671~~]~~
PDF	Gas peak day factor	Look up in Table 3-253~~Table 3-241~~254	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Peak Factors

Table 3-253~~241~~254 Peak Factors

Peak Factor	Value	Ref
Electric Coincedence (CF)	Look up in Table 3-244~~Table 3-231~~244 (in Section 3.7.1)	
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-~~254242~~255 Measure Life

Equipment	EUL	RUL	Ref
Delamping	16	5.33	[673]~~[652673]~~

References

~~[650]~~[671] Navigant, EmPOWER Maryland DRAFT Final Impact Evaluation Deemed Savings (June 1, 2017 – May 31, 2018) Commercial & Industrial Prescriptive, Small Business, and Direct Install Programs, (2018).

~~[651]~~[672] Navigant, *EmPOWER Maryland DRAFT Final Impact Evaluation Report Evaluation Year 4 (June 1, 2012 – May 31, 2013) Commercial & Industrial Prescriptive & Small Business Programs*, (2013)

~~[652]~~[673] GDS Associates, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, June 2007 available at https://library.cee1.org/sites/default/files/library/8842/CEE_Eval_MeasureLifeStudyLights&HVACGDS_1Jun2007.pdf

~~[653]~~[674] DNV KEMA (2013). *Impact Evaluation of 2010 Prescriptive Lighting Installations. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory*

~~[654]~~[675] Northeast Energy Efficiency Partnerships & KEMA, *C&I Lighting Load Shape Project FINAL Report - Prepared for the Regional Evaluation, Measurement and Verification Forum.* (2011).

~~[655]~~[676] *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs: Version 10* (2023) Appendix D, Pg 1162

Field Code Changed

3.7.4 EXIT SIGNS

Market	Commercial/Multifamily
Baseline Condition	DI
Baseline	Existing
End Use Subcategory	Equipment
Measure Last Reviewed	January 2023
Changes Since Last Version	~~Removed dual baseline algorithms~~

Description

This measure relates to the installation of an exit sign illuminated with light emitting diodes (LED). This measure should be limited to early replacement applications. Note: While this measure is characterized as an early replacement, a dual baseline is not used as it is assumed that the existing fixture would have been maintained with new baseline lamps (and ballasts, if required) for the duration of the measure life.

Baseline Case

The baseline condition is an existing exit sign with a non-LED light-source.

Efficient Case

The efficient condition is a new exit sign illuminated with light emitting diodes (LED).

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{W_b - W_q}{1{,}000} \times Hrs \times (1 + HVAC_c)$$

Annual Fuel Savings

$$\Delta Therms = \frac{W_b - W_q}{1{,}000} \times Hrs \times HVAC_{ff}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{W_b - W_q}{1{,}000} \times (1 + HVAC_d) \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-255~~243~~256 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
W_b	Actual Connected load of existing exit sign	Site-specific, if unknown look up in Table 3-256~~Table 3-244~~257	kW	
W_q	Actual Connected load of LED exit sign	Site-specific, if unknown look up in Table 3-256~~Table 3-244~~257	kW	
Hrs	Average hours of use per year	Site-specific, if unknown use 8,760	Hours	
$HVAC_c$	HVAC Interactive Factor for Annual Energy Savings	Look up in **Error! Reference source not found.**~~Appendix F: HVAC Interactivity Factors~~	N/A	[677]~~[656~~677~~]~~[674]~~[653~~674~~]~~
$HVAC_{ff}$	HVAC Interactive Factor for Annual Fuel Savings	Look up in **Error! Reference source not found.**~~Appendix F: HVAC Interactivity Factors~~	N/A	[683]~~[662~~683~~]~~
$HVAC_d$	HVAC Interactive Factor for Peak Demand Savings	Look up in **Error! Reference source not found.**~~Appendix F: HVAC Interactivity Factors~~	N/A	[677]~~[656~~677~~]~~[674]~~[653~~674~~]~~

Variable	Description	Value	Units	Ref
CF	Electric coincidence factor	Look up in Table 3-257~~Table 3-245~~258	N/A	
PDF	Gas peak day factor	Look up in Table 3-257~~Table 3-245~~258	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-256~~244~~257 Connected Load by Bulb Type

Type	Single-Sided kW	Dual-Sided kW
Incandescent	0.020	0.040
Fluorescent	0.009	0.020
LED	0.002	0.004

Peak Factors

Table 3-257~~245~~258 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1.00	[679]~~[658~~679]
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-258~~246~~259 Measure Life

Equipment	EUL	RUL	Ref
Exit Signs	15	5	[680]~~[659~~680]

References

~~[656]~~[677] EmPOWER Maryland DRAFT Final Impact Evaluation Report Evaluation Year 4 (June 1, 2012 – May 31, 2013) Commercial & Industrial Prescriptive & Small Business Programs, Navigant, March 31, 2014. WHF values for Washington, D.C. and Delaware assume values from Maryland, Pepco and Maryland, DPL, respectively.

~~[657]~~[678] Rundquist, R A, Johnson, K F, and Aumann, D J. 1993. 1993 ASHRAE Journal:"Calculating lighting and HVAC interactions". Typical aspect ratio for perimeter zones. Heating factor applies to perimeter zoneheat, therefore it must be adjusted to account for lighting in core zones.

~~[658]~~[679] Efficiency Vermont Technical Reference Manual 2009-55, December 2008.

~~[659]~~[680] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx.
~~[660]~~[681] DNV KEMA (2013). *Impact Evaluation of 2010 Prescriptive Lighting Installations. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory*
~~[661]~~[682] Northeast Energy Efficiency Partnerships & KEMA, *C&I Lighting Load Shape Project FINAL Report - Prepared for the Regional Evaluation, Measurement and Verification Forum.* (2011).
~~[662]~~[683] *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs: Version 10* (2023) Appendix D, Pg 1162

3.7.5 LED SIGN LIGHTING

Market	Commercial/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Lighting
Measure Last Reviewed	January 2023
Changes Since Last Version	~~Removed references to DI Baseline Condition and dual baseline~~

Description

This measure is applicable to the installation of LED sign lighting fixtures. This technology provides the required illumination at reduced input power. Typically, these signs are constructed from sheet metal sides forming the shape of letters and a translucent plastic lens. Luminance is most commonly provided by single or double strip neon lamps, powered by neon sign transformers. Retrofit kits are available to upgrade existing signage from neon to LED light sources, substantially reducing the electrical power and energy required for equivalent sign luminance. LED drivers can be either electronic switching or linear magnetic, with the electronic switching supplies being the most efficient. The on/off power switch may be found on either the power line or load side of the driver, with the line side location providing significantly lower standby losses when the sign is turned off and is not operating. All new open signs must meet UL-84 (UL-844) requirements. Replacement signs cannot use more than 20% of the input power of the sign that is being replaced.

Baseline Case

The baseline condition is fluorescent lighting or neon type illuminated LED open sign.

Efficient Case

The compliance condition is an LED type illuminated LED open sign.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{W_b - W_q}{1{,}000} \times Hrs \times (1 + HVAC_c)$$

Annual Fuel Savings

$$\Delta Therms = \frac{W_b - W_q}{1{,}000} \times Hrs \times HVAC_{ff}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{W_b - W_q}{1{,}000} \times (1 + HVAC_d) \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-259~~247~~260 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
W_b	Equipment wattage for baseline condition	Site-specific, if unknown use 46	Watts	[684]~~[663~~684]

Variable	Description	Value	Units	Ref
W_q	Equipment wattage for energy efficient condition	Site-specific	Watts	
$HVAC_c$	HVAC interaction factor for annual electric energy consumption	0 for Exterior and Unconditioned Spaces; otherwise see **Error! Reference source not found.**~~Appendix F: HVAC Interactivity Factors~~	N/A	
$HVAC_d$	HVAC interaction factor at utility summer peak hour	0 for Exterior and Unconditioned Spaces; otherwise see **Error! Reference source not found.**~~Appendix F: HVAC Interactivity Factors~~	N/A	
$HVAC_{ff}$	HVAC interaction factor for annual fuel consumption	0 for Exterior and Unconditioned Spaces; otherwise see **Error! Reference source not found.**~~Appendix F: HVAC Interactivity Factors~~	MMBtu/kWh	
Hrs	Annual hours of operation	Site-specific, If unknown use defaults:	Hrs	[690]~~[6690]~~[691]~~[670691]~~

Variable	Description	Value	Units	Ref
		Signage with photocell control operate = 4,380 hours Signage with time switch control = 2,190 hours		
1,000	Conversion factor, one kilowatt equals 1,000 watts	1,000	N/A	
CF	Electric coincidence factor	Lookup in Table 3-52 ~~Table 3-52~~	N/A	[685]~~[664685]~~[686]~~[6865]~~[687]~~[666687]~~[688]~~[667688]~~[689]~~[6689]~~
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-260~~248261~~ CF by Building Type

Building Type	CF
Education	0.39
Exterior, Photocell-Controlled (All Building Types)	0.11
Exterior, All Other (All Building Types)	0.11
Grocery	0.99
Health	0.47
Industrial Manufacturing – 1 Shift	0.96
Industrial Manufacuring – 2 Shift	0.96
Industrial Manufacturing – 3 Shift	0.96
Institutional/Public Service	0.23
Lodging	0.38
Miscellaneous/Other	0.33
Multifamily Common Areas	0.73
Office	0.26

Building Type	CF
Parking Garages	0.98
Restaurant	0.55
Retail	0.56
Street Lighting	0.00
Warehouse	0.50
Outdoor	0.00

Peak Factors

Table 3-261~~249~~262 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	Lookup in Table 3-52 ~~Table 3-52~~	[685]~~[664685]~~[686]~~[6865]~~[687]~~[666687]~~[688]~~[667688]~~[689]~~[6689]~~
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-262~~250~~263 Measure Life

Equipment	EUL	RUL	Ref
LED Sign Lighting	15	5	[684]~~[663684]~~

References

~~[663]~~[684] Measured average demand data. Southern California Edison, "Replace Neon Open Sign with LED Open Sign", Workpaper SCE13LG070, Revision 2, October 2015. Pg. 10.

~~[664]~~[685] Illinois Statewide Technical Reference Manual for Energy Efficiency v7.0. Multifamily common area value based on DEER 2008. http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_7/Final_9-28-18/IL-TRM_Effective_010119_v7.0_Vol_2_C_and_I_092818_Final.pdf Accessed December 2018.

Field Code Changed

~~[665]~~[686] Pennsylvania Statewide Act 129 2014 Commercial & Residential Lighting Metering Study. Prepared for Pennsylvania Public Utilities Commission. January 13, 2015. http://www.puc.pa.gov/pcdocs/1340978.pdf

~~[666]~~[687] U.S. Naval Observatory. Duration of Daylight/Darkness Table for One Year. https://aa.usno.navy.mil/data/docs/Dur_OneYear.php Assumes values for Philadelphia.

~~[667]~~[688] Mid-Atlantic Technical Reference Manual v8.0, https://neep.org/sites/default/files/resources/Mid_Atlantic_TRM_V7_FINAL.pdf

~~[668]~~[689] UI and CL&P Program Savings Documentation for 2013 Program Year, United Illuminating Company, September 2012.

~~[669]~~[690] ConEd Large C&I Program Impact and Process Evaluation Report prepared by Navigant, August 2019, slide 71.

~~[670]~~[691] Time switch control – assume 6 hours per day, 365 days per year

Field Code Changed

Field Code Changed

3.7.6 INDOOR HORTICULTURE LED

Market	Commercial
Baseline Condition	NC/TOS/DI
Baseline	ISP/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	January 2023
Changes Since Last Version	~~Added average row to baseline PPE table~~

Description

The method below is applicable to the installation of LED fixtures intended for indoor horticultural use that meet the DesignLights Consortium (DLC) Horticultural Lighting Technical Requirements Version 3.0 (Hort V3.0). This measure shall be used only for New Construction or fixture additions. Savings are based on the difference between the photosynthetic photon efficacies (PPE) of the efficient fixture and an industry standard practice fixture.

Baseline Case

The baseline fixtures meet the indoor agriculture industry standard practice photosynthetic photon efficacies (PPE) of 1.7 micromoles per Joule.

Efficient Case

The efficient case is the installation of new DLC qualified LED indoor agriculture fixtures having a PPE that meet is or exceeds the DLC Hort 3.0 standard of 2.3 micromoles per joule.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \Delta kW \times hrs \times (1 + HVAC_c)$$

Where,

$$\Delta kW = N_q \times W_q \times (\frac{PPE_q}{PPE_b} - 1)/1000$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \Delta kW \times CF \times (1 + HVAC_d)$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-~~251 Calculation Parameters~~

~~Variable~~	~~Description~~	~~Value~~	~~Units~~	~~Ref~~
~~ΔkWh~~	~~Annual electric energy savings~~	~~Calculated~~	~~kWh/yr~~	
~~ΔkW_{Peak}~~	~~Peak Demand Savings~~	~~Calculated~~	~~kW~~	
~~ΔkWh_{Life}~~	~~Lifetime electric energy savings~~	~~Calculated~~	~~kWh~~	

263~~264~~ Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
ΔkW	Change in connected load from baseline to efficient lighting level	Calculated	kW	

Variable	Description	Value	Units	Ref
Hrs	Annual hours of operation	Site-specific	hours	
N_q	Number of energy efficient fixtures	Site-specific	fixtures	
W_q	Wattage of energy efficient fixtures	Site-specific	W	
PPE_q	Photosynthetic photon efficacy (PPE) of qualifying equipment	Site-specific	µmol/j	
PPE_b	Photosynthetic photon efficacy (PPE) of baseline equipment	Lookup in Table 3-264~~Table 3-252~~265	µmol/j	[693]~~[672~~693~~]~~[694]~~[673~~694~~]~~ [695]~~[674~~695~~]~~
$HVAC_c$	HVAC interactive effects for electricity consumption	Look up in **Error! Reference source not found.**~~Appendix F: HVAC Interactivity Factors~~	N/A	[695]~~[674~~695~~]~~
$HVAC_d$	HVAC interactive effects for electricity peak demand	Look up in **Error! Reference source not found.**~~Appendix F: HVAC Interactivity Factors~~	N/A	[695]~~[674~~695~~]~~
CF	Electric coincidence factor	Lookup in Table 3-265~~Table 3-253~~266	N/A	
PDF	Gas peak demand factor	Lookup in Table 3-265~~Table 3-253~~266	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-264~~252~~265 Baseline Photosynthetic Photon Efficacy (PPE)

Crop Type	Baseline Technology Type	Baseline PPE
Flowering Crops (Tomatoes and Peppers)	High Pressure Sodium	1.7
Vegetative Growth	Metal Halide	1.25
Microgreens	T5 HO Fixture	1.0
Propogation	T5 HO Fixture	1.0
Medical Cannabis – Flowering Stage	High Pressure Sodium	1.7
Medical Cannabis – Vegetative Stage	Metal Halide	1.25
Medical Cannabis – Cloning, Seeding, and Propogation	T5 HO Fixture	1.0
Recreational Cannabis – Flowering Stage	HID/LED/Other	2.2
Recreational Cannabis – Vegetative Stage	HID/LED/Other	2.2
Recreational Cannabis – Cloning, Seeding, and Propogation	T5/LED/Other	2.2

Crop Type	Baseline Technology Type	Baseline PPE
Unknown	Average	1.55

Peak Factors

Table 3-~~253 Peak Factors~~

~~Peak Factor~~	~~Value~~	~~Ref~~
~~Electric coincidence factor (CF)~~	~~1~~	~~[675]~~

265~~266~~ Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1	[696]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-266~~254267~~ Measure Life

Equipment	EUL	RUL	Ref
Indoor Horticulture LED	12	4	[697]~~[6976]~~

References

~~[671]~~[692] Radetsky, Leora, "LED and HID Horticultural Luminaire Testing Report Prepared for Lighting Energy Alliance Members and Natural Resources Canada." Rensselaer Polytechnic Institute, May 3, 2018; https://www.lrc.rpi.edu/programs/energy/pdf/HorticulturalLightingReport-Final.pdf

~~[672]~~[693] Runkle, Erik and Bugbee, Bruce "Plant Lighting Efficiency and Efficacy; µmols per joule", Greenhouse Product News: https://gpnmag.com/article/plant-lighting-efficiency-and-efficacy-%CE%BCmol%C2%B7j-%C2%B9/

~~[673]~~[694] "LED Grow Light Buyer's Guide." 2016. Chilled Tech-LED Grow Lights & Spectrum Control. October 22, 2016. https://chilledgrowlights.com/education/led_buyers_guide

~~[674]~~[695] *2022 Illinois Statewide Technical Reference Manual Version 10: Volume 2 Commercial and Industrial Measures*. (2022), Pg 38, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010122_v10.0_Vol_2_C_and_I_09242021.pdf

~~[675]~~[696] Indoor Horticulture Lighting Study, Sacramento Municipal Utility District, March 14, 2018; available at: https://www.smud.org/-/media/Documents/Business-Solutions-and-Rebates/Advanced-Tech-Solutions/LED-Reports/Amplified-Farms-Indoor-Horticulture-LED-Study-Final.ashx

~~[676]~~[697] California Public Utilities Commission EUL Table, version 027 (updated November 12, 2022). Accessed December 30, 2022. https://www.caetrm.com/shared-data/value-table/EUL/

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

3.8 MOTORS AND DRIVES

3.8.1 MOTORS

Market	Commercial/Multifamily
Baseline Condition	TOS/NC/EREP/DI
Baseline	Code/Existing/Dual
End Use Subcategory	Motors
Measure Last Reviewed	January 2023

Description

This measure covers the installation of high efficiency, three-phase electric motors of 200 hp or less in commercial and industrial applications. Estimated energy savings are based on increased operating efficiency.

Efficient motors generally run at slightly higher RPM than standard motors. Unless the motor drive system is modified to correct for higher RPM operation, the power delivered by the motor may increase. This increase in power delivery may negate the effects of improved efficiency. Therefore, when replacing a standard-efficiency motor, a high-efficiency motor with lower or equal full-load speed must be selected to prevent any negation of predicted energy savings resulting from a higher efficiency. To provide the correct flow, it may be necessary to adjust fan sheaves or pump-impeller diameters.

Baseline Case

The baseline condition is a three-phase electric motor of equivalent type, speed and horsepower. For TOS, and NC, a minimally code compliant baseline should be applied. For EREP, the baseline will be of the existing equipment.

Efficient Case

The compliance condition is a three-phase electric HVAC fan or pump motor with a speed at or below that of the baseline motor and full-load efficiency exceeding the NEMA premium full-load efficiency.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = HP \times RLF \times 0.746 \times \left[\left(\frac{1}{Eff_b}\right) - \left(\frac{1}{Eff_q}\right)\right] \times FLH$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = HP \times RLF \times 0.746 \times \left[\left(\frac{1}{Eff_b}\right) - \left(\frac{1}{Eff_q}\right)\right] \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ usig\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-267~~255~~268 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
$\Delta kW_{Peak,}$	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
HP	Rated horsepower of the efficient equipment	Site-specific	HP	
Eff_q	Full-load efficiency of qualifying efficiency motor	Site-specific	N/A	
Eff_b	Full-load efficiency of code-compliant baseline motor	Site-specific or look up in Table 3-268~~Table 3-256~~269 & Table 3-269~~Table 3-257~~270	N/A	[698]~~[677~~698]

Variable	Description	Value	Units	Ref
RLF	Ratio of the peak annual motor load to the maximum connected load	Site-specific, if unknown, use 0.75	N/A	[699]~~[678~~699]
FLH	Full-load hours in the energy efficient case	Site-specific, if unknown look up in Table 3-270~~Table 3-258~~271	Hrs	[700]~~[679~~700]
0.746	Unit conversion, kW/HP	0.746	kW/HP	
CF	Electric coincidence factor	Look up in Table 3-271~~Table 3-259~~272	N/A	
PDF	Gas peak day factor	Look up in Table 3-271~~Table 3-259~~272	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-268~~256~~269 Baseline Efficiencies for NEMA Design A and NEMA Design B Motors[173]

Motor HP	Motor Nominal Full-Load Efficiencies							
	2 Pole (3600 RPM)		4 pole (1800 RPM)		6 Pole (1200 RPM)		8 Pole (900 RPM)	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
1	0.770	0.770	0.855	0.855	0.825	0.825	0.755	0.755
1.5	0.840	0.840	0.865	0.865	0.875	0.865	0.785	0.770
2	0.855	0.855	0.865	0.865	0.885	0.875	0.840	0.865
3	0.865	0.855	0.895	0.895	0.895	0.885	0.855	0.875
5	0.885	0.865	0.895	0.895	0.895	0.895	0.865	0.885
7.5	0.895	0.885	0.917	0.910	0.910	0.902	0.865	0.895
10	0.902	0.895	0.917	0.917	0.910	0.917	0.895	0.902
15	0.910	0.902	0.924	0.930	0.917	0.917	0.895	0.902
20	0.910	0.910	0.930	0.930	0.917	0.924	0.902	0.910
25	0.917	0.917	0.93.6	0.936	0.930	0.930	0.902	0.910
30	0.917	0.917	0.936	0.941	0.930	0.936	0.917	0.917

[173] Design indicates the torque/speed characteristics of the motor.
Design A: Maximum five percent slip, High to medium starting current, Normal locked rotor torque, Normal breakdown torque and Suited for a broad variety of applications, such as fans and pumps
Design B: Maximum five percent slip, Low starting current, High locked rotor torque, Normal starting torque, Normal breakdown torque and Suited for a broad variety of applications, such as fans and pumps - - common in HVAC application with fans, blowers and pumps

Motor HP	Motor Nominal Full-Load Efficiencies							
	2 Pole (3600 RPM)		4 pole (1800 RPM)		6 Pole (1200 RPM)		8 Pole (900 RPM)	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
40	0.924	0.924	0.941	0.941	0.941	0.941	0.917	0.917
50	0.930	0.930	0.945	0.945	0.941	0.94.1	0.924	0.924
60	0.936	0.936	0.950	0.950	0.945	0.945	0.924	0.930
75	0.936	0.936	0.954	0.950	0.945	0.945	0.936	0.941
100	0.941	0.936	0.954	0.954	0.950	0.950	0.936	0.941
125	0.950	0.941	0.954	0.954	0.950	0.950	0.941	0.941
150	0.950	0.941	0.958	0.958	0.958	0.954	0.941	0.941
200	0.954	0.950	0.962	0.958	0.958	0.954	0.945	0.941
250	0.958	0.950	0.962	0.958	0.958	0.958	0.950	0.950
300	0.958	0.954	0.962	0.958	0.958	0.958	N/A	N/A
350	0.958	0.954	0.962	0.958	0.958	0.958	N/A	N/A
400	0.958	0.958	0.962	0.958	N/A	N/A	N/A	N/A
450	0.958	0.962	0.962	0.962	N/A	N/A	N/A	N/A
500	0.958	0.962	0.962	0.962	N/A	N/A	N/A	N/A

Table 3-269~~257~~~~270~~ Baseline Motor Efficiencies for NEMA Design C Motors[174]

Motor HP	Motor Nominal Full-Load Efficiencies					
	4 Pole (1800 RPM)		6 Pole (1200 RPM)		8 Pole (900 RPM)	
	Enclosed	Open	Enclosed	Open	Enclosed	Open
1	0.855	0.855	0.825	0.825	0.755	0.755
1.5	0.865	0.865	0.875	0.865	0.785	0.770
2	0.865	0.865	0.885	0.875	0.840	0.865
3	0.895	0.895	0.895	0.885	0.855	0.875

[174] Design indicates the torque/speed characteristics of the motor.
Design C: Maximum five percent slip, Low starting current, High locked rotor torque, Normal breakdown torque and Suited for equipment with high inertia starts, such as positive displacement pumps

Motor HP	Motor Nominal Full-Load Efficiencies					
	4 Pole (1800 RPM)		6 Pole (1200 RPM)		8 Pole (900 RPM)	
	Enclosed	Open	Enclosed	Open	Enclosed	Open
5	0.895	0.895	0.895	0.895	0.865	0.885
7.5	0.917	0.910	0.910	0.902	0.865	0.895
10	0.917	0.917	0.910	0.917	0.895	0.902
15	0.924	0.930	0.917	0.917	0.895	0.902
20	0.930	0.930	0.917	0.924	0.902	0.910
25	0.936	0.936	0.930	0.930	0.902	0.910
30	0.936	0.941	0.930	0.936	0.917	0.917
40	0.941	0.941	0.941	0.941	0.917	0.917
50	0.945	0.945	0.941	0.941	0.924	0.924
60	0.950	0.950	0.945	0.945	0.924	0.930
75	0.954	0.950	0.945	0.945	0.936	0.941
100	0.954	0.954	0.950	0.950	0.936	0.941
125	0.954	0.954	0.950	0.950	0.941	0.941
150	0.958	0.958	0.958	0.954	0.941	0.941
200	0.962	0.958	0.958	0.954	0.945	0.941

Table 3-270~~258271~~ Full-load Hours Based on Application and Building Type

Facility Type	Distribution Fan Motor	CHWP & Cooling Towers	Heating Pumps
Auto Related	4,056	1,878	5,376
Bakery	2,854	1,445	5,376
Banks, Financial Centers	3,748	1,767	5,376
Church	1,955	1,121	5,376
College - Cafeteria	6,376	2,713	5,376
College - Classes/Administrative	2,586	1,348	5,376
College - Dormitory	3,066	1,521	5,376
Commercial Condos	4,055	1,877	5,376
Convenience Stores	6,376	2,713	5,376

Facility Type	Distribution Fan Motor	CHWP & Cooling Towers	Heating Pumps
Convention Center	1,954	1,121	5,376
Court House	3,748	1,767	5,376
Dining: Bar Lounge/Leisure	4,182	1,923	5,376
Dining: Cafeteria / Fast Food	6,456	2,742	5,376
Dining: Family	4,182	1,923	5,376
Entertainment	1,952	1,120	5,376
Exercise Center	5,836	2,518	5,376
Fast Food Restaurants	6,376	2,713	5,376
Fire Station (Unmanned)	1,953	1,121	5,376
Food Stores	4,055	1,877	5,376
Gymnasium	2,586	1,348	5,376
Hospitals	7,674	3,180	5,376
Hospitals / Health Care	7,666	3,177	5,376
Industrial - 1 Shift	2,857	1,446	5,376
Industrial - 2 Shift	4,730	2,120	5,376
Industrial - 3 Shift	6,631	2,805	5,376
Laundromats	4,056	1,878	5,376
Library	3,748	1,767	5,376
Light Manufacturers	2,857	1,446	5,376
Lodging (Hotels/Motels)	3,064	1,521	5,376
Mall Concourse	4,833	2,157	5,376
Manufacturing Facility	2,857	1,446	5,376
Medical Offices	3,748	1,767	5,376
Motion Picture Theatre	1,954	1,121	5,376
Multifamily (Common Areas)	7,665	3,177	5,376
Museum	3,748	1,767	5,376
Nursing Homes	5,840	2,520	5,376
Office (General Office Types)	3,748	1,767	5,376
Office/Retail	3,748	1,767	5,376
Parking Garages & Lots	4,368	1,990	5,376
Penitentiary	5,477	2,389	5,376

Facility Type	Distribution Fan Motor	CHWP & Cooling Towers	Heating Pumps
Performing Arts Theatre	2,586	1,348	5,376
Police / Fire Stations (24 Hr)	7,665	3,177	5,376
Post Office	3,748	1,767	5,376
Pump Stations	1,949	1,119	5,376
Refrigerated Warehouse	2,602	1,354	5,376
Religious Building	1,955	1,121	5,376
Residential (Except Nursing Homes)	3,066	1,521	5,376
Restaurants	4,182	1,923	5,376
Retail	4,057	1,878	5,376
School / University	2,187	1,205	5,376
Small Services	3,750	1,768	5,376
Sports Arena	1,954	1,121	5,376
Town Hall	3,748	1,767	5,376
Transportation	6,456	2,742	5,376
Warehouse (Not Refrigerated)	2,602	1,354	5,376
Waste Water Treatment Plant	6,631	2,805	5,376
Workshop	3,750	1,768	5,376

Peak Factors

Table 3-271~~259~~272 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.8	[440]~~[439~~440]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-272~~260~~273 Measure Life

Equipment	EUL	RUL	Ref
Motors	15	5	[702]~~[681~~702]

References

~~[677]~~[698] Energy Conservation Program: Energy Conservation Standards for Commercial and Industrial Electric Motors; Final Rule," 79 Federal Register 103, May 2014. https://www.gpo.gov/fdsys/pkg/FR-2014-05-29/html/2014-11201.htm

~~[678]~~[699] U.S. DOE, Determining Electric Motor Load and Efficiency, April 2014, https://energy.gov/sites/prod/files/2014/04/f15/10097517.pdf

~~[679]~~[700] Connecticut Program Savings Document, 12th Edition for 2017 Program Year, UIL Holdings Corporation and Eversource Energy Appendix 5, Hours of Use, October 2016.

~~[680]~~[701] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (TRM), Version 9, January 2022. https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V9.pdf.

~~[681]~~[702] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

3.8.2 SWITCHED RELUCTANCE MOTORS

Market	Commercial
Baseline Condition	NC/RF/EREP
Baseline	Code/Existing/Dual
End Use Subcategory	Motors and Drives
Measure Last Reviewed	February 2024
Changes Since Last Version	~~New measure~~

Description

A Switched Reluctance Motor (SRM) is a type of brushless DC electric motor that runs by reluctance torque. Unlike other DC motor types, power is delivered to windings in the stator rather than the rotor. This simplifies the mechanical design; power does not need to be delivered to a moving part, but requires a switching system through software control to deliver power to the different windings. Electronic devices can precisely time switch, facilitating SRM configurations. In applications on rooftop units (RTUs), the SRM is comparable or more efficient than an RTU equipped with a variable speed drive supply fan. It results in fan-energy savings and can also include cooling savings if coupled with compressor or ventilation control, compared to a baseline scenario of constant-volume, constant-ventilation operation that is typical of single-zone, packaged HVAC units. Fan energy savings come from the new integrated motor controls that allow for higher efficiency at varying loads and is achieved in all applications.

Baseline Case

The baseline equipment for this measure is a single-zone, packaged HVAC unit (with an existing functional integrated economizer) that lacks demand-controlled ventilation controls and lacks supply-fan speed control via a variable-frequency drive.

Efficient Case

The efficient equipment is a single-zone, packaged HVAC unit with a functional integrated economizer that has been fitted with a SRM supply-fan and integrated speed control.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = 0.746 \times HP \times hrs \times SF_{fan}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Summer Peak Demand Savings

$$\Delta kW_{Peak} = 0.746 \times HP \times SF_{fan} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \mathrm{N/A}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 3-273~~261~~274 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
HP	Fan horsepower	Site-specific	HP	
hrs	Annual operating hours for fan motor	Site-specific. If unknown, look up in Appendix D: HVAC Fan and Pump Operating Hours	hrs	
SF_{fan}	Savings factor for fan[175]	Look up in Table 3-170	N/A	[703]~~[682~~703], [704]~~[683~~704]
0.746	Conversion from horsepower to kW	0.746	kW/HP	
CF	Electric coincidence factor	Look up in Table 3-174	N/A	[705]~~[684~~705]
EUL	Effective useful life	See Measure Life Section	Years	[706]~~[685~~706]

[175] Savings factors are taken from Switched-Reluctance Motor Field Evaluation Final Report (pg. 26) and Performance Evaluation of Three RTU Energy Efficiency Technologies (pg. 24), averaged across building types. Building type average was weighted according to ComStock 2018 commercial building metadata.

Table 3-274~~262~~275 Energy Savings Factors

Energy Savings Factor	Retrofit Type	SRM on Single Stage Compressor	SRM on Single Two Stage Compressor	SRM on Variable Speed Compressor
SF_{fan}	New Construction/Early Replacement	0.390	0.522	0.533

Peak Factors

Table 3-275~~263~~276 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.913	[705]~~[684705]~~
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 12 years [705]~~[684705]~~.

