New Mexico Technical Resource Manual for the Calculation of Energy Efficiency Savings

Prepared for the New Mexico Public Regulation Commission

Final

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Table of Contents

1. Introduction

The intent of this Technical Reference Manual (TRM) is to provide a transparent and consistent basis for calculating energy (kWh or therms), and demand (kW) savings generated by the State of New Mexico's energy efficiency programs. In addition, estimated measure lives and measure costs are provided to assist with calculations of measure cost-effectiveness. The TRM is developed based on input from the following four investor-owned utilities:

- Southwestern Public Service Company (SPS)
- El Paso Electric (EPE)
- Public Service Company of New Mexico (PNM)
- New Mexico Gas Company (NMGC)

Measure savings were derived from existing work. Information was taken from the following data sources, listed in order of importance:

- Workpapers of the New Mexico investor-owned utilities
- Evaluations of the New Mexico utilities' programs conducted by the statewide evaluator
- California's Database for Energy Efficiency Resources (DEER)
- TRMs from other states
- The US Department of Energy (DOE)
- ENERGY STAR®
- Other sources cited in the individual documentation

Section 2 provides a discussion of parameters that are common to all measures, including both climate zones and building types. The remaining sections of the TRM are organized by measure. The following information is provided for each of the measures included in the TRM:

- Measure overview
- Savings summary
- Energy savings estimation
- Demand savings estimation
- Non-energy benefits
- Measure life
- Incremental cost

Default values are provided for various parameters throughout the TRM. These defaults are to be used when project-specific information cannot be gathered (e.g., upstream programs, retrofits of very old equipment). However, site-specific inputs should be used whenever possible to maximize the accuracy of savings estimates. During program evaluations, any available site-specific data will be used to calculate savings.

Utilities may choose to perform custom calculations in lieu of the methods presented in the TRM. This is acceptable as long as the custom calculations are performed according to industry-accepted modeling systems and practices and use site-specific data whenever possible. Custom calculations will be reviewed during program evaluations and will be compared to TRM calculations to determine the most accurate estimate of savings.

Additional parameters needed to determine net measure savings – installation rates and net-to-gross ratios (NTGRs), are not provided in this manual. These parameters are to be determined through program evaluations.

2. Common Parameters

2.1 Climate Zones

For this TRM, New Mexico is divided into four climate zones. Heating and cooling degree-days and other weather parameters for the four zones are based on the representative cities shown in Table 1. Degree-days were taken from National Oceanic and Atmospheric Administration (NOAA) 30-year averages for the four cities (at the location designated by "Station Name" in Table 1).

Table 1: New Mexico Climate Zones

Representative City	Station Name	Heating Degree-days (65 °F base)	Cooling Degree-days (65 °F base)
Albuquerque	ALBUQUERQUE INTERNATIONAL AIRPORT	4,180	1,322
Las Cruces	NEW MEXICO STATE UNIVERSITY	2,816	1,899
Roswell	ROSWELL INDUSTRIAL AIR PARK	3,289	1,790
Santa Fe	SANTA FE CO MUNICIPAL AIRPORT	5,417	645

While Las Cruces has a higher value for cooling degree days (CDD) than Roswell, Roswell has greater humidity, resulting in a higher air-conditioning demand. For hours with a dry-bulb temperature greater than 75 °F, the average relative humidity in Roswell is 29%, while that in Las Cruces is 23%, according to TMY3 data.

Distribution of New Mexico locations into the four climate zones is based on the map published by the International Energy Conservation Code (IECC),[1] with the following exceptions:

- Roswell is the representative city of a climate zone separate from Albuquerque – the IECC has Roswell in the Albuquerque climate zone
- In some cases, counties are assigned to climate zones based on demographics more than geography. For example, Sandoval County is assigned to the Albuquerque

[1] https://codes.iccsafe.org/content/IECC2021P1/chapter-3-ce-general-requirements

climate zone rather than the Santa Fe zone because most of the population of the county lives near Albuquerque.

Table 2 shows the assignment of county to weather zone.

Table 2: Weather Zones by County

County	Weather Zone City
Bernalillo	Albuquerque
Catron	Santa Fe
Chaves	Roswell
Cibola	Albuquerque
Colfax	Santa Fe
Curry	Roswell
De Baca	Albuquerque
Doña Ana	Las Cruces
Eddy	Roswell
Grant	Albuquerque
Guadalupe	Albuquerque
Harding	Santa Fe
Hidalgo	Las Cruces
Lea	Roswell
Lincoln	Albuquerque
Los Alamos	Santa Fe
Luna	Las Cruces
McKinley	Santa Fe
Mora	Santa Fe
Otero	Las Cruces
Quay	Albuquerque
Rio Arriba	Santa Fe
Roosevelt	Roswell
San Juan	Santa Fe
San Miguel	Santa Fe
Sandoval	Albuquerque
Santa Fe	Santa Fe

County	Weather Zone City
Sierra	Las Cruces
Socorro	Albuquerque
Taos	Santa Fe
Torrance	Santa Fe
Union	Albuquerque
Valencia	Albuquerque

2.2 Building Types

Residential measures are either applicable to all residences or, in some cases, to one of the following building types:

- Single-family
- Multi-family
- Manufactured home

Commercial measures are often broken out by building type. The selection of building types used here is primarily based on the DEER categories. Utilities may use additional building types, with the proviso that the source for additional building types be well-documented. Utilities may also wish to combine DEER building types. Table 3 shows the building types and their saturations, which can be used to derive weighted average values when combining building types.

The multi-family segment overlaps between the residential and commercial measures. For example, in-unit measures would likely be considered residential, while common area and exterior measures would likely be considered commercial. Multi-family projects may use measures from both the residential and commercial portions of this TRM, as is appropriate.

Table 3: DEER 2008 Building Types

Building Type	Abbreviation	Prevalence
Commercial	Com	100.00%
Assembly	Asm	6.10%
Education - Primary School	EPr	2.60%
Education - Secondary School	Ese	2.50%
Education - Community College	ECC	2.30%
Education - University	EUn	2.30%
Education - Relocatable Classroom	ERC	2.50%
Grocery	Gro	4.20%
Health/Medical - Hospital	Hsp	2.20%
Health/Medical - Nursing Home	Nrs	2.20%
Lodging - Hotel	Htl	2.20%
Lodging - Motel	Mtl	2.20%
Manufacturing - Bio/Tech	MBT	5.90%
Manufacturing - Light Industrial	MLI	5.90%
Office - Large	OfL	17.00%
Office - Small	OfS	5.10%
Restaurant - Sit-Down	RSD	1.40%
Restaurant - Fast-Food	RFF	1.40%
Retail - 3-Story Large	Rt3	5.50%
Retail - Single-Story Large	RtL	5.30%
Retail - Small	RtS	5.30%
Storage - Conditioned	SCn	7.40%
Storage - Unconditioned	SUn	7.40%
Storage - Refrigerated Warehouse	WRf	0.80%

2.3 Early Retirement

The equations and default parameters throughout the TRM are based on a time of sale or replace on burnout scenario. In these cases, the prevailing energy code is used to set the baseline efficiency. However, real world scenarios can include customers replacing equipment prior to the end of its useful life while it is still functioning properly.

Starting in 2021, this section of the TRM provides the allowance (but not requirement) of early retirement replacements for HVAC, appliances, and domestic hot water equipment. During an early retirement scenario, program administrators are allowed to use the in-situ baseline for the remaining useful life (RUL) of the baseline equipment, and then transition to a code required baseline for the balance of the useful life of the installed equipment. The RUL of the equipment will be equal to one third of the expected useful life (EUL) of the installed equipment.

For example, residential furnaces (Measure 4.10) have an EUL of 15 years. Under an early retirement scenario, the savings relative to the in-situ baseline are claimed for the first 5 years (5 = 1/3 * 15), and the savings relative to the code required equipment are claimed for the remaining 10 years.

The burden of proof to claim a particular project as early retirement falls to the program administrator. The selected evaluator is also responsible for validating that early retirement scenarios are applied appropriately for the various programs. If sufficient data to substantiate early retirement claims is not available, the standard efficiency presented in the TRM should be used. To be eligible for early retirement savings, the program administrator should:

1. For large individual projects, such as large commercial or industrial equipment, provide detailed project level documentation to substantiate the input parameters, such as efficiency, used in an early retirement calculation. This could include operational data or calculations, equipment specifications, or measured data.

2. For smaller projects, there must be validation from customers or trade allies that the existing equipment was in proper working condition, and there must be a reasonable estimate of the equipment's efficiency. Large scale application of a typical in-situ efficiency assumption, for example with a midstream hot water heater program, will be reviewed on a case-by-case basis between the program administrator and their evaluator.

3. Savings for early retirement projects should be tracked separately within program administrator tracking systems to allow for careful evaluation of early retirement savings if warranted by evaluators. The remaining useful life, expected useful life, first year savings relative to the in-situ baseline, and later savings relative to the code baseline should all be included in tracking systems.

4. The maximum allowable remaining useful life for any measure is one third of the installed equipment expected useful life.

The code or standard practice baseline used for the adjusted savings should be equal to the code requirements outlined in the current version of the TRM. Incremental costs for early retirement measures are the full measure replacement costs.

3. Commercial Measures

3.1 Low-flow Faucet Aerator

This measure saves water heating energy by reducing the consumption of hot water.

3.1.1 Measure Overview

Sector	Commercial
End use	Water heating
Fuel	Electricity and Natural Gas
Measure category	Low-flow faucet aerators
Delivery mechanism	Direct Install
Baseline description	Federal standard 2.2 GPM or average existing conditions if higher than 2.2 GPM
Efficient case description	0.5 gpm 1.0 gpm

3.1.2 Savings

The measure applies only to certain facility types, as shown in Table 4 and Table 5. The savings below are per aerator for different climate zones in New Mexico. For kit-based programs and programs for which the water heating fuel is unknown, multiply the savings listed below with the type of water-heating system fuel type percentage and the in-service rates provided in the next section. The savings listed in Table 4, Table 5, and Table 6 do NOT include the Fuel% or ISR parameters.

For facilities with gas-fired water heaters, energy savings (in therms) from this measure are listed below.

Table 4: Commercial Low-flow Faucet Aerator Savings (therms)

	Albuquerque		Las Cruces		Roswell		Santa Fe	
Facility Type	**0.5 gpm**	**1.0 gpm**	**0.5 gpm**	**1.0 gpm**	**0.5 gpm**	**1.0 gpm**	**0.5 gpm**	**1.0 gpm**
Prison	48.8	34.5	36.1	25.4	37.4	26.4	58.7	41.5
Hospital, Nursing Home	4.9	3.4	3.6	2.5	3.7	2.6	5.9	4.1
Dormitory	36.7	25.9	27.1	19.1	28.1	19.8	44.1	31.1
Hospitality	4.9	3.4	3.6	2.5	3.7	2.6	5.9	4.1
Commercial	34.9	24.7	25.8	18.2	26.7	18.9	42.0	29.6
Middle or High School	18.4	11.3	13.6	8.4	14.1	8.7	22.1	13.6
Elementary School	8.3	5.1	6.1	3.8	6.3	3.9	10.0	6.1

Electric savings for facilities with electric water heaters are shown in Table 5.

Table 5: Commercial Low-flow Faucet Aerator Savings (kWh)

	Albuquerque		Las Cruces		Roswell		Santa Fe	
Facility Type	**0.5 gpm**	**1.0 gpm**	**0.5 gpm**	**1.0 gpm**	**0.5 gpm**	**1.0 gpm**	**0.5 gpm**	**1.0 gpm**
Prison	1,169	825	863	609	895	632	1,405	992
Hospital, Nursing Home	117	82	86	61	89	63	141	99
Dormitory	877	619	647	457	672	474	1,055	745
Hospitality	117	82	86	61	89	63	141	99
Commercial	836	590	617	435	640	452	1,005	709
Middle or High School	441	271	325	200	338	208	530	326
Elementary School	198	122	146	90	152	93	238	147

Electric demand savings are shown in Table 6.

Table 6: Commercial Low-flow Faucet Aerator Demand Savings (kW)

	Albuquerque		Las Cruces		Roswell		Santa Fe	
Facility Type	**0.5 gpm**	**1.0 gpm**	**0.5 gpm**	**1.0 gpm**	**0.5 gpm**	**1.0 gpm**	**0.5 gpm**	**1.0 gpm**
Prison	0.1409	0.0994	0.1040	0.0734	0.1079	0.0762	0.1694	0.1196
Hospital, Nursing Home	0.0922	0.0651	0.0681	0.0480	0.0706	0.0498	0.1109	0.0783
Dormitory	0.1409	0.0994	0.1040	0.0734	0.1079	0.0762	0.1694	0.1196
Hospitality	0.0038	0.0027	0.0028	0.0020	0.0029	0.0021	0.0046	0.0033
Commercial	0.0820	0.0579	0.0605	0.0427	0.0628	0.0443	0.0985	0.0696
Middle or High School	0.1410	0.0868	0.1041	0.0641	0.1080	0.0665	0.1696	0.1043
Elementary School	0.0470	0.0289	0.0347	0.0214	0.0360	0.0222	0.0565	0.0348

3.1.3 Energy Savings Estimation

Savings are derived with the following formula.[2]

$$Svgs = \frac{(FlowPre - FlowPost) \times (\mathrm{TempUsage} - \mathrm{TempCold}) \times Minutes \times Days \times HeatCapacity \times Density \times Const \times Fuel\% \times ISR}{EffDHW}$$

Where:

Svgs = Annual energy savings, in therms

FlowPre = Baseline flow rate, depends on facility type, see Table 7, gpm

FlowPost = Measure flow rate, either 0.5 gpm or 1.0 gpm

$Temp_{Usage}$ = Temperature of water coming out of faucet, 87.8°F[3]

$Temp_{Cold}$ = Temperature of inlet water, see Table 8

[2] ADM Associates, Evaluation of 2011 DSM Portfolio, New Mexico Gas Company, 2012, citing CLEAResult Workpaper, "Low Flow Aerators – 0.5[1.0] gpm"

[3] According to Cadmus report "Michigan Evaluation Working Group Showerhead and Faucet Aerator Meter Study", the average usage temperature for faucets is 87.8 °F.

Minutes	= Minutes per day faucet is used, depends on facility type, see Table 7
Days	= Days per year faucet is used, depends on facility type, see Table 7
HeatCapacity	= Heat capacity of water, 1 Btu per pound per °F
Density	= Density of water, 8.33 pounds per gallon
Const	= Constant, 1 therm/100,000 Btus, or 0.00029307107 kWh/Btu
EffDHW	= Thermal efficiency of water heater, 0.80 for gas, or 98% for electric
Fuel%	= Percentage split between gas, electric and propane water heating. When water heating fuel is known, use 100%. For kit-based and other program types for which the water heating fuel is not known, use territory-specific percentages. If territory-specific values are not known, use default values of 50% gas and 50% electricity.[4]
ISR	= In-service rate, representing the proportion of distributed showerheads which are actually installed. For direct-install and downstream programs, use 1. For kit-based programs, use a territory-specific value. If a territory-specific value is not known, use a default value of 0.95.[5]

Values for facility-dependent parameters are shown in Table 7.

Table 7: Commercial Low-flow Faucet Aerator Facility-dependent Parameters

Facility Type	Baseline flow rate (gpm)	MinsPerDay	DaysPerYear
Prison	2.2	30	365
Hospital, Nursing Home	2.2	3	365
Dormitory	2.2	30	274
Hospitality	2.2	3	365
Commercial	2.2	30	261
Middle or High School	1.8	30	180

4 US Energy Information Administration. https://www.eia.gov/consumption/commercial/data/2012/bc/cfm/b31.php The percentages shown are based on the West Mountain region in the table.

5 Illinois Technical Reference Manual, measure 4.3.2

Facility Type	Baseline flow rate (gpm)	MinsPerDay	DaysPerYear
Elementary School	1.8	13.5	180

Table 8: Inlet Water Temperature[6]

City	Temperature Cold (°F)
Albuquerque	62.6
Las Cruces	69.2
Roswell	68.5
Santa Fe	57.5

Parameter values are based on the following sources.[7]

Table 9: Commercial Low-flow Faucet Aerator Parameter Sources

Baseline flow rate	Maximum flow rate federal standard for lavatories and aerators set in Federal Energy Policy Act of 1992 and codified at 2.2 gpm at 60 psi in 10 CFR 430.32.
Baseline flow rate	For schools, field data from school installs in Santa Fe and Albuquerque showed an average initial flow rate of 1.8 gpm
Measure flow rate	Product search shows many products available that cost-effectively ($2 per aerator) meet 1.0 gpm specification. ConservationWarehouse.com
Temperature Usage	According to Cadmus report "Michigan Evaluation Working Group Showerhead and Faucet Aerator Meter Study", the average usage temperature for faucets is 87.8 °F.
Days per year	365 for facilities that operate year-round; 365 x (5/7) = 261 for commercial facilities open weekdays; 180 for schools open weekdays except summer; 365 x (9/12) = 274 for dormitories with few occupants in the summer
Minutes per day	Three minutes per day is assumption for private lavatories used in hotel guest rooms, hospital patient rooms, nursing homes; Connecticut UI and CLP Program Savings Documentation, September 25, 2009 uses assumption of 3 faucets per household and 1 minute per faucet; Thirty minutes per day faucet use for

[6] Average annual cold water temperatures for each city were calculated using Equation 4 in the Department of Energy's "Building America Performance Analysis Procedures for Existing Homes" (https://www.nrel.gov/docs/fy06osti/38238.pdf). Ambient temperatures were taken from TMY3 data for each city.

[7] Ibid

	commercial lavatories from Federal Energy Management Program Energy Cost Calculator for Faucets and Showerheads (reference also used in the Massachusetts TRM), default for aerators in commercial applications. For schools, an initial assumption was made that a faucet runs for 30 minutes per day based on an initial assumption that there are 20 students to each faucet in a school. Field data acquired in fourteen elementary schools in Santa Fe and Albuquerque has shown that on average there is one faucet for every 9 students in an elementary school, partially due to additional faucets in classrooms. Minutes per faucet reflect that data (applying 9/20 ratio to 30 minutes). Limited data for middle and high schools (two middle schools and one high school) shows 22 students per aerator, consistent with the initial assumption of 30 minutes per faucet.
Thermal efficiency of water heater	Minimum federal standard (69 CFR 203, 10-21-2004) for a new commercial gas water heater (gas storage water heater 100 gallon or larger capacity)

3.1.4 Demand Savings Estimation

Demand savings are calculated using the following formula:

$$Svgs = (\Delta kWh / Hours) * CF$$

Where:

Svgs = Annual demand savings, in kW

ΔkWh = Calculated value above for electric energy savings

Hours = Minutes x Days x (1 hour / 60 minutes), see Table 7

CF = Coincidence factor for electric load reduction, see Table 10

Table 10: Coincidence Factor[8]

City	Coincidence Factors
Prison	0.0220
Hospital, Nursing Home	0.0144
Dormitory	0.0220

[8] Values taken from measure 4.3.2 in Illinois Technical Reference Manual version 7.0.

Hospitality	0.0006
Commercial	0.0128
Middle or High School	0.0288
Elementary School	0.0096

3.1.5 Non-energy Benefits

Water savings are shown in Table 11. Local water and wastewater rates need to be applied to these values to monetize savings.

Table 11: Commercial Low-flow Faucet Aerator Water Savings (gallons)

Facility Type	0.5 gpm Water Savings	1.0 gpm Water Savings
Prison	18,615	13,140
Hospital, Nursing Home	1,862	1,314
Dormitory	13,974	9,864
Hospitality	1,862	1,314
Commercial	13,311	9,396
Middle or High School	7,020	4,320
Elementary School	3,159	1,944

3.1.6 Measure Life

The lifetime for this measure is 10 years. [9]

3.1.7 Incremental Cost

The incremental cost for this measure is the total cost. The cost per direct-installed commercial aerator is $10. [10]

[9] DEER 2014 EUL Table

[10] SBW Consulting, Direct-install program operator, 2013

3.2 Pre-rinse Spray Valves

3.2.1 Measure Overview

Sector	Commercial
End use	Water heating
Fuel	Electricity and Natural Gas
Measure category	Low-flow pre-rinse spray valves
Delivery mechanism	Direct Install (retrofit)
Baseline description	Either federal standards or average existing conditions
Efficient case description	1.25 gpm

3.2.2 Savings

The measure applies only to certain facility types, as shown in Table 12.

Table 12: Commercial Low-flow Pre-rinse Spray Valve Savings (therms or kWh per year)

Facility Type	Therms/ year per unit	kWh/ year per unit
Restaurant	175	4,178
Fast Food	36	858
Prison	482	11,525
Hospital	482	11,525
Nursing Home	482	11,525
University Dining Hall	362	8,651
School	119	2,842

3.2.3 Energy Savings Estimation

Savings are derived with the following formula. [11]

[11] ADM Associates, Evaluation of 2011 DSM Portfolio, New Mexico Gas Company, 2012, citing CLEAResult Workpaper, "Low Flow Pre-Rinse Spray Valve"

$$Svgs = \frac{((FlowPre \times UsagePre) - (FlowPost \times UsagePost)) \times DeltaT \times Days \times Const}{EffDHW}$$

Where:

Svgs	= Annual energy savings, in therms or kWh
FlowPre	= Baseline flow rate, 2.25 gpm
UsagePre	= Baseline usage duration, depends on facility type, see Table 13, minutes per day
FlowPost	= Measure flow rate, 1.25 gpm
UsagePost	= Measure usage duration, depends on facility type, see Table 13, minutes per day
DeltaT	= Temperature difference between hot and cold water, see Table 13, °F
Days	= Days per year faucet is used, depends on facility type, see Table 13
Const	= Constant, 8.33 therms/100,000 gallons per °F for gas, or 8.33 Btu/gallon per °F/0.000293071 kWh/Btu for electric
EffDHW	= Thermal efficiency of water heater, 0.80 for gas, 98% for electric

Values for facility-dependent parameters are shown in Table 13.

Table 13: Commercial Low-flow Pre-rinse Spray Valve Facility-dependent Parameters

Facility Type	Baseline Usage (mins/day)	Measure Usage (mins/day)	Delta T (°F)	Days Per Year
Restaurant	76.2	80.6	65	365
Fast Food	32.4	43.8	52	365
Prison	210	222	65	365
Hospital	210	222	65	365
Nursing Home	210	222	65	365
Dormitory	210	222	65	274
School	105	111	65	180

Parameter values are based on the sources listed in Table 14. [12]

Table 14: Commercial Low-flow Pre-rinse Valve Parameter Sources

Average baseline flow rate of sprayer	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
Average post measure flow rate of spray head	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 3-5, p. 23
Baseline water usage duration	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 3-6, p. 24
	City of Calgary Pre-Rinse Spray Valve Pilot Study, Veritec Consulting Inc., 2005, Table 1, p.7
	CEE Guidance for Pre-Rinse Spray Valves gives 3.0 – 4.0 hours per day operation for institutional applications, averaging at 3.5 hours (210 minutes) per day; apply restaurant ratio of post to pre- retrofit usage (80.6/76.2) to calculate post-retrofit usage of 222 minutes per day
	Assuming that institutions (i.e. prisons, hospitals, nursing homes) are serving three meals a day, prorate schools by 1.5 to 3 (assuming schools serve breakfast to half of the students and lunch to all), yielding 105 minutes per day pre-retrofit, apply restaurant ratio of post to pre- retrofit usage (80.6/76.2) to calculate post-retrofit usage of 111minutes per day
Post measure water usage duration	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 3-5, p. 23
	CEE Commercial Kitchen Initiative Program Guidance on Pre-Rinse Spray Valves, p. 3
	CEE Guidance for Pre-Rinse Spray Valves gives 3.0 – 4.0 hours per day operation for institutional applications, averaging at 3.5 hours (210 minutes) per day; apply restaurant ratio of post to pre- retrofit usage (80.6/76.2) to calculate post-retrofit usage of 222 minutes per day
	Assuming that institutions (i.e. prisons, hospitals, nursing homes) are serving three meals a day, prorate schools by 1.5 to 3 (assuming schools serve breakfast to half of the students and lunch to all), yielding 105 minutes per day pre-retrofit, apply restaurant ratio of post to pre- retrofit usage (80.6/76.2) to calculate post-retrofit usage of 111minutes per day

[12] Ibid

Facility operating days per year	365 for facilities that operate year round; 180 for schools open weekdays except summer, 365 x (9/12) = 274 for dormitories with few occupants in the summer
Average temperature differential between hot and cold water	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 3-5, p. 23
	CEE Commercial Kitchen Initiative Program Guidance on Pre-Rinse Spray Valves, p. 3
	Applying temperature differential for restaurants to institutions and schools
Efficiency of gas water heater	Minimum federal standard (69 CFR 203, 10-21-2004) for a new commercial gas water heater (gas storage water heater 100 gallon or larger capacity)

3.2.4 Demand Savings Estimation

There are no demand savings associated with this measure.

3.2.5 Non-energy Benefits

Water savings are shown in Table 15. Local water and wastewater rates need to be applied to these values to monetize savings.

Table 15: Commercial Low-flow Pre-rinse Valve Water Savings (gallons)

Facility Type	Gallons/Year
Restaurant	25,806
Fast Food	6,625
Prison	71,175
Hospital	71,175
Nursing Home	71,175
Dormitory	53,430
School	17,550

3.2.6 Measure Life

The effective life for this measure is five years.[13]

3.2.7 Incremental Cost

The incremental cost for this measure is the total cost. The cost per direct-installed pre-rinse spray valve is $130.[14]

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13 *Final Report for California Urban Water Conservation Council 2004-5 Pre-Rinse Spray Valve Installation Program (Phase 2),* SBW Consulting, 2007, p. 30

14 SBW Consulting, direct-installation program operator actual cost, including $34 per spray valve; CUWCC Cost and Savings Update

3.3 Lighting – Retrofit

This measure category applies to upgrades to lighting fixtures or lamps in existing facilities, which are not part of a major remodel that requires the newly installed lighting to meet building energy codes. In general, these are considered early replacement measures, where the baseline is the pre-existing conditions. An exception is where incandescent lamps are replaced; the baseline in this case is minimum federal standards. The lighting retrofit measure category applies to reductions in lighting wattage; savings due to lighting controls are calculated separately after lighting wattage savings are determined.

3.3.1 Measure Overview

Sector	Commercial
End use	Lighting
Fuel	Electricity
Measure category	Lighting - retrofit
Delivery mechanism	Rebate
Baseline description	Either federal standards, existing conditions, or average existing conditions
Efficient case description	Fixtures or lamps with lower wattage than the baseline

3.3.2 Savings

High-performance and reduced-watt T8 linear fluorescent lamps need to be qualified by the Consortium for Energy Efficiency (CEE). Their respective ballasts need to be qualified by NEMA.LED lamps and fixtures must be qualified and listed by at least one of the following organizations: DesignLights Consortium (DLC), ENERGY STAR®, or DOE LED Lighting Facts. At the utilities' discretion, LED products not listed on a qualified products list (QPL) may receive approval if results of independent lab testing show the products comply with the Minimum Efficacy (lm/W) and L_{70} requirements listed in the most current version of the DLC Technical Requirements. In addition, when a product is non-qualified, such as in the case of a product for which a qualification category has not been established, then a custom approach may be used. If a utility chooses to approve a non-qualified LED, they must clearly demonstrate how any non-qualified aspects of the product have been accounted for (e.g., applying a shorter measure life).

Allowable methods of deriving savings are described in the following sections.

3.3.3 Energy Savings Estimation

Lighting energy savings per fixture or lamp are derived with the following formula.

$$Svgs = (kW_{PRE} - kW_{POST}) \times OperatingHours \times HVAC_{Ener\quad Factor}$$

Where:

Svgs	= Annual energy savings, in kWh
kW_{PRE}	= Wattage of the baseline lamp (divided by 1000)
kW_{POST}	= Wattage of the installed lamp (divided by 1000)
OperatingHours	= Annual hours the lamp is on, see Table 16 & Table 17 below
HVAC_Energy_Factor	= Adjustment to lighting savings to account for the decreased cooling load, see Table 18

The parameters in this equation can be derived with three general methods:

1. Prescriptive
2. Partial-prescriptive
3. Custom

The prescriptive methodology specifies measure descriptions, with baseline and efficient-case wattages embedded in the measure. An example is replacement of 8 ft. T-12 magnetic ballast fixtures with 8 ft. T-8 electronic ballast fixtures. Pre and post wattages are pre-determined as part of the measure definition. Also, part of the measure definition is annual operating hours, which vary by building type.

A partial-prescriptive methodology allows selection of pre and post fixtures or lamps from a wattage table. Certain restrictions apply, e.g., T-12 lamps are not allowed in the post case, but the general requirement is simply that the selections save energy. Operating hours can either be based on building type or be derived from a user-entered schedule.

The custom method allows wattages to be based on product cut sheets and hours to be based on user-entered schedules.

The HVAC Energy Factor is pre-determined in all cases according to building type (see below).

Wattage Sources

Utilities have flexibility in the sources for the wattage table, but the following restrictions apply.

- Source tables must be published by established and well-known sources and be provided or freely available via website.
- Sources for the table must be clearly shown.
- Incandescent baseline lamp wattages must be equivalent to federal standards for the year the measure is implemented.
- T-12 lamps and magnetic ballasts are permitted as retrofit baselines for the foreseeable future.
- Replacement ballasts must be electronic.

The following are recommended sources for the wattage table. These tables have been publicly reviewed and approved by state regulatory commissions. The most current version of these tables for the year the measure is implemented shall be used.

- California DEER
- New York Device Codes and Rated Lighting System Wattage Table
- Massachusetts Device Codes and Rated Lighting System Wattage Table - Retrofit
- Pennsylvania TRM Appendix C Lighting Inventory Tool
- State of Illinois Energy Efficiency Technical Reference Manual

Using the custom methodology, efficient fixture wattages can be specified by manufacturer's cut sheets, which are submitted with the application.

Operating Hours

Prescriptive hours are derived from DEER 2014 by facility type. Table 16 shows the building weighted average DEER 2014 commercial lighting operating hours. Additional building types are allowed, with the constraint that the operating hours must be taken from a published recognized source. As an alternative to using the building weighted average operating hours, hours can be assigned on an area-type basis, as shown in Table 17. If using the area-type method, an additional category of "Safety," or "Always on" can be assigned to any of the building types for lights which operate 8760 hours per year. One method or the other should be used for all hours assigned to a given facility. When sufficient information exists, using hours on an area-type basis is preferred to using building weighted average hours.

Site-specific custom hours may be used if they are determined using metering or other documented site-specific information (e.g., published hours, customer interviews). Custom operating hours must be derived from a user-entered schedule rather than a single entry for annual hours. The schedule must include entries for weekdays, Saturdays, Sundays, and holidays, and must note whether or not there is seasonal variation in the schedule.