References

~~[682]~~[703] NREL, *Performance Evaluation of Three RTU Energy Efficiency Technologies*. (2020), https://www.nrel.gov/docs/fy21osti/75551.pdf

~~[683]~~[704] Slipstream, *Switched-Reluctance Motor Field Evaluation*. (2022), https://turntide.com/wp-content/uploads/2022/05/SRM_final_report_03_25_2022-1.pdf

~~[684]~~[705] *2024 Illinois Statewide Technical Reference Manual for Energy Efficiency Version 12.0*. (2023). https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_2_C_and_I_09222023_FINAL_clean.pdf

~~[685]~~[706] P. Andrada, B. Blanque, E. Martınez, J.I. Perat, J.A. Sanchez, and M. Torrent, *Environmental and life cycle cost analysis of one switched reluctance motor drive and two inverter-fed induction motor drives*. (2010), page 2, https://www.researchgate.net/publication/309187141_Environmental_and_Life_Cycle_Cost_Analysis_of_a_Synchronous_Reluctance_Machine

3.8.3 VFD

Market	Commercial/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	February 2024
Changes Since Last Version	~~Removed references to DI Baseline Condition and dual baseline~~

Description

This measure defines savings associated with installing a variable frequency drive on a motor of 200 hp or less for the following HVAC applications: supply air fans, return air fans, chilled water and condenser water pumps, hot water circulation pumps, water source heat pump circulation pumps, cooling tower fans, and boiler feed water pumps. VFD applications for other end uses are not covered under this measure.

Baseline Case

The baseline condition is a motor, 200 hp or less, without a VFD control.

Efficient Case

The efficient condition is a motor, 200 hp or less, with a VFD control.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = 0.746 \times HP \times \frac{LF}{\eta_{motor}} \times hr \times ESF$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = 0.746 \times HP \times \frac{LF}{\eta_{motor}} \times \mathrm{DSF}$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \mathrm{N/A}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-276~~277~~ Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	

~~264 Calculation Parameters~~

~~Variable~~	~~Description~~	~~Value~~	~~Units~~	~~Ref~~
~~ΔkWh~~	~~Annual electric energy savings~~	~~Calculated~~	~~kWh/yr~~	
~~ΔkW_{Peak}~~	~~Peak Demand Savings~~	~~Calculated~~	~~kW~~	
~~ΔkWh_{Life}~~	~~Lifetime electric energy savings~~	~~Calculated~~	~~kWh~~	
HP	Rated horsepower of the motor	Site-specific	HP	
hr	Annual run hours of the baseline motor	Lookup in **Error! Reference source not found.**~~Appendix D: HVAC Fan and Pump Operating Hours~~	hours	
LF	Load Factor	Site-specific, if unknown use fans: 0.76, pumps: 0.79	N/A	[707]~~[686~~707]
η_{motor}	Motor efficiency at the full-rated load.	Site-specific	N/A	
ESF	Energy Savings Factor	Lookup in Table 3-277~~Table 3-265~~278	Fraction	[708]~~[687~~708]
DSF	Demand Savings Factor	Lookup in Table 3-277~~Table 3-265~~278	Fraction	[708]~~[687~~708]
0.746	Conversion factor for HP to kW	0.746	kW/HP	

~~Variable~~	~~Description~~	~~Value~~	~~Units~~	~~Ref~~
CF	Electric coincidence factor	Look up in Table 3-278~~Table 3-266~~279	N/A	
PDF	Gas peak demand factor	Look up in Table 3-278~~Table 3-266~~279	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-277~~265~~278 Energy and Demand Savings Factors

Equipment Type	Baseline Control Type	ESF	DSF
HVAC Fan	Constant Volume	0.500	0.200
	Two-Speed	0.450	0.200
	Air Foil/Backward Incline	0.396	0.220
	Air Foil/Backward Incline with Inlet Guide Vanes	0.210	0.050
	Forward Curved	0.191	0.110
	Forward Curved with Inlet Guide Vanes	0.055	0.010
HVAC Pump	Constant Volume	0.661	0.210
	Throttle Valve	0.523	0.180

Peak Factors

Table 3-~~266 Peak Factors~~

~~Peak Factor~~	~~Value~~	~~Ref~~

278~~279~~ Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 15 years[709]~~[688~~709].

References

~~[686]~~[707] Regional Technical Forum. Proposed Standard Savings Estimation Protocol for Ultra-Premium Efficiency Motors. November 5, 2012. Appendix C, Table 6.

~~[687]~~[708] 2019 Illinois Statewide Technical Reference Manual for Energy Efficiency Version 7.0. Volume 2: Commercial and Industrial Measures. September 28, 2018. https://www.ilsag.info/il_trm_version_7/
~~[688]~~[709] California eTRM, CPUC Support Tables: Effective Useful Life and Remaining Useful Life https://www.caetrm.com/cpuc/table/effusefullife/

Field Code Changed

Field Code Changed

3.8.4 ELEVATOR MODERNIZATION

Market	Commercial/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Controls
Measure Last Reviewed	May 2023

Description

This measure covers the upgrade of existing elevators by replacing critical components in order for elevators to be able to handle new technology, have better performance, and to operate more efficiently. This measure follows the New York TRM v10 [710]~~[689710]~~.

Elevator modernization typically includes motor upgrades, elevator drive system upgrades, and elevator controller replacement. This measure covers the installation of SiliconControlled Rectifier (SCR) drives, Pulse Width Modulation (PWM) drives, and Variable Voltage Variable Frequency (VVVF) drives only. Only the following upgrade configurations are applicable to this measure: VVVF drive systems replace PWM systems, VVVF or PWM drive systems replace SCR systems, and VVVF, PWM, or SCR drive systems replace Motor-Generator (M-G) set systems. The drives may either be regenerative or non-regenerative. This measure is only applicable as a retrofit and only applies to office and multifamily buildings (e.g. small office, large office, low-rise multifamily, high-rise multifamily). This measure does not cover Destination Dispatch optimization technique.

Methods for calculating savings for M-G set baseline systems are presented below separate from SCR or PWM drive baseline systems in order to differentiate the baseline efficiency term as described in the Baseline Efficiency section below, but also to account for AC motor idling energy consumption present in an M-G set drive. There is no idling motor present in PWM or SCR drive systems, and thus no savings associated with idle energy is claimed in those cases.

Baseline Case

The baseline case is an existing M-G set, SCR drive, or PWM drive elevator system.

Efficient Case

The efficient case may be either Silicon-Controlled Rectifier (SCR) drive, Pulse Width Modulation (PWM) drive or ***v***ariable Voltage Variable Frequency (VVVF) based on the baseline condition, as outlined in the table below:

Baseline Case	Efficient Case
M-G set	SCR, PWM, VVVF drives
SCR drive	PWM, VVVF drives
PWM drive	VVVF drive

Annual Energy Savings Algorithms

Annual Electric Energy Savings

Motor-Generator set (M-G) baseline:

$$\Delta kWh = kWh_b - kWh_q + (RegenSF \times \Delta kWh_{regen})$$

$$kWh_b = \left(\frac{\mathrm{lb_b} \times (1 - OCW_b) \times (ft/min)_b}{33{,}000 \times Eff_{hoist}} \times \frac{1}{Eff_b} \times 0.746 \times LF_{avg} \times hrs\right) + \left(\frac{hp \times 0.746 \times LF_{motor,idle}}{Eff_b} \times (8{,}760 - hrs) \times F_{idle}\right)$$

$$kWh_q = \frac{lb_q \times \left(1 - OCW_q\right) \times (ft/min)_q}{33{,}000 \times Eff_{hoist}} \times \frac{1}{Eff_q} \times 0.746 \times LF_{avg} \times hrs$$

$$\Delta kWh_{regen} = \frac{lb_q \times \left(1 - OCW_q\right) \times (ft/min)_q \times Eff_q \times 0.746}{33{,}000} \times Eff_{regen} \times F_{regen} \times hrs$$

$$Eff_b = Eff_{motor,b} \times Eff_{gear,b} \times Eff_{drive,b}$$

$$Eff_q = Eff_{motor,q} \times Eff_{gear,q} \times Eff_{drive,q}$$

SCR drive or PWM drive baseline:

$$\Delta kWh = kWh_b - kWh_q + (RegenSF \times \Delta kWh_{regen})$$

$$kWh_b = \left(\frac{\mathrm{lb_b} \times (1 - OCW_b) \times (ft/min)_b}{33{,}000 \times Eff_{hoist}} \times \frac{1}{Eff_b} \times 0.746 \times LF_{avg} \times hrs\right)$$

$$kWh_q = \frac{lb_q \times \left(1 - OCW_q\right) \times (ft/min)_q}{33{,}000 \times Eff_{hoist}} \times \frac{1}{Eff_q} \times 0.746 \times LF_{avg} \times hrs$$

$$\Delta kWh_{regen} = \frac{lb_q \times \left(1 - OCW_q\right) \times (ft/min)_q \times Eff_q \times 0.746}{33{,}000} \times Eff_{regen} \times F_{regen} \times hrs$$

$$Eff_b = Eff_{motor,b} \times Eff_{gear,b} \times Eff_{drive,b}$$

$$Eff_q = Eff_{motor,q} \times Eff_{gear,q} \times Eff_{drive,q}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Annual Peak Demand Savings

Motor-Generator set (M-G) baseline:

$$\Delta kW_{Peak} = \frac{hp \times 0.746 \times LF_{motor,run}}{Eff_b} - \frac{lb_q \times \left(1 - OCW_q\right) \times (ft/\min)_q \times 0.746 \times LF_{peak}}{33{,}000 \times Eff_{hoist} \times Eff_q}$$

SCR drive or PWM drive baseline:

$$\Delta kW_{Peak} = \left(\frac{lb_b \times (1 - OCW_b) \times (ft/\min)_b}{Eff_b} - \frac{lb_q \times \left(1 - OCW_q\right) \times (ft/\min)_q}{Eff_q}\right) \times \frac{LF_{peak} \times 0.746}{33{,}000 \times Eff_{hoist}}$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 3-279~~267~~280 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual fuel savings	Calculated	Therms/yr	
ΔkWh_{Peak}	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime fuel savings	Calculated	Therms	
kWh_b	Energy consumption of baseline	Calculated	kWh	
kWh_q	Energy consumption of qualifying	Calculated	kWh	
ΔkWh_{regen}	Energy savings due to regenerative braking system	Calculated	kWh	
Eff_b	Energy efficiency, baseline	Calculated	N/A	
Eff_q	Energy efficiency, qualifying	Calculated	N/A	
lb_b	Capacity of car, baseline	Site-specific	Lbs	
lb_q	Capacity of car, qualifying	Site-specific	Lbs	

Variable	Description	Value	Units	Ref
OCW_b	Overweight of counterbalance as fraction of car capacity, baseline	Site-specific	N/A	
$(ft/min)_b$	Rated top velocity of car, baseline	Site-specific	Ft/min	
Hp	Horsepower of M-G set motor	Site-specific	Hp	
OCW_q	Overweight of counterbalance as fraction of car capacity, qualifying	Site-specific	N/A	
$(ft/min)_q$	Rated top velocity of car, qualifying	Site-specific	Ft/min	
$Eff_{motor,b}$	NEMA premium efficiency, baseline	Site-specific	N/A	
$Eff_{motor,q}$	NEMA premium efficiency, qualifying	Site-specific	N/A	
Hrs	Annual hours of elevator operation	Site-specific, if unknown use 2,2750	Hours	[711][690711]
$Eff_{drive,b}$	Efficiency of drive, baseline	Site-specific, if unknown use defaults: SCR6 = 0.85 SCR12 = 0.90 PWM = 0.94	N/A	[712][691712]
$Eff_{drive,q}$	Efficiency of drive, qualifying	Site-specific, if unknown use defaults: SCR6 = 0.85 SCR12 = 0.90 PWM = 0.94 VVF = 0.95	N/A	[712][691712]
$Eff_{gear,b}$	Efficiency of gear system, baseline	Geared system: 0.85 Gearless system: 1.0	N/A	[712][691712]
$Eff_{gear,q}$	Efficiency of gear system, qualifying	Geared system: 0.85 Gearless system: 1.0	N/A	[712][691712]
RegenSF	Savings factor for regererative braking system	Regenerative braking: 1 No regenerative breaking: 0	N/A	[710][689710]
LF_{avg}	Average load factor	0.35	N/A	[713][692713]
Eff_{hoist}	Efficiency of elevator hoise system	0.9	N/A	[711][690711]
$LF_{motor,idle}$	M-G set motor load factor in idling mode	0.11	N/A	[591][5891]
F_{idle}	Idling factor; used to account for fraction of run hours M-G set system in idling mode	Timer incorporated: 0.7 No timer: 1.0 Unknown: 0.7	N/A	[714][693714]
$LF_{motor,run}$	M-G set motor load factor when loaded, assumed value to reflect that motors do not typically fun at 100% of rated power	0.9	N/A	[710][689710]
LF_{peak}	Peak load factor	0.75	N/A	[713][692713]

Variable	Description	Value	Units	Ref
Eff_{regen}	Efficiency of regenerative braking system	0.5	N/A	[710]~~[689~~710]
F_{regen}	Regenerative breaking factor; used account for fraction of run hours regenerative braking produces energy savings	0.5	N/A	[715]~~[694~~715]
8,760	Hours in a year	8,760	Hours	
33,000	Conversion factor	33,000	(ft-lb/min)/hp	
0.746	Conversion factor	0.746	kW/hp	
EUL	Effective useful life	See Measure Life section	Years	

Peak Factors

Table 3-280~~268~~281 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A: Appling average load factor at peak is a conservative approach for estimating summer peak demand savings. No further adjustment is required.	[591]~~[589~~1]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 15 years [716]~~[695~~716].

References

~~[689]~~[710] New York TRM v10, Elevator Modernization, pg. 887. https://dps.ny.gov/technical-resource-manual-trm

~~[690]~~[711] The Vertical Transportation Handbook, 4th Edition , by George R. Strakosch and Robert S. Caporale, Table 4.2, Table 4.3, Chart 4.2.

~~[691]~~[712] International Association of Elevator Consultants, Presentation in New York City, May 2011, Slide 11.

~~[692]~~[713] ISO 25745-2:2015: Energy Performance of Lifts, Escalators and Moving Walks -- Part 2: Energy Calculation and Classification for Lifts (elevators).

~~[693]~~[714] Actual idling time is based on specific site operating conditions. A value of 70% has been assumed based on a reasonable and conservative approach.

~~[694]~~[715] Baldor Motors and Drives, Elevator Application Guide, pg. 3-6.

~~[695]~~[716] Assumes same EUL as VFD measure, source DEER 2014.

Field Code Changed

3.9 PLUG LOAD

3.9.1 NETWORK POWER MANAGEMENT

Market	Commercial
Baseline Condition	RF
Baseline	ISP
End Use Subcategory	Office Equipment
Measure Last Reviewed	December 2022

Description

This measure covers savings achieved by controlling the power management settings of desktop computers, monitors, and laptops through centralized computer power management software that is installed on a network of computers to monitor and record the usage and manage the power settings of all units. This software is implemented at the network level and manipulates the internal power settings of the central processing unit (CPU) and monitor.

Eligible software should be capable of the following:

- Apply specific power management policies to network groups and monitor workstation keyboard, mouse, CPU and disk activity in determining workstation idleness.
- Allow centralized control and override of computer power management settings of workstations which include both a computer monitor and CPU (i.e. a desktop or laptop computer on a distributed network).
- Wake-on-LAN capability to allow networked workstations to be remotely wakened from or placed into any power-saving mode and to remotely boot or shut down ACPI-compliant workstations.
- Software should be compatible with multiple operating systems and hardware configurations on the same network.
- Have capability to produce system reports to confirm the inventory and performance of equipment on which the software is installed.

Baseline Case

Desktop computer, monitor, or laptop in which power management settings are not controlled by centralized power management software.

Efficient Case

Qualifying software which controls computer and monitor power settings from a central location.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = ESAV \times units$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = DSAV \times units$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \mathrm{N/A}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \mathrm{N/A}$$

Calculation Parameters

Table 3-281~~269~~282 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	[717]~~[696717]~~
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
ESAV	Energy Savings per unit	Look up in Table 3-282~~Table 3-270~~283	kWh/unit	
DSAV	Peak Demand Savings per unit	Look up in Table 3-282~~Table 3-270~~283	kW/unit	
units	Number of units	Site-specific	units	
CF	Electric coincidence factor	See Peak Factors ~~Peak Factors~~ section	N/A	
EUL	Effective useful life	See Measure Life Section	Years	[718]~~[697718]~~

To determine savings, the per unit estimate in Table 3-282~~Table 3-270~~283 will be multiplied by the number of units. The energy savings per unit includes power savings from the PC as well as the monitor. Default savings are based on the Low Carbon IT Savings Calculator sourced from the ENERGY STAR website [717]~~[696~~717] and assumes the absence of an enabled network power management as the baseline condition.

Table 3-282~~270~~283 Network Power Controls, Per Unit Summary Table

Measure	Unit	Energy Savings (SAV)	Peak Demand Savings ($DSAV$)
Network PC Plug Load Power Management Software	Workstation – Desktop Computer with Monitor	392	0.0527
Network PC Plug Load Power Management Software	Workstation – Laptop Computer with Monitor[176]	237	0.0319

Peak Factors

Peak savings are incorporated in the demand savings values above.

Measure Life

The effective useful life (EUL) is 5 years [718]~~[697~~718].

References

~~[696]~~[717] ENERGYSTAR Low Carbon IT Savings Calculator: https://www.energystar.gov/sites/default/files/asset/document/LowCarbonITSavingsCalc.xlsx

~~[697]~~[718] Computers and peripheral equipment are considered 5-year property. 2016 IRS Publication 946. https://www.irs.gov/pub/irs-prior/p946--2016.pdf.

Field Code Changed

Field Code Changed

[176] Savings assume workstation includes desktop with monitor and laptop computer with laptop screen in use. Please refer to ENERGY STAR Low Carbon IT Savings Calculator for different workstation configurations [717]~~[696~~717].

3.9.2 OFFICE EQUIPMENT

Market	Commercial/Multifamily
Baseline Condition	TOS
Baseline	ISP
End Use Subcategory	Electronics
Measure Last Reviewed	December 2022
Changes Since Last Version	~~Moved HVAC interactive factor look-up to appendix~~

Description

This section provides deemed savings for installing ENERGYSTAR office equipment compliant with Energy Star Computer Specification ver. 8.0 compared to standard efficiency equipment in commercial applications. Per unit savings are primarily derived from the ENERGY STAR calculator for office equipment [719][~~698~~719].

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

The baseline condition is assumed to be standard equipment of similar type used in a commercial setting.

Efficient Case

The efficient condition is ENERGY STAR equipment meeting the current ENERGY STAR ver. 8.0 Eligibility Criteria [720][~~699~~720] and used in a commercial setting.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = ESF \times (1 + HVAC_e)$$

Annual Fuel Savings

$$\Delta Therms = ESF \times HVAC_g$$

Peak Demand Savings

$$\Delta kW_{Peak} = DSF \times (1 + HVAC_d)$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-~~283~~~~271~~284 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ESF	Energy savings factor	Look up in Table 3-284~~Table 3-272~~285	kWh/yr	[719]~~[698~~719]
DSF	Electric Demand savings factor	Look up in Table 3-284~~Table 3-272~~285	kW	[719]~~[698~~719]
$HVAC_e$	HVAC Interactive Factor for Annual Energy Savings	Look up in **Error! Reference source not found.**~~Appendix F: HVAC Interactivity Factors~~	N/A	[721]~~[700~~721][722]~~[701~~722]
$HVAC_d$	HVAC Interactive Factor for Peak Demand Savings	Look up in **Error! Reference source not found.**~~Appendix F: HVAC Interactivity Factors~~	N/A	[721]~~[700~~721][722]~~[701~~722]
$HVAC_g$	HVAC Interactive Factor for Annual Fuel Savings	Look up in **Error! Reference source not found.**~~Appendix F:~~	N/A	[723]~~[70~~23]

Variable	Description	Value	Units	Ref
		~~HVAC Interactivity Factors~~		
ΔkW_{Peak}	Peak Demand Savings	Look up in Table 3-284~~Table 3-272~~285	kW	[719]~~[698~~719]
CF	Electric coincidence factor	Look up in Table 3-285~~Table 3-273~~286	N/A	
PDF	Natural gas peak day factor (PDF)	Look up in Table 3-285~~Table 3-273~~286	N/A	
EUL	Effective useful life of new unit	See Measure Life Section	Years	

Table 3-284~~272~~285 Office Equipment Energy and Demand Savings Factors per Unit

Measure		ESF (kWh)	DSF (kW)	Source
Computer (Desktop)		124	0.0161	[719]~~[698~~719]
Computer (Laptop)		37	0.0030	[719]~~[698~~719]
Fax Machine (laser)		16	0.0022	[719]~~[698~~719]
Copier (monochrome)	≤ 5images/min	37	0.0050	[719]~~[698~~719]
	5 < images/min ≤ 15	26	0.0035	
	15 < images/min ≤ 20	10	0.0011	
	20 < images/min ≤ 30	42	0.0057	
	30 < images/min ≤ 40	50	0.0068	
	40 < images/min ≤ 65	181	0.0244	
	65 < images/min ≤ 82	372	0.0502	
	82 < images/min ≤ 90	469	0.0633	
	> 90 images/min	686	0.0926	
Printer (laser, monochrome)	≤ 5 images/min	37	0.0050	[719]~~[698~~719]
	5 < images/min ≤ 15	26	0.0035	
	15 < images/min ≤ 20	24	0.0031	
	20 < images/min ≤ 30	42	0.0057	
	30 < images/min ≤ 40	50	0.0068	
	40 < images/min ≤ 65	181	0.0244	
	65 < images/min ≤ 82	372	0.0502	

Measure		ESF (kWh)	DSF (kW)	Source
	82 < images/min ≤ 90	542	0.0732	
	> 90 images/min	686	0.0926	
Printer (Ink Jet)		6	0.0008	[719]~~[698719]~~
Multifunction Device (laser, monochrome)	≤ 5 images/min	57	0.0077	[719]~~[698719]~~
	5 < images/min ≤ 10	48	0.0065	
	10 < images/min ≤ 26	52	0.0070	
	26 < images/min ≤ 30	93	0.0126	
	30 < images/min ≤ 50	248	0.0335	
	50 < images/min ≤ 68	420	0.0567	
	68 < images/min ≤ 80	597	0.0806	
	> 80 images/min	764	0.1031	
Multifunction Device (Ink Jet)		6	0.0008	[719]~~[698719]~~
Monitor		8	0.0032	[719]~~[698719]~~

Peak Factors

Table 3-285~~273~~286 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	Peak savings incorporated in the DSF Values found in Table 1-2 above	
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

Table 3-286~~274~~287 Measure Life [719]~~[698719]~~

Equipment	Measure Life
Computer	4 years
Monitor	4 years
Fax	4 years
Printer	5 years
Copier	6 years
Multifunction Device	6 years

References

~~[698]~~[719] ENERGY STAR Office Equipment Calculator. https://dnr.mo.gov/sites/dnr/files/media/file/2021/01/office-equipment-calculator.xlsx. Default values were used. Using a commercial office equipment load shape, the percentage of total savings that occur during the PJM

Field Code Changed

peak demand period was calculated and multiplied by the energy savings. As of December 1, 2018, the published ENERGY STAR Office Equipment Calculator does not reflect the current specification for computers (ENERGY STAR® Program Requirements Product Specification for Computers Eligibility Criteria Version 8.0). As a result, the savings values for computers presented in this measure entry reflect savings for V6-compliant models. This characterization should be updated when an updated ENERGY STAR Office Equipment Calculator becomes available.

~~[699]~~[720] ENERGY STAR Product Specifications & Partner Commitments Search, https://www.energystar.gov/products/spec

~~[700]~~[721] Navigant, EmPOWER Maryland DRAFT Final Impact Evaluation Report Evaluation Year 4 (June 1, 2012 – May 31, 2013) Commercial & Industrial Prescriptive & Small Business Programs, (2013)

~~[701]~~[722] DNV KEMA (2013). Impact Evaluation of 2010 Prescriptive Lighting Installations. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory

~~[702]~~[723] Northeast Energy Efficiency Partnerships & KEMA, C&I Lighting Load Shape Project FINAL Report - Prepared for the Regional Evaluation, Measurement and Verification Forum. (2011).

Field Code Changed

3.9.3 SMART STRIP

Market	Commercial/Multifamily
Baseline Type	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	December 2022

Description

This measure covers the installation of Tier 1 Advanced Power Strips (APS) in office workstations. The Tier 1 APS makes use of a control outlet to disconnect the controlled plugs when the load on the control outlet (usually a computer) is reduced below a threshold. In this case, the reduction below threshold of the control plug happens when the computer shuts down or enters standby mode. Therefore, the overall load of a centralized group of equipment (e.g., monitors and other peripherals for the computer) can be reduced. This measure assumes an office operating schedule of 7:30 AM to 5:30 PM from Monday to Fridays.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

The baseline condition is an office workstation with no plug load control system.

Efficient Case

The compliance condition is an office workstation with a tier 1 plug load control advanced power strip.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = \left(\Delta kW_{wkday} \times \left(Hrs_{wkday} - Hrs_{wkday-open}\right) + \Delta kW_{wkend} \times \left(Hrs_{wkend} - Hrs_{wkend-open}\right)\right) \times Wks$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = 0$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \mathrm{N/A}$$

Calculation Parameters

Table 3-287~~275~~288 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	0	kW	[726]~~[705~~726]
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Units	Number of measures installed under the program	Site-specific	N/A	
ΔkW_{wkday}	Average power reduction during weekday off hours	0.0315	kW	[725]~~[704~~725]~~[~~726]~~[705~~726]
Hrs_{wkday}	Total hours during the work week (Monday 7:30 AM to Friday 5:30 PM)	106	Hrs	
$Hrs_{wkday\text{-}open}$	Hours the office is open during the work week	Site-specific. If unknown, assume 50	Hrs	
ΔkW_{wkend}	Average power reduction during weekend off hours	0.0067	kW	[725]~~[704~~725]~~[~~726]~~[705~~726]
Hrs_{wkend}	Total hours during the weekend (Friday 5:30 PM to Monday 7:30 AM)	62	Hrs	
$Hrs_{wkend\text{-}open}$	Hours the office is open during the weekend	Site-specific, if unknown use 0	Hrs	
Wks	Weeks the office is open during the year	Site-specific, if unknown use 8760/168	Weeks/yr	
EUL	Effective useful life	See Measure Life Section	Years	

Peak Factors

Table 3-~~288~~~~276~~289 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The expected lifetime of this measure is 4 years [725]~~[704725]~~.

References

~~[703]~~[724] Sheppy, M, I Metzger, D Cutler, G Holland, and A Hanada. 2014. “Reducing Plug Loads in Office Spaces Hawaii and Guam Energy Improvement Technology Demonstration Project.” https://www.nrel.gov/docs/fy14osti/60382.pdf.

~~[704]~~[725] David Rogers, Power Smart Engineering, "Smart Strip Electrical Savings and Usability," October 2008.

~~[705]~~[726] *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs: Version 10* (2023) Pg 494. https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V10.pdf

Field Code Changed

Field Code Changed

3.9.4 UNINTERRUPTIBLE POWER SUPPLY

Market	Commercial
Baseline Condition	TOS
Baseline	Code
End Use Subcategory	Plug Load
Measure Last Reviewed	January 2023

Description

This measure is for replacing an inefficient uninterruptable power supply (UPS) with an efficient ENERGY STAR rated UPS within the scope of the Energy Star Uninterruptable Power Supply ver 2.0 Program Requirements. UPS units provide backup power in data centers and draw power constantly to keep their batteries charged. UPSs are utilized in many organizations to protect themselves from downtime with power distribution and avoid data processing errors due to downtimes. UPS systems are connected between the public power distribution system and mission critical loads.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified through a custom calculation.

Baseline Case

The baseline condition is a non-ENERGY STAR UPS in a telecommunication or similar application meeting minimum Federal Efficiency Standards as defined in 10 CFR 430.32(z)(3)

Efficient Case

The efficient condition is a new UPS meeting ENERGY STAR UPS in a telecommunication or similar application meeting Energy Star UPS version 2.0 criteria. For single-normal mode UPSs, the installed system must meet or exceed the average loading-adjusted efficiency values required by the ENERGY STAR program.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = Size \times \left(\frac{1}{Eff_{AVGBase}} - \frac{1}{Eff_{AVGee}}\right) \times EFLH$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = Size \times \left(\frac{1}{Eff_{AVGBase}} - \frac{1}{Eff_{AVGee}}\right) \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 3-289~~277~~290 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
Size	Size of UPS in rated output power, kW	Site-specific	kW	
$Eff_{AVGbase}$	Efficiency of existing UPS	**Site-specific, if unknown look up in Table 3-290** ~~Table 3-278~~291	W	[727]~~[706~~727]
Eff_{AVGee}	Efficiency of new ENERGY STAR UPS	Site-specific, if unknown look up in Table 3-291~~Table 3-279~~292	W or kW	[728]~~[707~~728]
E_{MOD}	An allowance of 0.004 for Modular UPSs applicable in the commercial 1500 – 10,000 W range	0.004	N/A	[728]~~[707~~728]
EFLH	Equivalent Full Load Hours	Look up in Table 3-292~~Table 3-280~~293	hours	[729]~~[708~~729]
CF	Electric coincidence factor	Look up in Table 3-293~~Table 3-281~~294	N/A	
PDF	Gas peak day factor	Look up in Table 3-293~~Table 3-281~~294	N/A	
EUL	Effective useful life	See Measure Life Section	Years	[730]~~[7~~30~~9]~~

Table 3-290~~278~~291 Efficiency of existing UPS

UPS Product Class	Rated Output Power (P) in watts	Minimum Efficiency
Voltage and Frequency Dependent (VFD)	P ≤ 300 W	$-1.20 \times 10^{-6} \times P^2 + 7.17 \times 10^{-4} \times P + 0.862$
	300 W < P ≤ 700 W	$-7.85 \times 10^{-8} \times P^2 + 1.01 \times 10^{-4} \times P + 0.946$
	P > 700 W	$-7.23 \times 10^{-9} \times P^2 + 7.52 \times 10^{-6} \times P + 0.977$
Voltage Independent (VI)	P ≤ 300 W	$-1.20 \times 10^{-6} \times P^2 + 7.19 \times 10^{-4} \times P + 0.863$
	300 W < P ≤ 700 W	$-7.67 \times 10^{-8} \times P^2 + 1.05 \times 10^{-4} \times P + 0.947$
	P > 700 W	$-4.62 \times 10^{-9} \times P^2 + 8.54 \times 10^{-6} \times P + 0.979$
Voltage and Frequency Independent (VFI)	P ≤ 300 W	$-3.13 \times 10^{-6} \times P^2 + 1.96 \times 10^{-3} \times P + 0.543$
	300 W < P ≤ 700 W	$-2.60 \times 10^{-7} \times P^2 + 3.65 \times 10^{-4} \times P + 0.764$
	P > 700 W	$-1.70 \times 10^{-8} \times P^2 + 3.85 \times 10^{-5} \times P + 0.876$

Table 3-291~~279~~292 Efficiency of ENERGY STAR UPS Version 2.0

UPS Product Class	Rated Output Power (P) in watts	Minimum Efficiency
Voltage and Frequency Dependent (VFD)	P ≤ 350 W	$5.71 \times 10^{-5} \times P + 0.962$
	350 W < P ≤ 1.5 kW	0.982
	1.5 W < P ≤ 10 kW	$0.981 - E_{MOD}$
	P > 10 kW	0.97
Voltage Independent (VI)	P ≤ 350 W	$5.71 \times 10^{-5} \times P + 0.964$
	350 W < P ≤ 1.5 kW	0.984
	1.5 kW < P ≤ 10 kW	$0.980 - E_{MOD}$
	P > 10 kW	0.940
Voltage and Frequency Independent (VFI)	P ≤ 350 W	$0.011 \times \ln(P) + 0.824$
	350 W < P ≤ 1.5 kW	$0.011 \times \ln(P) + 0.824$
	1.5 W < P ≤ 10 kW	$0.0145 \times \ln(P) + 0.8 - E_{MOD}$
	P > 10 kW	$0.0058 \times \ln(P) + 0.886$

Table 3-292~~280~~293 Equivalent Full Load Hours

Rated Output Power (P) in Watts	UPS Product Class	Time spent at specified proportion of reference test load (t)				EFLH[177]
		25%	50%	75%	100%	
P ≤ 1.5 kW	VFD	0.2	0.2	0.3	0.3	5913
	VI or VFI	0	0.3	0.4	0.3	6570
1.5 kW < P ≤ 10 kW	VFD, VI, or VFI	0	0.3	0.4	0.3	6570
P > 10 kW	VFD, VI, or VFI	0.25	0.5	0.25	0	4380

Peak Factors

Table 3-293~~281~~294 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1.0	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 10 years [730]~~[7309]~~.

References

~~[706]~~[727] Code of Federal Regulations, Energy Conservation Standards for Uninterruptible Power Supplies, effective January 10, 2022 (10 CFR 430.32(z)(3). https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32

Field Code Changed

~~[707]~~[728] ENERGY STAR Uninterruptible Power Supplies Final Version 2.0 Specification, effective January 1, 2019. https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Uninterruptible%20Power%20Supplies%20Final%20Version%202.0%20Specification.pdf

Field Code Changed

~~[708]~~[729] Calculation and inputs provided in ENERGY STAR Uninterruptible Power Supplies Final Version 2.0 Specification.

~~[709]~~[730] California Municipal Utilities Association. Savings Estimation Technical Reference Manual 2017, Third Edition. Section 8.12, p. 8–15. https://www.cmua.org/files/CMUA-POU-TRM_2017_FINAL_12-5-2017%20-%20Copy.pdf

Field Code Changed

[177] The EFLH values were derived using the following equation EFLH = ($t_{0.25}$ x 0.25 + $t_{0.5}$ x 0.5 + $t_{0.75}$ x 0.75 + $t_{1.0}$ x 1.0) x 8760 hours. The time spent at specified proportion of reference load (t) was sourced from the ENERGY STAR Uninterruptible Power Supplies Final Version 2.0 Specification document. The 8760 hours assumption is based on the fact that the power is uninterruptible, therefore available year-round, i.e 8760 hours a year.

3.9.5 REFRIGERATED BEVERAGE VENDING MACHINE

Market	Commercial/Multifamily
Baseline Condition	TOS
Baseline	Code
End Use Subcategory	Plug Load
Measure Last Reviewed	January 2023

Description

This measure applies to new or rebuilt ENERGY STAR®, Class A, Class B, Combination A or Combination B refrigerated vending machines. ENERGY STAR® vending machines incorporate more efficient compressors, fan motors, and lighting systems as well as a low power mode option that allows the machine to be placed in low-energy lighting and/or low-energy refrigeration states during times of inactivity. Class A machines have 25% or more of the front surface area that is transparent; Class B machines have less than 25% of the front surface area that is transparent. Combination machines have separate refrigerated and non-refrigerated compartments.

Baseline Case

The baseline equipment is a new Class A, Class B, Combination A or Combination B refrigerated vending machine that meets Federal Energy Efficiency Standards for refrigerated vending machines as defined in 10 CFR 431.294.

Efficient Case

A new or rebuilt ENERGY STAR®, Class A, Class B, Combination A or Combination B refrigerated vending machine that meets Energy Star Vending Machine Ver 4.0 program requirements.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \left(kWh_b - kWh_q\right) \times Days$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 3-294~~282~~295 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
kWh_b	Energy usage of baseline vending machine	Site Specific, if unknown calculate using Table 3-295~~Table 3-283~~296	kWh/day	[731]~~[7310]~~
kWh_q	Energy usage of ENERGY STAR vending machine	Site Specific, if unknown calculate using Table 3-295~~Table 3-283~~296	kWh/day	[732]~~[711~~732]
V	Refrigerated Volume	Site Specific, if unknown use 23.62	Ft^3	[733]~~[712~~733]
Days	Days of vending machine operation per year	365.25	days	[734]~~[7134]~~
CF	Electric coincidence factor	Look up in Table 3-296~~Table 3-284~~297	N/A	
PDF	Gas peak day factor	Look up in Table 3-296~~Table 3-284~~297	N/A	
EUL	Effective useful life	See Measure Life Section	Years	[733]~~[712~~733]

Table 3-295~~283~~296 Energy Consumption Default Values

Equipment Class	Baseline (kWh_b) kWh/day	Energy Star (kWh_q) kWh/day
Class A	0.052 x V + 2.43	0.04836 x V + 2.2599
Class B	0.052 x V + 2.20	0.04576 x V + 1.936

Equipment Class	Baseline (kWh_b) kWh/day	Energy Star (kWh_q) kWh/day
Combination A	0.086 × V † + 2.66	0.07998 x V + 2.4738
Combination B	0.111 × V † + 2.04	0.09768 x V + 1.7952

Peak Factors

There are no peak demand savings because this measure is aimed to reduce demand during times of low beverage machine use, which will typically occur during off-peak hours.

Table 3-296~~284297~~ Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 14 years [733]~~[712733]~~.

References

~~[710]~~[731] 10 CFR §431.296 - Energy Conservation Standards for Refrigerated Bottled or Canned Beverage Vending Machines.
~~[711]~~[732] ENERGY STAR® Version 4.0 requirements for maximum daily energy consumption.
~~[712]~~[733] Navigant Consulting, *Energy Savings Potential and R&D Opportunities for Commercial Refrigeration*. September 2009, https://www1.eere.energy.gov/buildings/publications/pdfs/corporate/commercial_refrig_report_10-09.pdf.
~~[713]~~[734] ENERGY STAR. US Environmental Protection Agency and US Department of Energy. “ENERGY STAR Certified Vending Machines Spread Sheet” available at https://www.energystar.gov/productfinder/download/certified-vending-machines/

Field Code Changed

Field Code Changed

3.9.6 VENDING MACHINE CONTROLS

Market	Commercial/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	January 2023

Description

This measure covers the installation of time clocks or occupancy sensors on refrigerated vending machines and novelty coolers to reduce compressor run time and lighting hours while ensuring units maintain desired product temperatures during occupied hours. This measure also covers the installation of either controls on non-refrigerated (snack) vending machines. In this case, savings are derived from a reduction in lighting hours during unoccupied hours. This measure is only applicable to vending machines and novelty coolers containing non-perishable products without a low power mode.

The time clock control mechanism is a programmed-schedule time clock that is assumed to be set to turn the equipment off coincident with the facility closing time and turn equipment on one hour before opening time to allow the products to return to the desired sale temperature.

The occupancy sensor control mechanism uses an infrared sensor to turn off the vending machine when the surrounding area is unoccupied. The device also monitors the ambient temperature and powers up the machine as required to keep products cool. Additionally, the sensor monitors the electrical current used by the machine to ensure it is not turned off during a compressor cycle to prevent a high head pressure start from occurring.

Baseline Case

The baseline equipment is assumed to be a standard efficiency refrigerated beverage vending machine, non-refrigerated snack vending machine, or glass front refrigerated cooler without a control system capable of powering down lighting and refrigeration systems during periods of inactivity.

Efficient Case

The efficient equipment is assumed to be a standard efficiency refrigerated beverage vending machine, non-refrigerated snack vending machine, or glass front refrigerated cooler with a control system capable of powering down lighting and refrigeration systems during periods of inactivity.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

Refrigerated Vending Machine and Novelty Cooler

$$\Delta kWh = kW_{unit} \times \left[hrs_{off} + F_{ctrl} \times ESF \times (8{,}760 - hrs_{off})\right]$$

Non-Refrigerated Vending Machine

$$\Delta kWh = kW_{unit} \times \left[hrs_{off} + F_{ctrl} \times ESF \times (8{,}760 - hrs_{off})\right]$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \mathrm{N/A}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \mathrm{N/A}$$

Calculation Parameters

Table 3-297~~285~~298 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
kW_{unit}	Vending machine power (kW)	Look up in Table 3-298~~Table 3-286~~299	kW	[735]~~[714735]~~[737]~~[716737]~~
hrs_{off}	Annual facility closed hours (Daily facility closed hours minus 1 multiplied by operating days)	Site-specific, if unknown see **Error! Reference source not found.**~~Appendix D: HVAC Fan and Pump Operating Hours~~	hours	
F_{ctrl}	Control type factor	Occupancy Sensor = 1 Time Clock = 0	N/A	
ESF	Energy savings of occupancy sensing control during building operating hours	0.1	N/A	[736]~~[715736]~~
CF	Electric coincidence factor	Look up in Table 3-299~~Table 3-287~~300	N/A	

Variable	Description	Value	Units	Ref
PDF	Gas peak day factor	Look up in Table 3-299~~Table 3-287300~~	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-298~~286299~~ Vending Machine Power

Peak Factor	Value
Refrigerated beverage vending machine	0.4
Non-refrigerated snack vending machine	0.02
Glass front refrigerated coolers	0.46

Peak Factors

Table 3-299~~287300~~ Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 5 years [738]~~[717738]~~.

References

~~[714]~~[735] *2021 Illinois Statewide Technical Reference Manual for Energy Efficiency Version 9: Volume 2 Commercial and Industrial Measures* (2020) Pg. 574 https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010121_v9.0_Vol_2_C_and_I_09252020_Final.pdf

~~[715]~~[736] Department of Energy, *Wireless Sensors for Lighting Energy Savings, Wireless Occupancy Sensors for Lighting Controls: An Applications Guide for Federal Facility Managers*, December 2019. https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/wireless_occupancy_sensor_guide.pdf

~~[716]~~[737] Southern California Edison, *Workpaper SCE17CS005, Revision 1, Beverage Merchandise Controller*, July 23, 2018. http://deeresources.net/workpapers

~~[717]~~[738] Energy Resource Solutions, *Measure Life Study: Prepared for the Massachusetts Joint Utilities*, November 2005, https://www.ers-inc.com/wp-content/uploads/2018/04/Measure-Life-Study_MA-Joint-Utilities_ERS.pdf.

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

3.9.7 ELECTRIC VEHICLE CHARGER

Market	Commercial/Multifamily
Baseline Condition	NC/RF
Baseline	ISP/Existing
End Use Subcategory	N/A
Measure Last Reviewed	January 2023

Description

Electric Vehicle Supply Equipment (EVSE) is the infrastructure that is used to charge electric vehicle batteries. At non-residential locations, EVSE may simply be a designated outlet in a parking lot or garage, or may include embedded intelligence that allows a fee to be charged for use of the EVSE and communications with a charging network such as ChargePoint. Additional functionality (the ability to charge a fee or communicate with a network) adds substantially to the cost of EVSE installation and often includes a monthly subscription fee.

Baseline Case

Level 1 - 120 volts Electric Vehicle Supply Equipment at a public or commercial location.

Efficient Case

Level 2 - 240 volts Electric Vehicle Supply Equipment at a public or commercial location.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = 403 \times N_{EVSE}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 3-300~~288~~301 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
403	Deemed Annual Energy Savings	403	kWh/yr	[739]~~[718739]~~
N_{EVSE}	Number of EVSE	N/A	N/A	[739]~~[718739]~~
CF	Electric coincidence factor	Look up in Table 3-301~~Table 3-289~~302	N/A	[739]~~[718739]~~
PDF	Gas peak demand factor	Look up in Table 3-301~~Table 3-289~~302	N/A	
EUL	Effective useful life	See Measure Life Section	Years	[739]~~[718739]~~

Peak Factors

Table 3-301~~289~~302 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	75%	[739]~~[718739]~~
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is the length of the warranty for EVSE given in the EVSE manufacturer websites. If unknown, use 10 years [739]~~[718739]~~.

References

~~[718]~~[739] Vermont Energy Investment Corporation, *Transportation Technical Reference Manual: Guide to Characterize the Savings, Benefits, and Costs of Transportation Efficiency,* June 2014, Page 23 available at https://www.veic.org/Media/default/documents/resources/manuals/veic-transportation-trm.pdf

Field Code Changed

3.9.8 LITHIUM ION FORK TRUCK BATTERIES

Market	Commercial
Baseline Condition	TOS/RF
Baseline	ISP/Existing
End Use Subcategory	N/A
Measure Last Reviewed	January 2025
Changes Since Last Version	• New Measure

Description

Based on the Illinois TRM. [740] This measure applies to electric fork trucks used in commercial, industrial, and warehouse environments. Electric fork trucks with lithium ion battery systems are more efficient than electric fork trucks with traditional lead acid battery systems because the lithium ion batteries have lower internal resistance. This allows the batteries to transfer power faster, reduces waste heat, and reduces standby losses.

Electric fork trucks can be purchased with lithium ion battery systems or an existing electric fork truck can be retrofitted to use a lithium ion battery system. An electric fork truck can be converted to a lithium ion battery system by removing the lead acid battery and installing a battery case that includes a series of lithium ion batteries and the appropriate ballast to meet weight and balance specifications for the fork truck. The lithium ion battery case is a one-for-one equivalent replacement of the lead acid battery in respect to capacity, shape, and weight. The fork truck may require a new charger to work with the new lithium ion battery system. Electric fork trucks can also replace propane or diesel powered fork truck in a one to one scenario. Where a facility normally operates a fleet of fossilfueled fork trucks a fossil-fuel baseline should be considered for any additional fork trucks that might be purchased beyond the current quantity of trucks operating at the facility.

Baseline Case

Class I, Class II, or Class III fork trucks that are powered by lead acid batteries or fossil-fuels such as propane or diesel with minimum 8-hour shift operation five days per week.

Efficient Case

Class I, Class II, or Class III fork trucks that are powered by lithium ion batteries with minimum 8-hour shift operation five days per week.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \ Look\ up\ in\ \text{Table 3-303}\cancel{\text{Table 3-304}}$$

Annual Fuel Savings

$$\Delta Therms = Look\ up\ in\ \text{Table 3-303}\cancel{\text{Table 3-304}}$$

Peak Demand Savings

$$\Delta kW_{Peak} = 0$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = 0$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-302~~303~~ Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Look up in Table 3-303~~Table 3-304~~	kWh/yr	[740]
ΔTherms	Annual fuel savings	Look up in Table 3-303~~Table 3-304~~	Therms/yr	[740]
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	

Table 3-303~~304~~ Lithium Ion Fork Truck Battery Savings

Facility Operation (assume 1-shift if unknown)	Lead Acid Baseline	Diesel Baseline		Propane Baseline	
	ΔkWh	ΔTherms	ΔkWh	ΔTherms	ΔkWh
1-shift (8 hrs/day – 5 days/week)	11,707	1,740	51,079	1,750	51,427
2-shift (16 hrs/day – 5 days/week)	23,414	3,490	102,158	3,510	102,855
3-shift (24 hrs/day – 5 days/week)	35,121	5,230	153,238	5,260	154,282
4-shift (24 hrs/day – 7 days/week)	49,169	7,320	214,533	7,370	215,995

Peak Factors

Table 3-304~~305~~ Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 15 years. [741]

References

[740] 2025 IL TRM v.13 Vol. 2, pg. 1005: https://www.ilsag.info/wpcontent/uploads/ILTRM_Effective_010125_v13.0_Vol_2_C_and_I_09202024_FINAL.pdf

[741] Lifetime of measure assumed to be limited by the lifetime of the lithium ion charger, per 2025 IL TRM v.13 Vol. 2

3.10 REFRIGERATION

3.10.1 ENERGY EFFICIENT GLASS DOORS ON VERTICAL OPEN REFRIGERATED CASES

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Refrigeration
Measure Last Reviewed	November 2022
Changes Since Last Version	~~Removed references to DI Baseline Condition and dual baseline~~

Description

This measure applies to retrofitting vertical, open, refrigerated display cases with high efficiency glass doors without anti-sweat heaters. The deemed savings factors are derived from the results of a controlled test designed to measure the impact of this measure. The results of the test were presented at the 2010 International Refrigeration and Air Conditioning conference.

Baseline Case

The baseline equipment is an existing vertical display case of medium temperature with no doors. The display cases should be medium temperature (typically for dairy, meats, or beverages) as opposed to low temperature (typically for frozen food and ice cream).

Efficient Case

The compliance condition is a vertical refrigerated display case fitted with glass doors without anti-sweat heaters.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = CL \times (\Delta kWh/ft) \times \left(1 - \frac{hrs_{cooling}}{8,760} - \frac{COP_{ref}}{COP_{HVAC}}\right)$$

Where,

$$COP_{ref} = \frac{3.517}{(kW/ton)}$$

$$COP_{HVAC} = \frac{EER}{3.412}$$

Annual Fuel Savings

$$\Delta Therms = CL \times \frac{(\Delta kWh/ft) \times 3{,}412}{100{,}000} \times \frac{hrs_{heating}}{8{,}760} \times \frac{1}{Eff}$$

Peak Demand Savings

$$\Delta kW_{Peak} = CL \times \frac{(\Delta kWh/ft)}{8{,}760} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-305~~290~~306 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWhLife	Lifetime electric energy savings	Calculated	kWh	
ΔThermsLife	Lifetime fuel savings	Calculated	Therms	
CL	Case Length, open length of the refrigerated case	Site-specific	ft	
ΔkWh/ft	Annual electric energy savings per foot of door opening	Look up in Table 3-306~~Table 3-291~~307	kWh/yr-ft	[742]~~[719~~742]
COP_{ref}	Coefficient of performance of refrigeration equipment	Calculated	N/A	
kW/ton	Rated efficiency of the compressor in input kW per ton of refrigeration capacity	Site-specific	kW/ton	

Variable	Description	Value	Units	Ref
COP_{HVAC}	Coefficient of performance of heating, ventilation, and cooling equipment	Site-specific. If unknown, look up in Table 3-307~~Table 3-292~~308	N/A	[743]~~[720~~743]
Eff	Fossil fuel-fired heating system efficiency	Site-specific[178]. If unknown, use 0.8		[744]~~[721~~744]
$Hrs_{cooling}$	Cooling HVAC load hours	Site-specific	Hours	
$Hrs_{heating}$	Heating HVAC load hours	Site-specific	hrs	
3,412	Conversion factor from kWh to Btu	3,412	Btu/kWh	
8,760	Number of hours in a year	8760	Hours	
100,000	Conversion factor from Btu to therms	100,000	Btu/therm	
CF	Coincidence factor	Look up in Table 3-308~~Table 3-293~~309	N/A	
PDF	Peak day factor	Look up in Table 3-308~~Table 3-293~~309	N/A	
EUL	Effective useful life	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 3-306~~291~~307 Annual electric energy savings per foot of door opening

Door Type	ΔkWh/ft[179]
High-Efficiency Doors on Cooler	477
High-Efficiency Doors on Freezer	747
Standard Doors on Cooler	183
Standard Doors on Freezer	392

Table 3-307~~292~~308 Coefficient of performance of HVAC systems

Location[180]	COP_{HVAC}
Grocery Store	2.93

[178] E_c, E_t or AFUE shall be used, based on nameplate rating metric of existing equipment

[179] Fricke, Brian and Becker, Bryan, "Energy Use of Doored and Open Vertical Refrigerated Display Cases". Energy savings of high efficiency doors are calculated by eliminating anti-condensation heater energy draw and proportionally reducing associated work required from the refrigeration equipment while assuming an HVAC system COP of 3.28, refrigeration COP of 3.03 for coolers and 1.66 for freezers. Measured energy savings on medium temperature units was adjusted with COPcooler/COPfreezer ratios to develop savings for standard doors installed on freezer units.

[180] Grocery Store default assumes a 25-ton packaged RTU (cooling only); Other default assumes a 10-ton packaged RTU (cooling only)

Location[180]	COP_{HVAC}
Other	3.57

Peak Factors

Table 3-308~~293309~~ Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1.0[181]	[745]~~[722745]~~
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-309~~294310~~ Measure Life

Equipment	EUL	RUL	Ref
Case Doors	4	1.3	[746]~~[723746]~~

References

~~[719]~~[742] Fricke, Brian and Becker, Bryan, "Energy Use of Doored and Open Vertical Refrigerated Display Cases" (2010). International Refrigeration and Air Conditioning Conference. Paper 1154. http://docs.lib.purdue.edu/iracc/1154

Field Code Changed

~~[720]~~[743] ASHRAE 90.1 2010 Energy Standard for Buildings Except Low Rise Residential Buildings: Standard for Unitary HVAC. https://www.ashrae.org/technical-resources/standards-and-guidelines

Field Code Changed

~~[721]~~[744] Gas boiler efficiency of 80% -ASHRAE Standards 90.1-2007 and 2016, Energy Standard for Buildings Except Low Rise Residential Buildings, Table 6.8.1F. https://www.ashrae.org/technical-resources/standards-and-guidelines

Field Code Changed

~~[722]~~[745] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs, Version 10, January 2023

~~[723]~~[746] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020. http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx.

Field Code Changed

[181] No source specified – update pending availability and review of applicable references.

3.10.2 DOOR CLOSER

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Controls
Measure Last Reviewed	February 2024
Changes Since Last Version	• ~~Updated the deemed kWh and kW savings values for freezers and coolers~~ • ~~Updated the peak factors for freezers and coolers~~

Description

This section provides energy savings algorithms for the installation of auto-closer to the main insulated opaque door(s) of a walk-in freezer or cooler. Auto-closers can reduce the amount of time that doors are open, thereby reducing infiltration and refrigeration loads. This measure applies to retrofit of doors not previously equipped with auto-closers, and assume the doors have strip curtains.

The auto-closer must be able to firmly close the door when it is within one inch of full closure. The walk-in door perimeter must be ≥ 16 feet.

Baseline Case

Walk in cooler/freezer without an auto closer and the doors have strip curtains.

Efficient Case

Walk in cooler/freezer with an auto closer.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = look\ up\ in\ \text{Table 3-311}\ \cancel{\text{Table 3-296312}}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = look\ up\ in\ \text{Table 3-311}\ \cancel{\text{Table 3-296312}}$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = N/A$$

Calculation Parameters

Table 3-310~~295~~311 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Look up in Table 3-311~~Table 3-296~~312	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Look up in Table 3-311~~Table 3-296~~312	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
CF	Electric coincidence factor	Lookup in Table 3-311~~Table 3-296~~312	N/A	[1]
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-311~~296~~312 Deemed savings for Walk-in Freezer and Coolers

Location	ΔkWh_{cooler}	ΔkW_{cooler}	$\Delta kWh_{freezer}$	$\Delta kW_{freezer}$
Northern	2,951	0.93	8,590	1.46
Central	2,894	0.91	8,425	1.43
Pine barrens	2,737	0.86	7,969	1.35
Southwest	2,864	0.90	8,338	1.42
Coastal	2,539	0.80	7,392	1.26
Statewide Average	2,825	**0.89**	8,225	**1.40**

Peak Factors

Peak demand is accounted for in the deemed savings values presented in Table 3-311~~Table 3-296~~312.

Measure Life

The effective useful life (EUL) is 8 years [3].

References

[1] Illinois Statewide Technical Reference Manual for Energy Efficiency , Volume 2: Commercial and Industrial Measures, v12.0, 2024, page 794, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_2_C_and_I.pdf

[2] Southern California Edison, Commercial Refrigeration: Auto-Closer for Refrigerated Storage Door (SWCR005-02), California eTRM, November 16, 2020). http://www.deeresources.net/workpapers.

[3] "DEER2014-EUL-table-update_2014-02-05". 2014. Deeresources.com. Accessed December 12, 2022. http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx

Field Code Changed

Field Code Changed

Field Code Changed

3.10.3 DOOR GASKETS

Market	Commercial
Baseline Condition	RF/DI
Baseline	Existing/Dual
End Use Subcategory	Load reduction
Measure Last Reviewed	January 2023

Description

This measure involves the replacement of worn-out gaskets with new, better-fitting gaskets on the doors of walk-in and/or reach-in coolers and freezers. When damaged and/or missing, the warmer, more humid air present in the store will infiltrate the case, increasing the refrigeration system load while often reducing the efficiency of the evaporator unit as a result of additional frost accumulation. Replacing the damaged gaskets reduces compressor run time and improves the overall heat removal effectiveness of the cooler/freezer.

Baseline Case

The baseline condition is a low-temperature walk-in and/or reach-in freezer and/or a medium-temperature walk-in and/or reach-in with damaged and/or missing gaskets with at least six inches of damage for reach-in units and at least two feet of damage for walk-in units.

Efficient Case

The efficient case is the installation of new, tight fitting door gaskets to reduce infiltration.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{\Delta kWh}{Door} \times Doors$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kW}{Door} \times Doors$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Thrms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-312~~297313~~ Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
ΔkWh/Door	Annual Energy Savings per Foot of gasket	Lookup in Table 3-313~~Table 3-298314~~	kWh	[4][5]
ΔkW/Door	Demand Savings per Foot of gasket	Lookup in Table 3-313~~Table 3-298314~~	kW	[4][5]
Doors	Total number of gasket doors replaced	Site-specific	N/A	[4][5]
CF	Electric coincidence factor	Lookup in Table 3-314~~Table 3-299315~~	N/A	
EUL	Effective useful life	See Measure Life Section	Years	[6]
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 3-~~313298~~314 Door Gasket Savings Per Foot of Gasket for Walk-in and Reach-in Coolers and Freezers

Type	Coolers		Freezers	
	ΔkW/door	ΔkWh/door	ΔkW/door	ΔkWh/door
Reach-in	0.032	248	0.032	243
Walk-in	0.027	204	0.045	347

Peak Factors

Table 3-~~314299~~315 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1.0	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-~~315300~~316 Measure Life

Equipment	EUL	RUL	Ref
Door Gaskets	4	1.3	[6]

References

[4] Database for UES Measures, Regional Technical Forum. Door Gasket Replacement, version 1.5. December 2016. https://rtf.nwcouncil.org/measure/door-gasket-replacement

[5] Pennsylvania TRM 2021, August 2019 available at https://www.puc.pa.gov/filing-resources/issues-laws-regulations/act-129/technical-reference-manual/

[6] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx.

Field Code Changed

Field Code Changed

Field Code Changed

3.10.4 NIGHT COVERS

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Refrigeration
Measure Last Reviewed	November 2022
Changes Since Last Version	~~Removed references to DI Baseline Condition and dual baseline~~

Description

This measure covers the installation of retractable curtains on open horizontal or multi-deck refrigerated display cases in grocery stores. These covers serve as a barrier between the contents of the refrigerated case and the ambient air during off-business hours. They conserve energy by reducing the infiltration of ambient air into the refrigerated space, thereby reducing the load on the refrigeration system. Grocery stores operating 24 hours per day are not eligible for energy savings.

Baseline Case

The baseline condition is a vertical or horizontal open refrigerated display case left uncovered during off-business hours and meeting the minimum federal energy standards presented in Table 3-317~~Table 3-302~~318 and Table 3-318~~Table 3-303~~319 [7]. E*quipment with an operating temperature above 32°F is classified as Medium with a rating temperature of 38°F, while equipment with an operating temperature of 32°F or below is classified as Low with a rating temperature of 0°F. Ice Cream freezers have a rating temperature of -15°F and operate at temperatures below -5°F.*

Total Daily Energy *Consumption (TDEC) shall be calculated per Table* 3-317~~*Table 3-302*~~318 *and Table* 3-318~~*Table 3-303*~~319 *for the appropriate display case type, configuration and rating temperature. For refrigeration equipment with two or more compartments (i.e. hybrid refrigerators, freezers, refrigerator-freezers and non-hybrid refrigerator freezers), the TDEC shall be established as the sum of the TDEC values associated with each component compartment.*

Efficient Case

The compliance condition is a vertical or horizontal open refrigerated display case with retractable night covers installed.

Operating Hours

Energy savings are based on installation of refrigerated case night covers in an 18-hour supermarket assumed to operate 365 days per year. Therefore, the annual hours that night covers are assumed to be in use are (24 – 18) x 365 = 2,190 hours [8].

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = TDEC \times ESF \times 365$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = 0$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithm

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

3-316~~301~~317 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
TDA[182]	Total Display Area of the open case	Site-specific	Ft^2	
units	Number night covers installed	Site-specific	N/A	
TDEC	Total Daily Energy Consumption	Look up in Table 3-317~~Table 3-302~~318, Table 3-318~~Table 3-303~~319	kWh/day	[7]

[182] TDA = L * H, where L is length of the display case opening (ft) and H is height (vertical) or depth (horizontal) of the display case opening (ft). These parameters are site specific.

Variable	Description	Value	Units	Ref
ESF	Energy Savings Factor	0.~~09~~054	N/A	[8]
365	Number of days in a year	365	days/yr	
EUL	Effective useful life	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 3-317~~302318~~ Baseline Efficiencies for Refrigerators, Freezers, or Refrigerator-freezers Manufactured on or after March 27, 2017

Equipment Family	Condensing Unit Configuration	Rating Temperature	TDEC (kWh/day)
Vertical Open	Remote Condensing	Medium (38°F)	0.64 x TDA + 4.07
Vertical Open	Remote Condensing	Low (0°F)	2.20 x TDA + 6.85
Vertical Open	Remote Condensing	Ice Cream (-15°F)	2.79 x TDA + 8.70
Vertical Open	Self-Contained	Medium (38°F)	1.69 x TDA + 4.71
Vertical Open	Self-Contained	Low (0°F)	4.25 x TDA + 11.82
Vertical Open	Self-Contained	Ice Cream (-15°F)	5.40 x TDA + 15.02
Horizontal Open	Remote Condensing	Medium (38°F)	0.35 x TDA + 2.88
Horizontal Open	Remote Condensing	Low (0°F)	0.55 x TDA + 6.88
Horizontal Open	Remote Condensing	Ice Cream (-15°F)	0.70 x TDA + 8.74
Horizontal Open	Self-Contained	Medium (38°F)	0.72 x TDA + 5.55
Horizontal Open	Self-Contained	Low (0°F)	1.90 x TDA + 7.08
Horizontal Open	Self-Contained	Ice Cream (-15°F)	2.42 x TDA + 9.00

Table 3-318~~303319~~ Baseline Efficiencies for Refrigerators, Freezers, and Refrigerator-freezers Manufactured before March 27, 2017

Equipment Family	Condensing Unit Configuration	Rating Temperature	TDEC (kWh/day)
Vertical Open	Remote Condensing	Medium (38°F)	0.82 × TDA + 4.07
Vertical Open	Remote Condensing	Low (0°F)	2.27 × TDA + 6.85
Vertical Open	Remote Condensing	Ice Cream (-15°F)	2.89 × TDA + 8.70
Vertical Open	Self-Contained	Medium (38°F)	1.74 × TDA + 4.71
Vertical Open	Self-Contained	Low (0°F)	4.37 × TDA + 11.82

Equipment Family	Condensing Unit Configuration	Rating Temperature	TDEC (kWh/day)
Vertical Open	Self-Contained	Ice Cream (-15°F)	5.55 × TDA + 15.02
Horizontal Open	Remote Condensing	Medium (38°F)	0.35 × TDA + 2.88
Horizontal Open	Remote Condensing	Low (0°F)	0.57 × TDA + 6.88
Horizontal Open	Remote Condensing	Ice Cream (-15°F)	2.44 × TDA + 9.00
Horizontal Open	Self-Contained	Medium (38°F)	0.77 × TDA + 5.55
Horizontal Open	Self-Contained	Low (0°F)	1.92 × TDA + 7.08
Horizontal Open	Self-Contained	Ice Cream (-15°F)	2.44 × TDA + 9.00

Peak Factors

Table 3-319~~304~~320 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-320~~305~~321 Measure Life

Equipment	EUL	RUL	Ref
Night Covers	5	1.67	[9]

References

[7] 10 CFR 431.66 Energy conservation standards and their effective dates. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-431#431.66

[8] Southern California Edison, Effects of the Low Emissivity Shields on Performance and Power Use of a Refrigerated Display Case, August 1997. https://www.econofrost.com/acrobat/sce_report_long.pdf

[9] DEER 2014 EUL ID: GrocDisp-DispCvrs.

Field Code Changed

Field Code Changed

3.10.5 STRIP CURTAINS

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Load Reduction
Measure Last Reviewed	September 2024
Changes Since Last Version	• ~~Updated doorway area assumptions~~ • ~~Removed references to DI Baseline Condition and dual baseline~~

Description

This measure involves the installation of strip curtains on the main door of walk-in freezers and walk-in coolers. Strip curtains prevent infiltration of non-refrigerated air into refrigerated spaces when the main door is open for routine stocking activity. In the absence of strip curtains, the warmer, more humid air present in the store will infiltrate the unit, increasing the load of the refrigeration system and often reducing the efficiency of the evaporator unit as frost accumulates, impairing its effectiveness. The total refrigeration load due to infiltration through the main door into the unit depends on the temperature differential between the refrigerated and non-refrigerated space, the door area and height, and the duration and frequency of door openings. The avoided infiltration depends on the efficacy of the newly installed strip curtains as infiltration barriers. Algorithms and assumptions in this measure are drawn from a Strip Curtains measure maintained by the Northwest Regional Technical Forum (RTF), which calculates savings using the formulas outlined in ASHRAE's Refrigeration Handbook for calculating refrigeration load from infiltration by air exchange.

Baseline Case

The baseline case is a walk-in cooler or freezer that previously had either no strip curtain installed or on old ineffective strip curtain installed. The baseline condition efficiency is a walk-in cooler or freezer door with damaged or missing strip curtains in excess of 15% of the door area. The most likely areas of application are large and small grocery stores, supermarkets, restaurants, and refrigerated warehouses.