Table 16: DEER 2014 Commercial Lighting Hours of Use – Building Weighted Average

Lighting Hours of Use	Indoor	Indoor	Outdoor[15]	Saturation
Building Type	**Other**	**Screw-In Bulb**	**All**	
Assembly	2,611	2,300	4,192	6.1%
Education - Primary School	2,140	2,240	4,192	2.6%
Education - Secondary School	2,280	2,330	4,192	2.5%
Education - Community College	2,420	2,420	4,192	2.3%
Education - University	2,350	2,370	4,192	2.3%
Education - Relocatable Classroom	2,480	2,600	4,192	2.5%
Grocery	4,910	3,890	4192	4.2%
Health/Medical - Hospital	5,260	4,200	4,192	2.2%
Health/Medical - Nursing Home	4,160	3,570	4,192	2.2%
Lodging - Hotel	1,950	1,670	4,192	2.2%
Lodging - Motel	1,550	1,370	4,192	2.2%
Manufacturing - Bio/Tech	3,530	3,090	4,192	5.9%
Manufacturing - Light Industrial	3,220	2,580	4,192	5.9%
Office - Large	2,640	3,000	4,192	17.0%
Office - Small	2,590	2,980	4,192	5.1%
Restaurant - Sit-Down	4,830	4,830	4,192	1.4%
Restaurant - Fast-Food	4,840	4,810	4,192	1.4%
Retail - 3-Story Large	3,380	3,710	4,192	5.5%
Retail - Single-Story Large	4,270	4,350	4,192	5.3%
Retail - Small	3,380	4,010	4,192	5.3%
Storage - Conditioned	3,420	2,760	4,192	7.4%
Storage - Unconditioned	3,420	2,760	4,192	7.4%
Storage - Refrigerated Warehouse	4,770	4,730	4,192	0.8%

[15] Outdoor lighting hours of use is based on the darkness hours provided in the US Naval Observatory (https://aa.usno.navy.mil/data/Dur_OneYear). Also, according to EPE's 2017 metering of streetlights, exterior lights controlled by a photocell turn on approximately 10 minutes after sunset, and turn off approximately 10 minutes before sunrise. The above outdoor lighting hours is the average value for Albuquerque, Roswell, Las Cruces and Santa Fe.

Lighting Hours of Use	Indoor	Indoor	Outdoor[15]	Saturation
Building Type	**Other**	**Screw-In Bulb**	**All**	
Commercial - general[16]	3,175	3,050	4,192	100%

Table 17: DEER Equivalent Full Load Hours for Screw-in Bulbs and Non-screw-in Fixtures – Area-Type

Building Type	Space Use	Other	Screw-In Bulbs
Assembly	Whole Building		
Assembly	Auditorium	2,601	2,304
Assembly	Office (General)	3,395	2,351
Education - Primary School	Whole Building		
Education - Primary School	Classroom/Lecture	2,415	2,484
Education - Primary School	Exercising Centers and Gymnasium	2,025	2,273
Education - Primary School	Dining Area	1,330	1,429
Education - Primary School	Kitchen and Food Preparation	1,648	1,724
Education - Secondary School	Whole Building		
Education - Secondary School	Classroom/Lecture	2,400	2,443
Education - Secondary School	Office (General)	2,280	2,297
Education - Secondary School	Exercising Centers and Gymnasium	2,322	2,372
Education - Secondary School	Computer Room (Instructional/PC Lab)	2,097	2,363
Education - Secondary School	Dining Area	2,321	2,336
Education - Secondary School	Kitchen and Food Preparation	1,146	1,269
Education – Relocatable Classroom	Whole Building	2,480	2,600
Education - Community College	Whole Building		
Education - Community College	Classroom/Lecture	2,705	2,777
Education - Community College	Office (General)	2,878	2,723

[16] This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g., a medical administration building could potentially be assessed using the "Office – Small" lighting hours).

Building Type	Space Use	Other	Screw-In Bulbs
Education - Community College	Computer Room (Instructional/PC Lab)	2,396	2,788
Education - Community College	Comm/Ind Work (General, Low Bay)	3,369	2,906
Education - Community College	Dining Area	2,824	2,778
Education - Community College	Kitchen and Food Preparation	3,237	2,759
Education - University	Whole Building		
Education - University	Classroom/Lecture	2,419	2,623
Education - University	Office (General)	2,753	2,550
Education - University	Computer Room (Instructional/PC Lab)	2,275	2,733
Education - University	Comm/Ind Work (General, Low Bay)	2,973	2,677
Education - University	Dining Area	2,842	2,620
Education - University	Kitchen and Food Preparation	2,947	2,726
Education - University	Hotel/Motel Guest Room (incl. toilets)	1,147	1,155
Education - University	Corridor	2,851	2,670
Grocery	Whole Building		
Grocery	Retail Sales, Grocery	4,988	3,956
Grocery	Office (General)	4,548	3,517
Grocery	Comm/Ind Work (Loading Dock)	4,988	3,956
Grocery	Refrigerated (Food Preparation)	4,402	3,517
Grocery	Refrigerated (Walk-in Freezer)	4,402	3,517
Grocery	Refrigerated (Walk-in Cooler)	4,402	3,517
Health/Medical - Hospital	Whole Building		
Health/Medical - Hospital	Office (General)	5,250	4,333
Health/Medical - Hospital	Dining Area	6,312	4,586
Health/Medical - Hospital	Kitchen and Food Preparation	6,312	4,586
Health/Medical - Hospital	Laboratory, Medical	4,587	3,544
Health/Medical - Hospital	Medical and Clinical Care	5,595	4,436
Health/Medical - Nursing Home	Whole Building		

Building Type	Space Use	Other	Screw-In Bulbs
Health/Medical - Nursing Home	Hotel/Motel Guest Room (incl. toilets)	4,269	3,526
Health/Medical - Nursing Home	Office (General)	3,640	3,465
Health/Medical - Nursing Home	Corridor	7,708	4,705
Health/Medical - Nursing Home	Dining Area	3,729	3,519
Health/Medical - Nursing Home	Kitchen and Food Preparation	3,729	3,519
Lodging - Hotel	Whole Building		
Lodging - Hotel	Hotel/Motel Guest Room (incl. toilets)	793	804
Lodging - Hotel	Corridor	7,828	5,949
Lodging - Hotel	Dining Area	3,460	3,127
Lodging - Hotel	Kitchen and Food Preparation	4,492	3,663
Lodging - Hotel	Bar, Cocktail Lounge	3,793	3,295
Lodging - Hotel	Lobby (Hotel)	7,828	5,949
Lodging - Hotel	Laundry	4,124	3,608
Lodging - Hotel	Office (General)	3,293	3,024
Lodging - Motel	Whole Building		
Lodging - Motel	Hotel/Motel Guest Room (incl. toilets)	702	679
Lodging - Motel	Office (General)	5,450	5,516
Lodging - Motel	Laundry	4,381	4,236
Lodging - Motel	Corridor	6,954	5,516
Manufacturing - Bio/Tech	Whole Building		
Manufacturing - Bio/Tech	Laboratory, Medical	2,834	2,306
Manufacturing - Bio/Tech	Office (General)	2,865	2,306
Manufacturing - Bio/Tech	Corridor	6,252	6,185
Manufacturing - Bio/Tech	Computer Room (Mainframe/Server)	2,737	2,306
Manufacturing - Bio/Tech	Dining Area	2,737	2,513
Manufacturing - Bio/Tech	Kitchen and Food Preparation	2,737	2,342
Manufacturing - Bio/Tech	Conference Room	3,303	2,362

Building Type	Space Use	Other	Screw-In Bulbs
Manufacturing - Light Industrial	Whole Building		
Manufacturing - Light Industrial	Comm/Ind Work (General, High Bay)	3,156	2,574
Manufacturing - Light Industrial	Storage (Unconditioned)	3,473	2,606
Office - Large	Whole Building		
Office - Large	Office (Open Plan)	2,630	2,951
Office - Large	Office (Executive/Private)	2,630	2,951
Office - Large	Corridor	2,630	3,675
Office - Large	Lobby (Office Reception/Waiting)	2,681	3,675
Office - Large	Conference Room	2,681	1,568
Office - Large	Copy Room (photocopying equipment)	2,681	3,675
Office - Large	Restrooms	2,681	3,675
Office - Large	Mechanical/Electrical Room	2,681	1,568
Office - Small	Whole Building		
Office - Small	Office (Executive/Private)	2,590	2,965
Office - Small	Corridor	2,590	3,249
Office - Small	Lobby (Office Reception/Waiting)	2,590	3,826
Office - Small	Conference Room	2,590	1,505
Office - Small	Copy Room (photocopying equipment)	2,590	3,826
Office - Small	Restrooms	2,590	3,826
Office - Small	Mechanical/Electrical Room	2,590	1,505
Restaurant - Sit-Down	Whole Building		
Restaurant - Sit-Down	Dining Area	4,851	4,851
Restaurant - Sit-Down	Lobby (Main Entry and Assembly)	4,851	4,851
Restaurant - Sit-Down	Kitchen and Food Preparation	4,819	4,819
Restaurant - Sit-Down	Restrooms	4,620	4,620
Restaurant - Fast-Food	Whole Building		
Restaurant - Fast-Food	Dining Area	4,855	4,825
Restaurant - Fast-Food	Lobby (Main Entry and Assembly)	4,855	4,825

Building Type	Space Use	Other	Screw-In Bulbs
Restaurant - Fast-Food	Kitchen and Food Preparation	4,817	4,787
Restaurant - Fast-Food	Restrooms	4,682	4,653
Retail - 3-Story Large	Whole Building		
Retail - 3-Story Large	Retail Sales and Wholesale Showroom	3,554	3,997
Retail - 3-Story Large	Storage (Conditioned)	2,708	2,564
Retail - 3-Story Large	Office (General)	2,602	2,564
Retail - Single-Story Large	Whole Building		
Retail - Single-Story Large	Retail Sales and Wholesale Showroom	5,545	5,147
Retail - Single-Story Large	Storage (Conditioned)	3,409	3,004
Retail - Single-Story Large	Office (General)	3,379	3,122
Retail - Single-Story Large	Auto Repair Workshop	4,269	4,588
Retail - Single-Story Large	Kitchen and Food Preparation	4,193	4,503
Retail - Small	Whole Building		
Retail - Small	Retail Sales and Wholesale Showroom	3,510	4,325
Retail - Small	Storage (Conditioned)	2,860	2,748
Storage - Conditioned	Whole Building		
Storage - Conditioned	Storage (Conditioned)	3,420	2,760
Storage - Conditioned	Office (General)	3,420	2,760
Storage - Unconditioned	Whole Building		
Storage - Unconditioned	Storage (Unconditioned)	3,420	2,760
Storage - Unconditioned	Office (General)	3,420	2,760
Warehouse – Refrigerated	Whole Building		
Warehouse – Refrigerated	Refrigerated (Frozen Storage)	4,791	4,767
Warehouse – Refrigerated	Refrigerated (Cooled Storage)	4,791	4,767
Warehouse – Refrigerated	Comm/Ind Work (Loading Dock)	4,791	4,767
Warehouse – Refrigerated	Office (General)	3,502	2,690

HVAC Energy Factor

This parameter accounts for the reduced cooling load due to the reduction in internal lighting waste heat. Values for each building type are shown in Table 18.[17] Albuquerque values were adjusted for other climate zones using a ratio of commercial cooling hours for the respective climate zones (see Commercial High Efficiency Packaged Air Conditioning measure).

Table 18: Statewide Table of HVAC Interactive Energy Factors

Building Type	Albuquerque	Santa Fe	Roswell	Las Cruces
College/University	1.169	1.101	1.198	1.181
Grocery	1.082	1.049	1.096	1.088
Heavy Industry	1.024	1.014	1.028	1.026
Hotel/Motel	1.372	1.222	1.437	1.399
Light Industry	1.024	1.014	1.028	1.026
Medical	1.285	1.170	1.334	1.306
Office	1.216	1.129	1.254	1.232
Restaurant	1.207	1.124	1.243	1.223
Retail/Service	1.196	1.117	1.230	1.210
K-12 School	1.295	1.176	1.346	1.316
Warehouse	1.048	1.029	1.057	1.052
Dwelling Unit	1.372	1.222	1.437	1.399
Miscellaneous	1.191	1.114	1.224	1.205
Garage	1.000	1.000	1.000	1.000
Exterior	1.000	1.000	1.000	1.000

Refrigerated Space HVAC Factors

When lighting is upgraded inside refrigerated spaces, the reduced load on the refrigeration system applies for all lighting hours, not just when the outside temperature is high. HVAC energy and demand factors are shown in Table 19 for lighting in refrigerated spaces.[18]

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[17] Values were derived by KEMA for PNM using simulations with Albuquerque weather. (Public Service Company of New Mexico Commercial & Industrial Incentive Program Work Papers, 2018.)

[18] EPE regulatory filing, based on a number of secondary sources.

Table 19: Lighting Energy and Demand Factors for Refrigerated Spaces

Refrigerated space type	Energy factor	Demand factor
Freezer	1.3	1.3
Cooler	1.25	1.25

3.3.4 Demand Savings Estimation

Demand savings are defined as the reduction in average kW attributable to the measure during 3:00-6:00 pm on the hottest summer weekdays. Demand savings are derived with the following equation.

$$Svgs = (kW_{PRE} - kW_{POST}) \times HVAC_{Demand_{Factor}} \times Coincident_{Factor}$$

Where:

Svgs	= Demand savings, in kW
kWPRE	= Wattage of the baseline lamp (divided by 1000)
kWPOST	= Wattage of the installed lamp (divided by 1000)
Coincident_Factor	= Adjusts the gross kW savings to account for overlap with the peak period, see Table 20 below
HVAC_Demand_Factor	= Adjustment to lighting savings to account for the decreased cooling load, see Table 20 below

The *HVAC Demand Factor* parameter accounts for the reduced cooling load due to the reduction in internal lighting waste heat. Values derived for Albuquerque are a good estimate for statewide values. Single statewide values for each building type are shown in Table 20,[19] which also shows the *Coincident Factor*, which accounts for the overlap between the kW reduction and the peak period.

Table 20: Statewide Table of HVAC Interactive Demand Factors and Coincidence Factors

Building Type	Coincident Factor	HVAC Demand Factor
College/University	0.76	1.326
Grocery	0.69	1.337
Heavy Industry	0.85	1.054

[19] Values were derived by KEMA for PNM using simulations with Albuquerque weather. (Public Service Company of New Mexico Commercial & Industrial Incentive Program Work Papers, 2018.)

Hotel/Motel	0.86	1.237
Light Industry	0.92	1.054
Medical	0.75	1.344
Office	0.70	1.374
Restaurant	0.81	1.313
Retail/Service	0.83	1.283
K-12 School	0.64	1.311
Warehouse	0.70	1.093
Dwelling Unit	0.095	1.237
Miscellaneous	0.72	1.247
Garage	1	1.000
Exterior	0	1.000

3.3.5 Non-energy Benefits

Well-designed lighting retrofits generally result in higher quality lighting.

3.3.6 Measure Life

Measure life for commercial lighting depends on the type of lighting and the building type. Values are shown in Table 21.[20]

Table 21: Statewide Table of Lighting Measure Life (years)

Enduse	Measure	Effective Useful Life
Indoor Lighting	CFL Fixtures	12
Indoor Lighting	CFL Lamps	EUL varies by building type
Indoor Lighting	Exit Lighting	16
Indoor Lighting	Linear Fluorescents	EUL varies by building type
Indoor Lighting	Linear Fluorescent - Fixtures	16
Indoor Lighting	LEDs (including LED tubes)	EUL varies by building type
Outdoor Lighting	HID Lighting - High Pressure Sodium	15
Outdoor Lighting	HID Lighting - Metal Halide	15

[20] DEER 2014 EUL Table

Outdoor Lighting	HID Lighting (T-5)	15
Outdoor Lighting	CFL Lamps	2.44
Outdoor Lighting	LEDs	16
Indoor Lighting	HID Lighting - High Pressure Sodium	EUL varies by building type
Indoor Lighting	HID Lighting - Metal Halide	EUL varies by building type
Indoor Lighting	HID Lighting (T-5)	EUL varies by building type

Values which vary by building type are shown in Table 22.

Table 22: Lighting Measure Life (years) Depending on Building Type

Building Type	CFL	Screw-In LED Bulbs[21]	Other LED[22]	Other
Assembly	4.37	21.7	19.1	15
Education - Primary School	4.17	22.3	23.4	15
Education - Secondary School	4.02	21.5	21.9	15
Education - Community College	4.38	20.7	20.7	15
Education - University	4.08	21.1	21.3	15
Education - Relocatable Classroom	3.76	19.2	20.2	15
Grocery	2.58	12.9	10.2	14.33
Health/Medical - Hospital	2.45	11.9	9.5	14.34
Health/Medical - Nursing Home	2.8	14	12	15
Lodging - Hotel	6.02	29.9	25.6	15
Lodging - Motel	6.57	36.5	32.3	15
Manufacturing - Bio/Tech	2.86	16.2	14.2	15
Manufacturing - Light Industrial	3.82	19.4	15.5	15
Office - Large	3.17	16.7	18.9	15
Office - Small	3.25	16.8	19.3	15
Restaurant - Sit-Down	2.08	10.4	10.4	14.54
Restaurant - Fast-Food	2.07	10.4	10.3	14.48
Retail - 3-Story Large	2.7	13.5	14.8	15
Retail - Single-Story Large	2.62	11.5	11.7	15
Retail - Small	2.69	12.5	14.8	15
Storage - Conditioned	3.6	18.1	14.6	15
Storage - Unconditioned	3.6	18.1	14.6	15
Storage - Refrigerated Warehouse	2.09	10.6	10.5	14.59

[21] Screw-In LED Bulb measure life determined by dividing 50,000 rated LED hours by the Screw-In Bulb annual operating hours listed in Table 16

[22] Screw-In LED Bulb measure life determined by dividing 50,000 rated LED hours by the Other annual operating hours listed in Table 16

Commercial - general	3.24	21.7	19.1	15

3.3.7 Incremental Cost

The incremental cost for a lighting retrofit is the full measure cost. Utilities have flexibility in the sources for the cost table, but the following restrictions apply.

- Source tables must be published by established and well-known sources and freely available via website.
- Sources for the table must be clearly shown.

The following are recommended sources for the cost table.

- DEER 2008, with updates
- State of Illinois Energy Efficiency Technical Reference Manual Final Technical Version 10.0[23]

Using the custom methodology, costs are based on invoices submitted with the application.

[23] https://www.ilsag.info/wp-content/uploads/IL-TRM-V10-Final-Word-Volumes-Clean-and-Redline-1.zip

3.4 Lighting – New Construction

This measure category applies to lighting fixtures or lamps in new facilities, or in an existing facility where the lighting upgrade is part of a major remodel that requires the newly installed lighting to meet building energy Codes. Measure Overview

Sector	Commercial
End use	Lighting
Fuel	Electricity
Measure category	Lighting - new
Delivery mechanism	Rebate
Baseline description	IECC 2018
Efficient case description	Fixtures or lamps with lower wattage than the baseline

3.4.1 Savings

The baseline is Code-minimum requirements. This measure applies to reductions in lighting wattage; savings due to lighting controls are calculated separately after lighting wattage savings are determined. Allowable methods of deriving savings are described below.

3.4.2 Energy Savings Estimation

Savings can be calculated either using the Lighting Power Density (LPD) method or with a fixture-by-fixture method.

With the LPD method, either the Building Area Method as defined in IECC 2018 or the Space-by-Space Method as defined in ASHRAE 90.1 2016 can be used for calculating the Interior Lighting Power Density. Savings for each space are determined with the following equation.

$$Svgs = (LPD_{CODE} \times SquareFeet - kW_{POST}) \times OperatingHours \times HVAC_{Energy_{Factor}}$$

Where:

Svgs = Annual energy savings, in kWh

LPD_{CODE} = Code Lighting Power Density, W/ft², see Table 23

SquareFeet	=	Square footage of the building or space area with the given LPD
OperatingHours	=	Annual hours the lamp is on, see note below
$HVAC_{EnergyFactor}$	=	Adjustment to lighting savings to account for the decreased cooling load, see note below

Operating Hours, kW_{POST}, and *HVAC Energy Factor* are determined as described in the "Lighting – Retrofit" section. LPD_{CODE} values by building type are shown in Table 23.[24]

Table 23: Baseline LPD by Building Type

Building Area Type	Lighting Power Density (W/ft²)
Automotive facility	0.71
Convention center	0.76
Courthouse	0.9
Dining: Bar Lounge/Leisure	0.9
Dining: Cafeteria/Fast Food	0.79
Dining: Family	0.78
Dormitory	0.61
Exercise Center	0.65
Gymnasium	0.68
Fire station	0.53
Health Care Clinic	0.82
Hospital	1.05
Hotel/Motel	0.75
Library	0.78
Manufacturing facility	0.9
Motion Picture Theater	0.83
Multifamily	0.68
Museum	1.06
Office	0.79
Parking garage	0.15

24 IECC 2018

Building Area Type	Lighting Power Density (W/ft^2)
Penitentiary	0.75
Performing Arts Theater	1.18
Police Station	0.8
Post Office	0.67
Religious Building	0.94
Retail	1.06
School/University	0.81
Sports Arena	0.87
Town Hall	0.8
Transportation	0.61
Warehouse	0.48
Workshop	0.9

Allowable LPD by space-type are shown in Table 24.[25]

Table 24: Baseline Interior LPD by Space Type

Common Space Types	LPD (watts/sq.ft)	Building Type Specific Space Types	LPD (watts/sq.ft)
Atrium		Automotive (see Vehicular maintenance area)	
Less than 40 feet in height	0.03 per foot in total height	Convention Center—exhibit space	0.88

[25] ASHRAE 90.1 2016

Greater than 40 feet in height	0.40 + 0.02 per foot in total height	Dormitory—living quarters	0.54
Audience seating area		Facility for the visually impaired	
In an auditorium	0.63	In a chapel (used primarily by residents)	1.06
In a convention center	0.82	In a recreation room (and not used primarily by the staff)	1.80
In a gymnasium	0.65	Fire Station—sleeping quarters	0.20
In a motion picture theater	1.14	Gymnasium/fitness center	
In a penitentiary	0.28	In an exercise area	0.50
In a performing arts theater	2.03	In a playing area	0.82
In a religious building	1.53	Healthcare facility	
In a sports arena	0.43	In an exam/treatment room	1.68
Otherwise	0.43	In an imaging room	1.06

Banking activity area	0.86	In a medical supply room	0.54
Classroom/lecture hall/training room		In a nursery	1.00
In a penitentiary	1.34	In a nurse's station	0.81
Otherwise	0.92	In an operating room	2.17
Computer room	1.33	In a patient room	0.62
Conference/meeting/multipurpose room	1.07	In a physical therapy room	0.84
Copy/print room	0.56	In a recovery room	1.03
Corridor		Library	
In a facility for the visually impaired (and not used primarily by the staff)	0.92	In a reading area	0.82
In a hospital	0.92	In the stacks	1.20
In a manufacturing facility	0.29	Manufacturing facility	

Otherwise	0.66	In a detailed manufacturing area	0.93
Courtroom	1.39	In an equipment room	0.65
Dining area		In an extra-high-bay area (greater than 50' floor-to-ceiling height)	1.05
In bar/lounge or leisure dining	0.93	In a high-bay area (25-50' floor-to-ceiling height)	0.75
In cafeteria or fast food dining	0.63	In a low-bay area (less than 25' floor-to-ceiling height)	0.96
In a facility for the visually impaired (and not used primarily by the staff)	2.00	Museum	
In family dining	0.71	In a general exhibition area	1.05
In a penitentiary	0.96	In a restoration room	0.85
Otherwise	0.63	Performing arts theater—dressing room	0.36
Electrical/mechanical room	0.43	Post office—sorting area	0.68
Emergency vehicle garage	0.41	Religious buildings	
Food preparation area	1.06	In a fellowship hall	0.55
Guestroom	0.77	In a worship/pulpit/choir area	1.53
Laboratory		Retail facilities	
In or as a classroom	1.20	In a dressing/fitting room	0.50
Otherwise	1.45	In a mall concourse	0.90
Laundry/washing area	0.43	Sports arena—playing area	

Loading dock, interior	0.58	For a Class I facilitye	2.47
Lobby		For a Class II facilityf	1.96
For an elevator	0.69	For a Class III facilityg	1.70
In a facility for the visually impaired (and not used primarily by the staff)	2.03	For a Class IV facilityh	1.13
In a hotel	1.06	Transportation facility	
In a motion picture theater	0.45	In a baggage/carousel area	0.45
In a performing arts theater	1.70	In an airport concourse	0.31
Otherwise	1.0	At a terminal ticket counter	0.62
Locker room	0.48	Warehouse—storage area	
Lounge/breakroom		For medium to bulky, palletized items	0.35
In a healthcare facility	0.78	For smaller, hand-carried items	0.69
Otherwise	0.62	Warehouse	
Office		Fine Material Storage	1.4
Enclosed	0.93	Medium/Bulky Material Storage	0.9
Open plan	0.81	Parking Garage—Garage Area	0.2
Parking area, interior	0.14	Transportation	
Pharmacy area	1.34	Airport—Concourse	0.6
Restroom		Air/Train/Bus—Baggage Area	1
In a facility for the visually impaired (and not used primarily by the staff)	0.96	Terminal—Ticket Counter	1.5

Otherwise	0.85
Sales area	1.22
Seating area, general	0.42
Stairwell	0.58
Storage room <50 ft^2	0.97
Storage room ≥50 ft^2 ≤1000 ft^2	0.46
All other storage rooms	0.46
Vehicular maintenance area	0.56
Workshop	1.14

Exterior LPD are shown in Table 25.

Table 25: Baseline Exterior LPD[26]

		Zone 1	Zone 2	Zone 3	Zone 4
Tradable Surfaces (Lighting power densities for uncovered parking areas, building grounds, building entrances and exits, canopies and overhangs and outdoor sales areas may be traded.)	**Uncovered Parking Areas**				
	Parking areas and drives	0.03W/ft^2	0.04 W/ft^2	0.06 W/ft^2	0.08 W/ft^2
	Building Grounds				
	Walkways less than 10 feet wide	0.5 W/linear foot	0.5 W/linear foot	0.6 W/linear foot	0.7 W/linear foot
	Walkways 10 feet wide or greater, plaza areas special feature areas	0.10 W/ft^2	0.10 W/ft^2	0.11 W/ft^2	0.14 W/ft^2
	Dining areas	0.65 W/ft^2	0.65 W/ft^2	0.75 W/ft^2	0.95 W/ft^2
	Stairways	0.6 W/ft^2	0.7 W/ft^2	0.7 W/ft^2	0.7 W/ft^2
	Pedestrian Tunnels	0.12 W/ft^2	0.12 W/ft^2	0.14 W/ft^2	0.21 W/ft^2
	Landscaping	0.03 W/ft^2	0.04 W/ft^2	0.04 W/ft^2	0.04 W/ft^2
	Building Entrances and Exits				
	Main entries	14 W/linear foot of door width	14 W/linear foot of door width	21 W/linear foot of door width	21 W/linear foot of door width
	Entry canopies	0.20 W/ft^2	0.25 W/ft^2	0.4 W/ft^2	0.4 W/ft^2
	Loading Docks	0.35 W/ft^2	0.35 W/ft^2	0.35 W/ft^2	0.35 W/ft^2
	Sales Canopies				
	Free standing and attached	0.4 W/ft^2	0.4 W/ft^2	0.6 W/ft^2	0.7 W/ft^2

[26] IECC 2018 Tables C405.4.2(2) and C405.4.2(3).

	Outdoor Sales				
	Open areas (including vehicle sales lots)	0.20 W/ft^2	0.20 W/ft^2	0.35 W/ft^2	0.50 W/ft^2
	Street frontage for vehicle sales lots in addition to "open area" allowance	No allowance	7 W/linear foot	7 W/linear foot	21 W/linear foot
Nontradable Surfaces (Lighting power density calculations for the following applications can be used only for the specific application and cannot be traded between surfaces or with other exterior lighting. The following allowances are in addition to any allowance otherwise permitted in the "Tradable Surfaces" section of this table.)	Building facades	No allowance	0.075 W/ft^2 of gross above-grade wall area	0.113 W/ft^2 of gross above-grade wall area	0.15 W/ft^2 of gross above-grade wall area
	Automated teller machines and night depositories	135 W per location plus 45 W per additional ATM per location	135 W per location plus 45 W per additional ATM per location	135 W per location plus 45 W per additional ATM per location	135 W per location plus 45 W per additional ATM per location
	Entrances and gatehouse inspection stations at guarded facilities	0.50 W/ft^2 of covered and uncovered area	0.50 W/ft^2 of covered and uncovered area	0.50 W/ft^2 of covered and uncovered area	0.50 W/ft^2 of covered and uncovered area
	Loading areas for law enforcement, fire, ambulance and other emergency service vehicles	0.35 W/ft^2 of covered and uncovered area	0.35 W/ft^2 of covered and uncovered area	0.35 W/ft^2 of covered and uncovered area	0.35 W/ft^2 of covered and uncovered area
	Drive-up windows/doors	200W per drive-through	200W per drive-through	200W per drive-through	200W per drive-through
	Parking near 24-hour retail entrances	400W per main entry	400W per main entry	400W per main entry	400W per main entry

The fixture-by-fixture method requires the assignment of a baseline fixture to each installed fixture. If all fixtures within a space are new, then all the fixtures must be included within a calculation, with the exception of those exempted by IECC.

Savings are determined as for retrofit lighting. However, if all fixtures within a space are new, the calculation still must show that the baseline meets code LPD requirements.

Linear fluorescent baseline fixtures shall be standard T8 lighting with electronic ballast. In high-bay applications, the baseline can be pulse-start metal halide lighting. Screw-in baseline lamps must meet EISA efficacy requirements.

3.4.3 Demand Savings Estimation

Using the LPD method, peak demand savings are determined with the following equation:

$$Svgs = (LPD_{CODE} \times SquareFeet - kW_{POST}) \times HVAC_{Demand_{Factor}} \times Coincident_{Factor}$$

Where:

Svgs	= Peak demand savings, in kW
LPD_{CODE}	= Code Lighting Power Density, W/ft^2, see note below
SquareFeet	= Square footage of the building area with the given LPD
$Coincident_{Factor}$	= Adjusts the gross kW savings to account for overlap with the peak period, see below
$HVAC_{DemandFactor}$	= Adjustment to lighting savings to account for the decreased cooling load, see below

HVAC Demand Factor, Coincident Factor, and kW_{POST} are determined as for "Lighting – Retrofit." LPD_{CODE} is determined as described above, by building type or by space type.

Using the fixture-by-fixture method, savings are determined as for "Lighting – Retrofit."

3.4.4 Non-energy Benefits

Well-designed lighting systems generally result in higher quality lighting.

3.4.5 Measure Life

Measure life is determined as described for "Lighting – Retrofit."

3.4.6 Incremental Cost

For this measure, the incremental cost is the difference between standard and efficient lighting. Costs for as-built lighting should be based on either invoices or standard tables as described for "Lighting – Retrofit." Baseline fixtures should be selected from the same table to align with the actual installed lighting on a one-for-one basis. Baseline fixtures cannot be T-12 and must have electronic ballasts.

3.5 Lighting – Controls

This measure category applies to lighting fixtures or lamps in retrofits, or in new facilities where building energy codes do not require controls. The baseline is the lighting with no controls.

3.5.1 Measure Overview

Sector	Commercial
End use	Lighting
Fuel	Electricity
Measure category	Lighting controls – new construction or retrofit
Delivery mechanism	Rebate
Baseline description	Lighting with either no controls, or manual controls
Efficient case description	Lighting controlled by occupancy sensor, interior lighting with daylighting controls, or exterior lighting with photocell controls

3.5.2 Savings

Allowable methods of deriving savings are described. The allowable methods are derived from the prescriptive methods used by ADM Associates in its evaluations of the New Mexico utilities, as well as a comparison of methodologies in use by the New Mexico utilities and other energy efficiency programs.