Efficient Case

The efficient equipment is a strip curtain added to a walk-in cooler or freezer. Strip curtains must be at least 0.06 inches thick. Low-temperature strip curtains must be used on low-temperature applications.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{\Delta kWh}{ft^2} \times A$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{ft^2} \times \frac{A}{Hrs}$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters 321~~306~~322

Table 3-322~~307~~323 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta kWh/ft^2$	Average annual kWh savings per square foot of insulation barrier	Look up in Table 3-323 ~~Table 3-308~~324	kWh/ft^2	[10]
A	Doorway area	Site-specific, if unknown look up in Table 3-324~~Table 3-309~~325	ft^2	[10]
Hrs	Annual hours of operation	Site-specific, if unknown use 8766	Hours	
CF	Electric coincidence factor	Look up in Table 3-325~~Table 3-310~~326	N/A	
PDF	Gas peak demand factor	Look up in Table 3-325~~Table 3-310~~326	N/A	
EUL	Effective useful life	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 3-323~~308~~324 Default Annual Energy Savings for Strip Curtains per Square Foot

Type	Energy Savings for no pre-exisitng curtains, $\frac{\Delta kWh}{ft^2}$	Energy Savings for pre-exisitng curtains, $\frac{\Delta kWh}{ft^2}$
Grocery - Cooler	119.88	40.87
Grocery - Freezer	494.32	168.52
Convenience Store - Cooler	23.58	6.27
Convenience Store - Freezer	33.15	9.99
Restaurant - Cooler	22.50	6.19
Restaurant - Freezer	114.01	32.37
Refrigerated Warehouse - Cooler	153.36	53.42

Table 3-324~~309~~325 Doorway Area Assumptions

Type	Doorway Area, ft^2
Grocery - Cooler	22.5
Grocery - Freezer	22.5
Convenience Store - Cooler	22.5
Convenience Store - Freezer	22.5
Restaurant - Cooler	22.5
Restaurant - Freezer	22.5
Refrigerated Warehouse - Cooler	120

Peak Factors

Table 3-325~~310~~326 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1.0	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-326~~311~~327 Measure Life

Equipment	EUL	RUL	Ref
Strip Curtains	4	1.33	[11]

References

[10] IL TRM v10, pg 650.

[11] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx. Accessed December 2018.

[12] JCPL PY2 Evaluation Report

Field Code Changed

3.10.6 ANTI-SWEAT HEAT CONTROL

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Refrigeration
Measure Last Reviewed	February 2024
Changes Since Last Version	~~Removed references to DI Baseline Condition and dual baseline~~

Description

Anti-sweat door heaters (ASDH) prevent condensation on cooler and freezer doors. Anti-sweat heater (ASH) controls sense the humidity in the store outside of reach-in, glass door refrigerated cases, and turn off anti-sweat heaters during periods of low humidity. Without controls, anti-sweat heaters run continuously whether they are necessary or not.

There are two commercially available control strategies – (1) ON/OFF controls and (2) micro pulse controls that respond to a call for heating, which is typically determined using either a door moisture sensor or an indoor air temperature and humidity sensor to calculate the dew point. In the first strategy, the ON/OFF controls turn the heaters on and off for minutes at a time, resulting in a reduction in run time. In the second strategy, the micro pulse controls pulse the door heaters for fractions of a second, in response to the call for heating. Savings are realized from the reduction in energy used by not having the heaters running at all times. In addition, secondary savings result from reduced cooling load on the refrigeration unit when the heaters are off.

Baseline Case

The baseline condition is assumed to be a commercial glass door cooler or refrigerator and freezer with a standard heated door running 24 hours a day, seven days per week (24/7), with no controls installed.

Efficient Case

The efficient equipment is assumed to be a door heater control on a commercial glass door cooler or refrigerator and freezer utilizing either ON/OFF or micro pulse controls.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = kW_d \times \left(\%ON_b - \%ON_q\right) \times N \times Hrs \times IF_e$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = kW_d \times IF_e \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-~~327~~~~312~~328 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
kW_d	Connected load kW per connected door	Site-specific, if unknown use 0.13	kW/door	[13]
N	Number of doors	Site-specific	N/A	
$\%ON_b$	Effective runtime of the uncontrolled ASDH	Site-specific, if unknown use 90.7%	N/A	[13]
$\%ON_q$	Effective runtime of the controlled ASDH	Look up in Table 3-328~~Table 3-313~~329	N/A	[13]
IF_e	Interactive effects factor for energy to account for cooling savings from offset refrigeration load	Look up in Table 3-329~~Table 3-314~~330	N/A	[13]
CF	Electric coincidence factor	Look up in Table 3-330 Coincidence Factors ~~Table 3-3315 Coincidence Factors~~	N/A	[13]
Hrs	Hours of operation	8,760	Hrs	
EUL	Effective useful life	See Measure Life Section	Years	[14]

Table 3-328~~313329~~ Effective run time of controlled ASDH

Control Type	Value	Ref
ON/OFF control style	58.9%	[13]
Micropulse control style	42.8%	[13]
Unknown control style	45.6%	[13]

Table 3-329~~314330~~ Interactive effects factor for energy[183]

System Type	IF_eValue	Ref
Cooler or Refrigerator	1.26	[13]
Freezer	1.51	[13]

Coincidence Factor

Table 3-330~~315331~~ Coincidence Factors[184]

Control Type	CF Value	Ref
ON/OFF control style	0.32	[13]
Micropulse control style	0.45	[13]
Unknown control style	0.44	[13]

Measure Life

The effective useful life (EUL) is 12 years [14].

References

[13] Commercial Refrigeration Loadshape Project, 2015 available at https://cadmusgroup.com/wp-content/uploads/2016/02/NEEP-CRL_Report_FINAL_clean.pdf?submissionGuid=cb214243-bab8-479a-a4c4-c8e5c64ae7b2

[14] California eTRM, CPUC Support Tables: Effective Useful Life and Remaining Useful Life https://www.caetrm.com/cpuc/table/effusefullife/

Field Code Changed

Field Code Changed

[183] Interactive effects factor for energy is calculated by dividing the PJM Summer Peak kW equipment and interactive savings for ASDH by the equipment savings from Table 52 of the report reference [13].

[184] Coincidence factors developed by dividing the PJM Summer Peak kW Savings for ASDH Controls from Table 52 of the reference [13] (0.057 kW/door for unknown control style, 0.041 kW/door for on/off controls, and 0.058 kW/door for micropulse controls) by the average wattage of ASDH per connected door (0.13 kW)

3.10.7 DEFROST CONTROLS

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	February 2024
Changes Since Last Version	~~Removed references to DI Baseline Condition and dual baseline~~

Description

This measure is applicable to existing refrigerated cases, walk in freezers, and walk in coolers with a traditional electric defrost mechanism. This control system overrides the defrost of evaporator coils when unnecessary, reducing annual energy consumption. The estimates for savings take into account savings from the reduced number of defrost cycles as well as the reduction in heat gain from the defrost process.

Baseline Case

The baseline case is an electric defrost system that uses a time clock mechanism to initiate defrost.

Efficient Case

The high-efficiency case is a defrost system with electric defrost controls.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

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

Where,

$$\Delta kWh_{Defrost} = kW_{Defrost} \times Hours \times DRF$$

$$\Delta kWh_{Heat} = \Delta kWh_{Defrost} \times 0.28 \times Eff_{RS}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{8760} X\ CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-331~~316~~332 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta kWh_{Defrost}$	Energy savings resulting from an increase in operating efficiency due to the addition of electronic defrost controls.	Calculated	kWh	
ΔkWh_{Heat}	Energy savings due to reduced heat from the reduced number of defrost cycles	Calculated	kWh	
$kW_{Defrost}$	Load of electric defrost	Site-specific, if unknown use 0.9 kW	kW	
Hours	Number of hours defrost occurs over a year without the defrost controls	From Application, if unknown use 487[185]	Hrs/yr	[17]
DRF	Defrost reduction factor- percent reduction in defrosts required per year	35%		[15]
Eff_{RS}	Efficiency of typical refrigeration system	From Application, if unknown 3.35 (cooler), 1.88 (freezer)	kW/ton	[18]
0.28	Conversion constant	0.28	ton/kW	
CF	Electric coincidence factor	Look up in Table 3-332~~Table 3-317~~333	N/A	

[185] The refrigeration system is assumed to be in operation every day of the year, while savings from the evaporator coil defrost control will only occur during set defrost cycles. This is assumed to be (4) 20-minute cycles per day, for a total of 487 hours.

Variable	Description	Value	Units	Ref
PDF	Gas peak demand factor	Look up in Table 3-332~~Table 3-317~~333	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Peak Factors

Table 3-332~~317~~333 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 10 years [27].

References

[15] Supported by third party evaluation: Independent Testing was performed by Intertek Testing Service on a Walk-in Freezer that was retrofitted with Smart Electric Defrost capability

[16] Vermont Technical Reference User Manual (TRM), March 16, 2015. Pg. 171. This is a conservative estimate is based on a discussion with Heatcraft based on the components expected life

[17] Brian A. Fricke, Vishal Sharma, *Demand Defrost Strategies in Supermarket Refrigeration Systems*. (Oct 2011), Pg 2, https://info.ornl.gov/sites/publications/files/pub31296.pdf.

[18] Naikaj Pandya and Jon Maxwell *X1931-5 PSD Commercial Refrigeration Efficiency Update Study* (EnergizeCT, 2022) https://energizect.com/sites/default/files/documents/CT%20x1931-5%20Commercial%20Refrigeration%20ACOP%20Final%20Report_051222.pdf

Field Code Changed

Field Code Changed

3.10.8 LED CASE LIGHTING

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	N/A
Measure Last Reviewed	January 2023

Description

This measure applies to the installation of LED lamps in vertical and horizontal display refrigerators, coolers, and freezers replacing T8 or T12 linear fluorescent lamps. Replacing fluorescent lamps with low heat generating LEDs reduces the energy consumption associated with the lighting components and reduces the amount of heat generated from the lamps that must be overcome through additional cooling.

Baseline Case

Existing T8 or T12 refrigerated case linear fluorescent lamps.

Efficient Case

DesignLights Consortium (DLC) version 5.1 qualified LED vertical or horizontal refrigerated case luminaires.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \left(\frac{W_b - W_q}{1{,}000}\right) \times units \times hrs \times \left(1 + \left(Eff_{comp} \times 0.284\right)\right)$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \left(\frac{W_b - W_q}{1{,}000}\right) \times units \times CF \times \left(1 + \left(Eff_{comp} \times 0.284\right)\right)$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-333~~318~~334 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
W_b	Rated baseline fixture wattage	Site-specific, if unknown: T8 Case Lighting System = 15.2/Linear Feet T12HO Case Lighting System = 18.7/Linear Feet	Watts	[23]
W_q	Rated energy efficient wattage	Site-specific	Watts	
Units	Number of LED fixtures installed under the program	Site-specific	N/A	
Hrs	Hours of use	Site-specific, if unknown assume 6,205	Hrs/yr	[19]
Eff_{comp}	Compressor efficiency	Site-specific, if unknown look up in Table 3-334~~Table 3-319~~335	kW/ton	[20]
0.284	Conversion factor from kW to tons of refrigeration	0.284	Tons/kW	
CF	Electric coincidence factor	Look up in Table 3-335~~Table 3-320~~336	N/A	
PDF	Gas peak demand factor	Look up in Table 3-335~~Table 3-320~~336	N/A	
EUL	Effective useful life	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 3-334~~319~~335 Compressor Efficiency

Case Type	Eff_{comp}
Cooler	1.00
Freezer	1.92

Peak Factors

Table 3-335~~320336~~ Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.92	[21]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is smaller of the measure EUL (16 years [22]) and the case RUL.

References

[19] Theobald, M. A., Emerging Technologies Program: Application Assessment Report #0608, LED Supermarket Case Lighting Grocery Store, Northern California, Pacific Gas and Electric Company, January 2006. Assumes refrigerated case lighting typically operates 17 hours per day, 365 days per year.

[20] Based on CDH Energy evaluation of actual refrigeration system performance for several commercially available compressors, dated 09/06/2017. Values presented reflect average efficiencies of R22 systems.

[21] Pennsylvania PUC, Technical Reference Manual, June 2016, p. 258.

[22] DEER 2014 EUL ID: GrocDisp-FixtLtg-LED

[23] Pacific Gas & Electric. May 2007. LED Refrigeration Case Lighting Workpaper 053007 rev1. Values normalized on a per linear foot basis.

3.10.9 REFRIGERATED CASE LIGHT OCCUPANCY SENSORS

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	January 2023
Changes Since Last Version	~~Removed references to DI Baseline Condition and dual baseline~~

Description

This measure documents the energy savings attributed to installing occupancy sensors to control LED refrigerated case lighting. Energy savings can be achieved from the installation of sensors that dim or turn off the lights when the space or aisle is unoccupied. Energy savings result from a combination of reduced lighting energy and reduced cooling load within the case.

Baseline Case

No motion-based controls.

Efficient Case

This measure requires the installation of motion-based lighting controls that allow the LED case lighting to be dimmed or turned off completely during unoccupied conditions.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{W}{1{,}000} \times Hrs \times RRF \times (1 + IF_e)$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

There are no peak demand savings associated, as the savings are assumed to occur off-peak.

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-~~321~~ ~~Calculation Parameters~~

~~Variable~~	~~Description~~	~~Value~~	~~Units~~	~~Ref~~
~~ΔkWh~~	~~Annual electric energy savings~~	~~Calculated~~	~~kWh/yr~~	
~~ΔkW_{Peak}~~	~~Peak Demand Savings~~	~~Calculated~~	~~kW~~	
~~ΔkWh_{Life}~~	~~Lifetime electric energy savings~~	~~Calculated~~	~~kWh~~	

336~~337~~ Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
W	Connected wattage of controlled refrigerated lighting fixtures	Site-specific	Watts	
Hrs	Annual operating hours	Site-specific. If unknown assume 6,205	Hours	[24]
IF_e	Interactive effects factor for energy to account for colling savings from offset refrigeration load	Lookup in Table 3-337~~Table 3-322~~338	N/A	[25]
RRF	Runtime reduction factor	Lookup in Table 3-338~~Table 3-323~~339	N/A	[26]
1,000	Conversion factor	1,000	W/kW	
CF	Electric coincidence factor	Lookup in Table 3-339~~Table 3-324~~340	N/A	

Variable	Description	Value	Units	Ref
PDF	Gas peak day factor	Lookup in Table 3-339~~Table 3-324~~340	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-337~~322~~338 Interactive Effects Factor

Refrigerator and Cooler	Freezer
0.29	0.50

Table 3-338~~323~~339 Runtime Reduction Factor

24 Hour Facility	18 Hour Facility
0.39	0.29

Peak Factors

Table 3-339~~324~~340 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-340~~325~~341 Measure Life

Equipment	EUL	RUL	Ref
Refrigeratred Case Lighting	8	2.66	[27]

References

[24] Matteson, Mary, Marc Senior, and Energy Analyst. n.d. *Pacific Gas and Electric Company Emerging Technologies Program Application Assessment Report #0608 LED Supermarket Case Lighting Grocery Store, Northern California Pacific Gas and Electric Company.* Assumes 6,205 annual operating hours and 50,000 lifetime hours. Most case lighting runs continuously (24/7) but some can be controlled. 6,205 annual hours of use can be used to represent the mix. Using grocery store hours of use (4,660 hr) is too conservative since case lighting is not tied to store lighting. https://www.etcc-ca.com/sites/default/files/OLD/images/stories/pdf/ETCC_Report_204.pdf

[25] 2021 Pennsylvania TRM, Volume 3, Commercial and Industrial Measures. Table 3 8: Interactive Factors for All Bulb Types. https://www.puc.pa.gov/pcdocs/1692532.docx

[26] "ComGroceryDisplayCaseMotionSensors_v3_3.Xlsm | Powered by Box." n.d. Nwcouncil.app.box.com. Accessed January 20, 2023. https://nwcouncil.app.box.com/s/brl01usbhxvtrjbp0i2xcqk016lndfd1

Field Code Changed

Field Code Changed

Field Code Changed

[27] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020. http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

Field Code Changed

3.10.10 EVAPORATOR FAN EC MOTOR

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	January 2023
Changes Since Last Version	~~Removed references to DI Baseline Condition and dual baseline~~

Description

This measure covers energy and demand savings associated with the replacement of existing shaded-pole (SP) evaporator fan motors or Permanent Split Capacitor (PSC) motors in refrigerated cases with an Electronically Commutated motor (ECM) or a Permanent Magnet Synchronous (PMS) motor. The baseline condition assumes the evaporator fan motor is uncontrolled (i.e., it runs continuously). This measure applies to equipment manufactured before January 1, 2009 only, as the Code of Federal Regulations requires the use of EC or three-phase motors in evaporator fans in equipment manufactured on or after that date. Savings are calculated per motor replaced.

There are two sources of energy and demand savings through this measure:

1) The direct savings associated with replacement of an inefficient motor with a more efficient one;

2) The indirect savings of a reduced cooling load on the refrigeration unit due to less heat gain from the more efficient evaporator fan motor in the air-stream.

Baseline Case

The baseline case is a walk-in cooler/freezer or refrigerated display case with shaded pole (SP) or permanent split capacitor (PSC) evaporator fan motors.

Efficient Case

The efficient case is a walk-in cooler/freezer or refrigerated display case with Permanent Magnet Synchronous (PMS) motor or electronically commutated evaporator fan motors (ECM) with full load efficiency exceeding that prescribed by federal energy conservation standards for electric motors in 10 CFR 431.446 and/or 10 CFR 431.25 as applicable.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \left(kW_b - kW_q\right) \times F_{uncontrolled} \times 8{,}760 \times IF_e$$

If motor power is unknown, calculate using the algorithms below:

$$kW_b = HP_b \times \frac{0.746}{Eff_b} \times LF$$

$$kW_q = HP_q \times \frac{0.746}{Eff_q} \times LF$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{8{,}760}$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-~~341326~~342 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
kW_b	Input wattage of the baseline motor	Site-specific, if unknown, calculated from motor HP	kW	
kW_q	Input wattage of the efficient motor	Site-specific, if unknown, calculated from motor HP	kW	
$F_{uncontrolled}$	Effective runtime fraction of the uncontrolled motor	Site-specific, if unknown, use 0.978	N/A	[28]
HP_b	Rated horsepower of the baseline motor	Site-specific, if unknown use HP_q	HP	

Variable	Description	Value	Units	Ref
HP_q	Rated horsepower of the efficient motor	Site-specific	HP	
LF	Load factor	Site-specific[186], if unknown, use 0.9		[30]
IF_e	Interactive effects factor for energy to account for cooling savings from offset refrigeration load	Look up in Table 3-342~~Table 3-327~~343	N/A	[28]
8,760	Annual operating hours of Evaporator Fan	8,760	hours	
0.746	Unit conversion, kW/HP	0.746	kW/HP	
Eff_b	Efficiency of the baseline motor	SP: 30% PSC: 60%	N/A	[29]
Eff_q	Efficiency of the qualifying motor	ECM: 70% PMS: 73%	N/A	[29]
CF	Electric coincidence factor	Look up in Table 3-343~~Table 3-328~~344	N/A	
PDF	Gas peak day factor	Look up in Table 3-343~~Table 3-328~~344	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-342~~327~~343 Interactive Factor for Energy

Equipment Type	IF_e Value
SP Base, Cooler	0.38
PSC Base, Cooler	0.19
SP Base, Freezer	0.76
PSC Base, Freezer	0.38

Peak Factors

Table 3-343~~328~~344 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1.0	
Natural gas peak day factor (PDF)	N/A	

[186] Load Factor is the ratio between the actual load and rated load. This can be estimated by spot metering and nameplate reading.

Measure Life

The effective useful life (EUL) is smaller of the RUL of the host equipment or 16 years [31].

References

[28] Cadmus, *Commercial Refrigeration Loadshape Project* (2015). https://cadmusgroup.com/wp-content/uploads/2016/02/NEEP-CRL_Report_FINAL_clean.pdf

Field Code Changed

[29] Department of Energy. “Energy Savings Potential and Opportunities for High-Efficiency Electric Motors in Residential and Commercial Equipment.” December 2013. Motor efficiencies for the baseline motors are drawn from Table 2.1, which provides peak efficiency ranges for a variety of motors. The motor efficiency for an ECM is drawn from the discussion in 2.4.3. https://www.energy.gov/sites/prod/files/2014/02/f8/Motor%20Energy%20Savings%20Potential%20Report%202013-12-4.pdf

Field Code Changed

[30] *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – Residential Multifamily, and Commercial/Industrial Measures. Version 6*. (April 16, 2018)

[31] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

3.10.11 EVAPORATOR FAN CONTROLLER

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	January 2023
Changes Since Last Version	• ~~Removed references to DI Baseline Condition and dual baseline~~ • ~~Added effective runtime assumption for unknown control type~~

Description

This measure is for the installation of evaporator fan controls in walk-in refrigerators or freezers with no pre-existing controls. An evaporator fan controller is a device or system that lowers airflow across an evaporator when there is no refrigerant flow through the evaporator (i.e., when the compressor is in an off-cycle). Evaporator fans run constantly to provide cooling when the compressor is running, and to provide air circulation when the compressor is not running. There are two commercially available strategies – ON/OFF controls and multispeed controls – that respond to a call for cooling. In the first strategy, the ON/OFF controls turn the motors on and off in response to the call for cooling, generating energy and demand savings as a result of a reduction in run time. In the second strategy, the multispeed controls change the speed of the motors in response to the call for cooling, saving energy and reducing demand by reducing operating power and run time (multispeed controls can also turn the motor off).

A fan controller saves energy by reducing fan usage, by reducing the refrigeration load resulting from the heat given off by the fan and by reducing compressor energy resulting from the electronic temperature control. This measure documents the energy savings attributed to evaporator fan controls.

Baseline Case

The baseline case is assumed to be a shaded pole (SP) motor or PSC motor in walk-in evaporators without controls or an electronically-commutated motor (ECM) without controls.

Efficient Case

The efficient equipment is assumed to be an evaporator fan powered by an ECM, SP or PSC motor utilizing either ON/OFF or multispeed controls.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = kW \times \left(\%ON_b - \%ON_q\right) \times Hrs \times IF_e$$

Where,

$$kW = HP \times LF \ \times 0.746/\eta$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times UL$$

Calculation Parameters

Table 3-344~~329345~~ Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
kW	Input wattage of the SP, PSC or ECM motor	Site-specific, if unknown calculated	kW	
0.746	Conversion factor	0.746	kW/HP	[34]
LF	Load Factor - Ratio between the actual load and the rated load.	Site-specific, if unknown use 0.9	N/A	[34]
HP	Horsepower of SP, PSC or ECM motor	Site-specific	HP	
η	Motor efficiency of the SP, PSC or ECM motor	SP: 30% PSC: 60% ECM: 70%		[35]
$\%ON_b$	Effective runtime of the uncontrolled motor	Site-specific, if unknown use 97.8%	N/A	[32]

Variable	Description	Value	Units	Ref
$\%ON_q$	Effective runtime of the controlled motor	Site-specific, if unknown look up in Table 3-345~~Table 3-330~~346	N/A	[32]
IF_e	Interactive effects factor for energy to account for cooling savings from offset refrigeration load	Look up in Table 3-346~~Table 3-331~~347	N/A	[32]
CF	Electric coincidence factor	Look up in Table 3-347~~Table 3-332~~348	N/A	[32]
Hrs	Hours of operation	8,760	Hrs	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-345~~330~~346 Effective run time of controlled motors

Control Type	Value	Ref
ON/OFF style controls	63.6%	[32]
Multi-speed style controls	69.2%	[32]
Unknown	66.5%	[32]

Table 3-346~~331~~347 Interactive Effects Factor for Energy[187]

System Type	IF_e Value	Ref
Cooler or Refrigerator	1.38	[32]
Freezer	1.76	[32]

Coincidence Factor

Table 3-347~~332~~348 Coincidence Factors[188]

Control Type	CF Value	Ref
ON/OFF control style	0.087	[32]
Micropulse control style	0.102	[32]
Unknown control style	0.094	[32]

[187] Interactive effects factor for energy is calculated by dividing the annual energy savings (kWh/HP) for “Equipment and Interactive” (shown in Table 43 of the reference [13]) by annual energy savings (kWh/HP) for the “Equipment Only” equipment type (also shown in Table 43).
[188] Coincidence factors are developed by dividing the PJM summer peak kW/HP savings for evaporator fan controls (shown in Table 47 of the report reference [13]) by the average annual energy savings (kWh/HP) for evaporator fan controls (shown in Table 43 of the report reference [13]).

Measure Life

The effective useful life (EUL) is 16 years [33].

References

[32] Commercial Refrigeration Loadshape Project, 2015 available at https://cadmusgroup.com/wp-content/uploads/2016/02/NEEP-CRL_Report_FINAL_clean.pdf?submissionGuid=cb214243-bab8-479a-a4c4-c8e5c64ae7b2

[33] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020 available at http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

[34] DNV KEMA (2013). *Impact Evaluation of 2010 Prescriptive Lighting Installations. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory*

[35] Department of Energy. “Energy Savings Potential and Opportunities for High-Efficiency Electric Motors in Residential and Commercial Equipment.” December 2013. Motor efficiency for SP motors is drawn from Table 2.1, which provides peak efficiency ranges for a variety of motors. The motor efficiency for an ECM is drawn from the discussion in 2.4.3. https://www.energy.gov/sites/prod/files/2014/02/f8/Motor%20Energy%20Savings%20Potential%20Report%202013-12-4.pdf

3.10.12 FLOATING HEAD PRESSURE CONTROL

Market	Commerical
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	January 2023

Description

Installers conventionally design a refrigeration system to condense at a set pressure-temperature point, typically 90°F. By installing a floating head pressure control (FHPCs) condenser system, the refrigeration system can change condensing temperatures in response to different outdoor temperatures. This means that the minimum condensing head pressure from a fixed setting (180 psig for R-22) is lowered to a saturated pressure equivalent at 70°F or less. Reduced head pressure improves the compressor efficiency at the expense of additional condenser fan power, with a net overall decrease in the compressor plus condenser fan power. Either a balanced-port or electronic expansion valve that is sized to meet the load requirement at a 70°F condensing temperature must be installed. Alternatively, a device may be installed to supplement the refrigeration feed to each evaporator attached to a condenser that is reducing head pressure.

Baseline Case

The baseline case is a refrigeration system without FHPC.

Efficient Case

The efficient case is a refrigeration system with FHPC.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = HP_{compressor} \times \frac{kWh}{HP}$$

If the refrigeration system is rated in tonnage:

$$\Delta kWh = \frac{4.715}{COP} \times Tons \times \frac{kWh}{HP}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = 0$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \mathrm{N/A}$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \mathrm{N/A}$$

Calculation Parameters

Table 3-348~~333~~349 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$HP_{compressor}$	Rated horsepower per compressor	Site-specific	HP	
Tons	Refrigerator tonnage of the system	Site-specific	ton	
kWh/HP	Annual Savings per HP	Look up in Table 3-349~~Table 3-334~~350	kWh/HP	[36][39]
COP	Coefficient of Performance	Look up in Table 3-350~~Table 3-335~~351	N/A	[36][38]
4.715	Unit Conversion, HP/ton	4.715	HP/ton	
CF	Electric coincidence factor	Look up in Table 3-351~~Table 3-336~~352	N/A	
PDF	Gas peak demand factor	Look up in Table 3-351~~Table 3-336~~352	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Annual Savings per HP

Table 3-349~~334~~350 Annual Savings per HP

System Type/Size	kWh/hp
Unitary Condenser, Low Temp, 0-3 hp	252.03

System Type/Size	kWh/hp
Unitary Condenser, Low Temp, >3-6 hp	241.86
Unitary Condenser, Low Temp, >6-10 hp	248.68
Unitary Condenser, Low Temp, >10 hp	282.24
Unitary Condenser, Medium Temp, 0-3 hp	131.45
Unitary Condenser, Medium Temp, >3-6 hp	127.32
Unitary Condenser, Medium Temp, >6-10 hp	128.1
Unitary Condenser, Medium Temp, >10 hp	132.58
Remote Condenser, Low Temp, 0-3 hp	505.37
Remote Condenser, Low Temp, >3-6 hp	481.06
Remote Condenser, Low Temp, >6-10 hp	484.96
Remote Condenser, Low Temp, >10 hp	503.32
Remote Condenser, Medium Temp, 0-3 hp	393.38
Remote Condenser, Medium Temp, >3-6 hp	387.53
Remote Condenser, Medium Temp, >6-10 hp	396.89
Remote Condenser, Medium Temp, >10 hp	404.66

Table 3-350~~335351~~ COP for refrigeration equipment

System Type	Freezer (Low Temp)	Refrigerator (Medium Temp)	Ref
Unitary Condenser	1.4	2.6	[36]
Remote Condenser	1.88	3.35	[38]

Peak Factors

Table 3-351~~336352~~ Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	

Peak Factor	Value	Ref
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The effective useful life (EUL) is 15 years [37] or one-third of the EUL of the host equipment.

References

[36] Regional Technical Forum (RTF) as part of the Northwest Power & Conservation Council, Commerical Grocery Floating Head Pressure Controls Single Compressor v3.0, April 18, 2022; available at https://rtf.nwcouncil.org/measure/floating-head-pressure-controls-single-compressor-systems/ Assumed the kWh/hp savings for NJ will be equivalent to the kWh/hp savings derived for NYC location.

[37] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020 available at http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

[38] DNV. 2022. "X1931-5 PSD Commercial Refrigeration Efficiency Update Study." Connecticut Energy Efficiency Board.

[39] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (TRM), Version 10, January 2023 available at https://www3.dps.ny.gov/W/PSCWeb.nsf/PFPage/72C23DECFF52920A85257F1100671BDD?OpenDocument

Field Code Changed

Field Code Changed

Field Code Changed

3.10.13 VFD COMPRESSOR

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Refrigeration
Measure Last Reviewed	January 2023
Changes Since Last Version	~~Removed references to DI Baseline Condition and dual baseline~~

Description

Variable frequency drive (VFD) compressors are used to control and reduce the speed of the compressor during times when the refrigeration system does not require the motor to run at full capacity. VFD control is an economical and efficient retrofit option for existing compressor installations. The performance of variable speed compressors can more closely match the variable refrigeration load requirements thus minimizing energy consumption.

Baseline Case

Existing rotary screw compressor with slide valve control system.

Efficient Case

Rotary screw compressor with VFD control system.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = 0.212 \times \frac{1}{COP} \times HP_{compressor} \times ES_{value}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = 0.212 \times \frac{1}{COP} \times HP_{compressor} \times DS_{value} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-352~~353~~ Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	

~~337 Calculation Parameters~~

~~Variable~~	~~Description~~	~~Value~~	~~Units~~	~~Ref~~
~~ΔkWh~~	~~Annual electric energy savings~~	~~Calculated~~	~~kWh/yr~~	
~~ΔkW_{Peak}~~	~~Peak Demand Savings~~	~~Calculated~~	~~kW~~	
~~ΔkWh_{Life}~~	~~Lifetime electric energy savings~~	~~Calculated~~	~~kWh~~	
$HP_{compressor}$	Rated horsepower per compressor	Site-specific	hp	
ES_{value}	Energy savings value	1,696	kWh/ton	[40]
DS_{value}	Demand savings value	0.22	Kw/ton	[40]
COP	Coefficient of performance	Site-specific, if unknown look up in Table 3-353~~Table 3-338~~354	N/A	[41]
0.212	Conversion factor from HP to ton	0.212	Ton/hp	
CF	Electric coincidence factor	Look up in Table 3-354~~Table 3-339~~355	N/A	
PDF	Gas peak demand factor	Look up in Table 3-354~~Table 3-339~~355	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-353~~338~~354 COP for refrigeration equipment

Equipment	COP
Coolers	3.35

Equipment	COP
Freezers	1.88

Peak Factors

Table 3-~~354339~~355 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 15 years[42].

References

[40] 2005 DEER (Database for Energy Efficiency Resources). This measure considered the associated savings by vintage and by climate zone for compressors. The deemed value was an average across all climate zones and all vintages (excluding new construction). http://www.deeresources.com/index.php/deer2005

[41] Connecticut Energy Efficiency Board (EEB) "PSD Commercial Refrigeration Efficiency Update Study", May 2022 https://energizect.com/sites/default/files/documents/CT%20x1931-5%20Commercial%20Refrigeration%20ACOP%20Final%20Report_051222.pdf

[42] California eTRM, CPUC Support Tables: Effective Useful Life and Remaining Useful Life https://www.caetrm.com/cpuc/table/effusefullife/

Field Code Changed

Field Code Changed

Field Code Changed

3.11 WATER HEATING

3.11.1 STORAGE WATER HEATER

Market	Commercial/Multifamily
Baseline Condition	NC/TOS/EREP
Baseline	Code/Existing/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	January 2023

Description

This measure covers the installation of gas and electric storage tank water heaters designed to heat and store water at a thermostatically controlled temperature. This measure applies to potable hot water delivery only; it is not applicable to hot water heaters used for process loads or space heating.