3.5.3 Energy Savings Estimation

Savings are determined with the following equation.

$$Svgs = kW_{POST} \times Operating_{Hours} \times \ Controls\ Factor \times HVAC_{Energ\ \ Factor}$$

Where:

$Svgs$ = Annual energy savings, in kWh

kW_{POST} = Power draw of the controlled lamps

$Operating_{Hours}$ = Annual hours the lamp is on in the baseline, determined as for a standard lighting measure

$Controls\ Factor$ = % savings achieved by controls, see Table 26

$HVAC\_Energy\_Factor$ = Adjustment to lighting savings to account for the decreased cooling load, as for a standard lighting measure

Table 26: Lighting Controls Reduction in Operating Hours.[27]

Control Type	Definition	Relevant Technology	Controls Factor
Occupancy	Adjusting light levels according to the presence of occupants	Occupancy sensors, time clocks, energy management system	24%
Daylighting	Adjusting light levels automatically in response to the presence of natural light	Photosensors, time clocks	28%
Personal Tuning	Adjusting individual light levels by occupants according to their personal preferences; for example, to private offices, workstation-specific lighting in open-plan offices, and classrooms	Dimmers, wireless on-off switches, bi-level switches, computer-based controls, pre-set scene selection	31%
Institutional	(1) Adjustment of light levels through commissioning and technology to meet location specific needs or building policies; or (2) provision of switches or controls for areas or groups of occupants; examples of the former include high-end trim dimming (also known as ballast tuning or reduction of ballast factor), task tuning, and lumen maintenance	Dimmable ballasts, on-off or dimmer switches for non-personal lighting	36%
Multiple Approaches	Any combination of two or more of the above strategies	Any combination of two or more of the above strategies	38%

3.5.4 Demand Savings Estimation

Demand savings are derived with the following equation.

$$Svgs = kW_{POST} \times \text{Controls Factor} \times HVAC_{Deman\ \ Factor} \times CoincidentFactor$$

[27] LBNL, A Meta-Analysis of Energy Savings from Lighting Controls in Commercial Buildings. http://eta-publications.lbl.gov/sites/default/files/a_meta-analysis_of_energy_savings_from_lighting_controls_in_commercial_buildings_lbnl-5095e.pdf

Where:

Svgs	= Demand savings, in kW
kW_{POST}	= Power draw of the controlled lamps
HVAC_Demand_Factor	= Adjustment to lighting savings to account for the decreased cooling load, as for a standard lighting measure, see Table 20
CoincidentFactor	= Adjusts the gross kW savings to account for overlap with the peak period, see Table 20

3.5.5 Non-energy Benefits

Well-designed daylighting increases occupant comfort and productivity.

3.5.6 Measure Life

Measure life for lighting controls is 8 years.[28]

3.5.7 Incremental Cost

The actual measure cost shall be used when it is available. Otherwise, the following default values are shown in Table 27.[29]

Table 27: Lighting Controls Measure Cost

Control Type	Measure Cost
Occupancy sensor, wall-mounted	$55
Occupancy sensor, ceiling-mounted	$125
Daylighting control	$65
Photocell	$60

3.6 High Efficiency Packaged/Split Air Conditioning/Heat Pump System

This measure promotes the installation of high-efficiency unitary air-cooled air conditioning or heat pump equipment, both single-package and split systems. This

[28] DEER 2014 EUL Table

[29] Utility work papers, DEER 2005

measure could apply to the replacement of an existing unit at the end of its useful life or the installation of a new unit in a new or existing building.

3.6.1 Measure Overview

Sector	Commercial
End use	HVAC
Fuel	Electricity
Measure category	High Efficiency Packaged Air Conditioning/Heat Pump
Delivery mechanism	Rebate
Baseline description	IECC 2018 efficiency
Efficient case description	Efficiency must exceed IECC 2018

3.6.2 Savings

Savings are calculated on a building type basis according to system capacity and efficiency level as described below.

3.6.3 Energy Savings Estimation

Savings for units under 5.4 tons are determined with the following equations:

$$Svgs = Cooling\ Savings + Heating\ Savings$$ [30]

$$Cooling\ Savings = Cooling\ Capacity \times Cooling\ EFLH \times \left(\frac{1}{SEER_{Base}} - \frac{1}{SEER_{Post}}\right)$$

$$Heating\ Savings = Heating\ Capacity \times Heating\ EFLH \times \left(\frac{1}{HSPF_{Base}} - \frac{1}{HSPF_{Post}}\right)$$

Savings for units between 5.4 tons and 20 tons are determined with the following equations:

$$Svgs = Cooling\ Savings + Heating\ Savings$$ [31]

$$Cooling\ Savings = Cooling\ Capacity \times Cooling\ EFLH \times \left(\frac{1}{EER_{Base}} - \frac{1}{EER_{Post}}\right)$$

[30] Heating savings are only applicable for heat pump units

[31] Heating savings are only applicable for heat pump units

$$Heating\ Savings = Heating\ Capacity \times Heating\ EFLH \times 0.293 \times \left(\frac{1}{COP_{Base}} - \frac{1}{COP_{Post}}\right)$$

Savings for units 20 tons and greater are determined with the following equations:

$$Svgs = Cooling\ Savings + Heating\ Savings^{32}$$

$$Cooling\ Savings = Cooling\ Capacity \times Cooling\ EFLH \times \left(\frac{1}{IPLV_{Base}} - \frac{1}{IPLV_{Post}}\right)$$

$$Heating\ Savings = Heating\ Capacity \times Heating\ EFLH \times 0.293 \times \left(\frac{1}{COP_{Base}} - \frac{1}{COP_{Post}}\right)$$

Where:

Svgs	= Annual energy savings, in kWh
Cooling Savings	= Annual cooling energy savings, in kWh
Heating Savings	= Annual heating energy savings, in kWh
Cooling Capacity	= System cooling capacity, in kBtu/h
Cooling EFLH	= Effective full load cooling hours, see Table 30
SEER	= Seasonal Energy Efficiency Ratio, nominal rating of system in Btu/Wh, see Table 28 for baseline values
IEER	= Integrated Energy Efficiency Ratio, nominal rating of system in Btu/Wh, see Table 28 for baseline values
IPLV	= Integrated Part Load Value, nominal rating of system in Btu/Wh, see Table 28 for baseline values
Heating Capacity	= System heating capacity, in kBtu/h
Heating EFLH	= Effective full load heating hours, see Table 31
HSPF	= Heating Seasonal Performance Factor, nominal rating of system in Btu/Wh, see Table 28 for baseline values
COP	= Coefficient of Performance, nominal rating of packaged system in Btu/Btu, see Table 28 for baseline values
0.293	= Convert from kBtu to kWh

[32] Heating savings are only applicable for heat pump units

Baseline efficiencies for packaged AC systems are shown in Table 28 and heat pumps systems are shown in Table 29.[33] Early retirement baselines are also eligible and should follow the guidance outlined in 2.3 Early Retirement.

Table 28: Packaged AC System Baseline Efficiency Ratings

Equipment Type	Size Category	Subcategory or rating condition	Minimum Efficiency[b]
Air Conditioners and Heat Pumps, Air cooled	< 65,000 Btu/h	*Split system*	*13.0 SEER*
		Single package	*14.0 SEER*
	≥65,000 Btu/h and <135,000 Btu/h	*Split system and single package*	*11.2 EER 12.8 IEER*
	≥135,000 Btu/h and <240,000 Btu/h	*Split system and single package*	*11.0 EER 12.4 IEER*
	≥240,000 Btu/h and <760,000 Btu/h	*Split system and single package*	*10.0 EER 11.6 IEER*
	≥760,000 Btu/h	*Split system and single package*	*9.7 EER 11.2 IEER*

[b] *IPLVs are only applicable to equipment with capacity modulation*

Table 29: Heat Pump System Baseline Efficiency Ratings

Equipment Type	Size Category	Subcategory or rating condition	Minimum Efficiency[b,c]
Air Conditioners and Heat Pumps, Air cooled	< 65,000 Btu/h	*Split system*	*14.0 SEER*
		Single package	*14.0 SEER*
	≥65,000 Btu/h and <135,000 Btu/h	*Split system and single package*	*11.0 EER 12.0 IEER*
	≥135,000 Btu/h and <240,000 Btu/h	*Split system and single package*	*10.6 EER 11.6 IEER*
	≥240,000 Btu/h	*Split system and single package*	*9.5 EER 10.6 IEER*

[33] IECC 2018 Table C403.3.2(1) and Table C403.3.2(2)

Heat Pumps, Air cooled (Heating mode)	< 65,000 Btu/h (cooling capacity)	*Split system*	*8.2 HSPF*
		Single package	*8.0 HSPF*
	≥65,000 Btu/h and <135,000 Btu/h (cooling capacity)	*47-F db/43-F wb Outdoor air*	*3.3 COP*
	≥135,000 Btu/h (cooling capacity)	*47-F db/43-F wb Outdoor air*	*3.2 COP*

[b] *IPLVs are only applicable to equipment with capacity modulation*

[c] *Deduct 0.2 from the required EERs and IPLVs for units with a heating section other than electric resistance heat*

Cooling EFLH values, derived from eQuest simulations of DEER building prototypes, are shown in Table 30.

Table 30: Cooling EFLH by Building Type and Climate Zone

Building Type	Albuquerque	Las Cruces	Roswell	Santa Fe
Assembly	1,471	1,343	1,576	812
Education - Community College	1,085	1,290	1,360	629
Education - Primary School	436	508	554	289
Education - Relocatable Classroom	490	560	595	354
Education - Secondary School	450	479	555	213
Education - University	1,032	1,233	1,324	643
Grocery	824	961	1,038	391
Health/Medical – Hospital	1,189	1,181	1,387	604
Health/Medical - Nursing Home	984	958	1,206	481
Lodging - Hotel	1,521	1,679	1,797	974
Manufacturing - Bio/Tech	1,115	1,238	1,332	795
Manufacturing - Light Industrial	743	958	950	519
Office - Small	1,083	1,174	1,292	770
Restaurant - Fast-Food	1,271	1,267	1,377	754
Restaurant - Sit-Down	1,236	1,218	1,361	681
Retail - Single-Story Large	1,437	1,470	1,603	885
Retail - Small	1,296	1,361	1,438	847
Storage - Conditioned	492	698	697	336

Warehouse - Refrigerated	1,477	1,498	1,596	745
Other[34]	1,033	1,109	1,213	617

Heating EFLH values are shown in Table 31. Heating EFLH values are derived from the Texas TRM version 5, adjusting the Texas values based on heating degree-days comparisons between Amarillo, Albuquerque, and Santa Fe, and El Paso, Las Cruces, and Roswell. Values that are blank in the Texas TRM were entered as zero in Table 31.

Table 31: Heating EFLH by Building Type and Climate Zone

Building Type	Albuquerque	Las Cruces	Roswell	Santa Fe
Assembly	0	0	0	0
Education - Community College	0	0	0	0
Education - Primary School	698	500	497	929
Education - Relocatable Classroom	733	528	525	975
Education - Secondary School	733	528	525	975
Education - University	0	0	0	0
Grocery	0	0	0	0
Health/Medical – Hospital	0	0	0	0
Health/Medical - Nursing Home	0	0	0	0
Lodging - Hotel	782	383	381	1,040
Manufacturing - Bio/Tech	339	179	178	450
Manufacturing - Light Industrial	339	179	178	450
Office - Small	339	179	178	450
Restaurant - Fast-Food	1,025	639	636	1,363
Restaurant - Sit-Down	1,119	751	747	1,488
Retail - Single-Story Large	903	470	468	1,202
Retail - Small	750	549	546	998
Storage - Conditioned	0	0	0	0
Warehouse - Refrigerated	0	0	0	0

[34] This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g., a medical administration building could potentially be assessed using the "Office – Small" EFLH).

Other[35]	339	179	178	450

3.6.4 Demand Savings Estimation

Peak demand savings are determined with the following equation,

$$PeakSvgs = Cooling\ Capacity \times \left(\frac{1}{EER_{Base}} - \frac{1}{EER_{Post}}\right) \times CF$$

Where:

CF = Coincidence Factor, see Table 32

Other parameters are as defined above for energy savings.

For units only rated in SEER, SEER can be converted to EER using the formula:[36]

$$EER = -0.02 * SEER^2 + 1.12 * SEER$$

Coincidence factors are shown in Table 32. These values were derived from the Texas TRM version 5. The value for El Paso was used for Las Cruces, the value for Amarillo was used for Roswell, and the average of these two values was used for Albuquerque and Santa Fe.

Table 32: CF by Building Type and Climate Zone

Building Type	Albuquerque	Las Cruces	Roswell	Santa Fe
Assembly	0.78	0.91	0.64	0.78
Education - Community College	0.78	0.87	0.69	0.78
Education - Primary School	0.78	0.91	0.64	0.78
Education - Relocatable Classroom	0.78	0.91	0.64	0.78
Education - Secondary School	0.78	0.87	0.69	0.78
Education - University	0.78	0.87	0.69	0.78

[35] This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g., a medical administration building could potentially be assessed using the "Office – Small" EFLH)

[36] Code specified SEER values converted to EER using EER = -0.02 x $SEER^2$ + 1.12 x SEER. National Renewable Energy Laboratory (NREL) 2010, "Building America House Simulation Protocols." U.S. DOE. Revised October www.nrel.gov/docs/fy11osti/49246.pdf

Building Type	Albuquerque	Las Cruces	Roswell	Santa Fe
Grocery	0.74	0.80	0.68	0.74
Health/Medical – Hospital	0.77	0.81	0.72	0.77
Health/Medical - Nursing Home	0.78	0.88	0.68	0.78
Lodging - Hotel	0.61	0.63	0.58	0.61
Manufacturing - Bio/Tech	0.34	0.38	0.29	0.34
Manufacturing - Light Industrial	0.34	0.38	0.29	0.34
Office - Small	0.76	0.81	0.72	0.76
Restaurant - Fast-Food	0.75	0.76	0.73	0.75
Restaurant - Sit-Down	0.80	0.76	0.83	0.80
Retail - Single-Story Large	0.80	0.80	0.80	0.80
Retail - Small	0.79	0.83	0.75	0.79
Storage - Conditioned	0.55	0.75	0.34	0.55
Warehouse - Refrigerated	0.55	0.75	0.34	0.55
Other[37]	0.34	0.38	0.29	0.34

Example:

A 14 SEER air conditioner of capacity 48 kBtu/h is installed in a primary educational institution in Albuquerque.

Cooling savings = 48 kBtu/h x 436 hours x (1/13 – 1/14)

= 115 kWh

$SEER_{Baseline}$ = $-0.02 \times (13)^2 + 1.12 \times 13 = 11.18$

$SEER_{Efficient}$ = $-0.02 \times (14)^2 + 1.12 \times 14 = 11.76$

Demand Savings = 48 kBtu/h x (1/11.18 – 1/11.76) x 0.78

= 0.165 kW

[37] This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g., a medical administration building could potentially be assessed using the "Office – Small" CF)

3.6.5 Non-energy Benefits

Well-designed HVAC systems increase occupant comfort and productivity.

3.6.6 Measure Life

Measure life for a packaged AC system is 15 years.[38]

3.6.7 Incremental Cost

The incremental cost for this measure is the incremental cost over a standard system. Costs are shown in Table 33.[39]

Table 33: Packaged AC Incremental Measure Cost

Measure	Minimum System (SEER 14)	Delta 1.0 SEER over 14/EER Improvement
65,000 Btuh or less	$113	$82
65,000 to 240,000 Btuh	$97	$48
240,000 to 760,000 Btuh	$247	$180
760,000 Btuh or more	$203	$181

[38] DEER 2008, IL, OH, PA TRMs

[39] PNM work papers, SPS work paper, DEER 2008, IL, OH TRMs

3.7 Low-flow Showerheads

This measure saves water heating energy by reducing the quantity of water heated.

3.7.1 Measure Overview

Sector	Commercial
End use	Water heating
Fuel	Electricity or Gas
Measure category	Low-flow showerheads
Delivery mechanism	Rebate/Direct Install/Mail-by-request
Baseline description	Federal standard 2.2 GPM or average existing conditions if higher than 2.2 GPM
Efficient case description	Showerhead with one of the following nominal flow rates 1) 2.0 gpm 2) 1.5 gpm In one of the following facility types 1) K-12 School 2) University dorm 3) Fitness center 4) Health in-patient shower 5) Employee shower (office or other) 6) Hospitality 7) Other commercial shower

3.7.2 Savings

Annual energy and demand savings are shown in the following table. Savings shown do not include in-service-rates, which vary by delivery mechanism. The savings below are per aerator for different climate zones in New Mexico. For kit-based programs and programs for which the water heating fuel is unknown, multiply the savings listed below with the type of water-heating system fuel type percentage and the in-service rates provided in the next section. The savings listed in Table 34, Table 35, and Table 36 do NOT include the Fuel% or ISR parameters.

Table 34: Gas Savings (therms)

	Albuquerque		Las Cruces		Roswell		Santa Fe	
	1.5 gpm	2.0 gpm	1.5 gpm	2.0 gpm	1.5 gpm	2.0 gpm	1.5 gpm	2.0 gpm
K-12 School	5.75	3.29	4.76	2.72	4.87	2.78	6.53	3.73
Fitness center	159.17	90.95	131.73	75.28	134.78	77.02	180.49	103.14
Health patient shower	7.07	4.04	5.85	3.34	5.99	3.42	8.02	4.58
Employee shower	5.30	3.03	4.39	2.51	4.49	2.56	6.01	3.43
Hospitality	9.82	5.61	8.12	4.64	8.31	4.75	11.13	6.36
Other commercial shower	8.47	4.84	7.01	4.01	7.18	4.10	9.61	5.49

Table 35: Energy Savings (kWh)

	Albuquerque		Las Cruces		Roswell		Santa Fe	
	1.5 gpm	2.0 gpm	1.5 gpm	2.0 gpm	1.5 gpm	2.0 gpm	1.5 gpm	2.0 gpm
K-12 School	137.68	78.67	113.95	65.11	116.58	66.62	156.12	89.21
Fitness center	3807.96	2175.98	3151.61	1800.92	3224.47	1842.55	4318.13	2467.50
Health patient shower	169.20	96.69	140.04	80.02	143.28	81.87	191.87	109.64
Employee shower	126.77	72.44	104.92	59.95	107.34	61.34	143.75	82.14
Hospitality	234.86	134.21	194.38	111.08	198.88	113.64	266.33	152.19
Other commercial shower	202.74	115.85	167.79	95.88	171.67	98.10	229.90	131.37

Table 36: Demand Savings (kW)

	1.5 gpm	2.0 gpm
Albuquerque	0.1116	0.0638
Las Cruces	0.0924	0.0528
Roswell	0.0945	0.0540
Santa Fe	0.1266	0.0723

3.7.3 Energy Savings Estimation

Savings are based on the methodology used by the Northwest Power and Conservation Council's Regional Technical Forum (RTF).[40] The basic equation for water heating energy used is:

$$Svgs = \frac{(FlowPre - FlowPost) \times (TempUsage - TempCo \quad) \times TimeOfUse \times HeatCapacity \times Density \times Const \times Fuel\% \times ISR}{Efficiency}$$

Where:

Svgs	= Annual energy savings, therms or kWh
FlowPre	= Baseline flow rate, gpm, see Table 37
FlowPost	= Measure flow rate, gpm, see Table 37
$Temp_{Usage}$	= Temperature of water coming out of showerhead, see Table 37
$Temp_{Cold}$	= Temperature of inlet water, see table
TimeOfUse	= Annual time shower is used, minutes, Table 37
HeatCapacity	= Heat capacity of water, 1 Btu per pound per ˚F
Density	= Density of water, 8.33 pounds per gallon
Const	= Constant, 1 therm/100,000 Btus, or .00029307107 kWh/Btu
Efficiency	= Assumed efficiency of water heater, see Table 37
Fuel%	= Percentage split between gas, electric and propane water heating. When water heating fuel is known, used 100%. For kit-based and other program types for which the water heating fuel is not known, use terrirory-specific percentages. If territory-specific values are not known, use default values of 50% gas and 50% electricity.[41]
ISR	= In-service rate, representing the proportion of distributed showerheads which are actually installed. For direct-install and downstream programs, use 1. For kit-based

[40] https://rtf.nwcouncil.org/measure/showerheads/

[41] US Energy Information Administration. https://www.eia.gov/consumption/commercial/data/2012/bc/cfm/b31.php The percentages shown are based on the West Moutain region in the table.

programs, use a territory-specific value. If a territory-specific value is not known, use a default value of 0.98[42]

Parameters used in this equation are drawn from the RTF measure, as shown in Table 37 below.

Table 37: Commercial Showerhead Parameters

Parameter	Value	
TimeOfUse (minutes per year)	Hospitality[43,44]	3,509
	Health Care[45]	2,528
	Commercial - Employee Shower[46]	1,894
	School[47]	2,057
	Any Commercial Except Fitness Center	3,029
	Fitness Center[48]	56,893
Water Heating Efficiency	Electric	98%
	Gas	80%
Temperature Usage (°F)	101°F[49]	
Temperature Cold (°F)	Table 8	
FlowPre (gpm)	2.2[50]	

42 Illinois Technical Reference Manual, measure 4.3.3

43 Gleick, P., Haasz, D., Henges-Jeck, C., Srinivasan, V., Wolff, G., Cushing, K. K., et al. (2003). Waste Not, Want Not: The Potential for Urban Water Conservation in California. Pacific Institute. Value can be found on page 5 of Appendix D of the report. A link to Appendix D: http://www.pacinst.org/reports/urban_usage/appendix_d.pdf

44 American Hotel and Lodging Association Website (http://www.ahla.com/content.aspx?id=34706), annual Lodging Industry Profile

45 StateHealthFacts.org; Gleick et al, "Waste Not, Want Not"; Professional judgment of RTF staff

46 Professional judgment that a commercial employee shower will use one half of RTF's residential shower usage

47 Planning and Management Consultants, Ltd., Aquacraft, Inc., and John Olaf Nelson Water Resources Management. "Commercial and Institutional End Uses of Water". For the American Water Works Association. 2000.

48 Phone survey of five PNW Fitness Centers conducted by RTF staff

49 Cadmus and Opinion Dynamics Evaluation Team. Showerhead and Faucet Aerator Meter Study. For Michigan Evaluation Working Group. June 2013. Temperature sensors provided the mixed water temperature readings resulting in an average of 101°F

50 Baseline: Median observed flow rate in 2007 SCL study. Median used instead of mean because study included some high (> 2.5 gpm, nominal) flow rate showerheads. The federal standard has been 2.5 gpm since January 1, 1994. "Single Family 2007 Showerhead Kit Impact Evaluation". SBW Consulting; Seattle City Light. October 2008 [<www.seattle.gov/light/Conserve/Reports/Evaluation_14.pdf>]

Parameter	Value
FlowPost (gpm)[51]	2.00 gpm rated: 1.8 gpm 1.5 gpm rated: 1.5 gpm

3.7.4 Demand Savings Estimation

Demand savings are calculated using the following formula:

$$Svgs = (\Delta kWh / Hours) * CF$$

Where:

Svgs	= Annual demand savings, in kW
ΔkWh	= Calculated value above for electric energy savings
Hours	= Annual electric DHW hours for faucet use
	= TimeOfUse x (1 hour / 60 minutes)
	= Calculate if usage is custom, default value see Table 37.
CF	= Coincidence factor for electric load reduction, 0.0278[52]

3.7.5 Non-energy Benefits

Water savings are calculated as part of the energy savings equation and are shown in Table 38.

[51] Ibid

[52] Calculated as follows: Assume 11% showers take place during peak hours (based on: http://www.aquacraft.com/sites/default/files/pub/DeOreo-%282001%29-Disaggregated-Hot-Water-Use-in-Single-FamilyHomes-Using-Flow-Trace-Analysis.pdf). There are 65 days in the summer peak period, so the percentage of total annual aerator use in peak period is 0.11*65/365.25 = 1.96%. The number of hours of recovery during peak periods is therefore assumed to be 1.96% * 369 = 7.23 hours of recovery during peak period where 369 equals the average annual electric DHW recovery hours for showerhead use including SF and MF homes with Direct Install and Retrofit/TOS measures. There are 260 hours in the peak period so the probability you will see savings during the peak period is 7.23/260 = 0.0278

Table 38: Commercial Showerhead Water Savings (in gallons/year)

	Savings with 1.5gpm	Savings with 2.0gpm
K-12 School	1,440	823
Fitness center	39,825	22,757
Health patient shower	1,770	1,011
Employee shower	1,326	758
Hospitality	2,456	1,403
Other commercial shower	2,120	1,212

3.7.6 Measure Life

Lifetime for this measure is 10 years.[53]

3.7.7 Incremental Cost

The incremental cost for this measure is the total measure cost. Incremental costs are shown in Table 39.

Table 39: Commercial Showerhead Water Savings

Retail[54]	$7.00
Direct Install[55]	$11.34
Mail-by-Request[56]	$8.11

[53] State of Illinois Energy Efficiency Technical Reference Manual, version 10.0

[54] State of Illinois Energy Efficiency Technical Reference Manual, 2012

[55] RTF: Material cost based on Mail-by-Request data below. 20 minutes install time at $20/hour for labor.

[56] $6 (2012$) bulk material cost, cited by Mark Jerome, Fluid Market Strategies. Fluid is the only entity that RTF staff has heard of running a mail-by-request program. Shipping and handling costs were unavailable. Assumed to be $3.06/showerhead, based on the $9/package (regardless of number of items in page) observed for residential direct mail CFL programs and assumed an average of 3 showerhead per package.

3.8 Anti-Sweat Heater Controls

This measure saves refrigeration energy by reducing the "ON" time of anti-sweat heaters (ASH).

3.8.1 Measure Overview

Sector	Commercial
End use	Refrigeration
Fuel	Electricity
Measure category	Anti-Sweat Heater Controls
Delivery mechanism	Rebate
Baseline description	Glass door display case with ASH operating at 100% duty cycle (i.e., no ASH controls installed).
Efficient case description	Installation of relative humidity sensors for the air outside of the display case and controls that reduce or turn off the glass door (if applicable) and frame anti-sweat heaters at low-humidity conditions.

3.8.2 Savings

Energy and demand savings are shown in Table 40.

Table 40: Energy and Demand Savings per Climate Zone for Anti-Sweat Heater Controls on Coolers and Freezers

	Medium Temperature Display Case (Cooler)		Low Temperature Display Case (Freezer)	
	Demand Savings kW/ft	Energy Savings kWh/ft	Demand Savings kW/ft	Energy Savings kWh/ft
Albuquerque	0.00753	423.9	0.00972	442.5
Santa Fe	0.00677	420.3	0.00868	436.5
Las Cruces	0.00795	416.2	0.01029	435.6
Roswell	0.00792	390.2	0.01025	408.4

ft = horizontal linear footage of the display case (i.e., the width of the display case)

3.8.3 Energy Savings Estimation

A door heater controller senses the dew point (DP) temperature in the store and cycles the power supplied to the heaters on and off accordingly. DP inside a building is primarily dependent on the moisture content of outdoor ambient air. Because the outdoor DP varies between climate zones, weather data from each climate zone must be analyzed to obtain a DP profile. The savings are on a per-linear foot of display case basis.

The energy savings are a result of both the decrease in the length of time the heater is running (kWh_{ASH}) and the reduction in load on the refrigeration (kWh_{comp}). These savings are calculated using the following equations and assumptions.

Savings are based on the following:

$$ASH\ ON\% = (DP_{meas} - AllOFF_{SetPoint}) / (AllON_{SetPoint} - AllOFF_{SetPoint})$$

Where:

DPmeas	= Measured dewpoint temperature inside the store.
AllOFFSetPoint	= Low end of the humidity scale where heaters are not needed (0% duty cycle).
AllONSetPoint	= High end of the humidity scale where heaters must operate all the time (100% duty cycle).
	Setpoints can be changed based on the requirements of a particular store location; the following are typical setpoints for a 72 °F supermarket.
AllOFFSetPoint	= 42.89F DP (35% RH)
AllONSetPoint	= 52.87F DP (50% RH)

Measured dew point (DP_{meas}) is related to outdoor dew point ($T_{dp\text{-}out}$) according to the equation:

$$DP_{meas} = 0.005379 \times T_{dp\text{-}out}^2 + 0.171795 \times T_{dp\text{-}out} + 19.87006$$ [57]

Where:

Tdp-out	= Outdoor dew point [58]

[57] Indoor and Outdoor Dew Point at a Supermarket in Fullerton, CA. (Oct. 2005 – Jan. 2006, 5-minute data)

[58] from National Solar Radiation Data Base; 1991- 2005 Update: Typical Meteorological Year 3

The controller only changes the run-time of the heaters. Instantaneous ASH power (kW_{ASH}) as a resistive load remains constant at:

kW_{ASH} = (0.37A/ft) (115V) = 0.04255kW/ft [59]

Energy consumption for each hour is the product of power and run time. Total annual ASH energy consumption is the sum of all 1-hour consumption values across 8760 hours/year.

$kWh_{baseline} = \Sigma_{1\text{-}8760}\ kW_{ASH} \times 100\%$

$kWh_{efficient} = \Sigma_{1\text{-}8760}\ kW_{ASH} \times \text{ASH ON\%}$

$kWh_{ASH} = kWh_{baseline} - kWh_{efficient}$

Some of the heat generated by ASHs ends up as a load on the refrigeration system. Therefore, any reduction in ASH power will not only reduce the ASH electric demand but will also result in secondary benefits on the refrigeration side. As a result, compressor run time and energy consumption are reduced. The compressor power requirements are based on calculated cooling load and energy-efficiency ratios obtained from manufacturers' data.

$kW_{comp} = Q_{ASH} / (EER \times 1000)$

It is assumed that 35% of sensible heat generated by the ASH ends up as a cooling load (Q_{ASH}) inside the case.[60] The cooling load contribution from ASH is given by:

$Q_{ASH} = 0.35 \times kW_{ASH} \times 3413\ Btu/hr/kW \times \text{ASH ON\%}$

The EER for both medium- and low-temperature applications is a function of the saturated condensing temperature (SCT) and part load ratio (PLR) of the compressor. For medium-temperature refrigerated cases, the SCT is calculated as the design dry-bulb temperature of the ambient or adjacent space where the compressor/condensing units reside (Db_{adj}) plus 15 degrees. For low-temperature refrigerated cases, the SCT is Db_{adj} plus 10 degrees. PLR is the ratio of total cooling load to compressor capacity and is assumed to be a constant 0.87 (i.e., compressor over-sizing factor of 15%).