Storage type units include commercial gas-fired storage water heaters with a nominal input of greater than 75,000 BTU/h and no more than one gallon of water per 4,000 BTU/h of input, and commercial electric storage water heaters with a nominal input of greater than 12 kilowatts and no more than one gallon of water per 4,000 BTU/h of input.

This measure applies to replacement of existing storage type water heaters using the same heating as the efficient case. For new construction, this measure assumes baseline to be a standard efficiency water heater using the same heating fuel as the efficient equipment.

This measure applies to commercial grade water heaters only. For residential-duty water heaters installed in commercial settings, the Residential Storage Tank and Instantaneous Domestic Water Heater methodology detailed in this document shall be employed utilizing typical GPD values as defined in the "Gallons per Day (GPD)" section below.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

New Construction, Time of Sale:

The baseline condition for replacement measures is a standard efficiency fossil fuel or electric storage type water heater (based on proposed conditions) with tank volume and input capacity equivalent to the efficient case, UA value calculated as prescribed in the savings algorithm and a thermal efficiency of 0.80 (fossil fuel) or 0.98 (electric).

Early Replacement

The baseline condition for the Early Replacement measure is the existing water heater for the remaining useful life of the unit, and then for the remainder of the measure life the baseline becomes a new replacement unit meeting the minimum federal efficiency standard.

Efficient Case

The compliance condition is a fossil fuel or electric storage type water heater as defined in the Measure Description section above, which exceeds the efficiency of the baseline equipment.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{3{,}412} \times \left(\frac{1}{E_{t,b}} - \frac{1}{E_{t,q}}\right)$$

Where,

$$\Delta T_{main} = T_{set} - T_{main}$$

$$SL_b = \frac{Q_b}{800} + 110\sqrt{v_b}$$

Annual Fuel Savings

$$\Delta Therms_{NR} = \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{100{,}000} \times \left(\frac{1}{E_{t,b}} - \frac{1}{E_{t,q}}\right)$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\left(UA_b - UA_q\right) \times \Delta T_{amb}}{3{,}412} \times CF$$

Where,

$$\Delta T_{amb} = T_{set} - T_{amb}$$

$$UA_q = \frac{SL_q}{70}$$

$$UA_b = \frac{SL_b}{70}$$

For baseline of large electric storage type water heaters (> 12kW and > 20 gallons):

$$SL_b = \frac{\left(0.3 + \frac{27}{v_b}\right)}{100} \times 70 \times v_b \times 8.33$$

For baseline of large oil and gas storage type water heaters (> 75,000 BTU/h input capacity (Q) and storage size > 1 gallon per 4000 BTU/h):

$$SL_b = \frac{Q_b}{800} + 110\sqrt{v_b}$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-~~355340~~356 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
ΔT_{main}	Average temperature difference between water heater set point temperature and the supply water temperature in water main	Calculated	°F	
ΔT_{amb}	Average temperature difference between water heater set point temperature and the surrounding ambient air temperature	Calculated	°F	

Variable	Description	Value	Units	Ref
UA_b	Overall heat loss coefficient of the baseline condition	Calculated	Btu/h-°F	
GPD	Gallons per day	Site Specific, if unknown look up in Table 3-356~~Table 3-341~~357	Gal/day	[53][54][55][56]
UA_q	Overall heat loss coefficient of the energy efficient measure	Site-specific	Btu/h-°F	
SL_b	Standby loss of baseline unit	Code baseline: calculated Existing baseline: site-specific, calculated if unknown	kBtu/hr	
SL_q	Standby loss of efficient unit from AHRI rating	Site-specific	kBtu/hr	
T_{set}	Water heater set point temperature	Site-specific, if unknown use 125	°F	[47]
$E_{t,b}$	Thermal efficiency of the baseline condition	Site-specific. If unknown, look up in Table 3-357~~Table 3-342~~358	N/A	[257]~~[2567]~~[398]~~[3978]~~
$E_{t,q}$	Thermal efficiency of the energy efficient condition	Site-specific	N/A	
v_b	Baseline tank volume, equal to the storage capacity of the efficient equipment	Site-specific	gal	
Q_b	Baseline input capacity, equal to the input capacity of the efficient equipment	Site-specific	Btu/hr	
T_{main}	Supply water temperature in water main[189]	60	°F	[251]~~[2501]~~
T_{amb}	Surrounding ambient air temperature	70	°F	[48]
365	Days per year	365	Days/yr	
3,412	Conversion factor	3,412	Btu/kWh	
8.33	Energy required (Btu) to heat one gallon of water by one degree Fahrenheit	8.33	Btu/gal°F	
100,000	Conversion factor	100,000	Btu/therm	
CF	Electric coincidence factor	Look up in Table 3-358~~Table 3-343~~359	N/A	

[189] Average value across 5 NJ climate zones. Calculated from annual average ambient air temperature + 6 °F.

Variable	Description	Value	Units	Ref
PDF	Gas peak day factor	Look up in Table 3-358~~Table 3-343~~359	N/A	
EUL	Effective useful life	See Measure Life Section	Years	
RUL	Remaining useful life	See Measure Life Section	Years	

Table 3-356~~341~~357 GPD[190]

Building Type	GPD	Rate	Notes/Assumptions	Source	REf
Assembly	239	7.02 GPD per 1,000 SF	Assumes 34,000 SF	EIA926: Public Assembly	[43]
Auto Repair	25	4.89 GPD per 1,000 SF	Assumes 5,150 SF	EIA: Other	[43]
Big Box Retail	448	3.43 GPD per 1,000 SF	Assumes 130,500 SF	EIA: Mercantile	[43]
Community College	1,520	1.9 GPD per person	Assumes 800 students	NREL927: School with Showers	[44]
Dormitory	8,600	17.2 GPD per resident	Assumes 500 residents	Water Research Foundation928	[45]
Elementary School	250	0.5 GPD per student	Assumes 500 students	NREL: School	[44]
Fast Food Restaurant	500	500 GPD per restaurant		FSTC929: Quick Service	[46]
Full-Service Restaurant	2,500	2,500 GPD per restaurant		FSTC: Full Service	[46]
Grocery	172	3.43 GPD per 1,000 SF	Assumes, 50,000 SF	EIA: Mercantile	[43]
High School	1,520	1.9 GPD per person	Assumes 800 students	NREL: School with Showers	[44]
Hospital	16,938	54.42 GPD per 1,000 SF	Assumes 250,000 SF	EIA: Health Care, Inpatient	[43]
Hotel	9,104	45.52 GPD per 1,000 SF	Assumes 200,000 SF	EIA: Lodging	[43]
Large Office	550	1.1 GPD per person	Assumes 500 people	NREL: Office	[44]
Large Retail	446	3.43 GPD per 1,000 SF	Assumes 130,000 SF	EIA: Mercantile	[43]
Light Industrial	489	4.89 GPD per 1,000 SF	Assumes 100,000 SF	EIA: Other	[43]
Motel	1,366	45.52 GPD per 1,000 SF	Assumes 30,000 SF	EIA: Lodging	[43]
Multifamily High-Rise	4,600	46 GPD per unit	Assumes 100 units	Water Research Foundation	[45]

[190] The estimates in this table rely on sources that present total water consumption. Site-specific GPD estimate should be used if possible. Calculated GPD estimate should be compared to water heater capacity to ensure it is reasonable, and reduced if needed to align with water heater capacity.

Building Type	GPD	Rate	Notes/Assumptions	Source	REf
Multifamily Low-Rise	552	46 GPD per unit	Assumes 12 units	Water Research Foundation	[45]
Refrigerated Warehouse	86	0.93 GPD per 1,000 SF	Assumes 92,000 SF	EIA: Warehouse and Storage	[43]
Religious	77	7.02 GPD per 1,000 SF	Assumes 11,000 SF	EIA: Public Assembly	[43]
Small Office	110	1.1 GPD per person	Assumes 100 people	NREL: Office	[44]
Small Retail	27	3.43 GPD per 1,000 SF	Assumes 8,000 SF	EIA: Mercantile	[43]
University	1,000	0.5 GPD per student	Assumes 2,000 students	NREL: School	[44]
Warehouse	465	0.93 GPD per 1,000 SF	Assumes 500,000 SF	EIA: Warehouse and Storage	[43]
Other	Calculate	4.89 GPD per 1,000 SF		EIA: Other	[43]

Table 3-357~~342~~358 Thermal efficiency baseline

Electric	Gas
0.98	0.80

Peak Factors

Table 3-358~~343~~359 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.8	[52]
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Equipment	EUL	RUL	Ref
Commercial Storage Water Heater	15	5	[50]

References

[43] U.S. Energy Information Administration, 2012 Commercial Buildings Energy Consumption Survey: Water Consumption in Large Buildings, Table WD1. Daily water consumption in large commercial buildings, 2012

[44] National Renewable Energy Laboratory, Saving Energy in Commercial Buildings: Domestic Hot Water Assessment Guidelines, Table 1. Hot Water Use By Building Type, June 2011

[45] Water Research Foundation: Residential End Uses of Water, Version 2, April 2016

[46] Food Service Technology Center, Design Guide – Energy Efficient Heating, Delivery and Use, Table 1. Typical hot water system cost for restaurants, March 2010

[47] 10 CFR 430 Appendix E to Subpart B of Part 430 Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature, December 2022.

[48] Water heaters are generally located in conditioned or partially conditioned spaces with a typical average temperature of 65°F to 70°F to avoid freezing. A value of 70°F is used for the purposes of estimating tank/ambient air temperature differential, which aligns with standby loss specification testing standards.

[49] 10 CFR 430 Appendix E to Subpart B of Part 430 Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-B/appendix-Appendix%20E%20to%20Subpart%20B%20of%20Part%20430

[50] 10 CFR 431.110 (a) – Energy conservation standards and their effective dates. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-431/subpart-G/subject-group-ECFR4c2d09a7e7a11ca/section-431.110California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx.

[51] Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory, 2022

[52] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (TRM), Version 9, January 2022. https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V9.pdf.

Field Code Changed

3.11.2 TANKLESS WATER HEATER

Market	Commercial/Multifamily
Baseline Type	NC/TOS/RF/DI/EREP
Baseline	Code/Existing/Dual
End Use Subcategory	Water Heating
Measure Last Reviewed	December 2022

Description

This measure covers the installation of high-efficiency fossil fuel and electric instantaneous water heaters, which heat water but contain no more than one gallon of water per 4,000 Btu/h of input. It is applicable to fossil fuel-fired instantaneous water heaters with a rated input greater than 200,000 Btu/h and electric instantaneous water heaters with a rated input greater than 12 kW. This measure applies to potable hot water delivery only; it is not applicable to water heaters used for process loads or space heating.

This measure applies to replacement of existing storage type water heaters using the same heating fuel (fossil fuel or electric) as the efficient case. For new construction, this measure assumes baseline to be a standard efficiency water heater using the same heating fuel (fossil fuel or electric) as the efficient case.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

The baseline condition is a standard efficiency fossil fuel or electric storage type water heater (fuel type equivalent to the efficient case) with tank volume and input capacity equivalent to those of the existing equipment, UA value calculated as prescribed below and a thermal efficiency of 0.80 (fossil fuel) or 0.98 (electric). If existing tank volume is unknown, assume a 120-gallon storage type water heater with an input capacity of 200,000 Btu/h.

Efficient Case

The compliance condition is a fossil fuel or electric instantaneous water heater as defined in the Measure Description section above. Fossil fuel tankless water heaters must meet the minimum qualifying efficiency for ENERGY STAR® certification of a thermal efficiency greater than or equal to 0.94. Electric tankless water heaters must meet or exceed the efficiency of the baseline condition with a thermal efficiency greater than or equal to 0.98.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = kWh_b - kWh_q$$

$$\Delta kWh = \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{3{,}412} \times \left(\frac{1}{E_{t,b}} - \frac{1}{E_{t,q}}\right) + \frac{UA_b \times \Delta T_{amb} \times 8{,}760}{E_{t,b} \times 3{,}412}$$

Where,

$$kWh_b = \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{3{,}412 \times E_{t,b}} + \frac{UA_b \times \Delta T_{amb} \times 8{,}760}{E_{t,b} \times 3{,}412}\ (Electric\ Baseline)$$

$$kWh_b = 0\ (Fossil\ Fuel\ Baseline)$$

$$kWh_q = \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{3{,}412 \times E_{t,q}} (Electric\ Energy\ Efficient\ Case)$$

$$kWh_q = 0\ (Fossil\ Fuel\ Energy\ Efficient\ Case)$$

$$\Delta T_{main} = T_{set} - T_{main}$$

$$\Delta T_{amb} = T_{set} - T_{amb}$$

$$UA_b = \frac{SL_b}{70}$$

For baseline of large electric storage type water heaters (> 12kW and > 20 gallons):

$$SL_b = \frac{\left(0.3 + \frac{27}{v_b}\right)}{100} \times 70 \times v_b \times 8.33$$

Annual Fuel Savings

$$\Delta Therms = \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{100{,}000} \times \left(\frac{1}{E_{t,b}} - \frac{1}{E_{t,q}}\right) + \frac{UA_b \times \Delta T_{amb} \times 8{,}760}{E_{t,b} \times 100{,}000}$$

Where,

$$\Delta Therms = Therms_b - Therms_q$$

$$Therms_b = \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{100{,}000 \times E_{t,b}} + \frac{UA_b \times \Delta T_{amb} \times 8{,}760}{E_{t,b} \times 100{,}000} (Fossil\ Fuel\ Baseline)$$

$$Therms_b = 0\ (Electric\ Baseline)$$

$$Therms_q = \frac{GPD \times 365 \times 8.33 \times \Delta T_{main}}{100{,}000 \times E_{t,q}} (Fossil\ Fuel\ Energy\ Efficient\ Case)$$

$$Therms_q = 0\ (Electric\ Energy\ Efficient\ Case)$$

$$\Delta T_{main} = T_{set} - T_{main}$$

$$\Delta T_{amb} = T_{set} - T_{amb}$$

$$UA_b = \frac{SL_b}{70}$$

For baseline of large oil and gas storage type water heaters (> 75,000 BTU/h input capacity (Q) and storage size > 1 gallon per 4000 Btu/h):

$$SL_b = \frac{Q_b}{800} + 110\sqrt{v_b}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{8{,}760} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-~~359~~~~344~~360 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	

Variable	Description	Value	Units	Ref
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔT_{main}	Average temperature difference between water heater set point and the supply water temperature in water main	Calculated	°F	
ΔT_{amb}	Average temperature difference between water heater set point and the surrounding ambient air temperature	Calculated	°F	
UA_b	Overall heat loss coefficient of the baseline condition, calculate based on baseline standby loss	Calculated	N/A	
$E_{t,q}$	Thermal efficiency for energy efficient measure	Site-specific	N/A	
GPD	Gallons per day	Site-specific, if unknown look up in Table 3-360~~Table 3-345~~361	Gal/day	[53][54][55][56]
v_b	Baseline tank volume	Site-specific, if unknown use 120	gal	
Q_b	Baseline input capacity	Site-specific, if unknown use 200,000	Btu/h	
$E_{t,b}$	Thermal efficiency of the baseline condition	For retrofit, use site-specific existing value. If unknown, use 0.80 for fossil fuel and 0.98 for electric. For new construction, look up in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~	N/A	[59]
T_{set}	Water heater set point temperature	Site-specific, if unknown use 125	°F	[57]
T_{main}	Supply water temperature in water main	60	°F	[58]
T_{amb}	Surrounding ambient air temperature	70[191]	°F	
365	Days per year	365	Days/yr	
3,412	Conversion from Btu to kWh	3,412	Btu/kWh	

[191] Water heaters are generally located in conditioned or partially conditioned spaces with a typical average temperature of 65°F to 70°F to avoid freezing. A value of 70°F is used for the purposes of estimating tank/ambient air temperature differential, which aligns with standby loss specification testing standards.

Variable	Description	Value	Units	Ref
8.33	Energy required (Btu) to heat one gallon of water by one degree Fahrenheit	8.33	Btu/gal°F	
100,000	Conversion from Btu to therms	100,000	Btu/therm	
70	Temperature difference associated with standby loss specification	70	(°F)	
CF	Coincident Factor	Look up in Table 3-361~~Table 3-346362~~	N/A	
PDF	Peak day factor	Look up in Table 3-361~~Table 3-346362~~	N/A	
EUL	Effective useful life	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

The average daily hot water usage, expressed in gallons per day, for several commercial facility types is tabulated below. Daily hot water usage can be calculated based on the GPD and site-specific metric in the Rate column, or default values can be referenced directly from the GPD column.

Table 3-360~~345361~~ GPD by Facility Type[192]

Building Type	GPD	Rate	Notes	Source	Ref
Assembly	239	7.02 GPD per 1,000 SF	Assumes 34,000 SF, 10% hot water	EIA: Public Assembly	[53]
Auto Repair	25	4.89 GPD per 1,000 SF	Assumes 5,150 SF, 10% hot water	EIA: Other	[53]
Big Box Retail	448	3.43 GPD per 1,000 SF	Assumes 130,500 SF, 10% hot water	EIA: Mercantile	[53]
Community College	1,520	1.9 GPD per person	Assumes 800 students	NREL School with Showers	[54]
Dormitory	8,600	17.2 GPD per resident	Assumes 500 residents	Water Research Foundation	[55]
Elementary School	250	0.5 GPD per student	Assumes 500 students	NREL: School	[54]
Fast Food Restaurant	500	500 GPD per restaurant		FSTC: Quick Service	[56]
Full-Service Restaurant	2,500	2,500 GPD per restaurant		FSTC: Full Service	[56]
Grocery	172	3.43 GPD per 1,000 SF	Assumes 50,000 SF, 10% hot water	EIA: Mercantile	[53]
High School	1,520	1.9 GPD per person	Assumes 800 students	NREL: School with Showers	[54]

[192] The estimates in this table rely on sources that present total water consumption. Site-specific GPD estimate should be used if possible. Calculated GPD estimate should be compared to water heater capacity to ensure it is reasonable, and reduced if needed to align with water heater capacity.

Building Type	GPD	Rate	Notes	Source	Ref
Hospital	16,938	54.42 GPD per 1,000 SF	Assumes 40% hot water, 250,000 SF	250,000 SF EIA: Health Care, Inpatient	[53]
Hotel	9,104	45.52 GPD per 1,000 SF	Assumes 40% hot water, 200,000 SF	EIA: Lodging	[53]
Large Office	550	1.1 GPD per person	Assumes 500 people	NREL: Office	[54]
Large Retail	446	3.43 GPD per 1,000 SF	Assumes 130,000 SF, 10% hot water	EIA: Mercantile	[53]
Light Industrial	489	4.89 GPD per 1,000 SF	Assumes 100,000 SF, 10% hot water	EIA: Other	[53]
Motel	1,366	45.52 GPD per 1,000 SF	Assumes 30,000 SF, 40% hot water	EIA: Lodging	[53]
Multifamily High-Rise	4,550	45.5 GPD per unit	Assumes 100 units	Water Research Foundation	[55]
Multifamily Low-Rise	546	45.5 GPD per unit	Assumes 12 units	Water Research Foundation	[55]
Refrigerated Warehouse	86	0.93 GPD per 1,000 SF	Assumes 92,000 SF, 10% hot water	EIA: Warehouse and Storage	[53]
Religious	77	7.02 GPD per 1,000 SF	Assumes 11,000 SF,10% hot water	EIA: Public Assembly	[53]
Small Office	110	1.1 GPD per person	Assumes 100 people	NREL: Office	[54]
Small Retail	27	3.43 GPD per 1,000 SF	Assumes 8,000 SF, 10% hot water	EIA: Mercantile	[53]
University	1,000	0.5 GPD per student	Assumes 2,000 students	NREL: School	[54]
Warehouse	465	0.93 GPD per 1,000 SF	Assumes 500,000 SF, , 10% hot water	EIA: Warehouse and Storage	[53]
Other	Calculate	4.89 GPD per 1,000 SF	Assumes 10% hot water	EIA: Other	[53]

Peak Factors

Table 3-361~~346~~362 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.8	[60]
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The remaining useful life (RUL) for retrofit projects is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-~~362347~~363 Measure Life

Equipment	New construction EUL	Retrofit RUL	Ref
Instantaneous Water Heater	20	6.66	[61]

References

[53] U.S. Energy Information Administration, 2012 Commercial Buildings Energy Consumption Survey: Water Consumption in Large Buildings, Table WD1. Daily water consumption in large commercial buildings, 2012.

[54] National Renewable Energy Laboratory, Saving Energy in Commercial Buildings: Domestic Hot Water Assessment Guidelines, Table 1. Hot Water Use By Building Type, June 2011.

[55] *Water Research Foundation: Residential End Uses of Water, Version 2*, (April 2016) Pg 5. https://www.circleofblue.org/wp-content/uploads/2016/04/WRF_REU2016.pdf

[56] Food Service Technology Center, Design Guide – Energy Efficient Heating, Delivery and Use, Table 1. Typical hot water system cost for restaurants, March 2010.

[57] 10 CFR 430 Appendix E to Subpart B of Part 430 Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature, December 2022.

[58] Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory, 2022.

[59] Fuel: 10 CFR 431.110 (a), December 2022.

[60] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs (TRM), Version 10, January 2023. https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V10.pdf

[61] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020. http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx

Field Code Changed

Field Code Changed

Field Code Changed

3.11.3 HEAT PUMP WATER HEATER

Market	Commercial/Multifamily
Baseline Condition	TOS/NC/EREP/DI
Baseline	Code/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	September 2024
Changes Since Last Version	• ~~Clarified baseline definition~~ • ~~Corrected efficiency parameter nomenclature~~ • ~~Added default GPD assumption~~ • ~~Added space heat fuel and equipment type default splits~~

Description

This measure covers the installation of electric storage tank water heaters that use heat pump technology to move heat from the air (in conditioned or unconditioned spaces) to the water storage tank and are designed to heat and store potable water at a thermostatically controlled temperature of less than 180°F. It is not intended for equipment delivering process or space heating hot water. The best applications of heat pump water heater is in a space where cooling is desired year round. Heat pump water heater interactions with the HVAC system should be calculated according to the existing HVAC system (TOS) in existing buildings or the planned HVAC system in new construction (NC). If the HVAC system is unknown, one may calculate savings for each scenario and use the average savings, using the following space heat fuel splits:

•Gas = 93%	•Boiler = 37% of gas heat •Furnace = 63% of gas heat
•Electric heat = 7%	•Air source heat pump = 22% of electric heat •Other = 78% of electric heat

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

Baseline equipment for TOS/NC projects is a minimally code-compliant, electric storage type water heater.

For EREP/DI projects, use dual baselines. The baseline equipment for the first baseline period is the site-specific existing equipment. The baseline equipment for the second baseline period is a minimally code-compliant water heater of the same type and fuel as the existing equipment.

Efficient Case

The efficient condition is an ENERGY STAR version 5.0 qualified commercial heat pump water heater.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{dhw} + \Delta kWh_{cooling} - \Delta kWh_{heating}$$

Where,

$$Load_{dhw} = GPD \times 365 \times 8.33 \times (T_{set} - T_{main})$$

$$\Delta kWh_{dhw} = \frac{Load_{dhw}}{3{,}412} \times \left(\frac{F_{dhw,electric}}{UEF_b} - \frac{1}{UEF_q \times F_{derate}}\right)$$

$$\Delta kWh_{cooling} = \frac{Load_{dhw}}{1{,}000} \times \left(1 - \frac{1}{UEF_q}\right) \times F_{location} \times \frac{F_{cool}}{IEER}$$

$$\Delta kWh_{heating} = \frac{Load_{dhw}}{1{,}000} \times \left(1 - \frac{1}{UEF_q}\right) \times F_{location} \times F_{heat,electric} \times \frac{F_{heat}}{COP\ x\ 3.412}$$

Annual Fuel Savings

$$\Delta Therms = \Delta Therms_{dhw} - \Delta Therms_{heating}$$

Where,

$$\Delta Therms_{dhw} = \frac{Load_{dhw}}{100{,}000} \times \left(\frac{F_{dhw,ff}}{UEF_b}\right)$$

$$\Delta Therms_{heating} = \frac{Load_{dhw}}{100{,}000} \times \left(1 - \frac{1}{UEF_q}\right) \times F_{location} \times F_{heat,ff} \times \frac{F_{heat}}{E_t}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \Delta kWh \times F_{ETD}$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-363~~348~~364 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkWh_{dhw}	Annual domestic hot water electric energy savings	Calculated	kWh/yr	
$\Delta kWh_{cooling}$	Annual cooling electric energy savings	Calculated	kWh/yr	
$\Delta kWh_{heating}$	Annual heating electric energy impacts	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{dhw}$	Annual domestic hot water fuel savings	Calculated	Therms/yr	
$\Delta Therms_{heat}$	Annual space heating fuel impacts	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$Load_{dhw}$	Annual hot water load	Calculated	Btu	
GPD	Gallons per day	Look up in Table 3-364~~Table 3-349~~365	Gal/day	[67]

Variable	Description	Value	Units	Ref
		If building type or size unknown, use 64		
v_r	Rated storage volume	Site-specific	Gal	
E_t	Thermal efficiency of space heating boiler or furnace	Site-specific, if unknown, look up in Table 3-369~~Table 3-354~~370	N/A	[64]
UEF_q	Uniform energy factor of efficient unit	Site-specific, if unknown look up in Table 3-366~~Table 3-351~~367	N/A	[63]
UEF_b	Uniform energy factor of baseline unit	Look up in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~	N/A	[63]
F_{derate}	Efficiency derating factor	Look up in Table 3-371~~Table 3-356~~372	N/A	[64]
$F_{location}$	Installation location factor	Look up in Table 3-371~~Table 3-356~~372	N/A	
$F_{DHW,electric}$	Electric water heating factor	Look up in Table 3-365~~Table 3-350~~366	N/A	
$F_{DHW,ff}$	Fossil fuel water heating factor	Look up in Table 3-365~~Table 3-350~~366	N/A	
$F_{DHW,boiler}$	Fossil fuel boiler heating factor	Look up in Table 3-365~~Table 3-350~~366	N/A	
$F_{heat.electric}$	Electric heating factor	Look up in Table 3-365~~Table 3-350~~366	N/A	
$F_{heat,ff}$	Fossil fuel heating factor	Look up in Table 3-365~~Table 3-350~~366	N/A	
F_{heat}	Heating factor, used to account for the percentage of heat extracted from ambient air by the heat pump water heater that increases space heating load	0.49	N/A	[68]
F_{cool}	Cooling factor, used to account for the percentage of heat extracted from ambient air by the heat pump water heater that reduces space cooling load	0.51	N/A	[68]
IEER	Space cooling Integrated energy efficiency ratio	Look up in Table 3-368~~Table 3-353~~369	Btu/W·hr	[67]
COP	Space heating COP	Look up in Table 3-366~~Table 3-351~~367	N/A	[67]

Variable	Description	Value	Units	Ref
T_{main}	Supply water temperature in water main	Look up in Table 3-370~~Table 3-355~~371	°F	[66]
F_{ETD}	Energy to demand factor	Look up in Table 3-371~~Table 3-356~~372	N/A	
T_{set}	Water heater setpoint temperature	Site-specific, if unknown use 125	°F	[62]
365	Days per year	365	Days/yr	
8.33	Unit conversion, Btu/gal·°F	8.33	Btu/gal·°F	
3,412	Unit conversion, Btu/kWh	3,412	Btu/kWh	
3.412	Unit conversion, Btu/W·hr	3.412	Btu/W·hr	
1000	Unit conversion, Watt/kW	1000	W/kW	
100,000	Unit conversion, Btu/therm	100,000	Btu/therm	
CF	Electric coincidence factor	Look up in Table 3-372~~Table 3-357~~373	N/A	
PDF	Gas peak demand factor	Look up in Table 3-372~~Table 3-357~~373	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-364~~349~~365 Gallons Per Day[193]

Building Type	GPD	Rate	Notes/Assumptions	Source	Ref
Assembly	239	7.02 GPD per 1,000 SF	Assumes 34,000 SF	EIA926: Public Assembly	[69]
Auto Repair	25	48.9 GPD per 1,000 SF	Assumes 5,150 SF	EIA: Other	[69]
Big Box Retail	448	34.3 GPD per 1,000 SF	Assumes 130,500 SF	EIA: Mercantile	[69]
Community College	1,520	1.9 GPD per person	Assumes 800 students	NREL927: School with Showers	[70]
Dormitory	8,600	17.2 GPD per resident	Assumes 500 residents	Water Research Foundation928	[71]
Elementary School	250	0.5 GPD per student	Assumes 500 students	NREL: School	[70]
Fast Food Restaurant	500	500 GPD per restaurant		FSTC929: Quick Service	[72]
Full-Service Restaurant	2,500	2,500 GPD per restaurant		FSTC: Full Service	[72]

[193] The estimates in this table rely on sources that present total water consumption. Site-specific GPD estimate should be used if possible. Calculated GPD estimate should be compared to water heater capacity to ensure it is reasonable, and reduced if needed to align with water heater capacity.

Building Type	GPD	Rate	Notes/Assumptions	Source	Ref
Grocery	172	3.43 GPD per 1,000 SF	Assumes, 50,000 SF	EIA: Mercantile	[69]
High School	1,520	1.9 GPD per person	Assumes 800 students	NREL: School with Showers	[70]
Hospital	16,938	54.42 GPD per 1,000 SF	Assumes 250,000 SF	EIA: Health Care, Inpatient	[69]
Hotel	9,104	45.52 GPD per 1,000 SF	Assumes 200,000 SF	EIA: Lodging	[69]
Large Office	550	1.1 GPD per person	Assumes 500 people	NREL: Office	[70]
Large Retail	446	3.43 GPD per 1,000 SF	Assumes 130,000 SF	EIA: Mercantile	[69]
Light Industrial	489	4.89 GPD per 1,000 SF	Assumes 100,000 SF	EIA: Other	[69]
Motel	1,366	45.52 GPD per 1,000 SF	Assumes 30,000 SF	EIA: Lodging	[69]
Multifamily High-Rise	4,600	46 GPD per unit	Assumes 100 units	Water Research Foundation	[71]
Multifamily Low-Rise	552	46 GPD per unit	Assumes 12 units	Water Research Foundation	[71]
Refrigerated Warehouse	86	0.93 GPD per 1,000 SF	Assumes 92,000 SF	EIA: Warehouse and Storage	[69]
Religious	77	7.02 GPD per 1,000 SF	Assumes 11,000 SF	EIA: Public Assembly	[69]
Small Office	110	1.1 GPD per person	Assumes 100 people	NREL: Office	[70]
Small Retail	27	3.43 GPD per 1,000 SF	Assumes 8,000 SF	EIA: Mercantile	[69]
University	1,000	0.5 GPD per student	Assumes 2,000 students	NREL: School	[70]
Warehouse	465	0.93 GPD per 1,000 SF	Assumes 500,000 SF	EIA: Warehouse and Storage	[69]
Other	Calculate	4.89 GPD per 1,000 SF		EIA: Other	[69]

Table 3-365~~350~~366 DHW and Heating Savings Factors

Baseline Scenario	$F_{DHW,electric}$	$F_{DHW,ff}$	$F_{heat,electric}$	$F_{heat,ff}$
NC/TOS: Use electric baseline	1.0	0	1.0	0
EREP/DI with electric dhw and electric heat baseline	1.0	0	1.0	0
EREP/DI with fuel dhw and fuel heat baseline	0	1.0	0	1.0
EREP/DI with electric dhw and fuel heat baseline	1.0	0	0	1.0
EREP/DI with fuel dhw and electric heat baseline	0	1.0	1.0	0

Table 3-366~~351~~367 Efficient COP_q

Product Class	COP_q
Commercial Heat Pump Water Heater	3.0

Table 3-367~~352~~368 Derating Factors

Area	F_{derate}	$F_{location}$
Unconditioned Space	0.77	0
Conditioned Space	1.16	1
Kitchen	1.45	1
Unknown (Midstream Delivery)	1.00	1

Table 3-368~~353~~369 IEER and COP Values

Type	IEER	COP
Air Conditioner	12.7	1.0
Air-Source Heat Pump	12.7	3.3

Table 3-369~~354~~370 E_t Values

Equipment Type	Size Range	E_t
Warm Air Furnace, Gas Fired	All Capacities	0.80
Boiler, Hot Water, Gas Fired	All Capacities	0.80
Boiler, Steam, Gas Fired	All Capacities	0.77

Table 3-370~~355~~371 Supply Water Temperature

Climate Region	T_{main}
Northern	56
Southwest	58
Coastal	60
Central	58
Pine Barrens	58
Statewide Average	58

Table 3-371~~356372~~ F_{ETD} by building type

Building Type	ETDF
Education - Other	0.0002545
Health - Hospital	0.0002011
Health - Other	0.0003020
Lodging	0.0001210
Miscellaneous/Other	0.0002590
Office	0.0002490
Restaurant	0.0001525
Retail	0.0002560
Warehouse - Refrigerated	0.0003018

Peak Factors

Peak coincidence is incorporated in the energy to demand factor presented above.