59 "Anti-Sweat Heat (ASH) Controls," Workpaper WPSCNRRN0009. Southern California Edison Company. 2007

60 A Study of Energy Efficient Solutions for Anti-Sweat Heaters. Southern California Edison RTTC. December 1999

For medium and low-temperature compressors, the following equation is used to determine the EER.[61]

$$EER = a + (b * SCT) + (c * PLR) + (d * SCT^2) + (e * PLR^2) + (f * SCT * PLR) + (g * SCT^3) + (h * PLR^3) + (i * SCT * PLR^2) + (j * SCT^2 * PLR)$$

Where for medium-temp display cases (coolers):

a	= 3.75346018700468
b	= -0.049642253137389
c	= 29.4589834935596
d	= 0.000342066982768282
e	= -11.7705583766926
f	= 0.212941092717051
g	= 1.46606221890819E-06
h	= 6.80170133906075
i	= .020187240339536
j	= 0.000657941213335828

And for low-temp display cases (freezers):

a	= 9.86650982829017
b	= 0.230356886617629
c	= 22.905553824974
d	= 0.00218892905109218
e	= 2.48866737934442
f	= 0.248051519588758
g	= 7.57495453950879E-06
h	= 2.03606248623924

61 Per "Anti-Sweat Heat (ASH) Controls," Workpaper WPSCNRRN0009. Southern California Edison Company. 2007, compressor performance curves were obtained from a review of manufacturer data for reciprocating compressors as a function of SCT, cooling load, and cooling capacity of the compressor.

i = 0.0214774331896676

j = 0.000938305518020252

Db_{adj},[62] SCT, and the resulting EER for each climate zone are shown in Table 41.

Table 41: EER per Climate Zone for Coolers and Freezers

		Medium Temperature Display Case (Cooler)		Low Temperature Display Case (Freezer)	
	Db_{adj} (F)	SCT (F)	EER	SCT (F)	EER
Albuquerque	93	108	6.75	103	5.23
Santa Fe	86	101	7.50	96	5.85
Las Cruces	97	112	6.34	107	4.90
Roswell	97	112	6.34	107	4.90

Energy consumption for each hour is the product of power and run time. Total annual compressor energy consumption (due to heat from ASHs) is the sum of all 1-hour consumption values across 8760 hours/year.

$$kWh_{comp\text{-}baseline} = \Sigma_{1\text{-}8760}\, Q_{ASH} / (EER \times 1000) \times 100\%$$

$$kWh_{comp\text{-}efficient} = \Sigma_{1\text{-}8760}\, Q_{ASH} / (EER \times 1000) \times ASH\ ON\%$$

$$kWh_{comp} = kWh_{comp\text{-}baseline} - kWh_{comp\text{-}efficient}$$

The total energy savings are a result of both the decrease in length of time the heater is running (kWh_{ASH}) and the reduction in load on the refrigeration (kWh_{comp}), i.e.:

$$kWhsavings = kWh_{ASH} + kWh_{comp}$$

62 The hottest month was selected from ASHRAE Climatic Design Condition 2009; Monthly Design Dry Bulb; 5%. Taos station was used for Santa Fe. White Sands station was used for Las Cruces.

3.8.4 Demand Savings Estimation

Demand savings are defined as the reduction in average kW during 3:00-6:00 pm on the hottest summer weekdays. Note: because the controller does not alter the instantaneous demand of the ASH, no direct peak demand savings are claimed.

$$kW_{demand\text{-}savings} = kW_{comp\text{-}baseline} - kW_{comp\text{-}efficient}$$

Where:

$kW_{comp\text{-}baseline} = Q_{ASH} / (EER \times 1000) \times 100\%$

$kW_{comp\text{-}efficient} = Q_{ASH} / (EER \times 1000) \times ASH\ ON\%$; the average of 3pm-6pm on the hottest days of summer

3.8.5 Non-energy Benefits

There are no non-energy benefits for this measure.

3.8.6 Measure Life

Measure Life for this measure is 12 years.[63]

3.8.7 Incremental Cost

The incremental cost for this measure is the total measure cost. Wisconsin Focus on Energy lists the average unit cost as $68.78.[64]

[63] California Measurement Advisory Committee Public Workshops on PY 2001 Energy Efficiency Programs. September 2000, p. 59

[64] Anti-Sweat Heater Controls. Wisconsin Focus on Energy. https://s3.us-east-1.amazonaws.com/focusonenergy/staging/inline-files/Focus_on_Energy_2022_TRM.pdf

3.9 Zero-Energy Doors

This measure saves refrigeration energy by eliminating the need for electric resistive heaters on cooler and freezer doors.

3.9.1 Measure Overview

Sector	Commercial
End-use	Refrigeration
Fuel	Electricity
Measure category	Zero-Energy Doors
Delivery mechanism	Rebate
Baseline description	Cooler or freezer glass door that is continuously heated to prevent condensation.
Efficient case description	Cooler or freezer glass door that prevents condensation with multiple panes of glass, inert gas, and low-E coatings instead of using electrically generated heat.

3.9.2 Savings

Energy and demand savings are shown in Table 42.

Table 42: Energy and Demand Savings Zero-Energy Doors on Coolers and Freezers

	Demand Savings kW per door	Energy Savings kWh per door
Low-Temp Freezer	0.2600	2,278
Medium-Temp Cooler	0.0900	788
High-Temp Cooler	0.0825	723

3.9.3 Energy Savings Estimation

Savings are calculated using the formula below:

$$kWh_{savings} = (kW_{baseline} - kW_{efficient}) \text{ x } BF \times 8760 \text{ hours/yr}$$

Where:

$kW_{baseline}$ = Connected load of a typical reach-in cooler or freezer door with a heater. The values shown in Table 43 below are based on a range of wattages from two manufacturers and metered data. [65]

BF = Bonus factor for reduced cooler or freezer load from eliminating heat generated by the door heater. $BF = 1+0.65/COP$; based on the assumption that 65% of the heat generated by the door enters the refrigerated case.

The values shown in Table 43 below are based on the average standard compressor efficiencies with the listed Saturated Suction Temperatures and a condensing temperature of 90°F. [66]

$kW_{efficient}$ = Connected load of a zero-energy door = 0.0 kW by definition

Table 43: Connected Load and Bonus Factor for Typical Cooler and Freezer Doors

	$kW_{baseline}$	Saturated Suction Temperature (^{0}F)	COP	BF
Low-Temp Freezer	0.200	-20	2.0	1.30
Medium-Temp Cooler	0.075	20	3.5	1.20
High-Temp Cooler	0.075	45	5.4	1.10

3.9.4 Demand Savings Estimation

Demand savings are based on the following equation.

$$kW_{savings} = (kW_{baseline} - kW_{efficient}) \times BF$$

See section directly above for input parameter definitions and values.

3.9.5 Non-energy Benefits

There are no non-energy benefits for this measure.

65 Maine Technical Reference User Manual (TRM) No. 2010-1, 8/31/2010. Footnote 83 on page 95.

66 Maine Technical Reference User Manual (TRM) No. 2010-1, 8/31/2010. Footnote 84 on page 95.

3.9.6 Measure Life

The lifetime of a zero-energy door is expected to be 10 years.[67]

3.9.7 Incremental Cost

The incremental cost for this measure is the total measure cost: $275 for coolers, and $800 for freezers.[68]

[67] Maine Technical Reference User Manual (TRM) No. 2010-1, 8/31/2010, page 96.

[68] Maine Technical Reference User Manual (TRM) No. 2010-1, 8/31/2010, page 96.

3.10 Guest Room Energy Management

3.10.1 Measure Overview

Sector	Commercial
End use	Lighting and HVAC Control
Fuel	Electricity
Measure category	Guest Room Energy Management
Delivery mechanism	Direct Install, On-bill Financing, Rebates
Baseline description	Manual Heating/Cooling Temperature Setpoint and Fan On/Off/Auto Thermostat
Efficient case description	Guest room temperature set point must be controlled by automatic occupancy detectors or keycard that indicates the occupancy status of the room. During unoccupied periods the default setting for controlled units differs by at least 5 degrees from the operating set point. Theoretically, the control system may also be tied into other electric loads, such as lighting and plug loads to shut them off when occupancy is not sensed. This measure bases savings on improved HVAC controls. If system is connected to lighting and plug loads, additional savings would be realized. The incentive is per guestroom controlled, rather than per sensor, for multi-room suites. Replacement or upgrades of existing occupancy-based controls are not eligible for an incentive.

3.10.2 Savings

Energy and demand savings are shown in Table 44.

Table 44: Energy and Demand Savings Guest Room Energy Management

Demand Savings (kW/room)	Energy Savings (kWh/room)
0.1875	625

3.10.3 Energy Savings Estimation

This Guest Room Energy Management (GREM) measure assumes that a typical HVAC unit in hotel rooms is 1 ton, rated at 1.25 kW/ton. The demand kW savings are based on the assumption that there is a 15% reduction in usage during the peak period. Therefore, the savings are 0.15 * tons * kW/ton. The baseline assumes that there are no controls based on occupancy in hotel rooms. The energy savings assume that there is a 500-hour reduction in operating hours. These reduced hours are considered to be equivalent full load hours. These are all DNV GL estimates.[69]

3.10.4 Demand Savings Estimation

The DNV GL savings estimate assumes a 15% demand reduction. GREM demand savings in the Illinois TRM confirms this with empirical observations taken by KEMA for a NV Energy study.[70]

3.10.5 Non-energy Benefits

There are no non-energy benefits for this measure.

3.10.6 Measure Life

The lifetime of Guest Room EM is expected to be 15 years.[71]

3.10.7 Incremental Cost

The incremental cost for this measure is $260 per room HVAC controller, which is the cost difference between a non-programmable thermostat and a GREM.[72]

[69] These estimates were verified against Guest Room EM measures studied in a San Diego Gas and Electric Workpaper as well as the Illinois Energy Efficiency TRM.

[70] "State of Illinois Energy Efficiency Technical Reference Manual". SAG. Illinois. August 20, 2012.

[71] DEER 2008 value for energy management systems.

[72] This is a DNV GL derived cost estimate.

3.11 Efficient Water Heaters

3.11.1 Measure Overview

Sector	Commercial
End use	Water Heating
Fuel	Natural Gas
Measure category	Efficient water heaters
Delivery mechanism	Rebate
Baseline description	Federal standard minimum efficiency levels
Efficient case description	Energy Star or Consortium for Energy Efficiency (CEE) efficiency level, varies with type of water heater

3.11.2 Savings

Energy savings are shown in the following tables. Building type abbreviations are explained in Table 3. The "Com" building type can be used as an average across all commercial buildings.

Table 45: Energy Savings for Residential Style, EF Rated, Water Heaters, Therms per Unit per Year, Part 1

Small (< 55 gallons) storage	Com	Asm	ECC	EPr	ERC	ESe	EUD	EUn	Gro	HGR	Hsp	Htl	MBT
CEE Tier 1 (Energy Star) EF=0.67	63	69	55	46	46	46	37	64	86	51	89	112	57
CEE Tier 2 EF=0.8	189	215	162	127	127	127	118	197	278	168	295	375	169
Large (> 55 gallons) storage													
Energy Star EF=0.77	78	83	62	49	50	49	42	77	110	64	114	153	70
Instantaneous less than 200 kBtuh, less than 2 gal													
CEE Tier 1 EF=0.82	301	344	276	225	223	225	185	317	421	250	447	552	278
CEE Tier 2 (Energy Star) EF=0.9	618	727	541	418	416	418	395	637	912	563	983	1,240	558

Table 46: Energy Savings for Residential Style, EF Rated, Water Heaters, Therms per Unit per Year, Part 2

Small (< 55 gallons) storage	MLI	Mtl	Nrs	OfL	OfS	RFF	RSD	Rt3	RtL	RtS	SCn	SUn	WRf
CEE Tier 1 (Energy Star) EF=0.67	58	64	98	56	53	52	54	59	65	54	70	69	116
CEE Tier 2 EF=0.8	170	200	326	167	154	156	163	178	202	162	206	204	369
Large (> 55 gallons) storage													
Energy Star EF=0.77	70	74	130	69	64	53	57	65	75	59	100	100	179
Instantaneous less than 200 kBtuh, less than 2 gal													
CEE Tier 1 EF=0.82	282	320	488	270	258	266	278	298	323	277	302	294	498
CEE Tier 2 (Energy Star) EF=0.9	562	664	1088	542	507	530	557	609	670	555	613	604	1097

Table 47: Energy Savings for Commercial Style, Et Rated, Water Heaters, Therms per kBtuh per Year, Part 1

Storage, greater than 75 kBtuh	Com	Asm	ECC	EPr	ERC	ESe	EUn	Gro	Hsp	Htl	MBT	MLI
CEE Tier 1 Et=0.9	1.85	2.54	2.13	1.36	1.46	1.49	2.47	3.08	4.50	3.14	1.52	1.81
CEE Tier 2 (Energy Star) Et=0.94	2.48	3.40	2.86	1.82	1.96	2.00	3.31	4.13	6.03	4.21	2.04	2.43
Instantaneous	**Com**	**Asm**	**ECC**	**EPr**	**ERC**	**ESe**	**EUn**	**Gro**	**Hsp**	**Htl**	**MBT**	**MLI**
CEE Tier 1 Et=0.9	2.20	2.91	2.47	1.72	1.85	1.86	2.90	3.21	4.83	3.28	1.89	2.17
CEE Tier 2 (Energy Star) Et=0.94	2.94	3.90	3.30	2.31	2.47	2.49	3.89	4.30	6.47	4.40	2.53	2.90

Table 48: Energy Savings for Commercial Style, Et Rated, Water heaters, Therms per kBtuh per Year, Part 2

Storage, greater than 75 kBtuh	MtI	Nrs	OfL	OfS	RFF	RSD	Rt3	RtL	RtS	SCn	SUn	WRf
CEE Tier 1 Et=0.9	1.46	3.27	2.22	0.44	1.28	2.21	0.95	0.61	1.22	1.70	1.70	3.26
CEE Tier 2 (Energy Star) Et=0.94	1.96	4.38	2.98	0.58	1.72	2.96	1.27	0.82	1.64	2.28	2.28	4.37
Instantaneous	**MtI**	**Nrs**	**OfL**	**OfS**	**RFF**	**RSD**	**Rt3**	**RtL**	**RtS**	**SCn**	**SUn**	**WRf**
CEE Tier 1 Et=0.9	1.83	3.63	2.58	0.79	1.65	2.59	1.31	0.97	1.59	2.07	2.05	3.71
CEE Tier 2 (Energy Star) Et=0.94	2.45	4.86	3.46	1.06	2.21	3.47	1.75	1.31	2.13	2.77	2.74	4.97

3.11.3 Energy Savings Estimation

Savings are based on the California Database for Energy Efficiency Resources (DEER)[73] values for commercial water heaters. Water heaters can be either residential or commercial style. Residential water heaters are rated with an Energy Factor (EF). Residential storage water heaters are rated at less than 75 thousand Btu per hour (kBtuh).[74] Residential instantaneous water heaters are rated at less than 200 kBtuh and have less than or equal to 2 gallons of storage. Commercial water heaters are rated with a thermal efficiency (Et).[75] The DEER values vary slightly based on climate zone. The values here are based on the SCG region-wide zone.

Savings derived here are based on slightly different efficiency levels than those assumed by DEER. Following the approach of Southern California Gas (SCG),[76] DEER savings are adjusted according to efficiency level as follows. Energy savings are based on the following formula.

$$EnergySvgs = \frac{EHW}{Eff_{Baseline}} - \frac{EHW}{Eff_{Measure}}$$

Where:

EnergySvgs	= Annual savings in therms
EHW	= Net energy that effectively heats the water, after losses, in therms
Eff	= Efficiency of water heater

Since this equation applies to both the DEER savings and the TRM savings, we can derive the following formula to adjust DEER savings to TRM savings.

$$Svgs_{TRM} = Svgs_{DEER}\left(\frac{\frac{1}{Eff_{BaselineTRM}} - \frac{1}{Eff_{MeasureTRM}}}{\frac{1}{Eff_{BaselineDEER}} - \frac{1}{Eff_{MeasureDEER}}}\right)$$

The adjustments to DEER savings are most needed to be consistent with current commercial Energy Star standards, which require an Et of 94%, while DEER estimated savings using an Et of 90%.

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[73] Deeresources.com, accessed on Oct 6, 2015 with READI version 2.3.0.

[74] Federal standards for residential water heaters, https://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/27

[75] Federal standards for commercial water heaters, https://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/51

[76] Southern California Gas Company, Workpaper WPSCGNRWH120206B Revision 3 Tankless Water Heaters, 2012

3.11.4 Non-energy Benefits

There are no non-energy benefits.

3.11.5 Measure Life

The lifetime of storage water heaters is 15 years.[77] The lifetime for instantaneous water heaters is 20 years.[78]

3.11.6 Incremental Cost

The incremental cost is the difference between a standard efficiency water heater and an efficient unit, as shown in the table below.

Table 49: Incremental Measure Costs for Efficient Commercial Water Heaters

Residential-style water heaters, Energy Factor (EF) rated	Incremental Cost per kBtuh
Small (< 55 gallons) storage	
CEE Tier I (Energy Star) EF=0.67[79]	$7.22
CEE Tier 2 EF=0.8[80]	$28.00
Large (> 55 gallons) storage	
Energy Star EF=0.77	$28.00
Instantaneous less than 200 kBtuh, less than 2 gal, EF rated	
CEE Tier I EF=0.82[81]	$0.94
CEE Tier 2 (Energy Star) EF=0.9	$3.44
Commercial water heaters, thermal efficiency (Et) rated	
Storage, greater than 75 kBtuh	
CEE Tier I Et=0.9[82]	$7.97
CEE Tier 2 (Energy Star) Et=0.94	$7.97
Instantaneous	

77 Pacific Gas & Electric Company, Work Paper PGECODHW103 Non-res Gas Storage Water Heater Revision # 3, 2012, based on DEER

78 Southern California Gas Company, Workpaper WPSCGNRWH120206B Revision 3 Tankless Water Heaters, 2012, based on DEER

79 SCG Workpaper

80 TecMarket Works, Indiana Technical Resource Manual Version 1.0, 2013

81 SCG Workpaper

82 Online: http://www.supplyhouse.com/AO-Smith-Commercial-Water-Heaters-1249000

CEE Tier 1 Et=0.9	$3.01
CEE Tier 2 (Energy Star) Et=0.94	$12.55

3.12 HVAC Variable Frequency Drives

3.12.1 Measure Overview

Sector	Commercial
End use	HVAC
Fuel	Electric
Measure category	Variable Frequency Drive (VFD)
Delivery mechanism	Rebate
Baseline description	HVAC fan or pump, not controlled by VFD
Efficient case description	HVAC fan or pump, 50 HP or less, of one of the following types, controlled by VFD ■ Supply Fan ■ Return Fan ■ Chilled water pump (central plant) ■ Hot water pump (central plant) ■ Cooling tower fan (central plant) ■ Water source heat pump (WSHP) circulation pump

3.12.2 Savings

Annual energy savings are shown in Table 50, per unit horsepower.

Table 50: Energy Savings (kWh per HP) for HVAC VFD

Equipment Type	Albuquerque	Santa Fe	Roswell	Las Cruces
Supply Fans	2,033	2,033	2,033	2,033
Return Fans	1,788	1,788	1,788	1,788
Cooling Water Pumps	1,944	1,576	2,199	2,286
Hot Water Pumps	1,431	1,510	1,373	1,344
WSHP Circulation Pumps	2,562	2,562	2,562	2,562
Cooling Tower Fan	784	784	784	784

Demand savings are shown in Table 51, per unit horsepower.

Table 51: Demand Savings (kW per HP) for HVAC VFD

Equipment Type	Albuquerque	Santa Fe	Roswell	Las Cruces
Supply Fans	0.286	0.286	0.286	0.286
Return Fans	0.297	0.297	0.297	0.297
Cooling Water Pumps	0.185	0.185	0.185	0.185
Hot Water Pumps	0.096	0.096	0.096	0.096
WSHP Circulation Pumps	0.234	0.234	0.234	0.234
Cooling Tower Fan	0	0	0	0

3.12.3 Energy Savings Estimation

Savings estimates are based on a study sponsored by Northeast Energy Efficiency Partnerships (NEEP) of HVAC VFD savings.[83] The NEEP team metered, post-installation, around 400 HVAC VFD installations in the mid-Atlantic and New England regions in 2012-2013. The study also included a previous, pre/post, VFD metering study in Massachusetts of 26 sites.

The NEEP study found many VFD's were run at a constant speed, and that energy savings were often not closely related to weather. The NEEP study presented single savings values for each HVAC application across the entire region in order to achieve higher statistical significance. For applications which apply to both heating and cooling, the NEEP savings values are unchanged for New Mexico. For the applications which are specific to heating or cooling, the values are adjusted for New Mexico climate zones. The adjustment is based on a degree-day ratio of the New Mexico climate zone to an

[83] Arlis Reynolds, Jennifer Huckett, Andrew Wood, Dave Korn, Jay Robbins (DMI), Variable Speed Drive Loadshape Project Final Report, Cadmus, Inc., NEEP, August, 2014

approximate average New England degree day value. This degree-day ratio is given a weight to estimate the portion of the savings that are dependent on weather. The New Mexico climate zone savings are calculated with the following formula.

$$Svgs_{NM} = \frac{DD_{NM}}{DD_{NE}} \times Weight \times Svgs_{NE} + (1 - Weight) \times Svgs_{NE}$$

Where:

SvgsNM	= Annual energy or demand savings, in kWh or kW
DDNM	= Degree-days (base 65) for the New Mexico climate zone, either heating or cooling
DDNE	= Degree-days for the New England region, either heating or cooling, approximated as 6000 for heating and 750 for cooling
Weight	= Weight to give the degree-day ratio portion of the savings estimate relative to the original NEEP estimate, 25%
SvgsNE	= Savings estimate from the NEEP study

In addition, a savings value is provided for a cooling tower fan, which is not an application that was metered in the NEEP study. This value is taken from the Indiana state TRM,[84] and is based on building simulations using the DEER building prototypes. No adjustment for New Mexico climate zones is attempted given the high uncertainty around all aspects of this estimate.

3.12.4 Demand Savings Estimation

The demand savings are based on the NEEP demand savings values. The demand savings were not adjusted using New Mexico weather. The demand savings value for the cooling tower fan application was referenced from the Indiana TRM.

3.12.5 Non-energy Benefits

There are no non-energy benefits.

[84] TecMarket Works, Indiana Statewide Evaluation Team, "Indiana Technical Resource Manual" version 1.0, 2013

3.12.6 Measure Life

The lifetime for this measure is 15 years.[85]

3.12.7 Incremental Cost

The incremental cost for this measure is the total installed cost of the VFD. The costs are taken from the Ohio TRM, shown below.[86] For motors larger than 20 HP, costs should be on a per-site basis.

Table 52: Incremental Costs for HVAC VFD

For motors up to this size, HP	Total Installed Cost
5	$1,330
7.5	$1,622
10	$1,898
15	$2,518
20	$3,059

[85] DEER 2014

[86] State of Illinois Energy Efficiency Technical Reference Manual, version 10.0

3.13 Efficient Boilers

This measure saves space heating energy by using less gas to heat water used in HVAC heating coils.

3.13.1 Measure Overview

Sector	Commercial
End use	Space heating
Fuel	Natural Gas
Measure category	HVAC Boilers
Delivery mechanism	Rebate
Baseline description	Hot water boiler (300 - 2500 kBtuh, 80.0 Et, OA Reset from 140 to 165 F) Hot water boiler (> 2500 kBtuh, 80.0 Et, 82.0Ec, OA Reset from 140 to 165 F) Hot water boiler (< 300 kBtuh, 82.0 AFUE, OA Reset from 140 to 165 F) Steam boiler (300 - 2500 kBtuh, 79.0 Et, OA Reset from 140 to 165 F) Steam boiler (> 2500 kBtuh, 79.0 Et, 82.0Ec, OA Reset from 140 to 165 F) Steam boiler (< 300 kBtuh, 80.0 AFUE, OA Reset from 140 to 165 F)
Efficient case description	Similar Boiler with higher efficiency and/or lower reset temperature (load or outdoor air)

3.13.2 Savings

This measure is only applicable to hot water and steam boilers which are used to provide space heating to commercial buildings. Boilers used for other processes, or boilers used for both space heating and service water heating must use a custom approach.

Replace on Burnout

All gas savings for a boiler improvement are tabulated by climate, improvement type, building type, and climate zone in Table 53 through Table 68. For multi-use buildings with distinct and quantifiable service areas, it is appropriate to use a weighted average of the tables based on floor area. For multifamily boilers, refer to the residential boiler measures. Gas savings are in therms per thousand Btu per hour boiler capacity (kBtuh).

Table 53: Savings for Water Boiler 300 to 2500 kBtuh – Albuquerque (Therms/kBtuh)

	Commercial Typical[87]	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large Retail
83.0 Et, OA Reset from 140 to 165 F	2.00	0.66	0.52	0.86	3.57	1.46	0.16	1.84	0.52	0.33	0.44
85.0 Et, OA Reset from 140 to 165 F	2.25	0.80	0.68	1.03	4.51	1.83	0.18	2.43	0.61	0.41	0.56
90.0 Et, condensing, OA reset from 115 to 140 F	2.96	1.44	1.18	1.80	6.23	2.83	0.40	3.18	1.06	0.74	1.05
90.0 Et, condensing, load reset from 115 to 140 F	3.27	1.58	1.25	1.92	7.58	2.61	0.47	3.79	1.17	0.80	1.09
90.0 Et, condensing, OA reset from 140 to 165 F	2.60	1.27	1.04	1.54	4.39	2.29	0.34	2.68	0.92	0.66	0.95
94.0 Et, condensing, OA reset from 115 to 140 F	3.37	1.66	1.43	2.06	7.83	3.45	0.43	4.20	1.20	0.86	1.24
94.0 Et, condensing, load reset from 115 to 140 F	3.66	1.81	1.50	2.18	9.10	3.24	0.49	4.79	1.30	0.92	1.28
94.0 Et, condensing, OA reset from 140 to 165 F	3.03	1.51	1.29	1.81	6.05	2.93	0.36	3.72	1.06	0.79	1.14

[87] This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g., a medical administration building could potentially be assessed using the "Office – Small" lighting hours).

Table 54: Savings for Water Boiler 300 to 2500 kBtuh – Roswell (Therms/kBtuh)

	Commercial Typical[88]	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large Retail
83.0 Et, OA Reset from 140 to 165 F	1.20	0.57	0.63	0.72	5.43	2.29	0.19	1.89	0.68	0.39	0.42
85.0 Et, OA Reset from 140 to 165 F	1.34	0.66	0.73	0.82	6.33	2.59	0.21	2.30	0.75	0.45	0.50
90.0 Et, condensing, OA reset from 115 to 140 F	1.83	1.15	1.18	1.38	8.26	3.55	0.36	3.03	1.17	0.71	0.84
90.0 Et, condensing, load reset from 115 to 140 F	2.03	1.29	1.30	1.48	9.59	3.48	0.51	3.54	1.34	0.78	0.89
90.0 Et, condensing, OA reset from 140 to 165 F	1.62	1.04	1.06	1.24	6.55	3.01	0.28	2.63	1.01	0.64	0.77
94.0 Et, condensing, OA reset from 115 to 140 F	2.04	1.29	1.35	1.53	9.78	4.04	0.39	3.72	1.28	0.81	0.97
94.0 Et, condensing, load reset from 115 to 140 F	2.23	1.42	1.46	1.62	11.04	3.97	0.53	4.21	1.44	0.87	1.02
94.0 Et, condensing, OA reset from 140 to 165 F	1.84	1.18	1.23	1.39	8.14	3.53	0.32	3.34	1.13	0.74	0.90

[88] This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g., a medical administration building could potentially be assessed using the "Office – Small" lighting hours).

Table 55: Savings for Water Boiler 300 to 2500 kBtuh – Santa Fe (Therms/kBtuh)

	Commercial Typical[89]	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large Retail
83.0 Et, OA Reset from 140 to 165 F	2.58	0.85	0.67	1.11	4.60	1.88	0.20	2.37	0.67	0.43	0.57
85.0 Et, OA Reset from 140 to 165 F	2.90	1.04	0.87	1.33	5.81	2.36	0.23	3.14	0.78	0.53	0.73
90.0 Et, condensing, OA reset from 115 to 140 F	3.82	1.85	1.52	2.32	8.03	3.65	0.52	4.10	1.37	0.95	1.36
90.0 Et, condensing, load reset from 115 to 140 F	4.21	2.04	1.61	2.48	9.77	3.36	0.61	4.89	1.51	1.03	1.41
90.0 Et, condensing, OA reset from 140 to 165 F	3.36	1.64	1.34	1.98	5.66	2.95	0.43	3.45	1.19	0.85	1.22
94.0 Et, condensing, OA reset from 115 to 140 F	4.34	2.15	1.84	2.66	10.09	4.45	0.55	5.42	1.54	1.11	1.60
94.0 Et, condensing, load reset from 115 to 140 F	4.72	2.33	1.93	2.82	11.73	4.17	0.63	6.18	1.68	1.19	1.65
94.0 Et, condensing, OA reset from 140 to 165 F	3.91	1.95	1.67	2.34	7.81	3.77	0.47	4.80	1.36	1.02	1.47

[89] This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g., a medical administration building could potentially be assessed using the "Office – Small" lighting hours).

Table 56: Savings for Water Boiler 300 to 2500 kBtuh – Las Cruces (Therms/kBtuh)

	Commercial Typical[90]	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large Retail
83.0 Et, OA Reset from 140 to 165 F	1.22	0.58	0.64	0.73	5.52	2.32	0.19	1.92	0.69	0.40	0.43
85.0 Et, OA Reset from 140 to 165 F	1.36	0.67	0.75	0.83	6.43	2.63	0.21	2.34	0.76	0.45	0.51
90.0 Et, condensing, OA reset from 115 to 140 F	1.86	1.17	1.20	1.41	8.40	3.61	0.37	3.08	1.19	0.72	0.86
90.0 Et, condensing, load reset from 115 to 140 F	2.06	1.31	1.32	1.50	9.74	3.53	0.52	3.60	1.36	0.79	0.90
90.0 Et, condensing, OA reset from 140 to 165 F	1.65	1.06	1.07	1.26	6.66	3.06	0.29	2.67	1.02	0.65	0.78
94.0 Et, condensing, OA reset from 115 to 140 F	2.07	1.31	1.38	1.55	9.93	4.10	0.40	3.78	1.30	0.82	0.99
94.0 Et, condensing, OA reset from 140 to 165 F	2.27	1.44	1.48	1.65	11.22	4.03	0.54	4.28	1.47	0.88	1.03
94.0 Et, condensing, OA reset from 140 to 165 F	1.87	1.20	1.25	1.42	8.27	3.58	0.32	3.40	1.15	0.75	0.92

[90] This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g., a medical administration building could potentially be assessed using the "Office – Small" lighting hours).

Table 57: Savings for Water Boiler Greater than 2500 kBtuh – Albuquerque (Therms/kBtuh)

	Commercial Typical[91]	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large Retail
83.0 Et, 85.0Ec, OA Reset from 140 to 165 F	2.00	0.66	0.52	0.86	3.57	1.46	0.16	1.84	0.52	0.33	0.44
85.0 Et, 87.0Ec, OA Reset from 140 to 165 F	2.25	0.80	0.68	1.03	4.51	1.83	0.18	2.43	0.61	0.41	0.56
90.0 Et, condensing, OA reset from 115 to 140 F	2.96	1.44	1.18	1.80	6.23	2.83	0.40	3.18	1.06	0.74	1.05
90.0 Et, condensing, load reset from 115 to 140 F	3.27	1.58	1.25	1.92	7.58	2.61	0.47	3.79	1.17	0.80	1.09
90.0 Et, condensing, OA reset from 140 to 165 F	2.60	1.27	1.04	1.54	4.39	2.29	0.34	2.68	0.92	0.66	0.95
94.0 Et, condensing, OA reset from 115 to 140 F	3.37	1.66	1.43	2.06	7.83	3.45	0.43	4.20	1.20	0.86	1.24
94.0 Et, condensing, load reset from 115 to 140 F	3.66	1.81	1.50	2.18	9.10	3.24	0.49	4.79	1.30	0.92	1.28
94.0 Et, condensing, OA reset from 140 to 165 F	3.03	1.51	1.29	1.81	6.05	2.93	0.36	3.72	1.06	0.79	1.14

[91] This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g., a medical administration building could potentially be assessed using the "Office – Small" lighting hours).

Table 58: Savings for Water Boiler Greater than 2500 kBtuh – Roswell (Therms/kBtuh)

	Commercial Typical[92]	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large Retail
83.0 Et, 85.0Ec, OA Reset from 140 to 165 F	1.20	0.57	0.63	0.72	5.43	2.29	0.19	1.89	0.68	0.39	0.42
85.0 Et, 87.0Ec, OA Reset from 140 to 165 F	1.34	0.66	0.73	0.82	6.33	2.59	0.21	2.30	0.75	0.45	0.50
90.0 Et, condensing, OA reset from 115 to 140 F	1.83	1.15	1.18	1.38	8.26	3.55	0.36	3.03	1.17	0.71	0.84
90.0 Et, condensing, load reset from 115 to 140 F	2.03	1.29	1.30	1.48	9.59	3.48	0.51	3.54	1.34	0.78	0.89
90.0 Et, condensing, OA reset from 140 to 165 F	1.62	1.04	1.06	1.24	6.55	3.01	0.28	2.63	1.01	0.64	0.77
94.0 Et, condensing, OA reset from 115 to 140 F	2.04	1.29	1.35	1.53	9.78	4.04	0.39	3.72	1.28	0.81	0.97
94.0 Et, condensing, load reset from 115 to 140 F	2.23	1.42	1.46	1.62	11.04	3.97	0.53	4.21	1.44	0.87	1.02
94.0 Et, condensing, OA reset from 140 to 165 F	1.84	1.18	1.23	1.39	8.14	3.53	0.32	3.34	1.13	0.74	0.90

[92] This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g., a medical administration building could potentially be assessed using the "Office – Small" lighting hours).

Table 59: Savings for Water Boiler Greater than 2500 kBtuh – Santa Fe (Therms/kBtuh)

	Commercial Typical[93]	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large Retail
83.0 Et, 85.0Ec, OA Reset from 140 to 165 F	2.58	0.85	0.67	1.11	4.60	1.88	0.20	2.37	0.67	0.43	0.57
85.0 Et, 87.0Ec, OA Reset from 140 to 165 F	2.90	1.04	0.87	1.33	5.81	2.36	0.23	3.14	0.78	0.53	0.73
90.0 Et, condensing, OA reset from 115 to 140 F	3.82	1.85	1.52	2.32	8.03	3.65	0.52	4.10	1.37	0.95	1.36
90.0 Et, condensing, load reset from 115 to 140 F	4.21	2.04	1.61	2.48	9.77	3.36	0.61	4.89	1.51	1.03	1.41
90.0 Et, condensing, OA reset from 140 to 165 F	3.36	1.64	1.34	1.98	5.66	2.95	0.43	3.45	1.19	0.85	1.22
94.0 Et, condensing, OA reset from 115 to 140 F	4.34	2.15	1.84	2.66	10.09	4.45	0.55	5.42	1.54	1.11	1.60
94.0 Et, condensing, load reset from 115 to 140 F	4.72	2.33	1.93	2.82	11.73	4.17	0.63	6.18	1.68	1.19	1.65
94.0 Et, condensing, OA reset from 140 to 165 F	3.91	1.95	1.67	2.34	7.81	3.77	0.47	4.80	1.36	1.02	1.47

93 This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g., a medical administration building could potentially be assessed using the "Office – Small" lighting hours).

Table 60: Savings for Water Boiler Greater than 2500 kBtuh – Las Cruces (Therms/kBtuh)

	Commercial Typical[94]	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large Retail
83.0 Et, 85.0Ec, OA Reset from 140 to 165 F	1.22	0.58	0.64	0.73	5.52	2.32	0.19	1.92	0.69	0.40	0.43
85.0 Et, 87.0Ec, OA Reset from 140 to 165 F	1.36	0.67	0.75	0.83	6.43	2.63	0.21	2.34	0.76	0.45	0.51
90.0 Et, condensing, OA reset from 115 to 140 F	1.86	1.17	1.20	1.41	8.40	3.61	0.37	3.08	1.19	0.72	0.86
90.0 Et, condensing, load reset from 115 to 140 F	2.06	1.31	1.32	1.50	9.74	3.53	0.52	3.60	1.36	0.79	0.90
90.0 Et, condensing, OA reset from 140 to 165 F	1.65	1.06	1.07	1.26	6.66	3.06	0.29	2.67	1.02	0.65	0.78
94.0 Et, condensing, OA reset from 115 to 140 F	2.07	1.31	1.38	1.55	9.93	4.10	0.40	3.78	1.30	0.82	0.99
94.0 Et, condensing, load reset from 115 to 140 F	2.27	1.44	1.48	1.65	11.22	4.03	0.54	4.28	1.47	0.88	1.03
94.0 Et, condensing, OA reset from 140 to 165 F	1.87	1.20	1.25	1.42	8.27	3.58	0.32	3.40	1.15	0.75	0.92

[94] This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g., a medical administration building could potentially be assessed using the "Office – Small" lighting hours).

Table 61: Savings for Water Boiler Less than 300 kBtuh – Albuquerque (Therms/kBtuh)

	Commercial Typical[95]	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large Retail
84.0 AFUE, OA Reset from 140 to 165 F	1.28	0.41	0.30	0.56	2.23	0.93	0.11	0.98	0.34	0.19	0.26
84.5 AFUE, OA Reset from 140 to 165 F	1.07	1.82	0.86	2.23	6.75	4.31	0.24	4.00	0.97	0.59	0.71
85.0 AFUE, OA Reset from 140 to 165 F	1.38	0.47	0.37	0.63	2.64	1.09	0.12	1.24	0.37	0.23	0.31
87.0 AFUE, OA Reset from 140 to 165 F	1.59	0.59	0.50	0.77	3.43	1.40	0.14	1.74	0.45	0.29	0.41
90.0 AFUE, condensing, OA reset from 115 to 140 F	2.04	1.07	0.83	1.36	4.10	1.99	0.34	1.81	0.81	0.53	0.77
90.0 AFUE, condensing, OA reset from 140 to 165 F	1.67	0.90	0.68	1.10	2.24	1.44	0.28	1.31	0.66	0.46	0.66
94.0 AFUE, condensing, OA reset from 115 to 140 F	2.40	1.27	1.05	1.60	5.52	2.55	0.37	2.73	0.93	0.65	0.94
94.0 AFUE, condensing, load reset from 115 to 140 F	2.69	1.41	1.12	1.72	6.82	2.33	0.43	3.33	1.04	0.71	0.98
94.0 AFUE, condensing, OA reset from 140 to 165 F	2.05	1.11	0.91	1.34	3.73	2.01	0.30	2.24	0.79	0.57	0.84

[95] This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g., a medical administration building could potentially be assessed using the "Office – Small" lighting hours).

Table 62: Savings for Water Boiler Less than 300 kBtuh – Roswell (Therms/kBtuh)

	Commercial Typical[96]	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large Retail
84.0 AFUE, OA Reset from 140 to 165 F	0.81	0.37	0.40	0.49	3.61	1.63	0.14	1.07	0.48	0.24	0.24
84.5 AFUE, OA Reset from 140 to 165 F	1.26	1.25	0.80	1.55	7.04	3.56	0.19	3.24	0.80	0.57	0.62
85.0 AFUE, OA Reset from 140 to 165 F	0.87	0.41	0.44	0.53	4.00	1.76	0.15	1.25	0.51	0.27	0.28
87.0 AFUE, OA Reset from 140 to 165 F	0.98	0.48	0.53	0.61	4.75	2.02	0.16	1.60	0.58	0.32	0.35
90.0 AFUE, condensing, OA reset from 115 to 140 F	1.34	0.88	0.87	1.07	5.68	2.65	0.30	1.86	0.91	0.52	0.60
90.0 AFUE, condensing, OA reset from 140 to 165 F	1.12	0.76	0.74	0.93	3.96	2.11	0.21	1.46	0.75	0.45	0.52
94.0 AFUE, condensing, OA reset from 115 to 140 F	1.52	1.00	1.02	1.21	7.04	3.08	0.32	2.49	1.01	0.60	0.71
94.0 AFUE, condensing, load reset from 115 to 140 F	1.71	1.13	1.13	1.30	8.30	3.02	0.46	2.99	1.18	0.67	0.76
94.0 AFUE, condensing, OA reset from 140 to 165 F	1.31	0.89	0.89	1.07	5.37	2.57	0.24	2.10	0.86	0.53	0.64

[96] This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g., a medical administration building could potentially be assessed using the "Office – Small" lighting hours).

Table 63: Savings for Water Boiler Less than 300 kBtuh – Santa Fe (Therms/kBtuh)

	Commercial Typical[97]	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large Retail
84.0 AFUE, OA Reset from 140 to 165 F	1.64	0.52	0.39	0.72	2.87	1.20	0.15	1.26	0.43	0.25	0.33
84.5 AFUE, OA Reset from 140 to 165 F	1.38	2.34	1.11	2.87	8.70	5.56	0.31	5.16	1.25	0.76	0.92
85.0 AFUE, OA Reset from 140 to 165 F	1.78	0.60	0.47	0.82	3.40	1.41	0.16	1.60	0.48	0.29	0.40
87.0 AFUE, OA Reset from 140 to 165 F	2.06	0.76	0.64	1.00	4.42	1.81	0.18	2.25	0.58	0.38	0.53
90.0 AFUE, condensing, OA reset from 115 to 140 F	2.63	1.37	1.07	1.76	5.29	2.57	0.44	2.34	1.04	0.69	0.99
90.0 AFUE, condensing, OA reset from 140 to 165 F	2.16	1.16	0.88	1.42	2.89	1.86	0.36	1.69	0.86	0.59	0.85
94.0 AFUE, condensing, OA reset from 115 to 140 F	3.09	1.64	1.36	2.06	7.12	3.28	0.47	3.52	1.20	0.83	1.21
94.0 AFUE, condensing, load reset from 115 to 140 F	3.48	1.82	1.45	2.22	8.80	3.00	0.56	4.29	1.34	0.91	1.26
94.0 AFUE, condensing, OA reset from 140 to 165 F	2.65	1.43	1.18	1.73	4.81	2.60	0.39	2.89	1.02	0.73	1.08

[97] This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g., a medical administration building could potentially be assessed using the "Office – Small" lighting hours).

Table 64: Savings for Water Boiler Less than 300 kBtuh – Las Cruces (Therms/kBtuh)

	Commercial Typical[98]	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large Retail
84.0 AFUE, OA Reset from 140 to 165 F	0.83	0.37	0.40	0.50	3.66	1.66	0.14	1.09	0.49	0.25	0.25
84.5 AFUE, OA Reset from 140 to 165 F	1.28	1.27	0.81	1.58	7.15	3.61	0.19	3.29	0.81	0.58	0.63
85.0 AFUE, OA Reset from 140 to 165 F	0.88	0.41	0.45	0.54	4.06	1.79	0.15	1.27	0.52	0.27	0.28
87.0 AFUE, OA Reset from 140 to 165 F	1.00	0.49	0.54	0.62	4.83	2.05	0.17	1.62	0.59	0.32	0.35
90.0 AFUE, condensing, OA reset from 115 to 140 F	1.36	0.89	0.88	1.09	5.77	2.69	0.30	1.89	0.93	0.53	0.61
90.0 AFUE, condensing, OA reset from 140 to 165 F	1.14	0.77	0.75	0.95	4.02	2.15	0.22	1.49	0.76	0.46	0.53
94.0 AFUE, condensing, OA reset from 115 to 140 F	1.54	1.02	1.03	1.23	7.15	3.13	0.33	2.53	1.03	0.61	0.72
94.0 AFUE, condensing, load reset from 115 to 140 F	1.74	1.15	1.15	1.32	8.43	3.06	0.47	3.03	1.20	0.68	0.77
94.0 AFUE, condensing, OA reset from 140 to 165 F	1.33	0.91	0.91	1.09	5.46	2.61	0.25	2.13	0.87	0.54	0.65

[98] This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g., a medical administration building could potentially be assessed using the "Office – Small" lighting hours).

Table 65: Savings for Steam Boiler – Albuquerque (Therms/kBtuh)

	Commercial Typical[99]	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large Retail
Steam boiler 300 - 2500 kBtuh											
81.0 Et, OA Reset from 140 to 165 F	1.71	0.53	0.40	0.71	2.94	1.19	0.13	1.41	0.43	0.26	0.34
82.0 Et, OA Reset from 140 to 165 F	1.84	0.60	0.48	0.80	3.44	1.39	0.14	1.72	0.48	0.30	0.40
Steam Greater Than 2500 kBtuh											
80.0 Et, OA Reset from 140 to 165 F	1.57	0.46	0.32	0.62	2.43	0.99	0.12	1.08	0.39	0.22	0.28
81.0 Et, OA Reset from 140 to 165 F	1.71	0.53	0.40	0.71	2.94	1.19	0.13	1.41	0.43	0.26	0.34
82.0 Et, OA Reset from 140 to 165 F	1.84	0.60	0.48	0.80	3.44	1.39	0.14	1.72	0.48	0.30	0.40
Steam Boiler Less Than 300 kBtuh											
82.0 AFUE, OA Reset from 140 to 165 F	1.11	0.36	0.26	0.50	2.07	0.86	0.10	0.85	0.30	0.16	0.22
83.0 AFUE, OA Reset from 140 to 165 F	1.22	0.42	0.33	0.57	2.50	1.03	0.11	1.12	0.34	0.20	0.27

[99] This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g., a medical administration building could potentially be assessed using the "Office – Small" lighting hours).

Table 66: Savings for Steam Boiler – Roswell (Therms/kBtuh)

	Commercial Typical[100]	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large Retail
Steam boiler 300 - 2500 kBtuh											
81.0 Et, OA Reset from 140 to 165 F	1.04	0.47	0.52	0.60	4.70	1.98	0.16	1.50	0.59	0.32	0.33
82.0 Et, OA Reset from 140 to 165 F	1.10	0.51	0.57	0.65	5.18	2.13	0.17	1.72	0.63	0.35	0.37
Steam Greater Than 2500 kBtuh											
80.0 Et, OA Reset from 140 to 165 F	0.97	0.42	0.46	0.55	4.21	1.82	0.15	1.28	0.55	0.29	0.29
81.0 Et, OA Reset from 140 to 165 F	1.04	0.47	0.52	0.60	4.70	1.98	0.16	1.50	0.59	0.32	0.33
82.0 Et, OA Reset from 140 to 165 F	1.10	0.51	0.57	0.65	5.18	2.13	0.17	1.72	0.63	0.35	0.37
Steam Boiler Less Than 300 kBtuh											
82.0 AFUE, OA Reset from 140 to 165 F	0.72	0.32	0.35	0.43	3.32	1.49	0.12	0.89	0.44	0.21	0.20
83.0 AFUE, OA Reset from 140 to 165 F	0.78	0.36	0.39	0.47	3.73	1.62	0.13	1.07	0.47	0.23	0.24

[100] This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g., a medical administration building could potentially be assessed using the "Office – Small" lighting hours).

Table 67: Savings for Steam Boiler – Santa Fe (Therms/kBtuh)

	Commercial Typical[101]	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large Retail
Steam boiler 300 - 2500 kBtuh											
81.0 Et, OA Reset from 140 to 165 F	2.20	0.69	0.52	0.92	3.79	1.54	0.17	1.81	0.56	0.33	0.44
82.0 Et, OA Reset from 140 to 165 F	2.37	0.78	0.62	1.03	4.44	1.79	0.18	2.22	0.61	0.38	0.52
Steam Greater Than 2500 kBtuh											
80.0 Et, OA Reset from 140 to 165 F	2.03	0.59	0.41	0.80	3.13	1.28	0.16	1.40	0.50	0.28	0.36
81.0 Et, OA Reset from 140 to 165 F	2.20	0.69	0.52	0.92	3.79	1.54	0.17	1.81	0.56	0.33	0.44
82.0 Et, OA Reset from 140 to 165 F	2.37	0.78	0.62	1.03	4.44	1.79	0.18	2.22	0.61	0.38	0.52
Steam Boiler Less Than 300 kBtuh											
82.0 AFUE, OA Reset from 140 to 165 F	1.43	0.46	0.34	0.65	2.67	1.11	0.13	1.09	0.39	0.21	0.28
83.0 AFUE, OA Reset from 140 to 165 F	1.57	0.54	0.42	0.74	3.22	1.32	0.14	1.44	0.43	0.25	0.35

[101] This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g., a medical administration building could potentially be assessed using the "Office – Small" lighting hours).

Table 68: Savings for Steam Boiler – Las Cruces (Therms/kBtuh)

	Commercial Typical[102]	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large Retail
Steam boiler 300 - 2500 kBtuh											
81.0 Et, OA Reset from 140 to 165 F	1.05	0.47	0.53	0.61	4.78	2.01	0.17	1.53	0.60	0.33	0.34
82.0 Et, OA Reset from 140 to 165 F	1.12	0.52	0.58	0.66	5.27	2.17	0.18	1.74	0.64	0.35	0.38
Steam Greater Than 2500 kBtuh											
80.0 Et, OA Reset from 140 to 165 F	0.99	0.43	0.47	0.56	4.28	1.85	0.16	1.30	0.56	0.30	0.30
81.0 Et, OA Reset from 140 to 165 F	1.05	0.47	0.53	0.61	4.78	2.01	0.17	1.53	0.60	0.33	0.34
82.0 Et, OA Reset from 140 to 165 F	1.12	0.52	0.58	0.66	5.27	2.17	0.18	1.74	0.64	0.35	0.38
Steam Boiler Less Than 300 kBtuh											
82.0 AFUE, OA Reset from 140 to 165 F	0.73	0.32	0.35	0.43	3.37	1.51	0.13	0.91	0.45	0.21	0.21
83.0 AFUE, OA Reset from 140 to 165 F	0.79	0.36	0.40	0.48	3.79	1.65	0.13	1.09	0.48	0.24	0.24

Early Replacement

The baseline efficiency standards for early replacement projects are based on the IECC 2018, as shown in Table 69.

[102] This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g., a medical administration building could potentially be assessed using the "Office – Small" lighting hours).

Table 69. Commercial and INdustrial Boi Baseline Efficiencies

Size Category (Btu/hr)	Subcategory or Rating Condition	Baseline Efficiency[103,104]	Test Procedure
< 300,000	Hot Water	82% AFUE	DOE 10 CFR Part 430.23
	Steam	80% AFUE	
> 300,000 and ≤2,500,000	Hot Water	80% E_t	DOE 10 CFR Part 431.86
	Steam	79% E_t	
> 2,500,000	Hot Water	82% E_c	
	Steam	79% E_t[105]	

Early Replacement determination will be based on meeting the following conditions:

- The existing unit is operational when replaced, or
- The existing unit requires minor repairs (<$528).[106]

3.13.3 Energy Savings Estimation

Replace on Burnout

Energy Savings are taken from DEER 2016 simulation data for commercial water and steam boilers with federally established baseline efficiencies.[107] The data from the CA

103 E_c = Combustion efficiency (100 percent less flue losses). See reference document for detailed information.

104 E_t = Thermal efficiency. See reference document for detailed information.

105 IECC 2018 calls for an efficiency of 79% for steam boilers greater than 2,500,000 BTU/hr. However, because this is higher than the federal requirement, early retirement projects may use the replace on burnout baseline efficiency.

106 The Technical Advisory Committee agreed that if the cost of repair is less than 20% of the new baseline replacement cost it can be considered early replacement. Note the non-inflated cost is used as this would be a cost consideration in the program year.

107 DEER 2016, This file created on 10/05/2018 while connected to deeresources.net by READI (v2.5.1) tool.

climate zones were normalized to NM weather as described below. Data were separated by building types and boiler sizes.

To adjust simulations to different weather design conditions, heating degree-days were used for each climate zone.[108] TMY 3 data for New Mexico climate zones were used.

$$\Delta \frac{Therms}{KBtuh}_{Climate\ Adjusted\ Heating} = \Delta \frac{Therms}{KBtuh}_{Baseline\ Climate\ Heating} \frac{HDD_{Target\ Climate}}{HDD_{Baseline\ Climate}}$$

California Climate Zones 4, 8, 9, 15 did not have TMY 3 data available for the representative city selected by the California energy commission. Climate Zone 1 (Arcata) was closest in HDD to Albuquerque and Santa Fe. Climate Zone 14 (China Lake) was closest in HDD to Roswell and Las Cruces.[109] DEER data was filtered to only include information from the most similar climate zone for heating.

Early Replacement

Annual kWh and kW should be calculated for two different time periods:

- The estimated remaining life of the equipment that is being removed, designated the Remaining Useful Life (RUL; see Table 70)
- The remaining time in the EUL period, (i.e., EUL-RUL)

For Remaining Useful Life (RUL):

$$Therms_{savings,RUL} = Capacity \times EFLH_H \times \left(\frac{1}{\eta_{base}} - \frac{1}{\eta_{eff}}\right) \times \frac{1}{100{,}000}$$

Where:

$Therms_{savings,ER}$ = Therms savings for Early Replacement

Capacity = Rated equipment heating capacity, Btu/hr

$EFLH_H$ = Equivalent full-load hours for heating from **Error! Reference source not found.**, or custom entry of full-load hours if project is for non-space heating applications. If site-specific ELFH values are used, then a full analysis showing how the EFLH are

[108] Day, T. (2006). *Degree-Days: Theory and Application.* London: The Chartered Institution of Building Services Engineers.

[109] HDD for CZ1 are 4295 and CZ14 are 2422. Degree days for CZ1 and CZ4 is used from "The Pacific Energy Center's Guide to: California Climate Zones". kftp://ftp2.cpuc.ca.gov/PG&E20150130ResponseToA1312012Ruling/2013/07/SB_GT&S_0882437.pdf

calculated shall be provided with any submittal information

η_{base} = Efficiency of the existing boiler, or if unavailable, efficiency from **Error! Reference source not found.**. Alternately, participants can use measured boiler full load efficiency. If actual efficiency is used, then a full boiler efficiency test report shall be provided with any submittal information

η_{eff} = Efficiency of the new boiler

100,000 = Convert Btu to Therms

For remaining time in the Estimated Useful period (EUL – RUL):

$$Therms_{Savings,EUL-RUL} = Capacity * EFLH_H * \left(\frac{1}{\eta_{base}} - \frac{1}{\eta_{eff}}\right) * \frac{1}{100{,}000}$$

Hence,

$$Lifetime\ Energy\ Savings\ = Therms_{Savings,RUL} * RUL + Therms_{Savings,EUL-RUL} * (EUL - RUL)$$

Where:

RUL = Remaining Useful Life (Table 210)

EUL = Estimate Useful Life

= 20 Years

Table 70: Commercial Boilers Remaining Useful Life (RUL) of Replaced Systems[110]

Age of Replaced System (Years)	RUL (Years)
5	14.7
6	13.7
7	12.7
8	11.8
9	10.9
10	10.0
11	9.1
12	8.3
13	7.5
14	6.8
15	6.2
16	5.5
17	5.0
18	4.5
19	4.0
20	3.6
21	3.2
22	2.9
23	2.6
24+	0.0

Heating EFLH values are derived from the Texas TRM version 5, adjusting the Texas values based on heating degree-days comparisons between Amarillo, Albuquerque, and Santa Fe, and El Paso, Las Cruces, and Roswell. Values that are blank in the Texas TRM were entered as zero in **Error! Reference source not found.**.

Table 71: Heating EFLH by Building Type and Climate Zone

Building Type	Albuquerque	Las Cruces	Roswell	Santa Fe
Assembly	0	0	0	0
Education - Community College	0	0	0	0
Education - Primary School	698	500	497	929

110 Use of the early retirement baseline is capped at 23 years, representing the age at which 75 percent of existing equipment is expected to have failed. Equipment older than 23 years should use the ROB baseline.

Education - Relocatable Classroom	733	528	525	975
Education - Secondary School	733	528	525	975
Education - University	0	0	0	0
Grocery	0	0	0	0
Health/Medical – Hospital	0	0	0	0
Health/Medical - Nursing Home	0	0	0	0
Lodging - Hotel	782	383	381	1,040
Manufacturing - Bio/Tech	339	179	178	450
Manufacturing - Light Industrial	339	179	178	450
Office - Small	339	179	178	450
Restaurant - Fast-Food	1,025	639	636	1,363
Restaurant - Sit-Down	1,119	751	747	1,488
Retail - Single-Story Large	903	470	468	1,202
Retail - Small	750	549	546	998
Storage - Conditioned	0	0	0	0
Warehouse - Refrigerated	0	0	0	0
Other[111]	339	179	178	450

3.13.4 Demand Savings Estimation

There are no demand savings for this measure.

3.13.5 Non-energy Benefits

No non-energy benefits are associated with this measure.

3.13.6 Measure Life

20 years[112]

[111] This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g., a medical administration building could potentially be assessed using the "Office – Small" EFLH)

[112] DEER 2014 EUL Table

3.13.7 Incremental Cost

Table 72: Incremental Boiler Costs[113]

Boiler	Baseline Boiler Cost ($/kBTUh)	Efficient Boiler Cost ($/kBTUh)	Incremental Cost ($/kBTHu)
<=200 MBtu/hr (Small / Medium), Tier 1 (>=0.84 EF)	4.42	6.06	1.64
<=200 MBtu/hr (Small / Medium), Tier 2 (>=0.90 EF)	4.42	8.13	3.71
>200 MBtu/hr (Large), Tier 1 (>=84% TE)	9.06	13.54	4.48
>200 MBtu/hr (Large), Tier 1 (>=84% TE)	9.06	20.48	11.42

3.14 Refrigerated Walk-in Efficient Evaporator Fan Motor

This measure promotes the retrofit of shaded pole (SP) motors with electronically commutated motors (ECMs) for evaporator fans in refrigerated walk-in spaces.

3.14.1 Measure Overview

Sector	Commercial
End use	Refrigeration
Fuel	Electricity
Measure category	Efficient motors
Delivery mechanism	Rebate
Baseline description	Evaporator fan driven by shaded pole motor
Efficient case description	Evaporator fan driven by ECM in one of the following applications 1) Low temperature walk-in case (freezer) 2) Medium temperature walk-in case (cooler) 3) Average walk-in case

3.14.2 Savings

Energy and demand savings are shown in Table 73 below.

113 DEER 2015, This file created on 10/27/2015 10:18:26 AM while connected to deeresources.net as sptviewer.

Table 73: Energy and Demand Savings of Walk-in Evaporator Fan ECM's per Motor

	Savings (kWh/year)	Savings (kW)
Medium Temperature walk-in evaporator fan ECM	1,263	0.144
Low Temperature walk-in evaporator fan ECM	1,317	0.158
Average walk-in evaporator fan ECM	1,281	0.149

3.14.3 Energy Savings Estimation

Savings are based on the work of the Regional Technical Forum (RTF) of the Northwest Power & Conservation Council.[114] The RTF relied on data from the Energy Smart Grocer (ESG) program of Portland Energy Conservation, Inc. (PECI). ESG audit data showed the following distribution of walk-in evaporator fan motor sizes.

Table 74: Walk-in Evaporator Motor Size Distribution

1/20 HP and 1/15 HP (> 23 Watt)	75%
16-23 Watt (≤ 23 Watt)	25%
Of the > 23 Watt:	
1/20 HP	15%
1/15 HP	85%

In addition, 33% of walk-in units were freezers, and 67% were coolers. Savings are the sum of direct savings and refrigeration savings, where direct savings are determined with the following equation.

$$DirectSvgs = (kW_{Baseline} - kW_{Installed}) \times FLH$$

Where:

DirectSvgs = Annual motor savings, kWh

kW = Power draw of motor, see Table 75 below

FLH = Full load hours, 8766 for cooler, and 8328 for freezer (includes defrost cycle)

Motor power is shown in the following table, based on manufacturer data.

[114] https://rtf.nwcouncil.org/measure/ecms-walk-ins/

Table 75: Walk-in Evaporator Motor Size Distribution

Motor Output (watts) for Walk-In	SP Input watts	ECM Input watts	ECM Efficiency	SP Efficiency
37.3 (1/20 HP)	142	56	67%	26%
37.3 (1/20 HP)	136	44	85%	28%
49.7 (1/15 HP)	191	75	66%	26%
16-23 (19.5)	75	29	66%	26%

Refrigeration savings are based on the following formula.

$$RefrigSvgs = DirectSvgs \times \frac{ConvConst}{EER}$$

Where:

RefrigSvgs	= Annual refrigeration savings due to reduced waste heat, kWh
ConvConst	= 3.413 Btu/Wh
EER	= Efficiency of walk-in refrigeration, see Table 76 below, Btu/Wh

EER values were derived for reach-in cases for New Mexico climate for the ASH measure. Assume that these are good approximations of the walk-in values. Average New Mexico values are shown below.

Table 76: New Mexico Average Grocery EER

Medium temperature EER (Btu/Wh)	Low Temperature EER (Btu/Wh)
6.74	5.22

3.14.4 Demand Savings Estimation

Since the motors are assumed to run full time, demand savings are the average kW savings over the year.

3.14.5 Non-energy Benefits

There are no non-energy benefits.

3.14.6 Measure Life

The lifetime for this measure is 15 years, based on the RTF measure.

3.14.7 Incremental Cost

Costs are taken from the RTF measure, which are based on DEER and the SCE workpaper.[115] Two costs are provided in the following table, one for normal replacement and one for early replacement. In a normal replacement, the cost is the difference between an ECM and SP installation. In an early replacement, the cost is the full cost of an ECM installation.

Table 77: Incremental Cost for Walk-in ECM's

Normal replacement measure cost	$178
Early replacement measure cost	$255

[115] Southern California Edison 2012 Workpaper: SCE13RN011, Revision 0

3.15 Refrigerated Reach-in Efficient Evaporator Fan Motor

This measure promotes the retrofit of shaded pole (SP) motors with electronically commutated motors (ECMs) for evaporator fans in refrigerated reach-in display cases.

3.15.1 Measure Overview

Sector	Commercial
End use	Refrigeration
Fuel	Electricity
Measure category	Efficient motors
Delivery mechanism	Rebate
Baseline description	Evaporator fan driven by shaded pole (SP) motor
Efficient case description	Evaporator fan driven by ECM in one of the following applications 1) Low temperature reach-in case (freezer) 2) Medium temperature reach-in case (cooler) 3) Average reach-in case

3.15.2 Savings

Energy and demand savings are shown in Table 78 below.

Table 78: Energy and Demand Savings of Reach-in Evaporator Fan ECM's per Motor

	Savings (kWh/year)	Savings (kW)
Medium Temperature reach-in evaporator fan ECM	687	0.078
Low Temperature reach-in evaporator fan ECM	754	0.086
Average reach-in evaporator fan ECM	709	0.081

3.15.3 Energy Savings Estimation

Savings are based on the work of the Regional Technical Forum (RTF) of the Northwest Power & Conservation Council.[116] The RTF relied on data from the Energy Smart Grocer (ESG) program of Portland Energy Conservation, Inc. (PECI). ESG audit data

[116] https://rtf.nwcouncil.org/measure/ecms-display-cases/

showed the following average motor size in reach-in evaporator fan motors. The equivalent SP motor size is derived from the DOE-reported efficiency.