Table 3-372~~357373~~ Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

3-373~~358374~~ Measure Life

Equipment	EUL	RUL	Ref
Heat Pump Water Heater	10	3.37	[65]

References

[62] 10 CFR 430 Appendix E to Subpart B of Part 430 Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature, December 2022.

[63] 10 CFR Subpart C of Part 430, https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32

Field Code Changed

[64] ENERGY STAR Program Requirements Product Specification for Commercial Water Heaters, Eligibility Criteria, Version2.0. (2021),

[65] California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx. Accessed November 13, 2018

[66] NSRDB, TMY3 data, December 2022. https://nsrdb.nrel.gov/data-sets/tmy

[67] International Energy Conservation Code (IECC) 2022

[68] From NY TRM V10, Pg 128

[69] U.S. Energy Information Administration, 2012 Commercial Buildings Energy Consumption Survey: Water Consumption in Large Buildings, Table WD1. Daily water consumption in large commercial buildings, 2012

[70] National Renewable Energy Laboratory, Saving Energy in Commercial Buildings: Domestic Hot Water Assessment Guidelines, Table 1. Hot Water Use By Building Type, June 2011

[71] Water Research Foundation: Residential End Uses of Water, Version 2, April 2016

[72] Food Service Technology Center, Design Guide – Energy Efficient Heating, Delivery and Use, Table 1. Typical hot water system cost for restaurants, March 2010

Field Code Changed

3.11.4 FAUCET AERATORS AND SHOWERHEADS

Market	Commercial/Multifamily
Baseline Condition	TOS, RF
Baseline	Code, Existing
End Use Subcategory	Control
Measure Last Reviewed	February 2024
Changes Since Last Version	• ~~Updated baseline and efficient case description~~ • ~~Updated baseline and efficient flowrates~~ • ~~Updated the electric DHW recovery hours algorithm for faucet aerator~~

Description

This measure covers the installation of low-flow faucet aerators and showerheads in commercial, industrial, and multifamily applications. In multifamily applications, only units installed in common areas are eligible for this measure. Savings for low-flow faucet aerator and showerhead measures are determined using the total change in flow rate (gallons per minute) per unit from the baseline (existing) fixture to the efficient low-flow fixture.

Note: Measures in common areas of high-rise multifamily buildings (more than three stories) follow commercial protocol. Measures in low-rise multifamily buildings or within dwelling units of high-rise multifamily buildings follow residential protocol.

Baseline Case

For TOS, the baseline is a standard faucet or a showerhead meeting maximum flow given in the NJ A5160 [73]. For retrofit applications,, the actual flow rate of the existing faucet should be used in the algorithm below.

Efficient Case

The efficient condition is an energy efficient faucet aerator or showerhead with rated flow rate less than maximum flow rate given in the NJ A5160 [6]. Actual flow rates of the installed fixture are used to estimate the savings.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = \Delta H_2O \times \left(T_{operating} - T_{main}\right) \times \frac{8.33}{3{,}412 \times E_{t,elec}}$$

Where,

$$\Delta H_2O = (GPM\_b \times F\_(Throttle, b) - GPM\_q \times F\_(Throttle, q)\ ) \times t\_(min/day) \times Days$$

$$t_{min/day} = t_{min/use} \times N_{uses/day}$$

Annual Fuel Savings

$$\Delta Therms = \frac{\Delta H_2O \times (T_{operating} - T_{main}) \times 8.33}{(100{,}000 \times E_{t,fuel})}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hours} \times CF$$

Where,

$$Hours_{FA} = \frac{GPM_b \times t_{min/use} \times N_{uses/day} \times days \times 0.44}{GPH}$$

$$Hours_{SH} = \frac{GPM_b \times t_{min/use} \times N_{uses/day} \times days \times 0.608}{GPH}$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-374~~359~~375 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔH_2O	Annual water savings	Calculated	Gal/yr	
$Hours_{FA}$	Annual electric DHW recovery hours for faucet aerators	Calculated	hr/yr	

Variable	Description	Value	Units	Ref
$Hours_{SH}$	Annual electric DHW recovery hours for showerheads	Calculated	hr/yr	
$t_{min/day}$	Average minutes of fixture use per day	Calculated. If unknown, use 30 (faucet) or 20 (showerhead)	min/day	[75]
GPM_b	Flowrate of baseline fixture	For DI: Site-specific For RF: Look up in Table 3-375~~Table 3-360~~376	Gal/min	[73]
GPM_q	Flowrate of efficient fixture	Site-specific	Gal/min	
$N_{uses/day}$	Number of times the fixture is used per day	Site-specific. If unknown, use 60 (faucet) or 2.4 (showerhead)	/day	[75]
days	Days fixture used per year	Site-specific. If unknown, look up in Table 3-376~~Table 3-361~~377	days/yr	[82]
$T_{operating}$	Fixture operating temperature	Look up in Table 3-375~~Table 3-360~~376	°F	
T_{main}	Temperature of supply water temperature in water main[194]	60	°F	[76]
$F_{throttle,b}$	Flowrate restricted: ratio of user setting to full throttle flow rate for baseline fixture	0.83 (faucets) 0.90 (showerheads)	N/A	[74]
$F_{throttle,q}$	Flowrate rescrticted: ratio of user setting to full throttle flowrate for efficient fixture	0.95 (faucets) 0.90 (showerheads)	N/A	[74]
$t_{min/use}$	Average duration a fixture runs each time it is used	0.5 (faucet) 8.2 (showerhead)	min	[75]
GPH	Gallon per hour recovery of electric water heater	53.9	Gal/hr	
$E_{t,elec}$	Thermal efficiency of electric water heater	0.98	N/A	[78]
$E_{t,fuel}$	Thermal efficiency of fossil fuel water heater	0.80	N/A	[78]
0.44	Proportion of hot 140°F water mixed with 50.7°F supply water to give 90°F mixed faucet water	0.44	N/A	

194 Average value across 5 NJ climate zones. Calculated from annual average ambient air temperature + 6°F.

Variable	Description	Value	Units	Ref
0.608	Proportion of hot 140°F water mixed with 50.7°F supply water to give 105°F shower water	0.608	N/A	
8.33	Energy required to heat one gallon of water by one degree Farenheit	8.33	Btu/gal°F	
3,412	Conversion factor from Btu/h to kW	3,412	Btu/h/kW	
100,000	Conversion factor from Btu to therms	100,000	Btu/therm	
CF	Coincidence factor	Look up in Table 3-377~~Table 3-362~~378	N/A	[81]
PDF	Peak day factor	Look up in Table 3-377~~Table 3-362~~378	N/A	
EUL	Effective useful life of new unit	See Measure Life Section	Years	

Table 3-375~~360~~376 Installed Flowrates and Fixture Operating Temperatures

Fixture Type	Location	GPM_b	$T_{operating}$(°F)
Faucet aerator	Kitchen	1.8	93
	Public restroom	0.5	86
	Private restroom	1.5	86
Showerhead	Any	2.0	105

Table 3-376~~361~~377 Operating Days per Year

Building Type	Operating Days per Year
Assembly	355
Auto	355
Big Box	355
Community College	284
Dormitory	355
Fast Food	355
Full Service Restaurant	303
Grocery	365
Hospital	365

Building Type	Operating Days per Year
Hotel	365
Large Office	303
Light Industrial	251
Motel	365
Multi-story Retail	355
Primary School	218
Religious	355
Secondary School	218
Small Office	303
Small Retail	355
University	284
Warehouse	251

Peak Factors

Table 3-377~~362~~378 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF) – Faucet Aerators	Lookup in Table 3-378~~Table 3-363~~379	[81]
Electric coincidence factor (CF) – Showerheads	0.0278	[81]
Natural gas peak day factor (PDF)	See Appendix G	

Table 3-378~~363~~379 Electric Coincidence Factors for Faucet Aerators

Building Type	Coincidence Factor
Small Office	0.0064
Large Office	0.0288
Fast Food Restaurant	0.0084
Sit-Down Restaurant	0.0184
Retail	0.0043
Grocery	0.0043
Warehouse	0.0064
Elementary School	0.0096
Jr High/High School	0.0288

Building Type	Coincidence Factor
Health	0.0144
Motel	0.0006
Hotel	0.0004
Other	0.0128

Non-Energy Impacts

Water savings:

$$\Delta H2O = units \times \left(GPM_b \times F_{throttle,b} - GPM_q \times F_{throttle,q}\right) \times \frac{min}{day} \times days$$

Measure Life

Table 3-379~~364380~~ Measure Life

Equipment	EUL	Ref
Faucet Aerators and Showerheads	10	[79]

References

[73] Baseline flow rates established by State of New Jersey, 219th Legislature, Assembly No 5610 Bill Text: NJ S3324 | 2020-2021 | Regular Session

[74] Energy Related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes, American Council for an Energy-Efficient Economy, August 2008, pg. 1-265.

[75] Michigan Evaluation Work Group Showerhead Showers and Faucet Aerator Meter Study from 2016 34102 (mo.gov)

[76] Burch, Jay and Christensen, Craig, "Towards Development of an Algorithm for Mains Water Temperature." National Renewable Energy Laboratory. https://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/water_heaters/AlgorithmForMainsWaterTemperature.pdf

[77] FEMP Cost Calculator: https://www.ces.ncsu.edu/wp-content/uploads/2014/03/Federal-Energy-Management-Program-Energy-Cost-Calculator-for-Faucets-and-Showerheads.htm

[78] 10 CFR 430 Subpart B Appendix E – Uniform Test Method for Measure Energy Consumption of Water Heaters: 6.3.2 *Recovery Efficiency*. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-B

[79] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. http://www.energizect.com/sites/default/files/Measure%20Life%20Report%202007

[80] Existing faucet flow rate assumption taken from Pennsylvania Technical Reference Manual; effective June 2016, pp. 114ff. http://www.puc.pa.gov/pcdocs/1370278.docx

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

[81] *IL 2022 Illinois Statewide Technical Reference Manual for Energy Efficiency : Version 10* (2022), Pg 171 (faucet aerators) and pg 177 (showerheads). https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010122_v10.0_Vol_2_C_and_I_09242021.pdf
[82] Operating days per year estimates based on simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

Field Code Changed

3.11.5 COMBINATION BOILER

Market	Commercial/Multifamily
Baseline Type	TOS/NC/EREP/DI
Baseline Condition	Code/Existing/Dual
End Use Subcategory	Equipment
Measure Last Reviewed	December 2022
Changes Since Last Version	• ~~Added GPD assumption for unknown building type or size~~

Description

This section provides energy savings algorithms for qualifying gas combination boilers installed in commercial and industrial settings. A combination boiler is a space heating system that also has the capability to provide instantaneous domestic hot water. The input values are based on the specifications of the actual equipment being installed, federal equipment efficiency standards, DOE2.2 simulations completed by the NJ SWE and regional estimates of average baseline water heating energy usage.

For new construction, replacement of failed equipment, and end of useful life, the baseline unit is a code compliant unit with an efficiency as required by ASHRAE Std. 90.1 – 2019 and IECC 2021, which are the current codes adopted by the State of New Jersey.

For retrofit programs where an existing boiler is replaced , the baseline efficiency is the existing boiler efficiency. For early replacement programs, the baseline efficiency is the existing boiler efficiency for the remaining life of the existing boiler and a code efficiency boiler for the remaining life of the measure.

Baseline Case

Space Heating Component:

- New Construction/Replacement of Failed Equipment/End of Useful Life: Boiler compliant with ASHRAE Std. 90.1 – 2019 and IECC 2021.
- Retrofit/Direct Install: Existing boiler efficiency for first baseline. If unknown, use minimally code-compliant efficiency based on boiler age. As second baseline, use current code for measure remaining life.

Domestic Hot Water Component:

- New Construction/Replacement of Failed Equipment/End of Useful Life: Water heater compliant with ASHRAE Std. 90.1 – 2019 and IECC 2021.
- Retrofit: Existing water heater efficiency for first baseline. If unknown use minimally code compliant efficiency based on water heater age. As second baseline, use current code for measure remaining life.

Efficient Case

The compliance condition is a combi-boiler unit with a heating efficiency higher than code. Qualifying systems must not have a water storage tank.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = N/A$$

Annual Fuel Savings

$$\Delta Therms = \Delta Therms_{Boiler} + \Delta Therms_{DHW}$$

Where,

$$\Delta Therms_{Boiler} = Cap_{in} \times EFLH_h \times \frac{Eff_q/Eff_b - 1}{100}$$

$$\Delta Therms_{DHW} = \frac{GPD \times 365 \times 8.33 \times (T_{set} - T_{main})}{100{,}000} \times \left(\frac{1}{E_{t,b}} - \frac{1}{Eff_q}\right) + \frac{UA_b}{E_{t,b}} \times \frac{(T_{set} - T_{amb})}{100{,}000} \times 8{,}760$$

Peak Demand Savings

$$\Delta kW_{Peak} = N/A$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms:

No dual baseline:

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Dual baseline:

$$\Delta kWh_{Life} = (\Delta kWh\ using\ existing\ baseline) \times RUL + (\Delta kWh\ using\ code\ baseline) \times (EUL - RUL)$$

Lifetime Fuel Energy Savings

No dual baseline:

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Dual baseline:

$$\Delta Therms_{Life} = (\Delta Therms\ using\ existing\ baseline) \times RUL + (\Delta Therms\ using\ code\ baseline) \times (EUL - RUL)$$

Calculation Parameters

Table 3-380~~365~~381 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$\Delta Therms_{Boiler}$	Annual fuel savings from space heating	Calculated	Therms/day	
$\Delta Therms_{DHW}$	Annual fuel savings from water heating	Calculated	Therms/day	
Cap_{in}	Input capacity of qualifying boiler	Site-specific	kBtu/hr	
Eff_q	Boiler proposed efficiency	Site-specific	N/A	
$EFLH_h$	Boiler equivalent full load hours of operation during heating season	Look up in **Error! Reference source not found.**~~Appendix C:~~	Hours	[83]
Eff_b	Boiler baseline efficiency	Look up in **Error! Reference source not found.**~~Appendix E: Code-Compliant Efficiencies~~	N/A	[89][90][91]
GPD	Gallons per day of hot water use	Look up in Table 3-381~~Table 3-366~~382 If building type or size unknown, use 64 GPD[195]	Gal/day	[92][93][94][95]
100	Unit conversion from kBtu to therm	100	kBtu/therm	

[195] Based on PSEG implementor review of NREL NJ commercial building stock data

Variable	Description	Value	Units	Ref
365	Days per year	365	Day/yr	
8.33	Unit conversion, Btu/gal·F	8.33	Btu/gal·F	
100,000	Unit conversion, Btu/therm	100,000	Btu/therm	
$E_{t,b}$	Baseline water heating designation thermal efficiency	0.8	N/A	[86]
T_{set}	Water heater setpoint temperature	Site-specific, if unknown use 125	°F	[84]
T_{main}	Incoming water main temperature[196]	60	°F	[85]
UA_b	Overall heat loss coefficient of the baseline condition[197]	7.85	Btu/h·F	[87]
T_{amb}	Surrounding ambient air temperature[198]	70	°F	
8,760	Hours in one year	8760	Hours	
PDF	Peak day factor	Look up in Table 3-382~~Table 3-367~~383	N/A	
EUL	Estimated useful life	See Measure Life Section	Years	[88]

Table 3-381~~366~~382 Gallons Per Day (GPD)[199]

Building Type	GPD	Rate	Notes	Source	Ref
Assembly	239	7.02 GPD per 1,000 SF	Assumes 34,000 SF, 10% hot water	EIA: Public Assembly	[93]
Auto Repair	25	4.89 GPD per 1,000 SF	Assumes 5,150 SF, 10% hot water	EIA: Other	[93]
Big Box Retail	448	3.43 GPD per 1,000 SF	Assumes 130,500 SF, 10% hot water	EIA: Mercantile	[93]
Community College	1,520	1.9 GPD per person	Assumes 800 students	NREL School with Showers	[94]

[196] Average value across 5 NJ climate zones. Calculated from annual average ambient air temperature + 6 deg F.
[197] Based on computation of heat loss coefficients via conversion equations found in 10 CFR 429, 430, and 431 Docket No. EERE-2015-BT-TP-0007, Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment: Test Procedures for Consumer and Commercial Water Heaters. Heat loss coefficient was calculated for a minimally code compliant fuel storage water heater found to be the most typical in terms of storage and input capacity, representing storage type water heaters of between 20 and 55 gallon capacity (40 gallon, 40,000 Btu/h assumed). Results of heat loss coefficient evaluation for this assumed baseline is used to represent the UAbaseline term.
[198] Water heaters are generally located in conditioned or partially conditioned spaces with a typical average temperature of 65°F to 70°F to avoid freezing. A value of 70°F is used for the purposes of estimating tank/ambient air temperature differential, which aligns with standby loss specification testing standards.
[199] The estimates in this table rely on sources that present total water consumption. Site-specific GPD estimate should be used if possible. Calculated GPD estimate should be compared to water heater capacity to ensure it is reasonable, and reduced if needed to align with water heater capacity.

Building Type	GPD	Rate	Notes	Source	Ref
Dormitory	8,600	17.2 GPD per resident	Assumes 500 residents	Water Research Foundation	[95]
Elementary School	250	0.5 GPD per student	Assumes 500 students	NREL: School	[94]
Fast Food Restaurant	500	500 GPD per restaurant		FSTC: Quick Service	[96]
Full-Service Restaurant	2,500	2,500 GPD per restaurant		FSTC: Full Service	[96]
Grocery	172	3.43 GPD per 1,000 SF	Assumes 50,000 SF, 10% hot water	EIA: Mercantile	[93]
High School	1,520	1.9 GPD per person	Assumes 800 students	NREL: School with Showers	[94]
Hospital	16,938	54.42 GPD per 1,000 SF	Assumes 40% hot water, 250,000 SF	250,000 SF EIA: Health Care, Inpatient	[93]
Hotel	9,104	45.52 GPD per 1,000 SF	Assumes 40% hot water, 200,000 SF	EIA: Lodging	[93]
Large Office	550	1.1 GPD per person	Assumes 500 people	NREL: Office	[94]
Large Retail	446	3.43 GPD per 1,000 SF	Assumes 130,000 SF, 10% hot water	EIA: Mercantile	[93]
Light Industrial	489	4.89 GPD per 1,000 SF	Assumes 100,000 SF, 10% hot water	EIA: Other	[93]
Motel	1,366	45.52 GPD per 1,000 SF	Assumes 30,000 SF, 40% hot water	EIA: Lodging	[93]
Multifamily High-Rise	4,550	45.5 GPD per unit	Assumes 100 units	Water Research Foundation	[95]
Multifamily Low-Rise	546	45.5 GPD per unit	Assumes 12 units	Water Research Foundation	[95]
Refrigerated Warehouse	86	0.93 GPD per 1,000 SF	Assumes 92,000 SF, 10% hot water	EIA: Warehouse and Storage	[93]
Religious	77	7.02 GPD per 1,000 SF	Assumes 11,000 SF,10% hot water	EIA: Public Assembly	[93]
Small Office	110	1.1 GPD per person	Assumes 100 people	NREL: Office	[94]
Small Retail	27	3.43 GPD per 1,000 SF	Assumes 8,000 SF, 10% hot water	EIA: Mercantile	[93]
University	1,000	0.5 GPD per student	Assumes 2,000 students	NREL: School	[94]
Warehouse	465	0.93 GPD per 1,000 SF	Assumes 500,000 SF, , 10% hot water	EIA: Warehouse and Storage	[93]
Other	Calculate	4.89 GPD per 1,000 SF	Assumes 10% hot water	EIA: Other	[93]

Peak Factors

Table 3-~~382~~367~~383~~ Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-~~383~~368~~384~~ Measure Life

Equipment	EUL	RUL	Ref
Combination Boiler	22	7.3	[88]

References

[83] Simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

[84] 10 CFR 430 Appendix E to Subpart B of Part 430 Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature, December 2022.

[85] Burch, Jay and Christensen, Craig, *Towards Development of an Algorithm for Mains Water Temperature* (National Renewable Energy Laboratory). https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.515.6885&rep=rep1&type=pdf

[86] eCFR :: 10 CFR 431.110 -- Energy conservation standards and their effective dates December 1, 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430

[87] "Regulations.gov." n.d. www.regulations.gov. Accessed December 13, 2022. Based on computation of heat loss coefficients via conversion equations found in 10 CFR 429, 430, and 431 Docket No. EERE-2015-BT-TP-0007, Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment: Test Procedures for Consumer and Commercial Water Heaters. Heat loss coefficient was calculated for a minimally code compliant fuel storage water heater found to be the most typical in terms of storage and input capacity, representing storage type water heaters of between 20 and 55 gallon capacity (40 gallon, 40,000 Btu/h assumed). Results of heat loss coefficient evaluation for this assumed baseline is used to represent the UAbaseline term.

[88] https://www.regulations.gov/document/EERE-2015-BT-TP-0007-0004

[89] *Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Furnaces*. (DOE, 2016), Table 8.2.17.

[90] *ASHRAE Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings*. (ASHRAE, 2019), Table 6.8.1-5. https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

[91] *ASHRAE Standard 90.1-2013, Energy Standard for Buildings Except Low-Rise Residential Buildings*. (ASHRAE, 2019), Table 6.8.1-5. https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

[92] *2021 INTERNATIONAL ENERGY CONSERVATION CODE (IECC) | ICC DIGITAL CODES* (IECC 2021), Table C403.3.2(6) https://codes.iccsafe.org/content/IECC2021P2/chapter-4-ce-commercial-energy-efficiency

[93] U.S. Energy Information Administration, *2012 Commercial Buildings Energy Consumption Survey: Water Consumption in Large Buildings*, Table WD1. Daily water consumption in large commercial buildings, 2012

[94] National Renewable Energy Laboratory, *Saving Energy in Commercial Buildings: Domestic Hot Water Assessment Guidelines*, Table 1. Hot Water Use By Building Type, June 2011.

[95] Water Research Foundation: *Residential End Uses of Water, Version 2* (April 2016), Pg 5. https://www.circleofblue.org/wp-content/uploads/2016/04/WRF_REU2016.pdf

[96] Food Service Technology Center, Design Guide – Energy Efficient Heating, Delivery and Use, Table 1. Typical hot water system cost for restaurants, March 2010 E

Field Code Changed

Field Code Changed

3.11.6 PRE-RINSE SPRAY VALVES (PRSV)

Market	Commercial/Multifamily
Baseline Condition	RF/ TOS
Baseline	Existing
End Use Subcategory	Water Conservation
Measure Last Reviewed	December 2022
Changes Since Last Version	• ~~Added fuel parameters and default assumption~~

Description

This measure section documents the energy savings and demand reductions attributed to efficient low flow pre-rinse sprayers in grocery and food service applications including fast food restaurants, full-service restaurants, multifamily buildings, and other. The most likely areas of application are kitchens in restaurants and hotels.

Pre-rinse spray valves include a nozzle, squeeze lever, and dish guard bumper. The spray valves usually have a clip to lock the handle in the “on” position. Pre-rinse valves are inexpensive and easily interchangeable with different manufacturers’ assemblies. The primary impacts of this measure are water savings. Energy savings depend on the facility’s water heating fuel - if the facility does not have electric water heating, there are no electric savings for this measure; if the facility does not have fossil fuel water heating, there are no MMBtu (Therms) savings for this measure.

Baseline Case

The baseline for the Retrofit/Early Replacement vintage is based on the EPA 2005 standard. Baseline flowrates are site specific. If unknown, they are assumed to be 1.6 gallons/minute.

Efficient Case

High efficiency PRSV with a flowrate less than the max flow rate by product class as defined by DOE/WaterSense.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = N_{units} \times \frac{hours}{day} \times 60 \times \frac{days}{year} \times \left(GPM_b - GPM_q\right) \times 8.33 \times \frac{\Delta \mathrm{T}}{E_{t,elec} \times 3{,}412} \times F_{Elec}$$

Where,

$$\Delta T = T_{PRSV} - T_{Main}$$

Annual Fuel Savings

$$\Delta Therms = N_{units} \times \frac{hours}{day} \times 60 \times \frac{days}{year} \times \left(GPM_b - GPM_q\right) \times 8.33 \times \frac{\Delta T}{E_{t,fuel} \times 100{,}000} \times F_{Fuel}$$

Where,

$$\Delta T = T_{PRSV} - T_{Main}$$

Peak Demand Savings

$$\Delta kW_{Peak} = ETDF \times Energy\ Savings$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-384~~369~~385 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔT	Average temperature different between PRSV operating temperature and the supply water temperature	60	°F	[99][101]
N_{units}	Number of fixtures	Site-specific	N/A	
GPM_q	Flow rate of the installed prsv	Site-specific. If unknown, use 1.28	Gal/min	[106]
Days/year	Number of days the fixture is in use in one year	Site-specific. If unknown, look up in Table 3-386~~Table 3-371~~387	Days/year	[109]

Variable	Description	Value	Units	Ref
$E_{t, elc}$	Thermal Efficiency for electrical heaters	Site-specific. If unknown, assume 98%	N/A	[107]
$E_{t, fuel}$	Thermal efficiency for fuel heaters	Site-specific. If unknown, assume 80%	N/A	[108]
ETDF	Energy to Demand Factor	Look up in Table 3-387~~Table 3-372~~388	(kW/ kWh/yr)	[105]
GPM_b	Flow rate of the baseline prsv	Site-specific. If unknown, use 1.6	Gal/min	[97] [98]
Hours/day	Operating hours of fixture usage per day	Look up in Table 3-385 Operating Hours/Day~~Table 3-370~~386 ~~Operating Hours/Day~~	Hours/day	
F_{Elec}	Factor to account for electric water heat[200]	If building water heat fuel is electric: 1 If building water heat fuel is not electric: 0 If unknown: 0.28		
F_{Fuel}	Factor to account for fuel water heat	If building water heat fuel is electric: 0 If building water heat fuel is not electric: 1 If unknown: 0.72		
8.33	Specific mass in pounds of one gallon of water	8.33	lbs/gal	
3,412	Btu to kWh electric conversion factor	3,412	Btu/kwh	
CF	Electric coincidence factor	Lookup in Table 3-388~~Table 3-373~~389	N/A	
PDF	Gas peak day factor	Lookup in Table 3-388~~Table 3-373~~389	N/A	
EUL	Effective useful life of new unit	See Measure Life Section	Years	
RUL	Remaining useful life of existing unit	See Measure Life Section	Years	

Table 3-385~~370~~386 Operating Hours/Day

Facility Type	Hours of Pre-Rinse Spray Value Use Per Day (hours)	Ref
Full Service Restaurant	4	[101]

[200] Unknown electric and fuel water heat factors from PSE&G PY3 Evaluation report

Facility Type	Hours of Pre-Rinse Spray Value Use Per Day (hours)	Ref
Limited Service (fast food) Restaurant	1	[101]
Other	1.067	[102]

Table 3-386~~371~~387 Operating Days per Year

Building Type	Operating Days per Year
Assembly	355
Warehouse	251
Auto	355
Big Box	355
Community College	284
Dormitory	355
Fast Food	355
Full Service Restaurant	303
Grocery	365
Hospital	365
Hotel	365
Large Office	303
Light Industrial	251
Motel	365
Multi-story Retail	355
Primary School	218
Religious	355
Secondary School	218
Small Office	303
Small Retail	355
University	284

Table 3-387~~372~~388 ETDF

Facility Type	ETDF
Quick-service Restaurant	0.000186
Full-Service Restaurant	0.0001189
Standalone Retail (Grocery)	0.000237
Default – Unknown	0.000259

Peak Factors

Table 3-388~~373~~389 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	N/A	
Natural gas peak day factor (PDF)	Error! Reference source not found.~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The remaining useful life (RUL) for existing equipment is limited to 1/3 of the effective useful life (EUL) of the equipment.

Table 3-389~~374~~390 Measure Life

Equipment	EUL	RUL	Ref
PRSV	5	1.67	[105]

References

[97] The Energy Policy Act (EPAct) of 2005. http://www.psc.state.ga.us/electric/federal/EPA/EPA2005.pdf

[98] Impact and Process Evaluation Final Report for California Urban Water Conservation Council 2004-5 Pre-Rinse Spray Valve Installation Program (Phase 2), SBW Consulting, 2007, Table 3-4, p. 23. https://p2infohouse.org/ref/50/49026.pdf

[99] *CEE Commercial Kitchens Initiative Program Guidance on Pre-Rinse Spray Valves*, (CEE 2005), pg. 3. https://library.cee1.org/system/files/library/4252/PRSV%20Program%20Guidance.pdf

[100] Burch, J., and C. Christensen*, Towards Development of an Algorithm for Mains Water Temperature*. American Solar Energy Annual Conference Proceedings (2007).

[101] Hours estimates based on PG&E savings estimates, algorithms, sources (2005). Food Service Pre-Rinse Spray Valves.

[102] "WaterSense Specification for Commercial Pre-Rinse Spray Valves Supporting Statement" n.d. WaterSense® Draft Specification for Commercial Pre-Rinse Spray Valves - Supporting Statement (epa.gov)

[103] "Federal Register :: Request Access." n.d. Unblock.federalregister.gov. Accessed December 8, 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430

[104] *Technical Reference Manual Volume 3: Commercial and Industrial Measures* Pg 138 (August 2019). https://www.puc.pa.gov/filing-resources/issues-laws-regulations/act-129/technical-reference-manual/

[105] *Technical Support Document: Energy Efficiency Program For Consumer Products And Commercial And Industrial Equipment:Commercial Prerinse Spray Valves* (December 2015) Pg 8-13. https://www.regulations.gov/document/EERE-2014-BT-STD-0027-0046

[106] EPA WaterSense Specification for Commercial Pre-Rinse Spray Valves. https://www.epa.gov/watersense/pre-rinse-spray-valves

[107] *2022 Illinois Statewide Technical Reference Manual for Energy Efficiency Version 10.0: Volume 2* (2022), Pg 124, https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010122_v10.0_Vol_2_C_and_I_09242021.pdf

[108] ASHRAE Standards 90.1-2019, *Energy Standard for Buildings Except Low Rise Residential Buildings*. https://www.ashrae.org/standards-research--technology/standards--guidelines

[109] Operating days per year estimates based on simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

3.11.7 RECIRCULATING PUMP CONTROL

Market	Commercial/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Control
Measure Last Reviewed	February 2024
Changes Since Last Version	• ~~Removed references to DI Baseline Condition and dual baseline~~

Description

This measure covers the installation of temperature modulation or demand controls on central domestic hot water (DHW) systems with recirculation:

- Temperature modulation controls reduce circulator pump energy and recirculation heat losses by modulating DHW system supply temperatures when hot water demand is expected to be low (usually based on occupancy schedules).
- Demand controls limit energy consumption by activating recirculation loops based on demand detected by a flow sensing device on the makeup water pipe and a temperature sensor installed on the recirculating return pipe.
- Temperature control. An aquastat control is used to switch the recirculating pump on and off to maintain a target temperature in the loop.
- Timer control. A timer is used to turn the recirculating pump on during peak usage times and off overnight.

Temperature modulation and demand controls achieve savings without significant interruptions to hot water availability. Recirculation systems are commonly used in larger buildings because the hot water must be quickly provided to spaces that are far from the water heating plant. The recirculation pump reduces wait time at the faucets by keeping the domestic hot water (DHW) piping loop hot as it gradually loses heat to the surrounding air. Without the recirculation pump, occupants would have to run their faucets until the cooled, stagnant water is removed from the piping between the faucet and the DHW plant and would waste water in the process; however, constant pumping operation increases energy consumption by exposing supply and return line piping to continuous heat loss, even in absence of the demand for hot water.

This measure is not applicable in facilities where twenty-four hour recirculation and delivered hot water temperature is required by code (refer to Section 7: Service Water Heating of ASHRAE 90.1 2019 to check for code requirements) [126]. This measure is not applicable to new construction or gut rehab installations.

Baseline Case

The base case for this measure category is existing, un-controlled recirculation pumps on central domestic hot water systems that continuously recirculates maintaining a constant supply temperature of the DHW.