Table 79: Walk-in Evaporator Motor Size Distribution

Motor Output (watts) for Display Case[1]	SP Input watts	ECM Input watts	ECM Efficiency[2]	SP Efficiency[2]
14.94	75	23	66%	20%

[1] EnergySmart Grocer Invoice Data.

[2] From DOE TSD for commercial refrigeration. Data corroborated from the US DOE Report: Energy Savings Potential and Opportunities for High-Efficiency Electric Motors in Residential and Commercial Equipment.

The distribution of low temperature vs. medium temperature is assumed to be as for walk-in units, 33% are freezers, and 67% are coolers. Savings are the sum of direct savings and refrigeration savings, where direct savings are determined with the following equation.

$$DirectSvgs = (kW_{Baseline} - kW_{Installed}) \times FLH$$

Where:

DirectSvgs	= Annual motor savings, kWh
kW	= Power draw of motor, see Table 79 above
FLH	= Full load hours, 8760

Refrigeration savings are based on the following formula.

$$RefrigSvgs = DirectSvgs \times \frac{ConvConst}{EER}$$

Where:

RefrigSvgs	= Annual refrigeration savings due to reduced waste heat, kWh
ConvConst	= 3.413 Btu/Wh
EER	= Efficiency of walk-in refrigeration, see Table 80 below, Btu/Wh

EER values were derived for reach-in cases for New Mexico climate for the ASH measure. Average New Mexico values are shown below.

Table 80: New Mexico Average Grocery EER

Medium temperature EER (Btu/Wh)	Low Temperature EER (Btu/Wh)
6.74	5.22

3.15.4 Demand Savings Estimation

Since the motors are assumed to run full time, demand savings are the average kW savings over the year.

3.15.5 Non-energy Benefits

There are no non-energy benefits.

3.15.6 Measure Life

The lifetime for this measure is 15 years, based on the RTF measure.

3.15.7 Incremental Cost

Costs are taken from the RTF measure, which are based on PECI installation data and the PG&E workpaper. Two costs are provided in the following table, one for normal replacement and one for early replacement. In a normal replacement, the cost is the difference between an ECM and SP installation. In an early replacement, the cost is the full cost of an ECM installation.

Table 81: Incremental Cost for Reach-in ECM's

Normal replacement measure cost	$32
Early replacement measure cost	$107

3.16 Chillers

Savings are provided for the installation of electric chillers. This document covers assumptions made for baseline equipment efficiencies for replace-on-burnout (ROB) and new construction (NC) situations based on current and previous efficiency standards. Early retirement (ER) projects should claim savings using the ROB/NC baseline.

Applicable efficient measure types include:[117]

- Compressor Types: Centrifugal or Positive-displacement (Screw, Scroll, or Reciprocating)
- Condenser/Heat Rejection Type: Air-cooled or Water-cooled System Type Conversions.
- Chiller Type Conversions: Conversion from an air-cooled chiller system to a water-cooled chiller system is also addressed in this measure. An additional adjustment is made to the basic chiller savings to account for the auxiliary equipment associated with a water-cooled chiller.

3.16.1 Measure Overview

Sector	Commercial
End use	HVAC
Fuel	Electricity
Measure category	Chillers
Delivery mechanism	Direct Install, Rebate
Baseline description	Chiller with Code-minimum efficiency
Efficient case description	Chiller exceeding Code-minimum efficiency

3.16.2 Savings

Baseline efficiency levels for chillers are provided in Table 82 which includes both full load and Integrated Part Load Value (IPLV) ratings. The IPLV accounts for chiller efficiency at part-load operation for a given duty cycle. These baseline efficiency levels

[117] Savings can also be claimed by a retrofit involving a change in equipment type (i.e., Air cooled packaged DX system to a water-cooled centrifugal chiller, or a split system air cooled heat pump to an air-cooled non-centrifugal chiller). In the event that this type of retrofit is performed, the tables from the following HVAC measure templates will need to be referenced: HVAC – Chillers, Split System/Single Packaged Heat Pumps and Air Conditioners

reference the 2018 IECC, adopted as New Mexico's state energy code. The Code contains two paths for compliance: Path A or Path B. According to ASHRAE 90.1-2007 Addenda M, Path A is intended for applications where significant operating time is expected at full-load conditions, while Path B is an alternative set of efficiency levels for chillers intended for applications where significant time is spent at part-load operation (such as with a VSD chiller). Either Path can be used for compliance on any particular chiller, but the chiller must meet the minimum requirements for both full and part-load efficiency that are set forth in the following sections.

Table 82: Baseline Efficiencies for ROB and NC Air-Cooled and Water-Cooled Chillers[118]

System Type [Efficiency Units]		Efficiency Type	Capacity [Tons]	INSTALLED BEFORE 1/1/2015				INSTALLED AFTER 1/1/2015			
				Path A		Path B		Path A		Path B	
				Full-Load	IPLV	Full-Load	IPLV	Full-Load	IPLV	Full-Load	IPLV
Air-Cooled Chiller		EER	< 150	≥ 9.562	≥ 12.500	--	--	≥ 10.100	≥ 13.700	≥ 9.700	≥ 15.800
			≥ 150	≥ 9.562	≥ 12.500	--	--	≥ 10.100	≥ 14.000	≥ 9.700	≥ 16.100
Water-Cooled Chiller	Screw/Scroll/ Recip.	kW/ton	< 75	≤ 0.780	≤ 0.630	≤ 0.800	≤ 0.600	≤ 0.750	≤ 0.600	≤ 0.780	≤ 0.500
			≥ 75 and < 150	≤ 0.775	≤ 0.615	≤ 0.790	≤ 0.586	≤ 0.720	≤ 0.560	≤ 0.490	≤ 0.680
			≥ 150 and < 300	≤ 0.680	≤ 0.580	≤ 0.718	≤ 0.540	≤ 0.660	≤ 0.540	≤ 0.680	≤ 0.440
			≥ 300 and < 600	≤ 0.620	≤ 0.540	≤ 0.639	≤ 0.490	≤ 0.610	≤ 0.520	≤ 0.625	≤ 0.410
			≥ 600	≤ 0.620	≤ 0.540	≤ 0.639	≤ 0.490	≤ 0.560	≤ 0.500	≤ 0.585	≤ 0.380
	Centrifugal		< 150	≤ 0.634	≤ 0.596	≤ 0.639	≤ 0.450	≤ 0.610	≤ 0.550	≤ 0.695	≤ 0.440
			≥ 150 and < 300	≤ 0.634	≤ 0.596	≤ 0.639	≤ 0.450	≤ 0.610	≤ 0.550	≤ 0.635	≤ 0.400
			≥ 300 and < 600	≤ 0.576	≤ 0.549	≤ 0.600	≤ 0.400	≤ 0.560	≤ 0.520	≤ 0.595	≤ 0.390
			≥ 600	≤ 0.570	≤ 0.539	≤ 0.590	≤ 0.400	≤ 0.570	≤ 0.539	≤ 0.590	≤ 0.400

[118] IECC 2018 Table C403.2.3(7).

Chillers must exceed the minimum efficiencies specified in Table 82 for either Path A or Path B. For whichever path is used, the chiller must exceed the minimum baseline efficiency for both Full-load and IPLV of that path to qualify. To qualify for use of this deemed measure, no additional measures may be installed that directly affect the operation of the cooling equipment (i.e., control sequences, cooling towers, and condensers).

Coincidence factor (CF) and equivalent full-load hour (EFLH) values are presented building type and climate zone. EFLH and CF values are derived from the values in the Texas TRM version 5. EFLH values were adjusted based on a cooling degree-day comparison of Amarillo, Albuquerque, and Santa Fe, and a comparison of El Paso, Las Cruces, and Roswell. CF values were adjusted considering cooling degree-days for the months of June through August.[119]

These tables also include an "Other" building type, which can be used for business types that are not explicitly listed. The CF and EFLH values used for Other are the most conservative values from the explicitly listed building types. When the Other building type is used, a description of the actual building type, the primary business activity, the business operating hours, and the HVAC schedule must be collected for the project site and stored in the utility tracking data system.

3.16.3 Energy Savings Estimation

$$Energy\ (Cooling)\ [kWh_{Savings,C}] = \left(\left(\frac{Cap_{C,pre}}{IPLV_{baseline,C}} \times EFLH_{C-pre}\right) - \left(\frac{Cap_{C,post}}{IPLV_{installed,C}} \times EFLH_{C-post}\right)\right) \times \frac{1\ kW}{1{,}000\ W}$$

Where:

$Cap_{C,pre}$	=	Rated equipment cooling capacity of the existing equipment at AHRI standard conditions [Btu/H]. If there is no existing equipment (e.g. new construction) set $Cap_{C,pre}$ equal to $Cap_{C,post}$; 1 ton = 12,000 Btuh
$Cap_{C,post}$	=	Rated equipment cooling capacity of the newly installed equipment at AHRI standard conditions [Btuh]; 1 ton = 12,000 Btuh

119 TX Value x (NM CDD / TX CDD) = NM Value

$IPLV_{baseline,C}$ = Part-load cooling efficiency of standard baseline equipment [IPLV, Btu/W-h; for units rated in kW/ton, convert to Btu/W-h using 12 / (kW/ton) = Btu/W-h] (See Table 82)

$IPLV_{installed,C}$ = Rated part-load cooling efficiency of the newly installed equipment [IPLV, Btu/W-h; for units rated in kW/ton, convert to Btu/W-h using 12 / (kW/ton) = Btu/W-h] (Must exceed minimum standards Table 82)

$EFLH_{C-pre}$ = Cooling equivalent full-load hours for existing equipment based on appropriate climate zone, building type, and equipment type. If there is no existing equipment (e.g. new construction) set $EFLH_{C,pre}$ equal to $EFLH_{C,post}$; [hours] (See Table 83 through Table 86)

$EFLH_{C-post}$ = Cooling equivalent full-load hours for newly installed equipment based on appropriate climate zone, building type, and equipment type; [hours] (See Table 83 through Table 86)

Air-to Water-Cooled Replacement: Adjustments for Auxiliary Equipment

The equipment efficiency for an air-cooled chiller includes condenser fans, but the equipment efficiency for a water-cooled chiller does not include the condenser water pump and cooling tower (auxiliary equipment). Therefore, when an air-cooled chiller is replaced with a water-cooled chiller, the savings must be reduced to account for the impact of the water-cooled system's additional equipment. This type of retrofit is only applicable for ER situations. The following equations are used:

$$kW_{adjust} = \left(HP_{CW\ pump} + HP_{CT\ fan}\right) \times \frac{0.746}{0.86}$$

$$kWh_{adjust} = kW \times EFLH_{C-pos}$$

Where:

$HP_{CW\ pump}$ = Horsepower of the condenser water pump

$HP_{CT\ fan}$ = Horsepower of the cooling tower fan

0.746 = Conversion from HP to kW [kW/HP]

0.86 = Assumed equipment efficiency

The energy and demand of the condenser water pump and cooling tower fans are subtracted from the final savings, to reach the net savings:

$$kW_{savings,net} = kW_{Chi} \quad - kW_{adjust}$$

$$kWh_{savings,net} = kWh_{Chiller} - kWh_{adjust}$$

Table 83: CF and EFLH - Albuquerque

		Chiller			
		Air Cooled		Water Cooled	
Building Type	**Principal Building Activity**	**CF**	**EFLHc**	**CF**	**EFLHc**
Education	College	0.84	1,061	0.66	1,183
	Primary School	0.43	548	0.51	924
	Secondary School	0.68	763	0.56	1,686
Healthcare	Hospital	0.68	1,909	0.63	2,579
Large Multifamily	Midrise Apartment	0.40	401	0.49	1,045
Lodging	Large Hotel	0.56	1,221	0.57	1,478
	Nursing Home	0.40	407	0.49	1,061
Mercantile	Stand-Alone Retail	0.51	465	0.52	684
	24Hr Retail	0.65	648	0.60	927
Office	Large Office	0.68	1,149	0.59	1,433
Public Assembly	Public Assembly	0.43	736	0.51	1,243
Religious Worship	Religious Worship	0.51	280	0.52	412
Other[120]	Other	0.40	280	0.49	412

120 This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g., a medical administration building could potentially be assessed using the "Office" EFLH and CF

Table 84: CF and EFLH - Las Cruces

		Chiller			
		Air Cooled		Water Cooled	
Building Type	Principal Building Activity	CF	EFLHc	CF	EFLHc
Education	College	0.98	1,259	1.01	1,436
	Primary School	0.64	740	0.56	1,096
	Secondary School	0.81	1,023	0.57	2,163
Healthcare	Hospital	0.75	2,319	0.62	2,946
Large Multifamily	Midrise Apartment	0.59	828	0.55	1,529
Lodging	Large Hotel	0.66	1,787	0.61	2,007
	Nursing Home	0.59	841	0.55	1,553
Mercantile	Stand-Alone Retail	0.67	711	0.58	934
	24Hr Retail	0.64	871	0.63	1,350
Office	Large Office	0.81	1,420	0.63	1,657
Public Assembly	Public Assembly	0.64	995	0.56	1,473
Religious Worship	Religious Worship	0.67	428	0.58	562
Other[121]	Other	0.59	428	0.55	562

[121] This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g., a medical administration building could potentially be assessed using the "Office" EFLH and CF

Table 85: CF and EFLH - Roswell

Building Type	Principal Building Activity	Chiller			
		Air Cooled		Water Cooled	
		CF	EFLHc	CF	EFLHc
Education	College	0.88	1,149	0.91	1,310
	Primary School	0.58	675	0.50	1,000
	Secondary School	0.73	934	0.51	1,974
Healthcare	Hospital	0.68	2,117	0.56	2,689
Large Multifamily	Midrise Apartment	0.53	756	0.49	1,396
Lodging	Large Hotel	0.60	1,631	0.55	1,832
	Nursing Home	0.53	768	0.49	1,417
Mercantile	Stand-Alone Retail	0.61	649	0.52	852
	24Hr Retail	0.58	794	0.57	1,232
Office	Large Office	0.73	1,296	0.57	1,513
Public Assembly	Public Assembly	0.58	908	0.50	1,344
Religious Worship	Religious Worship	0.61	391	0.52	513
Other[122]	Other	0.53	391	0.49	513

[122] This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g., a medical administration building could potentially be assessed using the "Office" EFLH and CF

Table 86: CF and EFLH - Santa Fe

Building Type	Principal Building Activity	Chiller			
		Air Cooled		Water Cooled	
		CF	EFLHc	CF	EFLHc
Education	College	0.55	631	0.43	703
	Primary School	0.28	326	0.34	549
	Secondary School	0.44	454	0.37	1,002
Healthcare	Hospital	0.44	1,135	0.41	1,534
Large Multifamily	Midrise Apartment	0.26	238	0.32	621
Lodging	Large Hotel	0.37	726	0.37	879
	Nursing Home	0.26	242	0.32	631
Mercantile	Stand-Alone Retail	0.33	277	0.34	407
	24Hr Retail	0.42	385	0.39	551
Office	Large Office	0.44	683	0.39	852
Public Assembly	Public Assembly	0.28	438	0.34	739
Religious Worship	Religious Worship	0.33	166	0.34	245
Other[123]	Other	0.26	166	0.32	245

3.16.4 Demand Savings Estimation

$$Peak\ Demand\ [kW_{Savings}] = \left(\left(\frac{Cap_{C,pre}}{EER_{baseline,C}} \times CF_{pre}\right) - \left(\frac{Cap_{C,post}}{EER_{installed,C}} \times CF_{post}\right)\right) \times \frac{1\ kW}{1{,}000\ W}$$

Where:

CF_{pre} = Seasonal peak demand factor for existing equipment for appropriate climate zone, building type, and equipment type. If there is no existing equipment (e.g., new construction) set CF_{pre} equal to CF_{post}; (See tables above)

123 This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g., a medical administration building could potentially be assessed using the "Office" EFLH and CF

CF_{post}	=	Seasonal peak demand factor for newly installed equipment for appropriate climate zone, building type, and equipment type; (See tables above)
$EER_{baseline,C}$	=	Rated full-load cooling efficiency of standard baseline equipment [IPLV, Btu/W-h; for units rated in kW/ton, convert to Btu/W-h using 12 / (kW/ton) = Btu/W-h] (see Table 82)
$EER_{installed,C}$	=	Rated full-load cooling efficiency of the newly installed equipment [EER, Btu/W-h; for units rated in kW/ton, convert to Btu/W-h using 12 / (kW/ton) = Btu/W-h] (Must exceed minimum standards in Table 82)

Example:

Air-cooled chiller (IPLV=12.5, EER=9.562) is replaced with an efficient chiller (IPLV=13.6, EER=10.4) of capacity 746,400 Btuh in a College in Albuquerque.

Energy (Cooling) $[kWh_{Savings,C}]$ = (746,400 Btuh/ 12.5 Btu/W-h - 746,400 Btuh/ 13.6 Btu/W-h) x 1061 hours x 1 kW/1000 W

= 5,124 kWh

Peak Demand $[kW_{Savings}]$= (746,400 Btuh/ 9.562 Btu/W-h - 746,400 Btuh/ 10.4 Btu/W-h) x 0.86 x 1 kW/1000 W

= 5.41 kW

3.16.5 Non-energy Benefits

There are no non-energy benefits.

3.16.6 Measure Life

The estimated useful life (EUL) for chillers is provided below:

- Screw/Scroll/Reciprocating Chillers: 20 years[124]
- Centrifugal Chillers: 25 years[125]

3.16.7 Incremental Cost

Incremental cost estimates should be gathered as part of the application process if utilities wish to test the cost effectiveness of this measure using the TRC test.

[124] PUCT Docket No. 36779. The original source was DEER 2008, but DEER 2014 provides the same value of 20 years for "High Efficiency Chillers". DEER does not differentiate between centrifugal and non-centrifugal chillers.

[125] PUCT Docket No. 40885, review of multiple studies looking at the lifetime of Centrifugal Chillers as detailed in petition workpapers.

3.17 Ozone Laundry

A new ozone laundry system(s) is added-on to new or existing commercial washing machine(s) using hot water heated with natural gas. The system generates ozone (O_3), a naturally occurring molecule, which helps clean fabrics by chemically reacting with soils in cold water. Adding an ozone laundry system(s) will reduce the amount of chemicals, detergents, and hot water needed to wash linens.

Natural gas energy savings will be achieved at the hot water heater as it will be required to produce less hot water to wash each load of laundry. Electric energy savings will be achieved through reduced washer cycle length, and reduced water pumping load. The decrease in hot water usage will increase cold water usage, but overall water usage at the facility will decrease.

In the commercial sector, water heating for laundry purposes is usually done using gas boilers or gas water heaters since they are much cheaper to operate and are more economical to use for large batches of water. Hence, the measure lists savings for gas heated water. If the energy efficiency programs encounter electric water heaters for this measure on a large scale, adjustments can be made to the measure upon request.

3.17.1 Measure Overview

Sector	Commercial
End use	Efficient Laundry
Fuel	Electricity and Natural Gas
Measure category	Efficient Laundry Appliances
Delivery mechanism	Prescriptive
Baseline description	Conventional Washing Machine with no Ozone Generator
Efficient case description	Ozone System added to a new or existing Washing Machine

3.17.2 Savings

Electric savings can be realized through reduced washer cycle length and reduced pumping load at the boiler feeding the commercial washers. The increased usage associated with operating the ozone system should also be accounted for when determining total kWh impact.

This incentive only applies to the following facilities with on-premise laundry operations:[126]

- Hotels/motels
- Fitness and recreational sports centers.
- Healthcare (excluding hospitals)
- Assisted living facilities

In the efficient case, a new ozone laundry system(s) is added-on to new or existing commercial washing machine(s) using hot water heated with natural gas. The ozone laundry system(s) must transfer ozone into the water through:

- Venturi Injection
- Bubble Diffusion
- Additional applications may be considered upon program review and approval on a case-by-case basis

Natural gas energy savings will be achieved at the hot water heater/boiler as they will be required to produce less hot water to wash each load of laundry. The decrease in hot water usage will increase cold water usage, but overall water usage at the facility will decrease.

The base case equipment is a conventional washing machine system with no ozone generator installed. The washing machines are provided hot water from a gas-fired boiler.

3.17.3 Energy Savings Estimation

Electric savings can be realized through reduced washer cycle length and reduced pumping load at the boiler feeding the commercial washers. There is also an increased usage associated with operating the ozone system.

$$\Delta kWh_{pump} = HP * Conversion\ Factor * Hours * \%Water_{savings}$$

Where:

ΔkWh_{pump} = Electric savings from reduced pumping load

HP = Brake horsepower of boiler feed water pump;

[126] The results included in this analysis are based heavily on analysis provided in Illinois TRM v7.0, for the mentioned facility types and may not apply to facilities outside of this list due to variances in number of loads and average pound (lbs.)-capacity per project site. More facilities need to be analyzed in the future to be included in this measure.

= Actual or use 5 HP if unknown[127]

Conversion Factor = Conversion from horsepower to kW; 0.746

Hours = Actual associated boiler feed water pump hours; 800 hours128 if unknown

$\%Water_{savings}$ = Water reduction factor, i.e., how much more efficient an ozone injection washing machine is compared to a typical conventional washing machine as a rate of hot and cold water reduction; 25%[129]

Natural gas energy savings will be achieved at the hot water heater/boiler as they will be required to produce less hot water to wash each load of laundry.

$$\Delta Therms = Therm_{Baseline} * \%Hot\ Water_{savings}$$

Where:

$\Delta Therms$ = Gas Savings resulting from a reduction in hot water use, in therms

$Therm_{Baseline}$ = Annual Gas Baseline consumption

$$Therm_{Baseline} = \frac{(TempUsage - TempCold) * HeatCapacity * Density * Const}{Efficiency} * UF_{Wash} * HWUF$$

Where:

TempUsage = Boiler water temperature (if unknown, 140°F)

TempCold = Temperature of inlet water, Table 8

HeatCapacity = Heat capacity of water, 1 Btu per pound per ˚F

Density = Density of water, 8.33 pounds per gallon

Constant = Constant, 1 therm/100,000 Btus, or .00029307107 kWh/Btu

Efficiency = Assumed boiler efficiency, 80%

127 Assumed average horsepower for boilers connected to applicable washer (IL TRM v7.0)

128 Engineering estimate from analysis of Nicor custom projects done by CLEAResult and presented in Illinois Technical Resource Manual v7.0

129 Average water reduction factors were generated using data collected from existing ozone laundry projects that received incentives under the Non-Residential Retrofit Demand Reduction program (NRR-DR) implemented by Nicor Gas. (Source: Illinois TRM v7.0)

UF_{Washer} = Washer Utilization Factor: Annual pounds of clothes washed per year;

= Actual, if unknown use 916,150 lbs laundry[130] approximately equal to 13 cycles/day

HWUF = Hot Water Usage Factor: amount of hot water a typical conventional washing machine utilizes, normalized per pounds of clothes washed; 1.19 gallon/lbs of laundry[131]

Using defaults from above for an ozone laundry system in Albuquerque:

$$Therm_{Baseline} = \frac{(140.0-69.2)*1*8.33}{0.8*100{,}000} * 916{,}150 * 1.19 \text{ therms}$$

$$= 8{,}037 \text{ therms}$$

$\%\text{Hot Water}_{savings}$ = Hot Water Reduction Factor, how much more efficient an ozone injection washing machine is, compared to a typical conventional washing machine, as a rate of hot water reduction; 81%132

Using defaults from above:

$$\Delta Therms = Therm_{Baseline} * \%Hot\ Water_{savings}$$

$$= 8{,}037 * 0.81 \text{ therms}$$

$$= 6{,}510 \text{ therms}$$

3.17.4 Demand Savings Estimation

At this moment peak demand savings cannot be associated with this measure as not enough study has been done regarding operation of ozone laundry systems and coincident peak demand.

130 In the Illinois TRM v7.0, average utilization factors were generated using data collected from existing ozone laundry projects that received incentives under the Non-Residential Retrofit Demand Reduction program (NRR-DR) program.

131 In the Illinois TRM v7.0, average hot water usage factors were generated using data collected from existing ozone laundry projects that received incentives under the NRR-DR program.

132 In the Illinois TRM v7.0, average hot water reduction factors were generated using data collected from existing ozone laundry projects that received incentives under the Non-Residential Retrofit Demand Reduction program (NRR-DR).

3.17.5 Non-energy Benefits

There are no non-energy benefits.

3.17.6 Measure Life

The measure equipment effective useful life (EUL) is estimated at 10 years based on typical lifetime of the ozone generator's corona discharge unit.[133]

3.17.7 Incremental Cost

The actual measure costs should be used if available. If not a deemed value of $79.84/lbs capacity should be used.[134]

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[133] Based on data presented in Illinois TRM v10.0 (confirmed via vendor interviews)

[134] In the Illinois TRM v10.0, average costs per unit of capacity were generated using data collected from existing ozone laundry projects that received incentives under the Non-Residential Retrofit Demand Reduction program (NRR-DR), as well as from the Nicor Custom Incentive Program, and the Nicor Emerging Technology Program (ETP).

3.18 Water Heater Pipe Insulation

This measure requires the installation of pipe insulation on un-insulated domestic water heater pipes.

3.18.1 Measure Overview

Sector	Commercial (DHW only)
End use	Insulation
Fuel	Electric, Natural Gas
Measure category	Water Heater
Delivery mechanism	Prescriptive
Baseline description	Uninsulated Hot Water Pipe
Efficient case description	Insulated Hot Water Pipe

3.18.2 Savings

The baseline is assumed to be a typical electric/gas/heat pump water heater with no heat traps and no insulation on water heater pipes.

New construction and retrofits involving the installation of new water heaters are not eligible for this new measure.

The efficiency standard requires an insulation thickness R-3. The International Residential Code (IRC) 2018 section N1103.3: Mechanical system piping insulation requires R-3 insulation.

Example:

Insulation (R-3) added to an uninsulated natural gas water heater pipe with diameter 0.5 inches and 20 feet total length.

Annual Energy Savings = [(1/(2.03 + 0) – 1/(2.03 + 0 + 3)] Btu/hr sq. ft. °F x (0.13 x 20) sq. ft. x (127.5 – 61.6) °F x 1/0.80 x 8760 hours x 1/(100,000 BTU/Therm)

= 5.5 Therms

3.18.3 Energy Savings Estimation

Hot water pipe insulation energy savings are calculated using the formula below.

$$Annual\ Energy\ Savings = (U_{Pre} - U_{Post}) * A * (T_{Pipe} - T_{Ambient}) * \left(\frac{1}{Eff}\right) * Hours_{Total} * \frac{1}{Conversion\ Factor}$$

Where:

U_{Pre}[135]	= $1/(2.03 + R_{Pipe})$ Btu/hr sq. ft. °F, (R_{Pipe} is assumed to be 0 given the high conductivity of bare metal pipe)
U_{Post}	= $1/(2.03+R_{Pipe}+R_{insulation})$ Btu/hr sq. ft. °F
$R_{insulation}$	= R-value of insulation
A	= Pipe surface area insulated in square feet (πDL) with L (length) and D (pipe diameter) in feet, use Table 87below

Table 87: Pipe Surface Area and Pipe Diameter

Pipe Diameter (inches)	Pipe Surface Area (sq. ft.)
0.5	0.13 * Pipe Length Insulated (in feet)
0.75	0.20 * Pipe Length Insulated (in feet)
1.0	0.26 * Pipe Length Insulated (in feet)
1.25	0.33 * Pipe Length Insulated (in feet)
1.5	0.39 * Pipe Length Insulated (in feet)
2.0	0.52 * Pipe Length Insulated (in feet)

T_{Pipe}	= Average temperature of the heated water in the pipe, use 127.5 °F[136]
$T_{Ambient}$	= Average annual temperature, use Table 88 below

[135] 2.03 is the R-value representing the film coefficients between water and the inside of the pipe, and between the surface and air. Mark's Standard Handbook for Mechanical Engineers, 8th edition.

[136] Preliminary visits to schools in New Mexico has shown water heater temperatures set at 125 – 130°F, within typical range for domestic hot water. Average of 127.5°F used.

Table 88: Annual Ambient Temperature for Unconditioned and Conditioned Spaces

Climate Zone	$T_{ambient}$ (Unconditioned)[137]	$T_{ambient}$ (Conditioned)
Albuquerque	61.6°F	72.0 °F[138]
Roswell	67.5°F	
Santa Fe	56.5°F	
Las Cruces	68.2 °F	

Eff = System Efficiency (AFUE for gas water heater) of installed water heater. If unknown, use 0.98 as a default for electric resistance water heaters or 0.80 for natural gas storage or instantaneous water heaters

$Hours_{Total}$ = 8,760 hours per year

Conversion Factor = 3,412 Btu/kWh, for Electric Water Heater

= 100,000 Btu/Therm, for Gas Water Heater

3.18.4 Demand Savings Estimation

Peak kW demand savings (only for electric and heat pump water heaters) for tank insulation are calculated with the equation below:

$$Demand\ Savings = \frac{Annual\ Energy\ Savings}{8{,}760}$$

3.18.5 Non-energy Benefits

There are no non-energy benefits for this measure.

3.18.6 Measure Life

As per 2014 California Database for Energy Efficiency Resources (DEER), the EUL for this measure is listed as 13 years.[139]

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[137] Average ambient temperatures were taken from TMY3 data. 5-F was added to each average to approximate the difference between outdoor temperature and unconditioned interior temperature.

[138] As per OSHA Office Temperature Guidelines, office temperature varies between 68 -76°F. Hence, averaged to 72°F https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=interpretations&p_id=24602

[139] 2014 California Database for Energy Efficiency Resources.

3.18.7 Incremental Cost

The measure cost is the actual cost of material and installation. If the actual cost is unknown, assume a default cost of $4 per linear foot[140] including material and installation.

[140] Consistent with DEER 2008 Measure Cost Summary, Revised June 2, 2008 (www.deeresources.com)

3.19 Pool Pumps

This measure involves replacing a single-speed pool pump with an ENERGY STAR® qualified multi-speed or variable speed pool pump. Savings are achieved by using more efficient pumps and operating multi-speed or variable speed pumps at speeds lower than the maximum design speed for tasks which need water flow less than the maximum design flow.

3.19.1 Measure Overview

Sector	Commercial
End use	Pool Water Pumping
Fuel	Electricity
Measure category	Water Pumping
Delivery mechanism	Rebate
Baseline description	0.5 – 3 HP standard-efficiency single-speed pool pump
Efficient case description	0.5 – 3 HP ENERGY STAR® qualified multi-speed or variable-speed pool pump

3.19.2 Savings

Savings are calculated using the algorithms and assumptions found in the ENERGY STAR® Pool Pump Calculator.[141] To be eligible for this measure, the installed pool pump must be either a multi-speed or variable-speed pump and must meet the energy efficiency requirements for ENERGY STAR® qualified pool pumps, which state that a pump must have a minimum energy factor (EF) of 3.8 for the most efficient speed.[142] The most efficient speed is defined as the speed with the highest EF for a given pump.

The savings for this measure is based on an assumed pipe diameter of 2.5” and Pump Performance Curve C.

Example:

ENERGY STAR® pool pump (capacity = 2 HP) is installed in place of standard efficiency single speed pool pump.

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[141] Savings Calculator for ENERGY STAR® Certified Inground Pool Pumps, Updated December 2013: https://www.energystar.gov/sites/default/files/asset/document/Pool%20Pump%20Calculator.xlsx

[142] ENERGY STAR® Pool Pumps Key Product Criteria, Version 1.1, Effective February 15, 2013: https://www.energystar.gov/products/other/pool_pumps/key_product_criteria

$kWh_{conventional}$ = 88.67 gal/min x 60 x 24 hours x 365 days / (2.3 gal/W ·hr x 1000)

= 20,263 kWh

$kWh_{Energy\ Star}$ = [89.71 gal/min x 60 x 12 hours x 365 days / (2.4 gal/W ·hr x 1000)] + [44.75 gal/min x 60 x 12 hours x 365 days / (6.5 gal/W ·hr x 1000)]

= 11,633 kWh

$kWh_{Savings}$ = 20,263 kWh – 11,633 kWh = 8,631 kWh

$kW_{Savings}$ = [20,263 kWh/24 hours – 11,632 kWh/(12 hours + 12 hours)] x 1 / 365 days

= 0.985 kW

3.19.3 Energy Savings Estimation

Savings are determined with the following equations.

$$kWh_{savings} = kWh_{conventional} - kWh_{ENERGY\ STAR}$$

Where:

$kWh_{savings}$	= Annual energy savings, kWh
$kWh_{conventional}$	= Annual energy consumption of a conventional single-speed pool pump, derived with the question below, kWh
$kWh_{ENERGYSTAR}$	= Annual energy consumption of an ENERGY STAR® qualified multi-speed or variable-speed pool pump, derived with the equation below, kWh

$$kWh_{conventional} = \frac{PFR_{conventional} * 60 * hours_{conventional} * days}{EF_{conventional} * 1000}$$

$$kWh_{ENERGYSTAR} = kWh_{HS} + kWh_{LS}$$

$$kWh_{HS} = \frac{PFR_{HS} * 60 * hours_{HS} * Days}{EF_{HS} * 1000}$$

$$kWh_{LS} = \frac{PFR_{LS} * 60 * hours_{LS} * Days}{EF_{LS} * 1000}$$

Where:

kWh_{HS}	= ENERGY STAR® variable speed pool pump energy at high speed, kWh
kWh_{LS}	= ENERGY STAR® variable speed pool pump energy at low speed, kWh
$hours_{conventional}$	= Conventional single-speed pump daily operating hours; 24 hours for 24/7 operation, 12 hours for limited operation
$hours_{HS}$	= ENERGY STAR® variable speed pump high speed daily operating hours; 12 hours for 24/7 operation, 6 hours for limited operation
$hours_{LS}$	= ENERGY STAR® variable speed pump low speed daily operating hours; 12 hours for 24/7 operation, 6 hours for limited operation
Days	= Operating days per year; actual, if not available, 365 days (default)
$PFR_{conventional}$	= Conventional single-speed pump flow rate, gal/min
PFR_{HS}	= ENERGY STAR® variable speed pump high speed flow rate, gal/min
PFR_{LS}	= ENERGY STAR® variable speed pump low speed flow rate, gal/min
$EF_{conventional}$	= Conventional single-speed pump energy factor, gal/W·hr
EF_{HS}	= ENERGY STAR® variable speed pump high speed energy factor, gal/W·hr
EF_{LS}	= ENERGY STAR® variable speed pump low speed energy factor, gal/W·hr
60	= Constant to convert between minutes and hours
1000	= Constant to convert from kilowatts to watts

Table 89: Conventional Pool Pumps Assumptions[143]

Rated Horsepower (HP)	$PFR_{Conventional}$	$EF_{Conventional}$
≤ 1.25	75.50	2.51
1.25 < HP ≤ 1.75	78.14	2.27
1.75 < HP ≤ 2.25	88.67	2.30
2.25 < HP ≤ 2.75	93.09	2.18
2.75 < HP ≤ 3.00	101.67	2.00

Table 90: ENERGY STAR® Pool Pumps Assumptions[144]

Rated Horsepower (HP)	PFR_{HS}	PFR_{LS}	EF_{HS}	EF_{LS}
HP ≤ 1.25	70.00	40.33	3.01	6.78
1.25 < HP ≤ 1.75	78.00	41.75	2.74	6.71
1.75 < HP ≤ 2.25	89.71	44.75	2.4	6.50
2.25 < HP ≤ 2.75	90.00	45.67	2.44	5.96
2.75 < HP ≤ 3.00	102.00	51.00	1.99	6.07

3.19.4 Demand Savings Estimation

$$kW_{Savings} = \left[\frac{kWh_{conventional}}{hours_{conventional}} - \left(\frac{kWh_{HS} + kWh_{LS}}{hours_{HS} + hours_{LS}}\right)\right] * \frac{DF}{Days}$$

Where:

$kWh_{conventional}$ = Annual energy consumption of a conventional single-speed pool pump, kWh

kWh_{HS} = ENERGY STAR® variable speed pool pump energy at high speed, kWh

kWh_{LS} = ENERGY STAR® variable speed pool pump energy at low speed, kWh

$hours_{conventional}$ = Conventional single-speed pump daily operating hours

143 Conventional pump PFR and EF values are taken from pump curves found in the ENERGY STAR® Pool Pump Savings Calculator

144 The daily average operating hours for low and high VSP settings, based on 2016 residential pool pump program data from CenterPoint Energy (Texas Technical Reference Manual V5.0, Volume 3: Nonresidential Measures)

$hours_{HS}$ = ENERGY STAR® variable speed pump high speed daily operating hours

$hours_{LS}$ = ENERGY STAR® variable speed pump low speed daily operating hours

Days = Operating days per year = 365 days (default)

DF = Demand Factor, see Table 91

Table 91: Demand Factor

Operation	Summer DF	Winter DF
24/7 Operation	1.0	1.0
Seasonal/Limited Hours	1.0	0.5

3.19.5 Non-energy Benefits

There are no non-energy benefits.

3.19.6 Measure Life

According to DEER 2014, the Estimated Useful Life for this measure is 10 years.[145]

3.19.7 Incremental Cost

For Multi-Speed Pumps, incremental cost is assumed to be $235 and $549 for Variable Speed Pumps.[146]

[145] Database for Energy Efficient Resources (2014).

[146] Savings Calculator for ENERGY STAR Certified Inground Pool Pumps https://www.energystar.gov/sites/default/files/asset/document/Pool%20Pump%20Calculator.xlsx

3.20 Packaged Terminal Air Conditioners and Heat Pumps and Room Air Conditioners

Savings are provided for the installation of Packaged Terminal Air Conditioners (PTAC), Packaged Terminal Heat Pumps (PTHP), and Room AC (RAC) systems. This document covers assumptions made for baseline equipment efficiencies for replace-on-burnout (ROB) and new construction (NC) situations based on current efficiency standards. Early retirement (ER) projects should claim savings using the ROB/NC baseline.

Applicable efficient measure types include:

Packaged Terminal Air Conditioners and Heat Pumps. Both Standard and Non-Standard size equipment types are covered. Standard Size refers to equipment with wall sleeve dimensions having an external wall opening greater than or equal to 16 inches high, or greater than or equal to 42 inches wide and a cross sectional area greater than 670 in^2. Non-Standard Size refers to equipment with existing wall sleeve dimensions having an external wall opening of less than 16 inches high, or less than 42 inches wide and a cross sectional area less than 670 in^2.

Room Air Conditioners. Includes all equipment configurations covered by the federal appliance standards,[147] including with or without reverse cycle, louvered or non-louvered sides, casement-only, and casement-slide.

3.20.1 Measure Overview

Sector	Commercial
End use	HVAC
Fuel	Electricity
Measure category	PTAC/PTHP, RAC
Delivery mechanism	Direct Install, Rebate
Baseline description	Minimum federal efficiency standards for PTAC/PTHP and RAC
Efficient case description	PTAC/PTHP or RAC exceeding minimum federal efficiency standards

[147] 10 CFR 430.32(b)

3.20.2 Savings

Table 92 shows the minimum efficiency standards for PTAC/PTHP units and reflects the federal standards for Packaged Terminal Air Conditioners and Heat Pumps reflected in 10 CFR 431.97(c).

Table 92: Minimum Efficiency Levels for PTAC/PTHP ROB and NC Units[148,149]

Equipment	Cooling Capacity [Btuh]	Minimum Cooling Efficiency [EER]	Minimum Heating Efficiency [COP]
PTAC New Construction (NC)	All Capacities	14.0 - (0.300 x Cap/1000) EER	–
PTAC Replace-on-Burnout (ROB)	All Capacities	10.9 - (0.213 x Cap/1000) EER	--
PTHP New Construction (NC)	All Capacities	14.0 - (0.300 x Cap/1000) EER	3.2 - (0.026 x Cap/1000) COP
PTHP Replace-on-Burnout (ROB)	All Capacities	10.8 - (0.213 x Cap/1000) EER	2.9 - (0.026 x Cap/1000) COP
Single Packaged Vertical Air Conditioner	< 65,000 Btu/h	9.0 EER	--
	≥ 65,000 Btu/h and < 135,000 Btu/h	8.9 EER	--
	≥ 135,000 Btu/h and < 240,000 Btu/h	8.6 EER	--
Single Packaged Vertical Heat Pump	< 65,000 Btu/h	9.0 EER	3.0 COP
	≥ 65,000 Btu/h and < 135,000 Btu/h	8.9 EER	3.0 COP
	≥ 135,000 Btu/h and < 240,000 Btu/h	8.6 EER	2.9 COP

148 IECC 2018 Table C403.3.2(3)

149 Cap refers to the rated cooling capacity in Btuh. If the capacity is less than 7,000 Btuh, use 7,000 Btuh in the calculation. If the capacity is greater than 15,000 Btuh, use 15,000 Btuh in the calculation.

Table 93 lists the federal standards for Room Air Conditioners specified in 10 CFR 430.32(b).

Table 93: Minimum Efficiency Levels for Room Air Conditioners ROB and NC Units[150]

Category	Cooling Capacity [Btuh]	Minimum Cooling Efficiency [CEER]
Without reverse cycle, with louvered sides	< 8,000	11.0
	≥ 8,000 and < 14,000	10.9
	≥ 14,000 and < 20,000	10.7
	≥ 20,000 and < 25,000	9.4
	≥ 25,000	9.0
Without reverse cycle, without louvered sides	< 8,000	10.0
	≥ 8,000 and < 11,000	9.6
	≥ 11,000 and < 14,000	9.5
	≥ 14,000 and < 20,000	9.3
	≥ 20,000	9.4
With reverse cycle, with louvered sides	< 20,000	9.8
	≥ 20,000	9.3
With reverse cycle, without louvered sides	< 14,000	9.3
	≥ 14,000	8.7
Casement-only	All capacities	9.5
Casement-slider	All capacities	10.4

The high efficiency condition must exceed the minimum federal standards from Table 92 and Table 93. The high efficiency retrofits must also meet the following criteria:

- Non-Standard Size PTAC/PTHPs cannot be used for New Construction.
- No additional measures are being installed that directly affect the operation of the cooling equipment (i.e., control sequences).

Deemed coincidence factor (CF) and equivalent full-load hour (EFLH) values are presented by building type and climate zone for PTAC/PTHP and RAC. EFLH and CF

[150] IECC 2018 Table C403.3.2(3)

values are derived from the values listed in Section 3.6 and a comparison of EFLH and CF values for the Air Conditioner/Heat Pump and PTAC/PTHP measures in the Texas TRM, as PTAC/PTHP are expected to have a slightly different operating profile than packaged AC/HP. In the Texas TRM, for Amarillo, dividing the PTAC/PTHP value by the Air Conditioner/Heat Pump value gives 0.88, 0.93, and 0.46 for CF, cooling EFLH, and heating EFLH, respectively. For El Paso, dividing the PTAC/PTHP value by the Air Conditioner/Heat Pump value gives 0.97, 1.01, and 0.66 for CF, cooling EFLH, and heating EFLH, respectively. These factors were multiplied by the CF and EFLH values listed in Section 3.6 to determine the values for this measure. The Albuquerque and Santa Fe values were derived based on the Amarillo factors, and the Las Cruces and Roswell values were derived based on the El Paso factors.

Example:

Efficient PTAC (20,000 Btuh capacity) is installed in place of standard PTAC in a hotel in Albuquerque.

$kWh_{Savings,C}$ = (20,000 Btuh/9.3 – 20,000 Btuh/10.5) x 1,411 hours x 1 kW/1000 W

= 347 kWh

Peak Demand $\left[kW_{Savings}\right]$ = (20,000 Btuh/9.3 – 20,000 Btuh/10.4) x 0.54 x 1 kW/1000 W

= 0.133 kWD

3.20.3 Energy Savings Estimation

$$Total\ Energy\ \left[kWh_{Savings}\right] = kWh_{Savings,C} + kWh_{Savings,H}$$

$$Energy\ (Cooling)\ [kWh_{Savings,C}] = \left(\frac{Cap_{C,pre}}{\eta_{baseline,C}} - \frac{Cap_{C,post}}{\eta_{installed,C}}\right) \times EFLH_C \times \frac{1\ kW}{1{,}000\ W}$$

$$Energy\ (Heating)\ \left[kWh_{Savings,H}\right] = \left(\frac{Cap_{H,pre}}{\eta_{baseline,H}} - \frac{Cap_{H,post}}{\eta_{installed,H}}\right) \times EFLH_H \times \frac{1\ kWh}{3{,}412\ Btu}$$

Where:

$Cap_{C/H,pre}$ = Rated equipment cooling/heating capacity of the existing equipment at AHRI standard conditions [BTUH]. If there is no existing equipment (e.g. new construction) set $Cap_{C/H,pre}$ equal to $Cap_{C/H,post}$; 1 ton = 12,000 Btuh

$Cap_{C/H,post}$ = Rated equipment cooling/heating capacity of the newly installed equipment at AHRI standard conditions [Btuh]; 1 ton = 12,000 Btuh

$\eta_{baseline,C}$ = Cooling efficiency of standard baseline equipment [EER or CEER, Btu/W-h] (See Table 92 and Table 93)

$\eta_{baseline,H}$ = Heating efficiency of standard baseline equipment [COP] (See Table 92 and Table 93)

$\eta_{installed,C}$ = Rated cooling efficiency of the newly installed equipment [EER or CEER, Btu/W-h]) (Must exceed minimum federal standards from Table 92 and Table 93)

$\eta_{installed,H}$ = Rated heating efficiency of the newly installed equipment [COP] (Must exceed minimum federal standards from Table 92 and Table 93)

$EFLH_{C/H}$ = Cooling/heating equivalent full-load hours for newly installed equipment based on appropriate climate zone, building type, and equipment type [hours] (See tables below)

Table 94: Cooling EFLH by Building Type and Climate Zone

Building Type	Albuquerque	Las Cruces	Roswell	Santa Fe
Assembly	1,364	1,360	1,596	753
Education - Community College	1,006	1,306	1,377	583
Education - Primary School	404	514	561	268
Education - Relocatable Classroom	455	567	603	328
Education - Secondary School	417	485	562	198
Education - University	957	1,249	1,341	596
Grocery	764	973	1,051	363
Health/Medical – Hospital	1,103	1,196	1,405	560
Health/Medical - Nursing Home	913	970	1,221	446
Lodging - Hotel	1,411	1,700	1,820	903
Manufacturing - Bio/Tech	1,034	1,254	1,349	737
Manufacturing - Light Industrial	689	970	962	481
Office - Small	1,005	1,189	1,308	714
Restaurant - Fast-Food	1,179	1,283	1,395	699
Restaurant - Sit-Down	1,147	1,234	1,378	632
Retail - Single-Story Large	1,333	1,489	1,623	821
Retail - Small	1,202	1,378	1,456	786

Storage - Conditioned	456	707	706	312
Warehouse - Refrigerated	1,370	1,517	1,616	691
Other[151]	958	1,123	1,228	572

Table 95: Heating EFLH by Building Type and Climate Zone

Building Type	Albuquerque	Las Cruces	Roswell	Santa Fe
Assembly	0	0	0	0
Education - Community College	0	0	0	0
Education - Primary School	321	332	330	427
Education - Relocatable Classroom	337	351	349	448
Education - Secondary School	337	351	349	448
Education - University	0	0	0	0
Grocery	0	0	0	0
Health/Medical – Hospital	0	0	0	0
Health/Medical - Nursing Home	0	0	0	0
Lodging - Hotel	359	254	253	478
Manufacturing - Bio/Tech	156	119	118	207
Manufacturing - Light Industrial	156	119	118	207
Office - Small	156	119	118	207
Restaurant - Fast-Food	471	425	423	626
Restaurant - Sit-Down	514	499	496	684
Retail - Single-Story Large	415	312	311	552
Retail - Small	345	365	363	459
Storage - Conditioned	0	0	0	0
Warehouse - Refrigerated	0	0	0	0
Other[152]	156	119	118	207

[151] This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g., a medical administration building could potentially be assessed using the "Office – Small" EFLH.

[152] This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g., a medical administration building could potentially be assessed using the "Office – Small" EFLH.

Table 96: CF by Building Type and Climate Zone

Building Type	Albuquerque	Las Cruces	Roswell	Santa Fe
Assembly	0.69	0.88	0.62	0.69
Education - Community College	0.69	0.84	0.67	0.69
Education - Primary School	0.69	0.88	0.62	0.69
Education - Relocatable Classroom	0.69	0.88	0.62	0.69
Education - Secondary School	0.69	0.84	0.67	0.69
Education - University	0.69	0.84	0.67	0.69
Grocery	0.65	0.78	0.66	0.65
Health/Medical – Hospital	0.68	0.79	0.70	0.68
Health/Medical - Nursing Home	0.69	0.85	0.66	0.69
Lodging - Hotel	0.54	0.61	0.56	0.54
Manufacturing - Bio/Tech	0.30	0.37	0.28	0.30
Manufacturing - Light Industrial	0.30	0.37	0.28	0.30
Office - Small	0.67	0.79	0.70	0.67
Restaurant - Fast-Food	0.66	0.74	0.71	0.66
Restaurant - Sit-Down	0.70	0.74	0.80	0.70
Retail - Single-Story Large	0.70	0.78	0.78	0.70
Retail - Small	0.69	0.80	0.73	0.69
Storage - Conditioned	0.48	0.73	0.33	0.48
Warehouse - Refrigerated	0.48	0.73	0.33	0.48
Other[153]	0.30	0.37	0.28	0.30

3.20.4 Demand Savings Estimation

$$Peak\ Demand\ [kW_{Savings}] = \left(\frac{Cap_{C,pre}}{\eta_{baseline,C}} - \frac{Cap_{C,post}}{\eta_{installed,C}}\right) \times CF \times \frac{1\ kW}{1{,}000\ W}$$

Where:

[153] This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g., a medical administration building could potentially be assessed using the "Office – Small" EFLH.

CF	= Coincidence factor for appropriate climate zone, building type, and equipment type (See Table 96 above)

The remaining variables are defined above in the kWh savings subsection.

3.20.5 Non-energy Benefits

There are no non-energy benefits for this measure.

3.20.6 Measure Life

The measure life for PTAC/PTHPs is 15 years. The measure life for RACs is 9 years. These values are consistent with the EULs reported in the 2014 California Database for Energy Efficiency Resources (DEER).[154]

3.20.7 Incremental Cost

The incremental cost is estimated to be $84/ton.[155]

[154] 2014 California Database for Energy Efficiency Resources.

[155] DEER 2008

3.21 Vending Machine and Merchandise Cooler Controls

Savings are presented for the installation of Vending Machine and Merchandise Cooler controls to reduce energy usage during periods of inactivity. These controls reduce energy usage by powering down the refrigeration and lighting systems when the control device signals that there is no human activity near the machine. If no activity or sale is detected over the manufacturer's programmed time duration, the device safely de-energizes the compressor, condenser fan, evaporator fan, and any lighting. For refrigerated machines, it will power up occasionally to maintain cooling to meet the machine's thermostat set point. When activity is detected, the system returns to full power. The energy and demand savings are determined on a per-vending machine basis.

3.21.1 Measure Overview

Sector	Commercial
End use	Appliance
Fuel	Electricity
Measure category	Vending Machine and Merchandise Cooler Controls
Delivery mechanism	Direct Install, Rebate
Baseline description	Vending machine, or non-refrigerated snack machine, or merchandise cooler without controls
Efficient case description	Controlled refrigerated vending machine, or non-refrigerated snack machine, or merchandise cooler

3.21.2 Savings

Deemed energy savings are listed in the following tables. Values are per-controlled machine. Values are sorted by building type and vending machine type. Vending machine values are given for machines manufactured before January 8, 2019, and on or after January 8, 2019. If the vending machine manufacture date is unknown, use the values for machines manufactured on or after January 8, 2019. Merchandise cooler values are given for machines manufactured before March 27, 2017, and on or after March 27, 2017. If the merchandise cooler manufacture date is unknown, use the values for machines manufactured on or after March 27, 2017.

Per federal standards,[156] vending machine types are defined as follows:

Class A means a refrigerated bottled or canned beverage vending machine that is not a combination vending machine and in which 25 percent or more of the surface area on the front side of the beverage vending machine is transparent.

Class B means a refrigerated bottled or canned beverage vending machine that is not considered to be Class A and is not a combination vending machine.

Combination vending machine means a bottled or canned beverage vending machine containing two or more compartments separated by a solid partition, that may or may not share a product delivery chute, in which at least one compartment is designed to be refrigerated, as demonstrated by the presence of temperature controls, and at least one compartment is not.

Combination A means a combination vending machine where 25 percent or more of the surface area on the front side of the beverage vending machine is transparent.

Combination B means a combination vending machine that is not considered to be Combination A.

If the type of vending machine is unknown, use the values for Class B machines.

Merchandise coolers are self-contained commercial reach-in refrigerators with transparent doors which display refrigerated goods for sale.

[156] 10 CFR 431.296

Table 97: Deemed Vending Machine Controls Energy Savings (kWh/yr per Vending Machine)

		Manufactured before 1/8/2019		Manufactured on or after 1/8/2019			
Building Type	**Uncooled**	**Class A**	**Class B**	**Class A**	**Class B**	**Combination A**	**Combination B**
Assembly	69	1,116	1,361	1,067	1,009	1,304	1,280
Education - Community College	59	965	1,177	923	873	1,128	1,107
Education - Primary School	68	1,110	1,354	1,062	1,004	1,297	1,273
Education - Relocatable Classroom	70	1,141	1,392	1,091	1,032	1,334	1,309
Education - Secondary School	65	1,048	1,279	1,003	949	1,225	1,203
Education - University	61	991	1,209	948	897	1,159	1,138
Grocery	36	592	722	566	536	692	680
Hospital	33	538	656	515	487	629	617
Hotel	68	1,104	1,347	1,056	999	1,290	1,267
Manufacturing - BioTech	59	956	1,167	915	865	1,118	1,097
Manufacturing - Light Industrial	58	942	1,149	901	852	1,101	1,081
Motel	70	1,135	1,384	1,085	1,027	1,326	1,302
Nursing Home	43	702	856	671	635	820	805
Office - Large	60	978	1,193	936	885	1,143	1,122
Office - Small	65	1,057	1,290	1,011	956	1,236	1,213
Restaurant - Fast Food	44	713	870	682	646	834	819
Restaurant - Sit Down	51	825	1,006	789	746	964	946
Retail - 3 Story or Larger	32	513	626	491	464	600	589
Retail - Large	51	835	1,019	799	755	976	958

Building Type	Uncooled	Manufactured before 1/8/2019		Manufactured on or after 1/8/2019			
		Class A	Class B	Class A	Class B	Combination A	Combination B
Retail - Small	54	880	1,074	842	796	1,029	1,010
Storage - Conditioned	61	984	1,200	941	890	1,150	1,129
Storage - Unconditioned	62	1,007	1,229	964	911	1,178	1,156
Warehouse - Refrigerated	39	627	765	600	568	733	720

Table 98: Deemed Vending Machine Demand Savings (kW/yr per Vending Machine)

Uncooled	Manufactured before 1/8/2019		Manufactured on or after 1/8/2019			
	Class A	Class B	Class A	Class B	Combination A	Combination B
0.0007	0.0134	0.0165	0.0128	0.0121	0.0158	0.0155

Table 99: Deemed Merchandise Cooler Energy Savings (kWh/yr per Cooler)

Building Type	Manufactured before 3/27/2017				Manufactured on or after 3/27/2017			
	Under Counter	Single Door	Double Door	Triple Door	Under Counter	Single Door	Double Door	Triple Door
Assembly	1,139	1,561	2,164	3,007	467	818	1,320	2,023
Education - Community College	986	1,350	1,871	2,601	404	708	1,142	1,750
Education - Primary School	1,134	1,553	2,152	2,991	464	814	1,313	2,012
Education - Relocatable Classroom	1,165	1,597	2,213	3,075	477	837	1,350	2,069
Education - Secondary School	1,071	1,467	2,033	2,826	439	769	1,241	1,901
Education - University	1,013	1,387	1,922	2,672	415	727	1,173	1,798

Building Type	Manufactured before 3/27/2017				Manufactured on or after 3/27/2017			
	Under Counter	Single Door	Double Door	Triple Door	Under Counter	Single Door	Double Door	Triple Door
Grocery	605	829	1,148	1,596	248	434	701	1,074
Hospital	550	753	1,043	1,450	225	395	637	976
Hotel	1,128	1,545	2,141	2,975	462	810	1,306	2,002
Manufacturing - BioTech	977	1,338	1,854	2,577	400	701	1,132	1,734
Manufacturing - Light Industrial	962	1,318	1,826	2,538	394	691	1,114	1,707
Motel	1,159	1,588	2,200	3,058	475	832	1,343	2,057
Nursing Home	717	982	1,361	1,892	294	515	831	1,273
Office - Large	999	1,369	1,897	2,636	409	717	1,158	1,774
Office - Small	1,080	1,479	2,050	2,849	442	775	1,251	1,917
Restaurant - Fast Food	729	998	1,384	1,923	299	523	844	1,294
Restaurant - Sit Down	842	1,154	1,599	2,223	345	605	976	1,495
Retail - 3 Story or Larger	524	718	995	1,383	215	376	607	931
Retail - Large	853	1,168	1,619	2,250	349	612	988	1,514
Retail - Small	899	1,232	1,707	2,372	368	646	1,042	1,596
Storage - Conditioned	1,005	1,377	1,908	2,652	412	722	1,164	1,784
Storage - Unconditioned	1,029	1,410	1,954	2,715	422	739	1,192	1,827
Warehouse - Refrigerated	641	878	1,216	1,691	262	460	742	1,137

Table 100: Deemed Merchandise Cooler Demand Savings (kW/yr per Cooler)

Manufactured before 3/27/2017				Manufactured on or after 3/27/2017			
Under Counter	Single Door	Double Door	Triple Door	Under Counter	Single Door	Double Door	Triple Door
0.0142	0.0194	0.0269	0.0374	0.0058	0.0102	0.0164	0.0252

3.21.3 Energy Savings Estimation

Energy savings are derived based on the methodology in the SCE workpapers SCE17CS005.0 Beverage Merchandise Controller[157].Savings are achieved in three different areas detailed below. Uncooled snack vending machines achieve savings per (1) below, and cooled vending machines achieve savings per both (2) and (3) below, and merchandise coolers achieve savings per (3).

(1) Energy savings for the reduction in lighting use from turning off an interior display light

In uncooled snack vending machines, a display light typically illuminates the products inside the vending machine. The SCE workpaper calculations assumed that illumination is provided by one 2-foot T8 linear fluorescent lamp. However, it is expected that vending machine lighting will increasingly transition to LED lamps. Therefore, the TRM calculations assume illumination is provided by one 2-foot 9-Watt LED tube lamp.

To estimate the specific energy savings, the DEER2017 linear fluorescent lighting effective full load operating hours will be used to represent when the unit is assumed to be enabled. The savings for occupancy based vending control will occur in a load profile complimentary to an 8,760 load shape.

$$Energy\ Savings = (8{,}760\ hrs - OccSnsrBldgHrs) \times Fixture\ Wattage$$

Sensor hours by building type are show in Table 101.[158]

Table 101: Operating Hours with Occupancy Sensor

Building Type	OccSnsrBldgHrs
Assembly	1,130
Education - Community College	2,160
Education - Primary School	1,170
Education - Relocatable Classroom	957
Education - Secondary School	1,590
Education - University	1,980
Grocery	4,710
Hospital	5,080

[157] http://deeresources.net/workpapers

[158] Derived from SDG&E workpaper WPSDGEENRCS0001

Building Type	OccSnsrBldgHrs
Hotel	1,210
Manufacturing - BioTech	2,220
Manufacturing - Light Industrial	2,320
Motel	1,000
Nursing Home	3,960
Office - Large	2,070
Office - Small	1,530
Restaurant - Fast Food	3,880
Restaurant - Sit Down	3,120
Retail - 3 Story or Larger	5,250
Retail - Large	3,050
Retail - Small	2,740
Storage - Conditioned	2,030
Storage - Unconditioned	1,870
Warehouse - Refrigerated	4,470

For example, in a small office, the DEER2017 occupancy sensor-based lighting effective full load operating hours is 1,530 hours; therefore the amount of time the vending machine control would turn the internal lights off would be 8,760 hours minus 1,530 hours, resulting in 7,230 hours of off time. The savings are calculated using the energy savings equation above.

(2) Energy savings for the reduction in lighting use from turning off a backlit display

The energy savings from reduction in backlit display lighting usage will be calculated using the same algorithm as (1) above.. The only deviation will be the wattage controlled. According to E Source tech Update TU-96-7,[159] the typical backlit display for a cooled beverage vending machine consists of two 5-foot linear fluorescent lamps. For the purposes of the calculation, the backlighting is assumed to be provided by two 4-foot 12-Watt LED tubes, for a total of 24 Watts for backlighting. Refer to Equation 1 for the general form of the savings calculation.

[159] Houghton, David PE (1996). Refrigerated Vending Machines - Overlooked Devices Hold Opportunities for Efficiency, New Services. E Source Tech Update, TU-96-7

(3) Energy savings for the reduction in refrigeration time for refrigerated canned and bottled beverage vending machines and merchandise coolers

For vending machines, the base case energy usage is established using the federal standards for vending machines.[160] The Federal Energy Management Program (FEMP) used a 21 ft^3 refrigerated volume when calculating efficient vending machine savings,.[161]and the savings for this measure are based on this volume.