Efficient Case

The efficient case is a central DHW recirculation system with a control system that regulates circulation pump operation based on demand and/or temperature or through timing and is in compliance with the current safety codes and standards in New Jersey.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{Pump} + \Delta kWh_{HW}$$

Where,

$$\Delta kWh_{Pump} = \frac{HP \times 0.746}{Eff_{Pump}} \times LF \times Hrs_{Recirc,B} \times ESF_{Pump}$$

$$\Delta kWh_{HW} = \frac{GPD \times 365 \times 8.33 \times (T_{Set} - T_{Main})}{3{,}412} \times \frac{F_{DHW,Elec}}{E_{T,Elec}} \times \frac{Hrs_{Recirc,B}}{8{,}760} \times ESF_{HW}$$

Annual Fuel Savings

$$\Delta Therms = \frac{GPD \times 365 \times 8.33 \times (T_{Set} - T_{Main})}{100{,}000} \times \frac{F_{DHW,Fuel}}{E_{T,Fuel}} \times \frac{Hrs_{Recirc,B}}{8{,}760} \times ESF_{HW}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hrs_{Recirc,B}} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms:

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Energy Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-390~~375391~~ Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkWh_{Pump}	Annual electric energy savings from pump	Calculated	kWh/yr	
ΔkWh_{HW}	Annual electric energy savings from hot water	Calculated	kWh/yr	
$\Delta Therms$	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	

Variable	Description	Value	Units	Ref
$Hrs_{Recirc, B}$	Annual hours of operation of recirculation system in baseline condition	Site-specific, if unknown use 8760	Hrs/yr	
HP	Pump nameplate horsepower	Site-specific	HP	
Eff_{Pump}	Pump efficiency	Site-specific, if unknown look up in Table 3-391~~Table 3-376~~392	N/A	
LF	Load factor	Site-specific, if unknown use 0.9	N/A	[112]
GPD	Average daily hot water usage	Site-specific, if unknown look up in Table 3-392~~Table 3-377~~393	Gal/day	
T_{Set}	Water heater set point temperature	Site-specific, if unknown use 125	°F	[117]
$E_{T, Fuel}$	Thermal efficiency of fossil fuel water heater	Site-specific, if unknown use 0.8	N/A	[121]
ESF_{HW}	Hot water energy savings factor	Look up in Table 3-394~~Table 3-379~~395	N/A	[125]
$F_{DHW, Elec}$	Electric water heating factor	Look up in Table 3-393~~Table 3-378~~394	N/A	
$F_{DHW, Fuel}$	Fossil fuel water heating factor	Look up in Table 3-393~~Table 3-378~~394	N/A	
CF	Electric coincidence factor	Look up in Table 3-395~~Table 3-380~~396	N/A	
PDF	Gas peak demand factor	Look up in Table 3-395~~Table 3-380~~396	N/A	
T_{Main}	Supply water temperature in water main[201]	60	°F	[118]
$E_{T,Elec}$	Thermal efficiency of electric water heater	0.98	N/A	[124]
ESF_{Pump}	Pump energy savings factor	0.87	N/A	[123]
365	Days per year	365	Day/yr	
0.746	Unit conversion, kW/HP	0.746	kW/HP	
8.33	Unit conversion, Btu/gal·°F	8.33	Btu/gal·°F	
3,412	Unit conversion, Btu/kWh	3,412	Btu/kWh	

[201] Average value across 5 NJ climate zones. Calculated from annual average ambient air temperature + 6°F.

Variable	Description	Value	Units	Ref
8,760	Unit conversion, Hrs/yr	8,760	Hrs/yr	
EUL	Effective useful life	See Measure Life Section	Years	

Table 3-391~~376~~392 Pump Efficiency

Pump Type	Value	Reference
PSC	0.60	[110]
ECM	0.80	[111]
Unknown	0.80	

Table 3-392~~377~~393 Average Daily Hot Water Usage[202]

Building Type	GPD	Rate	Notes	Source	Reference
Assembly	239	7.02 GPD per 1,000 SF	Assumes 34,000 SF, 10% hot water	EIA: Public Assembly	[113]
Auto Repair	25	4.89 GPD per 1,000 SF	Assumes 5,150 SF, 10% hot water	EIA: Other	[113]
Big Box Retail	448	3.43 GPD per 1,000 SF	Assumes 130,500 SF, 10% hot water	EIA: Mercantile	[113]
Community College	1,520	1.9 GPD per person	Assumes 800 students	NREL School with Showers	[114]
Dormitory	8,600	17.2 GPD per resident	Assumes 500 residents	Water Research Foundation	[115]

[202] The estimates in this table rely on sources that present total water consumption. Site-specific GPD estimate should be used if possible. Calculated GPD estimate should be compared to water heater capacity to ensure it is reasonable, and reduced if needed to align with water heater capacity.

Building Type	GPD	Rate	Notes	Source	Reference
Elementary School	250	0.5 GPD per student	Assumes 500 students	NREL: School	[114]
Fast Food Restaurant	500	500 GPD per restaurant		FSTC: Quick Service	[116]
Full-Service Restaurant	2,500	2,500 GPD per restaurant		FSTC: Full Service	[116]
Grocery	172	3.43 GPD per 1,000 SF	Assumes 50,000 SF, 10% hot water	EIA: Mercantile	[113]
High School	1,520	1.9 GPD per person	Assumes 800 students	NREL: School with Showers	[114]
Hospital	16,938	54.42 GPD per 1,000 SF		250,000 SF EIA: Health Care, Inpatient	[113]
Hotel	9,104	45.52 GPD per 1,000 SF	Assumes 40% hot water, 200,000 SF	EIA: Lodging	[113]
Large Office	550	1.1 GPD per person	Assumes 500 people	NREL: Office	[114]
Large Retail	446	3.43 GPD per 1,000 SF	Assumes 130,000 SF, 10% hot water	EIA: Mercantile	[113]
Light Industrial	489	4.89 GPD per 1,000 SF	Assumes 100,000 SF, 10% hot water	EIA: Other	[113]
Motel	1,366	45.52 GPD per 1,000 SF	Assumes 30,000 SF, 40% hot water	EIA: Lodging	[113]
Multifamily High-Rise	4,600	46 GPD per unit	Assumes 100 units	Water Research Foundation	[115]
Multifamily Low-Rise	552	46 GPD per unit	Assumes 12 units	Water Research Foundation	[115]
Refrigerated Warehouse	86	0.93 GPD per 1,000 SF	Assumes 92,000 SF, 10% hot water	EIA: Warehouse and Storage	[113]
Religious	77	7.02 GPD per 1,000 SF	Assumes 11,000 SF, 10% hot water	EIA: Public Assembly	[113]
Small Office	110	1.1 GPD per person	Assumes 100 people	NREL: Office	[114]

Building Type	GPD	Rate	Notes	Source	Reference
Small Retail	27	3.43 GPD per 1,000 SF	Assumes 8,000 SF, 10% hot water	EIA: Mercantile	[113]
University	1,000	0.5 GPD per student	Assumes 2,000 students	NREL: School	[114]
Warehouse	465	0.93 GPD per 1,000 SF	Assumes 500,000 SF, 10% hot water	EIA: Warehouse and Storage	[113]
Other	Calculate	4.89 GPD per 1,000 SF		EIA: Other	[113]

Table 3-393~~378~~394 Water Heating Factors

DHW System	$F_{DHW,Elec}$	$F_{DHW,Fuel}$
Electric	1.0	0.0
Fossil Fuel	0.0	1.0

Table 3-394~~379~~395 Hot Water Energy Savings Factors

Control Type	ESF_{HW}
Demand Control	0.07
Temperature Modulation	0.02
Demand Control and Temperature Modulation	0.15

Peak Factors

Table 3-~~395380~~396 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	0.8	[122]
Natural gas peak day factor (PDF)	See **Error! Reference source not found.**~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The effective useful life (EUL) is 15 years [120].

References

[110] "Energy Savings Potential and Opportunities for High-Efficiency Electric Motors in Residential and Commercial Equipment." 2013. https://www.energy.gov/sites/prod/files/2014/02/f8/Motor%20Energy%20Savings%20Potential%20Report%202013-12-4.pdf.

[111] "Comparing Motor Technologies – ACHR News." N.d. WWW.achrnews.com. https://achrnews.com/articles/112674-comparing-motor-technologies

[112] Regional Technical Forum. Proposed Standard Savings Estimation Protocol for Ultra-Premium Efficiency Motors. November 5, 2012. Appendix C, Table 6. Average of values for 1, 1.5, and 2 hp pumps.

[113] U.S. Energy Information Administration, 2012 Commercial Buildings Energy Consumption Survey: Water Consumption in Large Buildings, Table WD1. Daily water consumption in large commercial buildings, 2012

[114] National Renewable Energy Laboratory, Saving Energy in Commercial Buildings: Domestic Hot Water Assessment Guidelines, Table 1. Hot Water Use By Building Type, June 2011

[115] Water Research Foundation: Residential End Uses of Water, Version 2, April 2016

[116] Food Service Technology Center, Design Guide – Energy Efficient Heating, Delivery and Use, Table 1. Typical hot water system cost for restaurants, March 2010 E

[117] 10 CFR Appendix E to Subpart B of Part 430—Uniform Test Method for Measuring the Energy Consumption of Water Heaters, Section 2. Test Conditions, 2.5 Set Point Temperature.

Field Code Changed

Field Code Changed

Field Code Changed

[118] Burch, Jay, and Craig Christensen. n.d. "TOWARDS DEVELOPMENT of an ALGORITHM for MAINS WATER TEMPERATURE."
[119] Code of Federal Regulations. 2022. Review of Title 10, Chapter II, Subchapter D, Part 431. Appendix B to Subpart G of Part 431 - Uniform Test Method for the Measurement of Standby Loss of Electric Storage Water Heaters and Storage-Type Instantaneous Water Heaters, eCFR. December 1, 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-431/subpart-G
[120] 2022 California Public Utilities Commission. n.d. Review of DEER Resources - Water Heater - DEER Water Heater Calculator. Cedars - California Energy Data and Reporting System. https://cedars.sound-data.com/deer-resources/tools/water-heaters/.
[121] ASHRAE Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 7.8, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards
[122] "*New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs V10* (2023) Pg 612 https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V10.pdf
[123] Center for Energy and Environment, Evaluation of New DHW System Controls in Hospitality and Commercial Buildings. (2018), pg 12, https://mn.gov/commerce-stat/pdfs/card-dhw-system-controls.pdf
[124] 10 CFR 430 Subpart B Appendix E – Uniform Test Method for Measuring the Energy Consumption of Water Heaters: *6.3.2 Recovery Efficiency*
[125] NREL, Control Strategies to Reduce the Energy Consumption of Central Domestic Hot Water Systems, June 2016, https://www.nrel.gov/docs/fy16osti/64541.pdf
[126] ASHRAE Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Section 7: Service Water Heating Pg 151, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

3.11.8 PIPE INSULATION

Market	Commercial/Multifamily
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Insulation
Measure Last Reviewed	November 2022
Changes Since Last Version	• ~~Removed references to DI Baseline Condition and dual baseline~~

Description

This measure covers the installation of fiberglass, rigid foam, and cellular glass pipe insulation on exposed and uninsulated metal or steel piping with a nominal diameter between 0.50" and 8.00" for hot water and steam type space heating and/or domestic hot water (DHW) distribution systems in commercial, industrial, and multifamily high-rise buildings. The measure is restricted to insulation of hot water distribution pipe in conditioned and unconditioned spaces. Space heating pipe insulation is limited to insulation installed in unheated spaces only. Insulation of CPVC, PEX, and HDPE piping is not eligible for savings under this measure due to low potential of savings.

In New Jersey, the current state energy code (ASHRAE 90.1 2019 in 2023) defines the energy code standards for buildings except low rise residential. Hence, this has been used to define default thermal efficiencies of heating systems. However, when it does not include service water heating provisions, it leaves federal equipment efficiency standards to define baseline.

This measure caters for all insulation types given that they are ASHRAE 90.1 2019 code compliant and are installed by certified professionals. The R-value of an insulation is the thermal resistance of its constituent material, which is derived by dividing the thickness of the material by the material's thermal conductivity, or k-value. Thermal transmittance, or the material's U-factor, is the inverse of the R-value.

Baseline Case

The baseline condition is bare copper (metal) or steel domestic hot water or space heating piping in an unconditioned space.

Efficient Case

An insulated pipe in an unconditioned spaced conforming to the requirements of ASHRAE 2019 Section 6.8.3, Table 3-1.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = \frac{\left[\left(\frac{UA}{L}\right)_b - \left(\frac{UA}{L}\right)_q\right] \times L \times \left(T_{pipe} - T_{amb}\right) \times hrs \times SF_{elec}}{Et_{elec} \times 3{,}412}$$

Annual Fuel Savings

$$\Delta Therms = \frac{\left[\left(\frac{UA}{L}\right)_b - \left(\frac{UA}{L}\right)_q\right] \times L \times \left(T_{pipe} - T_{amb}\right) \times hrs \times SF_{fuel}}{Et_{fuel} \times 100{,}000}$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{8{,}760} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-396~~381397~~ Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{life}$	Lifetime fuel savings	Calculated	Therms	
L	Length of installed insulation	Site-specific	ft	
T_{pipe}	Average temperature of hot water or steam in distribution system piping	Site-specific, if unknown lookup in **Table 3-401** ~~Table 3-386402~~	°F	[130][131][134]
T_{amb}	Surrounding average ambient air temperature	Site-specific, if unknown: DHW: 70 Space Heat: 50	°F	[138]
Et_{fuel}	Recovery Efficiency of fuel water heaters or AFUE of boiler for space heating	Site-specific, if unknown: DHW[203]: 0.8 Space Heating Boilers: Lookup in Table 3-399~~Table 3-384400~~	N/A	[135][136]
Et_{elec}	Recovery Efficiency of electric water heaters	Site-specific, if unknown: Non-Heat Pump DHW[204]: 0.98	N/A	[308]~~[3078]~~[129]

[203] The 80% default assumption comes from most ASHRAE 90.1 2019 minimum thermal efficiencies listed for water heater.
[204] ASHRAE 90.1 2019 does not list thermal efficiencies for electric water heaters. Instead it references UEF values for the respective classes. The 98% assumption comes from the Code of Federal regulations. The 98% default value should not be used for heat pump water heaters.

Variable	Description	Value	Units	Ref
		Heat Pump DHW: Lookup in Table 3-400~~Table 3-385~~401		
hrs	Equivalent full load heating hours	Site-specific, if unknown: DHW: 8,760 Boilers: Lookup heating EFLH in **Error! Reference source not found.**~~Appendix C: Heating and Cooling EFLH~~	hrs	[234]~~[2334]~~[234]~~[2334]~~
$(UA/L)_b$	Product of Overall Heat Transfer Coefficient and Pipe Area (UA) per foot from uninsulated pipe[205]	Lookup in Table 3-397 ~~Table 3-382~~398	Btu/hr-°F-ft	[132]
$(UA/L)_q$	Product of Overall Heat Transfer Coefficient and Pipe Area (UA) per foot from insulated pipe[205~~181~~204]	Lookup in Table 2-208 ~~Table 2-207~~208	Btu/hr-°F-ft	[140]
SF_{elec}	Adjustment to electric water heating energy savings when water heating fuel is unknown	Electric WH: 1.0 Unknown WH: 0.55	N/A	[133]
SF_{fuel}	Adjustment to fossil fuel water heating energy savings based on water heating fuel[f]	Fossil Fuel WH & Space Heating: 1.0 Unknown WH: 0.56	N/A	[133]
CF	Electric coincidence factor	Lookup in Table 3-152	N/A	
PDF	Gas peak day factor	Lookup in Table 3-152	N/A	
EUL	Effective useful life	See Measure Life section	Years	

[205] Also called Building Load Coefficiienct per unit length

Table 3-397~~382~~398 Product of Overall Heat Transfer Coefficient and Pipe Area per foot from Uninsulated Pipe (UA/L)[b]

Nominal Pipe Size (in)	Bare Copper Piping			Bare Steel Piping	
	Domestic Hot Water	Hot Water Heat	Steam Heat	Hot Water Heat	Steam Heat
0.50	0.44	0.48	0.53	0.53	0.59
0.75	0.54	0.58	0.64	0.65	0.72
1.00	0.65	0.70	0.78	0.79	0.88
1.25	0.80	0.86	0.96	0.97	1.09
1.50	0.90	0.97	1.09	1.10	1.23
2.00	1.10	1.19	1.33	1.34	1.51
2.50	1.31	1.42	1.58	1.60	1.80
3.00	1.57	1.70	1.90	1.92	2.16
3.50	1.77	1.92	2.15	2.18	2.45
4.00	1.98	2.14	2.40	2.43	2.73
5.00	2.41	2.61	2.92	2.97	3.34
6.00	2.84	3.07	3.45	3.50	3.94
8.00	3.64	3.94	4.42	4.50	5.06

Table 3-398~~383~~399 Product of Overall Heat Transfer Coefficient and Pipe Area per foot from Insulated Pipe (UA/L)[q]

Nominal Pipe Size (in)	Fiberglass						Rigid Foam/Cellular Glass					
	0.5 in	1 in	1.5 in	2 in	2.5 in	3 in	0.5 in	1 in	1.5 in	2 in	2.5 in	3 in
0.50	0.13	0.09	0.08	0.07	0.06	0.06	0.15	0.12	0.10	0.09	0.09	0.08
0.75	0.14	0.11	0.09	0.08	0.07	0.07	0.17	0.13	0.11	0.10	0.10	0.09

Nominal Pipe Size (in)	Fiberglass						Rigid Foam/Cellular Glass					
	0.5 in	1 in	1.5 in	2 in	2.5 in	3 in	0.5 in	1 in	1.5 in	2 in	2.5 in	3 in
1.00	0.17	0.12	0.10	0.09	0.08	0.07	0.19	0.15	0.13	0.12	0.11	0.10
1.25	0.20	0.14	0.11	0.10	0.09	0.08	0.23	0.17	0.15	0.13	0.12	0.11
1.50	0.22	0.15	0.12	0.11	0.10	0.09	0.25	0.19	0.16	0.14	0.13	0.12
2.00	0.26	0.18	0.14	0.12	0.11	0.10	0.29	0.22	0.18	0.16	0.14	0.13
2.50	0.30	0.20	0.16	0.14	0.12	0.11	0.34	0.25	0.20	0.18	0.16	0.15
3.00	0.35	0.24	0.18	0.16	0.14	0.12	0.39	0.29	0.23	0.20	0.18	0.16
3.50	0.40	0.26	0.20	0.17	0.15	0.13	0.44	0.32	0.26	0.22	0.20	0.18
4.00	0.44	0.29	0.22	0.18	0.16	0.14	0.48	0.35	0.28	0.24	0.21	0.19
5.00	0.52	0.34	0.26	0.22	0.19	0.17	0.58	0.41	0.33	0.28	0.25	0.22
6.00	0.61	0.39	0.30	0.25	0.21	0.19	0.67	0.47	0.37	0.32	0.28	0.25
8.00	0.77	0.49	0.37	0.30	0.26	0.23	0.84	0.59	0.46	0.39	0.34	0.30

Table 3-399~~384400~~ Gas- and Oil-Fired Boilers—Minimum Efficiency Requirements

Equipment Type	Subcategory or Rating Condition	Size Category (Input)	Efficiency as of 3/2/2022	Test Procedure
Boilers, hot water	Gas fired	<300,000 Btu/h	82% AFUE	10 CFR 430 Appendix N
		≥300,000 Btu/h and ≤2,500,000 Btu/h	80% Et	10 CFR 431.86
		>2,500,000 Btu/h	82% Ec	
	Oil fired	<300,000 Btu/h	84% AFUE	10 CFR 430 Appendix N

Field Code Changed
Field Code Changed
Field Code Changed
Field Code Changed
Field Code Changed

Equipment Type	Subcategory or Rating Condition	Size Category (Input)	Efficiency as of 3/2/2022	Test Procedure
		≥300,000 Btu/h and ≤2,500,000 Btu/h	82% Et	10 CFR 431.86
		>2,500,000 Btu/h	84% Ec	
Boilers, steam	Gas fired	<300,000 Btu/h	80% AFUE	10 CFR 430 Appendix N
	Gas fired—all, except natural draft	≥300,000 Btu/h and ≤2,500,000 Btu/h	79% Et	10 CFR 431.86
		>2,500,000 Btu/h	79% Et	
	Gas fired—natural draft	≥300,000 Btu/h and ≤2,500,000 Btu/h	79% Et	
		>2,500,000 Btu/h	79% Et	
	Oil fired	<300,000 Btu/h	82% AFUE	10 CFR 430 Appendix N
		≥300,000 Btu/h and ≤2,500,000 Btu/h	81% Et	10 CFR 431.86
		>2,500,000 Btu/h	81% Et	

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Table 3-400~~385401~~ Default Heat Pump Water Heater COPs and UEF by Tank Storage Capacity

Size (Gallons)	UEF	Calculated COP
50	3.30	2.83
50	3.50	2.92
50	3.75	3.14
65	3.30	2.85
65	3.50	2.94
65	3.75	3.24

Size (Gallons)	UEF	Calculated COP
80	3.30	2.85
80	3.50	3.01
80	3.75	3.38
Unknown Size[206]	-	3.016

Table 3-401~~386~~402 Average Temperature of Hot Water or Steam in Distribution System Piping

System Type	Facility Type	Pipe Temperature °F
Hot Water	Commercial	138
Hot Water	Industrial	134
Low Pressure Steam[207]	C&I	240
Medium Pressure Steam	Commercial	304
Medium Pressure Steam	Industrial	258

Peak Factors

Table 3-402~~387~~403 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	Electric DHW: 1.0 Hot Water: N/A	

[206] Unknown COP is the average of storage tank heat pump water heater's COP for medium to high draw types covering a storage capacity range of 50 gallons to 80 gallons taken from California Energy Data and Reporting System's DEER Water Heater Calculator [129]

[207] Average of 2014 and 2015 values of the Low Pressure Steam related pipe temperature values in the 'NONRESIDENTIAL DOWNSTREAM ESPI DEEMED PIPE INSULATION IMPACT EVALUATION' studies by Ltron Inc and ERS [130].

Peak Factor	Value	Ref
Natural gas peak day factor (PDF)	See Error! Reference source not found.~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The effective useful life (EUL) is 13 years for electric water heaters and 11 years for gas water heaters [141].

References

[127] "2022 Illinois Statewide Technical Reference Manual for Energy Efficiency." 2021, Page 88. https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010122_v10.0_Vol_3_Res_09242021.pdf

[128] "Pipe Sizing Charts Tables | Energy-Models.com." 2013. Energy-Models.com. 2013. https://energy-models.com/pipe-sizing-charts-tables.

[129] 2022 California Public Utilities Commission. n.d. Review of DEER Resources - Water Heater - DEER Water Heater Calculator. Cedars - California Energy Data and Reporting System. https://cedars.sound-data.com/deer-resources/tools/water-heaters/.

[130] Ltron & ERS. 2016. Review of 2014 Nonresidential Downstream Deemed ESPI Pipe Insulation Impact Evaluation Report. California Public Utilities Commission. March 29, 2016. https://www.caetrm.com/media/reference-documents/Itron_2016_ESPI_Pipe_Insulation_Report_FINAL_20160329.pdf.

[131] Ltron & ERS. 2017. Review of 2015 NONRESIDENTIAL DOWNSTREAM ESPI DEEMED PIPE INSULATION IMPACT EVALUATION. California Public Utilities Commission. March 31, 2017. https://www.caetrm.com/media/reference-documents/2015_Nonresidential_Downstream_ESPI_DEEMED_Pipe_Insulation_Impact_Ev_cr3XPvt.pdf.

[132] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – Version 9. (New York State Joint Utilities, 2021), Pg 508, https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V9.pdf

[133] NREL. 2022. Review of US Commercial Sector circa 2018. ComStock. October 2021. https://comstock.nrel.gov/dataviewer/building-characteristics/?datasetName=vizstock_comstock_amy2018_release_1_by_state_vu&locationId=NJ

[134] Southern California Gas Company (SCG). 2017. WPSCGWP110812A_Rev4__Itron_2014_2015 WP Parameters.xlsx https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fwww.caetrm.com%2Fmedia%2Freference-documents%2FWPSCGWP110812A_Rev4__Itron_2014_2015_WP_Parameters.xlsx&wdOrigin=BROWSELINK

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

[135] ASHRAE Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 7.8, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

[136] ASHRAE Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-6, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

[137] Code of Federal Regulations. 2022. Review of Title 10, Chapter II, Subchapter D, Part 431. Appendix B to Subpart G of Part 431 - Uniform Test Method for the Measurement of Standby Loss of Electric Storage Water Heaters and Storage-Type Instantaneous Water Heaters, eCFR. December 1, 2022. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-431/subpart-G

[138] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – Version 9. (New York State Joint Utilities, 2021), Pg 506
https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V9.pdf
https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32

[139] Simulations of prototype buildings from NY TRM updated with NJ weather done by NJ Statewide Evaluator, May 2022

[140] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – Version 9. (New York State Joint Utilities, 2021), Pg 509, https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/NYS%20TRM%20V9.pdf

[141] California Public Utilities Commission EUL Table, version 027 (updated November 12, 2022). Accessed December 30, 2022. https://www.caetrm.com/shared-data/value-table/EUL/

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

3.12 PROCESS

3.12.1 VSD AIR COMPRESSORS

Market	Commercial and Industrial
Baseline Condition	TOS/NC
Baseline	Code
End Use Subcategory	Compressed Air
Measure Last Reviewed	December 2022

Description

Variable-Speed Drive (VSD) Air Compressors use a variable speed drive on the motor to match motor output to the load, resulting in greater efficiency than fixed-speed air compressors. Baseline compressors choke off inlet air to modulate the compressor output, resulting in increased energy consumption and peak demand. This measure relates to the installation of a new air compressor of 100 HP or less with a variable speed drive. Projects involving compressors larger than 100 HP should be treated as custom projects.

Baseline Case

The baseline condition is a typical load/unload compressor.

Efficient Case

A screw compressor with variable speed control on the motor to match output to the load.

Annual Energy Savings Algorithm

Annual Electric Energy Savings

$$\Delta kWh = 0.9 \times HP \times Hrs \times (COMP_b - COMP_q)$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \mathrm{N/A}$$

Calculation Parameters

Table 3-403~~388~~404 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
HP	Compressor motor nominal HP	Site-specific	hp	
$COMP_b$	Baseline compressor factor	Look up in Table 3-405~~Table 3-390~~406	N/A	[144]

Variable	Description	Value	Units	Ref
$COMP_q$	Installed compressor factor, actual	Site-specific, if unknown use 0.705	N/A	[142]
Hrs	Compressor total hours of operation	Site-specific, if unknown look up in Table 3-404~~Table 3-389~~405	Hrs/yr	[142]
CF	Coincidence factor	Look up in Table 3-404~~Table 3-389~~405	N/A	[142]
PDF	Gas peak demand factor	Look up in Table 3-406~~Table 3-391~~407	N/A	
0.9	Compressor motor nominal hp to full load kW Conversion factor	0.9	N/A	[142]
EUL	Effective useful life of new unit	See Measure Life Section	Years	

Table 3-404~~389~~405 Compressor Total Hours of Operation and Coincidence Factors

Number of Shifts	Description	Annual Operating Hours	Coincidence Factor (CF)
Single shift	7 AM – 3 PM, weekdays, minus holidays and scheduled down time	1,976	0.59
2 - shift	7AM – 11 PM, weekdays, minus holidays and scheduled down time	3,952	0.95
3 - shift	24 hours per day, weekdays, minus holidays and scheduled down time	5,928	0.95
4 - shift	24 hours per day, 7 days a week minus holidays and scheduled down time	8,320	0.95

Table 3-405~~390~~406 Baseline Compressor Factor

Baseline Compressor	Compressor Factor $COMP_b$ (≤45 hp)	Compressor Factor $COMP_b$ (>45 hp)
Modulating w/ Blowdown	0.890	0.863
Load/No Load w/ 1 Gallon-of-storage/ CFM_{Max}	0.909	0.887
Load/No Load w/ 3 Gallon-of-storage/ CFM_{Max}	0.831	0.811

Baseline Compressor	Compressor Factor $COMP_b$ (≤45 hp)	Compressor Factor $COMP_b$ (>45 hp)
Load/No Load w/ 5 Gallon-of-storage/ CFM_{Max}	0.806	0.786

Peak Factors

Table 3-~~406391~~407 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	Look up in Table 3-404~~Table 3-389~~405	[142]
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 13 years [143].

References

[142] Mid Atlantic Technical Reference Manual Version 10.0, (2020), https://neep.org/mid-atlantic-technical-reference-manual-trm-v10 Compressor factors were developed using DOE part load data for different compressor control types as well as load profiles from 50 facilities employing air compressors less than or equal to 40 hp, as sourced from the Efficiency Vermont TRM. (The "variable speed drive" compressor factor has been adjusted up from the 0.675 presented in the analysis to 0.705 to account for the additional power draw of the VSD).

[143] California Public Utilities Commission EUL Table, version 027 (updated November 12, 2022). Accessed December 30, 2022. https://www.caetrm.com/shared-data/value-table/EUL/

[144] Compressor factors for ≤40 hp motors were developed using DOE part load data for different compressor control types as well as load profiles from 50 facilities employing air compressors less than or equal to 40 hp, as sourced from the Efficiency Vermont TRM. (The "variable speed drive" compressor factor has been adjusted up from the 0.675 presented in the analysis to 0.705 to account for the additional power draw of the VSD). Compressor factors for >50 hp motors were developed using DOE part-load data for different compressor control types as well as load profiles from 45

Field Code Changed

Field Code Changed

compressors and 20 facilities. This data comes from ComEd Custom and Insustrial Systems programs. The compressors were filtered to reflect only rotary screw compressors, between 50 and 200 hp, and operating a minimum of 4 hour per day, Additionally, compressors with clear and consistent baseload profiles were excluded from this analysis.

3.12.2 COMPRESSED AIR LEAK DETECTION

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Maintenance
Measure Last Reviewed	March 2023

Description

This measure presents energy savings associated with reducing compressed air losses through ultrasonic leak detection and the repair of compressed air leaks.

Baseline Case

Industrial compressed air system with suspected leaks.

Efficient Case

Compressed air system with identified and repaired leaks.

Annual Energy Savings Algorithms

Annual Electric Energy Savings

$$\Delta kWh = N_{leaks} \times CFM_{leaks} \times Eff_{comp} \times Hrs \times F_{control}$$

Annual Fuel Savings

$$\Delta Therms = N/A$$

Peak Demand Savings

$$\Delta kW_{Peak} = \frac{\Delta kWh}{Hrs} \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = N/A$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-407~~392~~408 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
N_{leaks}	Number of leaks repaired	Site-specific	N/A	
Hrs	Hours of operation per year	Site-specific, if unknown use 6,240	Hrs/yr	[149]
CFM_{leak}	CFM loss per leak	Site-specific, look up in Table 3-408~~Table 3-393~~409	CFM	[145]
Eff_{comp}	Compresser efficiency	Site-specific, if unknown look up in Table 3-409~~Table 3-394~~410	kW/CFM	[146]

Variable	Description	Value	Units	Ref
$F_{control}$	Control factor, percent kW divided by percent load	Look up in Table 3-410~~Table 3-395~~411	N/A	[147]
CF	Electric coincidence factor	Look up in Table 3-152	N/A	[148]
PDF	Gas peak day factor	Look up in Table 3-152	N/A	
EUL	Effective useful life	See Measure Life section	Years	

Table 3-408~~393~~409 CFM per Leak Size and Compressed Air Pressure

Pressure (psig)	Orifice Diameter (inches)					
	1/64	1/32	1/16	1/8	1/4	3/8
70	0.29	1.16	4.66	18.62	74.4	167.8
80	0.32	1.26	5.24	20.76	83.1	187.2
90	0.36	1.46	5.72	23.1	92.0	206.6
100	0.40	1.55	6.31	25.22	100.9	227.0
125	0.48	1.94	7.66	30.65	122.2	275.5

Values should be multiplied by 0.97 for well-rounded orifices and by 0.61 for sharp orifices.

Table 3-409~~394~~410 Default Compressor Efficiencies

Compressor Type	Efficiency (kW/CFM)
Single-acting reciprocating air compressor	0.23
Double-acting reciprocating air compressor	0.155
Lubricant-injected rotary screw compressor	0.185
Lubricant-free rotary screw compressor	0.2
Centrifugal compressor	0.18

Compressor Type	Efficiency (kW/CFM)
Average	0.19

Table 3-~~410~~395~~411~~ Efficiency Factors per Control Type

Control Type	$F_{control}$ (% kW / % load)
Reciprocating – on/off control	1.00
Reciprocating – load/unload	0.74
Screw – load/unload oil free	0.73
Screw – load/unload 1 gal/CFM	0.43
Screw – load/unload 3 gal/CFM	0.53
Screw – load/unload 5 gal/CFM	0.63
Screw – load/unload 10 gal/CFM	0.73
Screw – inlet modulation	0.30
Screw – inlet modulation w/unloading	0.30
Screw – variable displacement	0.60
Screw – variable speed drive	0.97

Peak Factors

Table 3-411~~396~~412 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	Calculate as: CF = (annual operating hours) / 8,760	
Natural gas peak day factor (PDF)	See Error! Reference source not found.~~Appendix G: Natural Gas Peak Day Factors~~	

Measure Life

The effective useful life (EUL) is 1 year. [150]

References

[145] NREL, Chapter 22: Compressed Air Evaluation Protocol. https://www.energystar.gov/sites/default/files/buildings/tools/compressed_air3.pdf

[146] Data from Compressed Air Challenge "Fundamentals of Compressed Air Systems" Pgs. 28-32

[147] NREL, Chapter 22: Compressed Air Evaluation Protocol, October 2017. Pg 16

[148] KEMA, New Jersey’s Clean Energy Program Energy Impact Evaluation and Protocol Review, July 10, 2009.

[149] This is based on 3 shifts per day, 5 days per week. This figure is supported by a survey of previous compressed air projects within Michigan and Ohio energy efficiency programs.

[150] One year measure life is based on typical recommendation of annual leak survey.

3.13 WHOLE BUILDING

3.13.1 COMBINED HEAT AND POWER

Market	Commercial
Baseline Condition	NC/RF
Baseline	Code/Existing
End Use Subcategory	HVAC
Measure Last Reviewed	August 2024
Changes Since Last Version	~~Addition of emissions reduction calculations under non-energy impacts~~

Description

This measure applies to the installation of Combined Heat and Power (CHP) System in a commercial setting, defined as a system that sequentially generates both electrical energy and useful thermal energy from one fuel source. Eligible systems include: powered by non-renewable or renewable fuel sources, gas internal combustion engine, gas combustion turbine, microturbine, steam turbine, and fuel cells.

The measurement of energy and savings for CHP systems is based primarily on the characteristics of the individual systems subject to the general principles set out below. The majority of the inputs used to estimate energy and demand impacts of CHP systems will be drawn from individual project applications.

The methodology presented in the measure is based on the National Renewable Energy Laboratory's Combined Heat and Power, The Uniform Methods Project: Methods for Determining Energy- Efficiency Savings for Specific Measures 747~~724~~[151].If a CHP system cannot be evaluated using the methodology in this measure (due to complexity of the system or other factors), the project may be evaluated using a custom engineering analysis.

CHP systems typically use fossil fuels to generate electricity that displaces electric generation from other sources. Therefore, the electricity generated from a CHP system should not be reported as either electric energy savings or renewable energy generation. Exceptions may be made to this standard, such as CHP systems that use an absorption chiller to convert useful heat to cooling energy, and thus operates in the summer; or cases where the CHP system generates more electricity than consumed and is allowed to export electricity to the grid. Alternatively, electric generation and capacity from CHP systems should be reported as Distributed

Generation (DG) separate from energy savings and renewable energy generation. However, any waste heat recaptured and utilized should be reported as energy savings as discussed below.

Baseline Case

If the CHP system is replacing or adding on to an existing HVAC system, the baseline is the site-specific existing equipment. If the CHP system uses an absorption chiller, the baseline equipment is assumed to be a code-compliant electric chiller. For new construction, the baseline scenario is a standalone (no power generation) code-compliant HVAC system of the same capacity and fuel as the CHP system.

Efficient Case

The efficient case is the installed CHP system, defined as a system that sequentially generates both electrical energy and useful thermal energy from one fuel source. Eligible systems include: powered by non-renewable or renewable fuel sources, gas internal combustion engine, gas combustion turbine, microturbine, steam turbine, and fuel cells with and without heat recovery.

Annual Energy Savings Algorithms

Note: The alogirithms presented below are simplified. Users should adopt a level of rigor that matches the program needs and available data. As long as the energy impacts are calculated in an equivalent manner, alternative methodologies such as conducting a site-specific hourly/daily analysis are acceptable.

Annual Electric Energy Savings

$$\Delta kWh = kWh_{Net} + kWh_{ChillerOffset}$$

Where,

$$kWh_{Net} = kWh_{Gross} - kWh_{Consumed}$$

$$kWh_{ChillerOffset} = kWh_{Net} \times UHRR_C \times COP \times \frac{Eff_{ElecChiller}}{12}\ (if\ CHP\ is\ driving\ an\ absorption\ chiller)$$

$$UHRR_c = \frac{UHR_c}{kWh_{Net}}$$

$$kWh_{ChillerOffset} = 0\ (if\ no\ absorption\ chiller\ is\ involved)$$

Annual Fuel Savings

$$\Delta Therms = \frac{Fuel_{Offset} - Fuel_{Consumed}}{100}$$

Where,

$$Fuel_{Offset} = \frac{kWh_{Net} \times UHRR_H}{Eff_{Boiler}}$$

$$Fuel_{Consumed} = \frac{kWh_{Gross}}{Eff_{NetElec}} \times 3.412$$

$$UHRR_h = \frac{UHR_h}{kWh_{Net}}$$

$$Eff_{NetElec} = \frac{\Delta kW\mathrm{h} \times 3.412}{Fuel_{input}}$$

Annual Peak Demand Savings

Calculation of peak demand savings requires site-specific hourly analysis. See UMP: Section 3.1 Determining Electricity Impacts Pg 11 for more detail.

Daily Peak Fuel Savings

Calculation of peak fuel savings requires site-specific hourly analysis. See UMP: Section 3.2 Determining Fuel Impacts Pg 12 for more detail.

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-412~~397413~~ Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Annual peak demand savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
$Fuel_{Offset}$	Reduction in fuel consumption that would have been used for heating that can be attributed to the CHP system	Calculated	kBtu	
$Fuel_{Consumed}$	Utility delivered fuel consumed by CHP system	Calculated	kBtu	
$Eff_{NetElec}$	Net electrical efficiency, a measure of how much of the energy in the fuel input is converted to net electricity	Calculated	N/A	
$UHRR_C$	Useful heat recovery rate for absorption chiller	Calculated	kBtu/kWh	
$UHRR_h$	Useful heat recovery rate associated with heating offset	Calculated	kBtu/kWh	
$KWh_{ChillerOffset}$	Annual electrical energy offset from electrical chillers if heat from the CHP measure is driving an absorption chiller	Calculated	kWh/yr	
kWh_{gross}	Overall electricity generated by CHP System	Site-specific/engineering calculation	kWh/yr	
$kWh_{consumed}$	Annual electricity consumed by CHP system: parasitic losses due to fan and pump motors, dedicated HVAC system, and lighting	Site-specific; if unknown, assume 3% of kWh_{gross}	kWh/yr	

Variable	Description	Value	Units	Ref
UHR_h	Useful heat recovered: heat that is expected to be recovered from CHP system, including any heat recovered for absorption chiller use and used on-site	Site-specific/engineering calculation	kBtu	
UHR_c	Useful heat recovered: heat that is used to drive an absorption chiller	Site-specific/engineering calculation	kBtu	
kWh_{Net}	Net electricity generation by CHP: overall electricity generated by CHP System minus annual electricity consumed by CHP system	Site-specific/engineering calculation	kWh/year	
$Fuel_{Input}$	Annual Fuel input to CHP system	Site-specific/engineering cacluation	kBtu	
COP	COP of absorption chiller	Site-specific	N/A	
$Eff_{ElecChiller}$	Efficiency of baseline electric chiller	Site-specific, use 0.65 if unknown	kW/ton	[153]
12	Conversion factor	12	kBtu/ton	
Eff_{Boiler}	Efficiency of boiler that would serve heating loads in absence of CHP system	Site-specific, use 0.8 if unknown	N/A	[126]
100	Conversion factor	100	kBtu/therm	
3.412	Conversion factor	3.412	kBtu/kWh	
EUL	Effective useful life	See Measure Life ~~Measure Life~~	Years	

Peak Factors

Peak factors should be analyzed on a site-specific basis.

Non-Energy Impacts

CHP systems will result in emissions reductions in addition to energy savings. Annual and lifetime air emission reductions resulting from electric generation, electric savings, and net gas impacts at the system level shall be calculated as specified below:

Annual Emissions Reductions

$$\Delta CO2_{MT} = \left[\Delta MWh_{sav} \times LLF_{elec} \times F_{CO2,elec} + \frac{\Delta Therms}{10} \times LLF_{gas} \times F_{CO2,gas} + \Delta MWh_{gen} \times \left(LLF_{elec} \times F_{CO2,elec} - \frac{F_{CO2,CHP}}{2{,}000}\right)\right] \times \frac{2{,}000}{2{,}205}$$

$$\Delta SO2_{MT} = \left[\Delta MWh_{sav} \times LLF_{elec} \times F_{SO2,elec} + \Delta MWh_{gen} \times \left(LLF_{elec} \times F_{SO2,elec} - \frac{F_{SO2,CHP}}{2{,}000}\right)\right] \times \frac{2{,}000}{2{,}205}$$

$$\Delta NOx_{MT} = \left[\Delta MWh_{sav} \times LLF_{elec} \times F_{NOx,elec} + \frac{\Delta Therms}{10} \times LLF_{gas} \times F_{NOx,gas} + \Delta MWh_{gen} \times \left(LLF_{elec} \times F_{NOx,elec} - \frac{F_{NOx,CHP}}{2{,}000}\right)\right] \times \frac{2{,}000}{2{,}205}$$

$$\Delta Hg_{g} = \left[\Delta MWh_{sav} \times LLF_{elec} \times F_{Hg,elec}\right] \times \frac{1}{1{,}000}$$

Lifetime Emissions Reductions

$$\Delta CO2_{MT,Life} = \left[\Delta MWh_{sav,Life} \times LLF_{elec} \times AVG(F_{CO2,elec}) + \frac{\Delta Therms_{Life}}{10} \times LLF_{gas} \times F_{CO2,gas} + \Delta MWh_{gen,Life} \times \left(LLF_{elec} \times AVG(F_{CO2,elec}) - \frac{F_{CO2,CHP}}{2{,}000}\right)\right] \times \frac{2{,}000}{2{,}205}$$

$$\Delta SO2_{MT,Life} = \left[\Delta MWh_{sav,Life} \times LLF_{elec} \times AVG(F_{SO2,elec}) + \Delta MWh_{gen,Life} \times \left(LLF_{elec} \times AVG(F_{SO2,elec}) - \frac{F_{SO2,CHP}}{2{,}000}\right)\right] \times \frac{2{,}000}{2{,}205}$$

$$\Delta NOx_{MT,Life} = \left[\Delta MWh_{sav,Life} \times LLF_{elec} \times AVG(F_{NOx,elec}) + \frac{\Delta Therms_{Life}}{10} \times LLF_{gas} \times F_{NOx,gas} + \Delta MWh_{gen} \times \left(LLF_{elec} \times AVG(F_{NOx,elec}) - \frac{F_{NOx,CHP}}{2{,}000}\right)\right] \times \frac{2{,}000}{2{,}205}$$

$$\Delta Hg_{g,Life} = \left[\Delta MWh_{sav.Life} \times LLF_{elec} \times F_{Hg,elec}\right] \times \frac{1}{1{,}000}$$

Table 3-413~~398~~414 Calculation Parameters

Variable	Description	Value	Units	Ref
$\Delta CO2_{MT}$	Annual CO2 Emissions Reductions, in Metric Tons	Calculated	MT/yr	
$\Delta SO2_{MT}$	Annual SO2 Emissions Reductions, in Metric Tons	Calculated	MT/yr	

Variable	Description	Value	Units	Ref
ΔNOx_{MT}	Annual NOx Emissions Reductions, in Metric Tons	Calculated	MT/yr	
ΔHg_{g}	Annual Hg Emissions Reductions, in grams	Calculated	g/yr	
$\Delta CO2_{MT,Life}$	Lifetime CO2 Emissions Reductions, in Metric Tons	Calculated	MT	
$\Delta SO2_{MT,Life}$	Lifetime SO2 Emissions Reductions, in Metric Tons	Calculated	MT	
$\Delta NOx_{MT,Life}$	Lifetime NOx Emissions Reductions, in Metric Tons	Calculated	MT	
$\Delta Hg_{g,Life}$	Lifetime Hg Emissions Reductions, in grams	Calculated	g	
ΔMWh_{sav}	Annual electric energy savings	Site-specific/engineering calculation	MWh/yr	
ΔTherms	Annual fuel savings	Site-specific/engineering calculation	Therms/yr	
ΔMWh_{gen}	Annual electric generation	Site-specific/engineering calculation	MWh/yr	
$\Delta MWh_{sav,Life}$	Lifetime electric energy savings	Site-specific/engineering calculation	MWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Site-specific/engineering calculation	Therms	
$\Delta MWh_{gen,Life}$	Lifetime electric generation	Site-specific/engineering calculation	MWh	
LLF_{elec}	Electric line loss factor	1.087	N/A	[156]
LLFgas	Gas line loss factor	1.023	N/A	[156]
$F_{CO2,elec}$	Grid electric CO_2 emissions factor	Lookup from NJBPU Order [156], Attachment B, Table 6 based on year of installation	tons/MWh	[156]
$F_{SO2,elec}$	Grid electric SO_2 emissions factor	Lookup from NJBPU Order [156], Attachment B, Table 6 based on year of installation	tons/MWh	[156]
$F_{NOx,elec}$	Grid electric NO_x emissions factor	Lookup from NJBPU Order [156], Attachment B, Table 6 based on year of installation	tons/MWh	[156]
$F_{Hg,elec}$	Grid electric Hg emissions factor	1.1	mg/MWh	[157]
$F_{CO2,gas}$	Natural gas CO_2 emissions factor	0.058325	tons/MMBtu	[158]
$F_{NOx,gas}$	Grid electric NO_x emissions factor	0.000046	tons/MMBtu	[157]
$F_{CO2,CHP}$	CHP system electric generation CO_2 emissions factor	Site-specific	tons/MWh	

Variable	Description	Value	Units	Ref
$F_{SO2,CHP}$	CHP system electric generation SO_2 emissions factor	Site-specific	tons/MWh	
$F_{NOx,CHP}$	CHP system electric generation NO_x emissions factor	Site-specific	tons/MWh	
$AVG(F_{CO2,elec})$	Average lifetime grid electric CO_2 emissions factor	Average of annual emissions factors over the lifetime of the CHP system from NJBPU Order [156], Attachment B, Table 6 based on year of installation and EUL	tons/MWh	[156]
$AVG(F_{SO2,elec})$	Average lifetime grid electric SO_2 emissions factor	Average of annual emissions factors over the lifetime of the CHP system from NJBPU Order [156], Attachment B, Table 6 based on year of installation and EUL	tons/MWh	[156]
$AVG(F_{NOx,elec})$	Average lifetime grid electric NO_x emissions factor	Average of annual emissions factors over the lifetime of the CHP system from NJBPU Order [156], Attachment B, Table 6 based on year of installation and EUL	tons/MWh	[156]
10	Conversion factor	10	Therms/MMBtu	
2,000	Conversion factor	2,000	lbs/ton	
2,205	Conversion factor	2,205	lbs/MT	
1,000	Conversion factor	1,000	mg/g	

Emission factors may be updated by future BPU Orders addressing the New Jersey Cost Test and Decarbonization Pilot programs. Please consult the NJ BPU website for the most current information on emission factors.

Measure Life

The effective useful life (EUL) is 10 years [151].[208]

[208] Please note that the UMP estimates a range of 10-25 years for typical CHP lifetime. This measure presents the conservative estimate of 10 years. Note that CHP measure lifetime is dependant on facility operations, fuel, and maintenance; there may be scenarios where a site-specific lifetime estimate is most appropriate.

References

[151] Simons, George, Stephan Barsun, and Charles Kurnik. 2017. Chapter 23: Combined Heat and Power, The Uniform Methods Project: Methods for Determining Energy- Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68579. https://www.nrel.gov/docs/fy17osti/68579.pdf

[152] ASHRAE Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-6, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

[153] ASHRAE Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings. (ASHRAE, 2019), Table 6.8.1-3, https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

[154] Provided by the New Jersey Department of Environmental Protection, Office of Air and Energy Advisor, on May 25, 2018, Using Weighted Average of 2017 PJM On-Peak and Off-Peak annual data https://www.pjm.com/-/media/library/reports-notices/special-reports/20180315-2017-emissions-report.ashx

[155] US Environmental Protection Agency Emissions & Generation Resource Integrated Database (eGRID) Summary Tables 2021. Data viewer accessed 5-19-2023. https://www.epa.gov/egrid/data-explorer

[156] NJBPU ORDER DIRECTING THE UTILITIES TO PROPOSE SECOND TRIENNIUM ENERGY EFFICIENCY AND PEAK DEMAND REDUCTION PROGRAMS

[157] New Jersey's Clean Energy Program Protocols to Measure Resource Savings FY2020

[158] EIA Fuel Emissions

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

3.13.2 NEW CONSTRUCTION

Market	Commercial/Multifamily
Baseline Condition	NC
Baseline	Code
End Use Category	Whole Building
Measure Last Reviewed	January 2023
Changes Since Last Version	~~Expand measure description~~

Description

This measure addresses high performance commercial and industrial new building design and construction. High performance new construction projects must either perform whole building modeling per ASHRAE guidelines or follow requirements through nationally recognized programs, including US Green Building Council's Leadership in Energy and Environmental Design (LEED) [159], Passive House Institute US [160][339]~~[3389]~~ or Passive House [161].

Minimum energy performance requirements for all new construction projects are measured from baselines reflecting effective, applicable energy codes and standards (e.g., IECC and ASHRAE 90.1) at the time the project permit is pulled. Modeling software requirements shall be dictated by the selected high performance new construction compliance program (i.e., those listed above). Energy and demand savings for measures included in the program but not modeled by the software should be calculated using the appropriate TRM measure section.

For projects pursuing passive house certifications, savings shall be estimated based on a comparison of baseline and proposed/as-built OR minimally passive house compliant prototype models developed in approved program simulation software. Baseline models shall reflect input parameters relevant to climate zones 4A/5A and minimally compliant with effective, applicable energy codes and standards based on project permit date. Submitted proposed/as-built design models are compared against the corresponding baseline model to establish energy consumption savings by fuel type. For electric peak demand savings, where end use-level kWh savings are reported by simulation software, peak kW shall be established per end use and aggregated for project-level reporting. In the absence of end use-level savings, peak kW savings may be approximated per the equation shown below:

$$\Delta kW = \Delta kWh \times \frac{CF}{EFLH_{cool}}$$

Where:

CF = cooling coincidence factor from Section 3.5.1

$EFLH_{cool}$= cooling equivalent full load hours from Section 3.5.1

High performance new construction projects in NJ may target varying levels of energy performance, from a bundled measure approach per ASHRAE 90.1 Addendum AP [162] to simple DOE-2 based modeling (e.g., Slipstream's Sketchbox) to comprehensive modeling per ASHRAE 90.1 Appendix G [163]. Simulation software used for new construction projects must comply with ASHRAE Standard 140 [165].

References

[159] LEED requirements

[160] Passive House Institute US requirements.

[161] Passive House Institute requirements

[162] ASHRAE Addendum AP

[163] ASHRAE 90.1-2016/2019 Appendix G

[164] Commercial New Construction Industry Standard Practice Analysis

[165] ASHRAE Standard 140-2020 Method Of Test For Evaluating Building Performance Simulation Software

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

Field Code Changed

3.13.3 OPERATOR TRAINING

Market	Commercial
Baseline Condition	RF
Baseline	Existing
End Use Subcategory	Behavior
Measure Last Reviewed	January 2023

Description

Building Operator Certification (BOC) is a training and certification program for commercial and public sector building operators. The training program teaches participants how to improve building comfort and efficiency by optimizing the building's systems. BOC provide participants with knowledge about system operations, proper maintenance practices, occupant communication, and occupant comfort. Participants realize energy savings by utilizing the knowledge gained to improve their building operations through O&M and capital measures.

Deemed savings for this measure represent a convergence of analyses results from multiple BOC program evaluations that estimated net savings and were developed per square foot of building area to account for building size diversity. All savings algorithms presented in this work paper are for net savings. Participants must complete a rigorous BOC course and can only claim savings for the facilities for which the individual taking the course is responsible.

Measure Requirements

Participants must complete either the BOC Level I or Level II course and obtain a certificate of completion to be eligible for savings. Eligible BOC must cover the following subject areas:

BOC Level 1:

- Efficient Operation of HVAC Systems
- Measuring and Benchmarking Energy
- Efficient Lighting Fundamentals
- HVAC Controls Fundamentals

- Indoor Environmental Quality
- Common Opportunities for Low-Cost Operational Improvement

BOC Level 2:

- Building Scoping and Operational Improvements
- Optimizing HVAC Controls for Energy Efficiency
- Introduction to Building Commissioning
- Water Efficiency for Building Operators
- Project Peer Exchange

The BOC course must include formal instruction (i.e., lectures), individual projects, and group exercises, bringing the total course time to at least 61 hours. Participants must obtain a training certificate of completion to be eligible for savings. Individuals who participate are not eligible for savings more than twice over the measure life, once for BOC Level I and another for BOC Level II. The entire floor area for any given building can only be used once over the measure life, and evaluators will verify attendees' participation year-over-year.

The savings factors for this measure were developed based on an examination of savings using a weighted average approach from several similar BOC programs. It is important to note that the savings information referenced is net. Therefore, this measure does not require the additional application of a net-to-gross ratio.

Note: In the event there are multiple participants who operate the same building (i.e. service address), or group of buildings, care should be taken to ensure that savings are not claimed for based on the same square footage for multiple participants.

<u>Annual Energy Savings Algorithms</u>

<u>Annual Electric Energy Savings</u>

$$\Delta kWh = C_e \times Area$$

<u>Annual Fuel Savings</u>

$$\Delta Therms = C_g \times Area$$

Peak Demand Savings

$$\Delta kW_{Peak} = C_d \times Area/1000 \times CF$$

Daily Peak Fuel Savings

$$\Delta Therms_{Peak} = \Delta Therms \times PDF$$

Lifetime Energy Savings Algorithms

Lifetime Electric Energy Savings

$$\Delta kWh_{Life} = \Delta kWh \times EUL$$

Lifetime Fuel Savings

$$\Delta Therms_{Life} = \Delta Therms \times EUL$$

Calculation Parameters

Table 3-414~~399~~415 Calculation Parameters

Variable	Description	Value	Units	Ref
ΔkWh	Annual electric energy savings	Calculated	kWh/yr	
ΔTherms	Annual fuel savings	Calculated	Therms/yr	
ΔkW_{Peak}	Peak Demand Savings	Calculated	kW	
$\Delta Therms_{Peak}$	Daily peak fuel savings	Calculated	Therms/day	
ΔkWh_{Life}	Lifetime electric energy savings	Calculated	kWh	
$\Delta Therms_{Life}$	Lifetime fuel savings	Calculated	Therms	
C_e	Unit area kWh savings constant per participant	0.482	kWh/ft^2/participant	[166]
Area	Building area operated by the participant	Site-specific	ft^2	
C_g	Unit gas savings constant per participant	0.0145	Therms/ft^2/participant	[167]

Variable	Description	Value	Units	Ref
C_d	Unit demand savings constant per participant	0.039	W/ft²/participant	[167]
1,000	Conversion factor	1,000	W/kW	
CF	Electric coincidence factor	Look up in Table 3-415~~Table 3-400~~416	N/A	
PDF	Gas peak day factor	Look up in Table 3-415~~Table 3-400~~416	N/A	
EUL	Effective useful life	See Measure Life Section	Years	

Peak Factors

Table 3-415~~400~~416 Peak Factors

Peak Factor	Value	Ref
Electric coincidence factor (CF)	1	
Natural gas peak day factor (PDF)	N/A	

Measure Life

The effective useful life (EUL) is 9.2 years [168].

References

[166] Building Operator Certification, BOC Energy Savings Summary and FAQ available at 2020-BOC-Energy-Savings-FAQ_1.0.pdf (theboc.info)

[167] 2022 Illinois Statewide Technical Reference Manual for Energy Efficiency Version 10.0, Page 805

[168] The overall weighted average useful life for BOC savings are 1) Average measure life of capital measures from the ComEd CY2020 evaluation. 2) Useful Life for Custom Measure, Illinois TRM v10 for CY2022.

Field Code Changed

3.13.4 CUSTOM

Market	Commercial/Multifamily
Baseline Condition	TOS/NC/RF/EREP/ERET/DI
Baseline	Code/ISP/Existing/Dual
End Use Subcategory	Custom
Measure Last Reviewed	January 2023

Description

In addition to the typical measures for which savings algorithms have been developed, it is important to identify and address additional opportunities for energy savings. Custom measures can often provide significant energy savings and can be tailored to the specific needs of a building or facility. If necessary, the utilities may develop specific guidelines for frequent custom measures for use in reporting and contractor tracking. This will ensure that the custom measures are implemented correctly and consistently; and that the energy savings are accurately reported. Additionally, it is important to continuously monitor and evaluate the effectiveness of the custom measures implemented and make adjustments as needed.

To implement custom measures, it is necessary to develop individual calculations for each measure to determine the energy savings. These calculations should take into account factors such as the cost of implementation, the expected energy savings, and any potential changes in operations or maintenance. Once the calculations are complete, the project must be reviewed for reasonableness by either a third-party consulting engineer or a qualified in-house engineer. Before a full review of the project is started, the project package should first be checked for completeness and compliance with program eligibility rules. Once the project review is complete, savings can be reported based on these individual calculations.

Baseline

The project baseline depends on the baseline condition. For time of sale (TOS) and new construction (NC) measures, the baseline is the applicable equipment energy code or standard; or industry standard practice (ISP). For retrofit (RF), early replacement (EREP), early retirement (ER) and direct install (DI) measures, the baseline is the existing equipment. Early replacement and direct install projects replacing functioning equipment must use a dual baseline approach, where the existing equipment defines the first baseline and code or ISP defines the second baseline. In all cases, the baseline should be more efficient than the existing equipment; if the efficiency of the existing equipment exceeds code or ISP, the existing equipment baseline should also be used for the second baseline calculations. When existing functioning equipment is replaced and savings are based on early replacement, documentation of the existing equipment viability should be provided. Such documentation includes a customer affidavit affirming the viability of the equipment to function over its remaining useful life and a video or picture demonstrating the equipment in action. Trend logs, maintenance and repair records, and other evidence of existing equipment viability should be provided for larger projects.

Industry Standard Practice (ISP) shall take precedence over a code baseline when ISP can be established. Projects not subject to codes or standards shall define and document an ISP baseline as part of the project development package. ISP for specific custom projects can be established through interviews with equipment vendors or subject matter experts; or by examining similar equipment installation by customer in other facilities.

Efficient Case

The efficiency of the measure shall exceed the first (and if applicable the second) baseline efficiency, and a rationale for how the project saves energy shall be provided.

Energy Savings Algorithm

Energy and demand savings are calculated on a custom basis for each customer's specific situation. Savings are calculated as the difference between baseline energy usage/peak demand and the energy use/peak demand after implementation of the custom measure. Energy savings estimates should be calibrated against billing or metered data where possible to validate the model and test the reasonableness of energy savings. A project narrative description including system design diagrams should be provided to assist in the project review. Energy savings calculations vary according to the custom project requirements, but generally fall into the following classifications:[209]

Simple Engineering Equations

Custom engineering calculations may be developed to estimate energy savings. These may be presented as a series of simple engineering equations tailored to the custom project measure and process. The engineering calculations must be documented and spreadsheets used to calculate the savings must be provided with live calculations. The engineering analysis must be sufficiently documented to allow an independent calculation of the measure savings.

Bin Methods

One method for calculating energy savings for custom energy efficiency measures is through the use of weather based bin analysis. This method involves analyzing weather data and grouping it into "bins" based on temperature, humidity, and other environmental factors. The bin analysis presents the number hours a particular

[209] See the California Evaluation Framework Chapters 6 and 7 for more information about engineering methods.

weather condition exists during the year. Note, bin data to not consider time of day; hours tabulated for each weather bin are disconnected in time. Bin analysis is generally not applicable to time dependent measures.

Simulation

Another method for calculating energy savings for custom energy efficiency measures is through the use of whole building modeling simulations. This approach involves creating a computer model of a building that takes into account factors such as the building's layout, construction materials, HVAC systems, lighting, and other equipment. The model is then used to simulate different scenarios and analyze the building's energy consumption under different conditions. This can be useful for identifying opportunities for energy savings and for evaluating the potential impact of different custom measures. For example, a whole building simulation can be used to analyze the impact of different lighting systems, insulation materials, or window treatments on energy consumption. The simulation can also be used to analyze the impact of changes in occupancy, equipment usage, or other factors. Whole building modeling simulations can be a powerful tool for identifying and addressing opportunities for energy savings across a package of measures where significant measure interactions are expected.

Pre/Post Billing Analysis

Energy savings may be calculated through an analysis of whole building or submetered energy consumption before and after measure installation. The billing analysis should use a linear or multi-variate regression approach that normalizes the savings for differences in weather conditions, production and so on during the pre and post periods and also corrects for other non-routine conditions. The pre/post billing analysis should follow the International Measurement and Verification Protocol (IPMVP) Option C and/or ASHRAE Guideline 14. Open source software products compliant with IPMVP Option C or ASHRAE Guideline 14 such as OpenEEMeter are acceptable methods to evaluate energy savings under conditions where the energy consumption data can be fit to outdoor temperature or degree-day data and non-rountine events are not present or of insignificant magnitude.

Pre/Post Billing Analysis approaches are best suited for EREP, ERET and DI projects where an existing equipment baseline is appropriate. Pre/Post Billing Analysis approaches are not suitable for NC and TOS projects. When calculating lifetime savings, EREP, ERET and DI projects must adjust savings from an existing equipment baseline to an ISP baseline during the second baseline period.

Calculation Parameters

Energy savings calculations must identify the source of each parameter used in the analysis. Parameters that are uncertain should be identified as candidates for project specific measurement and verification (M&V).

Measurement and Verification

Projects where the input assumptions and savings estimates are uncertain may benefit from site specific measurement and verification (M&V). Project developers and reviewers should consider whether the project should include M&V as part of the project development process. For projects that include M&V, a site specific measurement and verification plan should be developed that documents measurement activities and their use in the energy savings analysis. Depending on the level of uncertainty, M&V may be conducted before measure installation (pre installation M&V) and/or after measure installation (post installation M&V). The International Measurement and Verification Protocol (IPMVP) and/or ASHRAE Guideline 14 should be referenced when developing an M&V plan. The M&V plans may follow IPMVP Option A (partially measured retrofit isolation), Option B (fully measure retrofit isolation) Option C (Whole building billing analysis) or Option D (Calibrated simulation) approaches.

Lifetime Energy Savings Algorithms

Lifetime energy savings for time of Sale (TOS) and new construction (NC) projects are calculated as the product of the first year kWh and/or therm savings and the measure effective useful life (EUL). Projects with multiple measures having different EULs shall use a savings weighted average EUL across all measures in the project.

Lifetime savings for early replacement (EREP), early retirement (ERET) and direct installation (DI) measures where functioning equipment is replaced must use a dual baseline approach. The first baseline savings considers the difference between the existing equipment consumption and the measure consumption for the remaining life (RUL) of the existing equipment. The second baseline savings considers the difference between code or standard practice equipment consumption and the measure consumption for the remaining life of the measure (EUL-RUL).

Peak Factors

The summer coincident peak demand savings shall be calculated consistent with the system peak definition presented in Chapter 1.

Measure Life

Measure life will be specific to each custom measure. For custom measures using technologies that are the same or similar to those addressed in other TRM measures, refer to those measures for measure lives. For measures not covered by the TRM, measure life assumptions shall be documented and justified in the project documentation package such as ASHRAE or manufacturer specifications. The EUL for retrofit (RF) measures shall be calculated as the smaller of the measure EUL or the host equipment remaining useful life (RUL). The overall project EUL shall be the savings weighted EUL of the measures included in the project.

References

[169] California Evaluation Framework. Available at https://www.cpuc.ca.gov/-/media/cpuc-website/files/uploadedfiles/cpuc_public_website/content/utilities_and_industries/energy/energy_programs/demand_side_management/ee_and_energy_savings_assist/caevaluationframework.pdf

[170] International Measurement and Verification Protocol (IPMVP) available at https://evo-world.org/en/products-services-mainmenu-en/protocols/ipmvp
[171] ASHRAE Guideline 14-2014. Available at https://webstore.ansi.org/standards/ashrae/ashraeguideline142014

Field Code Changed

Field Code Changed

~~e value.~~