Vending Machines manufactured before January 8, 2019:

Class A

*Maximum Daily Energy Consumption (kWh) = 0.055*V+2.56*

Where,

V = Refrigerated volume (ft^3)

= 21 ft^3

*Maximum Daily Energy Consumption (kWh) = 0.055*21 + 2.56 = 3.715 kWh*

Maximum Power (kW) = Maximum Daily Energy Consumption (kWh) / 24 hrs

= 3.715 / 24 = 0.155 kW

Class B

*Maximum Daily Energy Consumption (kWh)=0.073*V+3.16*

Where,

V = Refrigerated volume (ft^3)

= 21 ft^3

*Maximum Daily Energy Consumption (kWh) = 0.073*21+3.16*

=4.693 kWh

Maximum Power (kW) = Maximum Daily Energy Consumption (kWh) / 24 hrs

= 4.693 / 24

[160] 10 CFR 431.296

[161] https://www.energy.gov/eere/femp/purchasing-energy-efficient-refrigerated-beverage-vending-machines

= 0.196 kW

Vending machines manufactured on or after January 8, 2019:

Class A

*Maximum Daily Energy Consumption (kWh) = 0.052*V+2.43*

Where,

V = Refrigerated volume (ft^3)

= 21 ft^3

*Maximum Daily Energy Consumption (kWh) = 0.052*21+2.43*

= 3.522 kWh

Maximum Power (kW) = Maximum Daily Energy Consumption (kWh) / 24 hrs

= 3.522/24

= 0.147 kW

Class B

*Maximum Daily Energy Consumption (kWh)=0.052*V+2.20*

Where,

V = Refrigerated volume (ft^3)

= 21 ft^3

*Maximum Daily Energy Consumption (kWh) = 0.052*21+2.20*

= 3.292 kWh

Maximum Power (kW) = Maximum Daily Energy Consumption (kWh) / 24 hrs

= 3.292 / 24 = 0.137 kW

Combination A

*Maximum Daily Energy Consumption (kWh)=0.086*V+2.66*

Where,

V = Refrigerated volume (ft^3)

= 21 ft^3

*Maximum Daily Energy Consumption (kWh) = 0.086*21+2.66*

= 4.466 kWh

Maximum Power (kW) = Maximum Daily Energy Consumption (kWh) / 24 hrs

= 4.466 / 24

= 0.186 kW

Combination B

*Maximum Daily Energy Consumption (kWh)=0.111*V+2.04*

Where,

V = Refrigerated volume (ft^3)

= 21 (ft^3)

*Maximum Daily Energy Consumption (kWh) = 0.111*21+2.04*

= 4.371 kWh

Maximum Power (kW) = Maximum Daily Energy Consumption (kWh) / 24 hrs

= 4.371 / 24

=0.182 kW

For merchandise coolers, the base case energy usage is established using the federal standards for commercial refrigerators.[162] The SCE workpaper assumes volumes of 10 ft^2 for under-counter coolers, 24 ft^2 for single-door coolers, 44 ft^2 for double-door coolers, and 72 ft^2 for triple-door coolers, and the savings for this measure are based on these volumes.

Refrigerators with transparent doors manufactured before March 27, 2017:

*Maximum Daily Energy Consumption (kWh) = 0.12*V + 3.34*

Maximum Power (kW) = kWh / 24

[162] 10 CFR 431.66

Under Counter: 4.54 kWh, 0.189 kW

Single Door: 6.22 kWh, 0.259 kW

Double Door: 8.62 kWh, 0.359 kW

Triple Door: 11.98 kWh, 0.499 kW

Self-Contained Commercial Refrigerators and Commercial Freezers with Doors, Vertical Closed Transparent (VCT), Medium temperature, manufactured on or after March 27, 2017:

*Maximum Daily Energy Consumption (kWh) = 0.1*V + 0.86*

Maximum Power (kW)=kWh / 24

Under Counter: 1.86 kWh, 0.078 kW

Single Door: 3.26 kWh, 0.136 kW

Double Door: 5.26 kWh, 0.219 kW

Triple Door: 8.06 kWh, 0.336 kW

The amount of time that the refrigeration system will be on is equal to the occupancy sensor hours assumed for the lighting savings, and the amount of time that the refrigeration system will be turned on automatically in order to maintain the refrigerated temperature. Based on vending machine controls product literature, it is assumed that the compressor will automatically turn on after 90 minutes (1.5 hours) of being off. The duration of an automatic refrigeration cycle is assumed to be 24 minutes (0.4 hours).[163] Therefore, the amount of time the refrigeration system will be automatically turned on is calculated as follows:

$$Auto - On\ Hours = \left[\frac{(8{,}760 - OccSnsrBldgHrs)}{(1.5\ hours + 0.4\ hours)}\right] \times 0.4\ hours$$

Thus, the total time the refrigeration system will be on is calculated as follows:

On-Hours = OccSnsrBldgHrs + Auto-On Hours

Annual kWh savings associated with the refrigeration system are calculated by multiplying the maximum power by the number of off hours:

[163] Based on the Vending Miser savings calculator created by Sanders and Associates: http://www.vendingenergymisers.com/documents/calculator.xlsx

Refrigeration kWh Savings = Maximum Power x (8,760 – On-Hours)

Total annual kWh savings are calculated by adding the refrigeration kWh savings to the lighting kWh savings.

3.21.4 Demand Savings Estimation

Demand savings are calculated using the following formula:

$$kW_{Savin} \quad = (kW_{Lighting} + kW_{Refrigeration}) \times DSF$$

Where:

$kW_{Savings}$ = Peak demand savings, kW

$kW_{Lighting}$ = Connected lighting load, kW

$kW_{Refrigeration}$ = Maximum refrigeration power, kW

DSF = Demand Savings Factor, 0.075[164]

Table 102. Connected Lighting Load, kW

Uncooled Machines	Refrigerated Vending Machines	Merchandise coolers
0.009	0.024	0

$kW_{Refrigeration}$ = Maximum refrigeration power, kW

Table 103. Maximum refrigeration power for vending machines, kW

	Manufactured before 1/8/2019		Manufactured on or after 1/8/2019			
Uncooled	Class A	Class B	Class A	Class B	Combination A	Combination B
0.00	0.155	0.196	0.147	0.137	0.186	0.182

[164] Arkansas TRM v7.0

Table 104. Maximum refrigeration power for merchandise coolers, kW

Manufactured before 3/27/2017				Manufactured on or after 3/27/2017			
Under Counter	Single Door	Double Door	Triple Door	Under Counter	Single Door	Double Door	Triple Door
0.189	0.259	0.359	0.499	0.078	0.136	0.219	0.336

3.21.5 Non-energy Benefits

There are no non-energy benefits for this measure.

3.21.6 Measure Life

The estimated useful life (EUL) for vending machine and merchandise cooler controls is 5 years. This value is consistent with the EUL reported in the 2014 California Database for Energy Efficiency Resources (DEER).[165]

3.21.7 Incremental Cost

The incremental measure cost for this measure is the cost of the controller plus the labor to install the controller. Costs are estimated as follows:[166]

- Uncooled Vending Machine Controls: $239.72
- Refrigerated Vending Machine Controls: $267.57
- Merchandise Cooler Controls: $248.36

[165] 2014 California Database for Energy Efficiency Resources.

[166] SCE17CS005.0 Beverage Merchandise Controller

3.22 Window Treatments

Savings are provided for the installation of window films and solar screens. The installation of window film and solar screens decreases the window-shading coefficient and reduces the solar heat transmitted to the building space. During months when perimeter cooling is required in the building, this measure decreases cooling energy use.

3.22.1 Measure Overview

Sector	Commercial
End use	Building Envelope
Fuel	Electricity
Measure category	Window Treatments
Delivery mechanism	Direct Install, Rebate
Baseline description	Clear glass without existing window treatments
Efficient case description	Eligible window treatments installed on eligible windows

3.22.2 Savings

This measure is applicable for treatment of single-paned windows that do not have existing solar films or solar screens, are not shaded by exterior awnings or overhangs, and are in buildings that are mechanically cooled (DX or chilled water).

The baseline condition is clear glass without existing window treatment. Interior and exterior shading (including blinds, shades, and drapes; excluding exterior awnings and overhangs) is acceptable but should be considered in the savings calculation using the shading coefficients specified in Table 107. The high-efficiency condition is an eligible window treatment applied to eligible windows. No changes should be made to awnings or overhangs in order to claim savings from this measure.

The demand and energy savings equations in this section originated in calculations by the Texas EUMMOT utilities as presented in the EUMMOT program manual Commercial Standard Offer Program: Measurement and Verification Guidelines for Retrofit and New Construction Projects.[167] The method estimates reduction in solar heat gain/insolation attributable to a given window treatment using shading coefficients for

[167] See, for example, section 5.4 of the Equipment Efficiency Standards Appendices to the AEP companies' 2013 Commercial & Industrial Standard Offer Program Manual.

the treated and untreated window and solar heat gain estimates by window orientation according to ASHRAE Fundamentals.

Example:

Window treatments are installed on single-pane unshaded North-facing windows a building in Albuquerque with a PTAC and a gas furnace.

Cooling Energy Savings = 100 sq. ft. x 67,108 Btu/sq. ft.- year x (0.93 – 0.70) / (9.3 x1000)

= 166 kWh

Heating Energy Savings = -(100 sq. ft. x 110,730 Btu/sq. ft.- year x (0.93 – 0.70) / (0.8 x 100,000))

= -32 Therms

Total Energy Savings =

Demand Savings = 100 sq. ft. x 37 Btu/hr-sq.ft.-year x (0.93 – 0.70)/(9.3 x 1000)

= 0.092 kW

3.22.3 Energy Savings Estimation

$$Energy\ Savings = \sum (Cooling\ Energy\ Savings_o + Heating\ Energy\ Savings_o)$$ [168]

$$Cooling\ Energy\ Savings_o = \frac{A_{film,o} \times Cooling\ SHG_o \times (SC_{pre,o} - SC_{post,o})}{Cooling\ Efficiency_{PL} \times 1{,}000}$$

$$Heating\ Energy\ Savings_o = -\left(\frac{A_{film,o} \times Heating\ SHG_o \times (SC_{pre,o} - SC_{post,o})}{Heating\ Efficiency \times Heating\ Conversion}\right)$$

Where:

Cooling Energy Savings$_o$ = Cooling energy savings per window orientation

Heating Energy Savings$_o$ = Heating energy savings (consumption) per window orientation due to reduced natural heat in winter

$A_{film,o}$ = Area of window film applied to orientation [ft^2]

[168] Note that facilities with electric cooling and gas heating will have cooling savings in units of kWh and heating savings in units of therms. These savings values cannot be added and must be reported separately. The algorithm above shows the sum of cooling and heating savings to demonstrate that both cooling and heating effects must be considered when analyzing this measure.

Cooling SHG_o	= Cooling season solar heat gain for orientation of interest [Btu/ft^2-year]. See Table 105.
$SC_{pre,o}$	= Shading coefficient for existing glass/interior-shading device. See Table 107.
$SC_{post,o}$	= Shading coefficient for new film/interior-shading device, from manufacturer specs
Cooling $Efficiency_{PL}$	= Average part load cooling efficiency of commercial and industrial spaces, Assumed to be 12.64 SEER[169]
1,000	= Conversion factor [W/kW]
Heating SHG_o	= Heating season solar heat gain for orientation of interest [Btu/ft^2-year]. See Table 106.
Heating Efficiency	= Average heating efficiency of commercial and industrial spaces, Assumed to be 3.2 COP for electric heat and 80% for gas heat[170]
Heating Conversion	= Conversion factor based on units of Heating Efficiency For gas heat, 100,000 Btu/therm For electric heat COP, 3,412 Btu/kWh

Table 105: Cooling Season Solar Heat Gain Factors[171]

	Cooling Solar Heat Gain [Btu/ft²-year]			
Orientation	**Albuquerque**	**Las Cruces**	**Roswell**	**Santa Fe**
North	67,108	69,897	68,618	67,995
North-East	102,259	103,459	98,399	103,426
East	145,112	141,559	137,424	145,519
South-East	148,340	141,019	140,248	147,647
South	132,595	126,016	126,800	129,217
South-West	140,262	139,677	139,550	134,108

169 Weighted average of HVAC cooling part load system efficiency of commercial buildings in the DEER 2008 database

170 Weighted average of HVAC heating system efficiency of commercial buildings in the DEER 2008 database

171 Values are derived using NREL's PVWatts calculator, entering a 90-degree (i.e., vertical) tilt and varying the azimuth (i.e., orientation). Values for each direction listed are the average across the 45 degrees containing the listed direction at the center (i.e., the value listed for North is the average of the values for North-North-West, North, and North-North-East). The cooling season is assumed to be April through October.

	Cooling Solar Heat Gain [Btu/ft2-year]			
Orientation	**Albuquerque**	**Las Cruces**	**Roswell**	**Santa Fe**
West	133,326	139,363	137,442	127,718
North-West	93,741	100,581	99,132	91,707

Table 106: Heating Season Solar Heat Gain Factors[172]

	Heating Solar Heat Gain [Btu/ft2-year]			
Orientation	**Albuquerque**	**Las Cruces**	**Roswell**	**Santa Fe**
North	22,308	24,006	22,897	22,314
North-East	32,262	36,081	32,039	33,000
East	67,251	67,945	64,193	69,307
South-East	110,075	111,174	104,885	112,062
South	132,481	139,068	130,078	131,758
South-West	110,730	117,062	113,505	107,898
West	68,023	74,039	72,174	65,854
North-West	32,685	36,119	34,766	32,185

Table 107: Recommended Shading Coefficient (SC) for Different Pre-Existing Shade Types

Shading Type	Shading Coefficient[173]	Source[174]
Single-Pane - None	0.93	Table 10: Based on ¼" clear single-pane glass (ID 1b)
Single-Pane - Roller Shade	0.60	Table 13G: Based on ID 1b, dark opaque
Single-Pane - Louvered Interior Shades	0.56	Table 13A: Based on ID 1b, 0.50 reflection, excluded beam
Single-Pane - Draperies—Open Weave	0.67	Table 13G: Based on ID 1b, Medium Open Weave
Single-Pane - Draperies—Closed	0.56	Table 13G: Based on ID 1b, Medium Closed

[172] Values are derived using NREL's PVWatts calculator, entering a 90-degree (i.e., vertical) tilt and varying the azimuth (i.e., orientation). The heating season is assumed to be November through March.

[173] For shading devices, IAC is multiplied by unshaded SC to determine listed shading coefficient.

[174] Table numbers and shading coefficients provided are from 2009 ASHRAE Fundamentals Handbook, Chapter 15.

Weave		Weave
Double-Pane - None	0.80	Table 10: Based on ¼" clear double-pane glass (ID 5b)
Double -Pane - Roller Shade	0.62	Table 13G: Based on ID 5b, dark opaque
Double -Pane - Louvered Interior Shades	0.58	Table 13B: Based on ID 5b, 0.50 reflection, excluded beam
Double -Pane - Draperies—Open Weave	0.64	Table 13G: Based on ID 5b, Medium Open Weave
Double -Pane - Draperies—Closed Weave	0.58	Table 13G: Based on ID 5b, Medium Closed Weave

3.22.4 Demand Savings Estimation

$$Peak\ Demand\ Savings\ [kW] = DemandSaving_{o,max}$$

$$Demand\ Savings_o\ [kW] = \frac{A_{film,o} \times Peak\ SHG_o \times (SC_{pre,o} - SC_{post,o})}{1000 \times Cooling\ Efficiency_{FL}}$$

Where:

Demand Savings$_{o,max}$ = Peak demand savings for the orientation with the highest peak demand savings

Demand Savings$_o$ = Peak demand savings per window orientation

Peak SHG$_o$ = Peak solar heat gain factor for orientation of interest [Btu/hr-ft^2-year]. See Table 108.

Cooling Efficiency$_{FL}$ = Average cooling full load efficiency of commercial and industrial spaces; assumed to be 10.17 EER[175]

Table 108: Peak Hourly Solar Heat Gain Factors[176]

	Peak Hour Solar Heat Gain [Btu/hr-ft^2-year]			
Orientation	**Albuquerque**	**Las Cruces**	**Roswell**	**Santa Fe**
North	37	39	38	37
North-East	55	55	53	56
East	71	70	67	73

175 Weighted average of HVAC cooling full load system efficiency of commercial buildings in the DEER 2008 database

176 Values are derived using NREL's PV

South-East	64	61	60	65
South	50	46	48	49
South-West	58	59	60	54
West	63	67	67	58
North-West	49	53	53	46

3.22.5 Non-energy Benefits

There are no non-energy benefits for this measure.

3.22.6 Measure Life

The estimated useful life (EUL) for window film and solar screens is 10 years. This value is consistent with the EUL reported in the 2014 California Database for Energy Efficiency Resources (DEER).[177]

3.22.7 Incremental Cost

Incremental cost estimates should be gathered as part of the application process if utilities wish to test the cost effectiveness of this measure using the TRC test.

[177] 2014 California Database for Energy Efficiency Resources.

3.23 Cool Roofs

This section presents the deemed savings methodology for the installation of an ENERGY STAR® certified roof. The installation of an ENERGY STAR® roof decreases the roofing heat transfer coefficient and reduces the solar heat transmitted to the building space, thus impacting the cooling and heating energy use.

3.23.1 Measure Overview

Sector	Commercial
End use	Building Envelope
Fuel	Electricity
Measure category	Cool Roofs
Delivery mechanism	Direct Install, Rebate
Baseline description	Thermal resistance (R-value) of the existing roof make-up and solar reflectance and emissivity of the surface layer
Efficient case description	Depending on project scope, either adding surface layer only, adding insulation and surface layer, or rebuilding entire roof assembly

3.23.2 Savings

Deemed Energy Savings Factors (ESF) and Peak Summer Demand Factors (PSDF) are listed in Table 111, Table 112, Table 113, and Table 114. ESF values are in units of kWh/SF and PSDF values are in units of 10^{-5} kW/SF. See sections 3.23.3 and 3.23.4 for how to apply these factors to determine savings.

Measures installed through utility programs must be a roof that meets the NM IECC 2018 code requirements and is rated by the CRRC-1 Roof Product Rating Program (CRRC-1Program). For nonresidential facilities, these criteria for a high-efficiency roof include:

- An existing roof undergoing retrofit conditions as further defined under high-efficiency condition below; a roof installed in a new construction application is not eligible for applying these methodologies.
- A roof with a low-slope of 2:12 or less[178]
- An initial solar reflectance of greater than or equal to 65%

[178] As defined in proposed ASTN Standard E 1918-97.

- Maintenance of a three-year-aged solar reflectance greater than or equal to 55% and a three-year-aged thermal emittance greater than or equal to 75%.[179] AND/OR maintenance of a three-year-aged solar reflectance index of 64.[180] 75 percent of the roof surface over conditioned space must be replaced
- No significant obstruction of direct sunlight to roof
- The facility must be conditioned with cooling, heating, or both
- Be listed on theCRRC Rated Roof Products Directory.[181]

The baseline is the thermal resistance (i.e., R-value) of the existing roof make-up, and the solar reflectance and emissivity of the surface layer. The R-value is estimated based on code envelope requirements applicable in the year of construction. Solar reflectance and emissivity of the surface layer are assumed to be 0.2 and 0.9 respectively, based on roof properties listed in the LBNL Roofing Materials Database.[182]

The cooling and heating efficiencies are assumed based on the space conditioning of the top floor of the building and are based on typical code requirements applicable in the year of construction.

Table 109: Assumed Cooling Efficiencies (COP)

Year of Construction; Applicable Code	RTU	Heat Pump Cooling	Heat Pump Heating	Air Cooled Chiller	Water Cooled Chiller
Before 2011; 2000 IECC	2.9	2.9	2.9	2.5	4.2
2011 and later; 2009 IECC	3.8	3.1	2.9	2.8	5.5

The high-efficiency condition depends on the project scope. The project scope is defined as one of:

- Adding surface layer only
- Adding insulation and surface layer
- Rebuilding entire roof assembly

179 C402.3 Roof Solar Reflectance and Thermal Emittance, New Mexico IECC (2018)

180 Ibid.

181 CRRC Rated Roof Products Directory: https://coolroofs.org/directory/roof

182 Lawrence Berkeley National Lab Cool Roofing Material Database. https://heatisland.lbl.gov/resources/cool-roofing-materials-database. Accessed August 2018. Values are determined by taking an average of the reflectance and emissivity of the following materials: Black EPDM, Gray EPDM, Smooth Bitumen, White Granular Bitumen, Dark Gravel on Built-Up Roof, Light Gravel on Built-Up Roof.

If the project scope is only to add a new CRCC-rated cool roof as the new surface layer and does not include additional insulation, then the R-value used for the baseline condition is used for the high-efficiency condition. If the project scope is to add insulation and aCRCC-rated cool roof as the new surface layer, then the high-efficiency condition is calculated by adding the R-value of the additional insulation to the R-value used for the baseline condition. If the entire roof assembly is rebuilt, then the R-value for each layer of the new roof construction is summed to get a total new R-value.

ESF and PSDF values were derived using the savings values from the Texas TRM, version 5. Savings were first apportioned to estimate the savings resulting from the increased roof reflectance, and the savings resulting from the increased roof insulation. The reflectance savings values were adjusted based on a comparison of annual solar radiation for the Texas representative cities and the New Mexico representative cities. Solar radiation values were taken from NREL's PVWatts tool, with inputs representing a horizontal surface (i.e., tilt = 0 degrees). The insulation savings values were adjusted based on a comparison of annual cooling degree-days for the Texas representative cities and the New Mexico representative cities. Peak demand savings were adjusted using radiation and cooling degree-days for the months of June through August.

The savings values in the Texas TRM were estimated using EnergyPlus v8.3.0 whole-building simulation. The savings represent the difference of the modeled energy use of the baseline condition and the high efficiency condition divided by square foot of roof area. The demand savings are calculated based on peak conditions occurring on summer weekday afternoons.

If the existing insulation levels are unknown, use the mapping in Table 110 to estimate the R-value based on the year of construction.

Table 110: Estimated R-value based on Year of Construction

Year of Construction	Estimated R-value[183]
Before 2011	R ≤ 13
2011 and later	13 > R ≤ 20

Table 111: Albuquerque Savings Factors

Building Type[184]	Pre R-Value	Post R-Value	ESF (kWh/SF)	PSDF (10^{-5} kW/SF)
Retail	R ≤ 13	R ≤ 13	0.76	19.84

183 Estimated R-values are based on applicable code requirements in the year of construction.

184 Building types are derived from the US Energy Information Administration (EIA) Commercial Building Energy Consumption Survey (CBECS).

Building Type[184]	Pre R-Value	Post R-Value	ESF (kWh/SF)	PSDF (10^{-5} kW/SF)
	R ≤ 13	13 > R ≤ 20	1.27	36.31
	R ≤ 13	20 < R	1.26	38.59
	13 > R ≤ 20	13 > R ≤ 20	0.14	4.96
	13 > R ≤ 20	20 < R	0.12	6.56
	20 < R	20 < R	0.09	3.42
Education - Chiller	R ≤ 13	R ≤ 13	0.68	12.15
	R ≤ 13	13 > R ≤ 20	1.11	21.82
	R ≤ 13	20 < R	1.25	25.48
	13 > R ≤ 20	13 > R ≤ 20	0.27	5.00
	13 > R ≤ 20	20 < R	0.38	7.86
	20 < R	20 < R	0.18	3.50
Education - RTU	R ≤ 13	R ≤ 13	0.27	8.50
	R ≤ 13	13 > R ≤ 20	0.44	15.51
	R ≤ 13	20 < R	0.49	18.16
	13 > R ≤ 20	13 > R ≤ 20	0.13	4.23
	13 > R ≤ 20	20 < R	0.18	6.72
	20 < R	20 < R	0.08	2.99
Office - Chiller	R ≤ 13	R ≤ 13	0.22	7.00
	R ≤ 13	13 > R ≤ 20	0.32	3.74
	R ≤ 13	20 < R	0.34	19.14
	13 > R ≤ 20	13 > R ≤ 20	0.10	17.07
	13 > R ≤ 20	20 < R	0.11	6.73
	20 < R	20 < R	0.06	2.43
Office - RTU	R ≤ 13	R ≤ 13	0.30	7.68
	R ≤ 13	13 > R ≤ 20	0.86	15.47
	R ≤ 13	20 < R	1.07	18.51
	13 > R ≤ 20	13 > R ≤ 20	0.16	4.24
	13 > R ≤ 20	20 < R	0.37	6.77
	20 < R	20 < R	0.11	3.01
Hotel	R ≤ 13	R ≤ 13	0.07	1.37
	R ≤ 13	13 > R ≤ 20	0.07	1.85

Building Type[184]	Pre R-Value	Post R-Value	ESF (kWh/SF)	PSDF (10^{-5} kW/SF)
	R ≤ 13	20 < R	0.07	2.05
	13 > R ≤ 20	13 > R ≤ 20	0.04	0.84
	13 > R ≤ 20	20 < R	0.04	1.02
	20 < R	20 < R	0.03	0.62
Warehouse	R ≤ 13	R ≤ 13	0.04	3.94
	R ≤ 13	13 > R ≤ 20	0.11	7.01
	R ≤ 13	20 < R	0.14	8.06
	13 > R ≤ 20	13 > R ≤ 20	0.01	1.39
	13 > R ≤ 20	20 < R	0.04	2.26
	20 < R	20 < R	0.01	0.92
Other	R ≤ 13	R ≤ 13	0.04	1.37
	R ≤ 13	13 > R ≤ 20	0.07	1.85
	R ≤ 13	20 < R	0.07	2.05
	13 > R ≤ 20	13 > R ≤ 20	0.01	0.84
	13 > R ≤ 20	20 < R	0.04	1.02
	20 < R	20 < R	0.01	0.62

Table 112: Las Cruces Savings Factors

Building Type	Pre R-Value	Post R-Value	ESF (kWh/SF)	PSDF (10^{-5} kW/SF)
Retail	R ≤ 13	R ≤ 13	0.67	16.63
	R ≤ 13	13 > R ≤ 20	1.00	27.45
	R ≤ 13	20 < R	1.01	29.48
	13 > R ≤ 20	13 > R ≤ 20	0.19	5.86
	13 > R ≤ 20	20 < R	0.19	7.33
	20 < R	20 < R	0.15	4.76
Education - Chiller	R ≤ 13	R ≤ 13	0.70	9.13
	R ≤ 13	13 > R ≤ 20	0.97	14.73
	R ≤ 13	20 < R	1.07	16.95
	13 > R ≤ 20	13 > R ≤ 20	0.36	4.82
	13 > R ≤ 20	20 < R	0.44	6.58

Building Type	Pre R-Value	Post R-Value	ESF (kWh/SF)	PSDF (10^{-5} kW/SF)
	20 < R	20 < R	0.29	3.92
Education - RTU	R ≤ 13	R ≤ 13	0.30	8.25
	R ≤ 13	13 > R ≤ 20	0.41	13.74
	R ≤ 13	20 < R	0.46	15.90
	13 > R ≤ 20	13 > R ≤ 20	0.18	5.18
	13 > R ≤ 20	20 < R	0.22	7.22
	20 < R	20 < R	0.14	4.16
Office - Chiller	R ≤ 13	R ≤ 13	0.29	9.76
	R ≤ 13	13 > R ≤ 20	0.39	18.02
	R ≤ 13	20 < R	0.42	20.95
	13 > R ≤ 20	13 > R ≤ 20	0.17	6.71
	13 > R ≤ 20	20 < R	0.20	9.38
	20 < R	20 < R	0.14	5.41
Office - RTU	R ≤ 13	R ≤ 13	0.31	9.97
	R ≤ 13	13 > R ≤ 20	0.55	16.96
	R ≤ 13	20 < R	0.64	19.79
	13 > R ≤ 20	13 > R ≤ 20	0.20	5.78
	13 > R ≤ 20	20 < R	0.29	7.91
	20 < R	20 < R	0.16	4.72
Hotel	R ≤ 13	R ≤ 13	0.10	1.34
	R ≤ 13	13 > R ≤ 20	0.08	1.60
	R ≤ 13	20 < R	0.08	1.71
	13 > R ≤ 20	13 > R ≤ 20	0.07	0.95
	13 > R ≤ 20	20 < R	0.06	1.05
	20 < R	20 < R	0.06	0.81
Warehouse	R ≤ 13	R ≤ 13	0.04	2.77
	R ≤ 13	13 > R ≤ 20	0.09	5.03
	R ≤ 13	20 < R	0.15	8.57
	13 > R ≤ 20	13 > R ≤ 20	0.02	1.32
	13 > R ≤ 20	20 < R	0.07	4.13
	20 < R	20 < R	0.01	0.76

Building Type	Pre R-Value	Post R-Value	ESF (kWh/SF)	PSDF (10^{-5} kW/SF)
Other	R ≤ 13	R ≤ 13	0.04	1.34
	R ≤ 13	13 > R ≤ 20	0.08	1.60
	R ≤ 13	20 < R	0.08	1.71
	13 > R ≤ 20	13 > R ≤ 20	0.02	0.95
	13 > R ≤ 20	20 < R	0.06	1.05
	20 < R	20 < R	0.01	0.76

Table 113: Roswell Savings Factors

Building Type	Pre R-Value	Post R-Value	ESF (kWh/SF)	PSDF (10^{-5} kW/SF)
Retail	R ≤ 13	R ≤ 13	0.64	16.44
	R ≤ 13	13 > R ≤ 20	0.94	26.22
	R ≤ 13	20 < R	0.95	28.06
	13 > R ≤ 20	13 > R ≤ 20	0.18	5.79
	13 > R ≤ 20	20 < R	0.18	7.13
	20 < R	20 < R	0.15	4.70
Education - Chiller	R ≤ 13	R ≤ 13	0.67	9.02
	R ≤ 13	13 > R ≤ 20	0.92	14.09
	R ≤ 13	20 < R	1.01	16.09
	13 > R ≤ 20	13 > R ≤ 20	0.34	4.76
	13 > R ≤ 20	20 < R	0.41	6.36
	20 < R	20 < R	0.27	3.88
Education - RTU	R ≤ 13	R ≤ 13	0.29	8.15
	R ≤ 13	13 > R ≤ 20	0.39	13.11
	R ≤ 13	20 < R	0.43	15.07
	13 > R ≤ 20	13 > R ≤ 20	0.17	5.12
	13 > R ≤ 20	20 < R	0.21	6.96
	20 < R	20 < R	0.14	4.11
Office - Chiller	R ≤ 13	R ≤ 13	0.28	9.65
	R ≤ 13	13 > R ≤ 20	0.36	17.12
	R ≤ 13	20 < R	0.39	19.76

Building Type	Pre R-Value	Post R-Value	ESF (kWh/SF)	PSDF (10^{-5} kW/SF)
	13 > R ≤ 20	13 > R ≤ 20	0.16	6.63
	13 > R ≤ 20	20 < R	0.19	9.05
	20 < R	20 < R	0.14	5.35
Office - RTU	R ≤ 13	R ≤ 13	0.29	9.86
	R ≤ 13	13 > R ≤ 20	0.51	16.17
	R ≤ 13	20 < R	0.59	18.73
	13 > R ≤ 20	13 > R ≤ 20	0.19	5.71
	13 > R ≤ 20	20 < R	0.27	7.64
	20 < R	20 < R	0.16	4.67
Hotel	R ≤ 13	R ≤ 13	0.09	1.33
	R ≤ 13	13 > R ≤ 20	0.08	1.56
	R ≤ 13	20 < R	0.08	1.66
	13 > R ≤ 20	13 > R ≤ 20	0.07	0.94
	13 > R ≤ 20	20 < R	0.06	1.03
	20 < R	20 < R	0.06	0.80
Warehouse	R ≤ 13	R ≤ 13	0.04	2.74
	R ≤ 13	13 > R ≤ 20	0.08	4.78
	R ≤ 13	20 < R	0.14	7.98
	13 > R ≤ 20	13 > R ≤ 20	0.02	1.30
	13 > R ≤ 20	20 < R	0.06	3.84
	20 < R	20 < R	0.01	0.75
Other	R ≤ 13	R ≤ 13	0.04	1.33
	R ≤ 13	13 > R ≤ 20	0.08	1.56
	R ≤ 13	20 < R	0.08	1.66
	13 > R ≤ 20	13 > R ≤ 20	0.02	0.94
	13 > R ≤ 20	20 < R	0.06	1.03
	20 < R	20 < R	0.01	0.75

Table 114: Santa Fe Savings Factors

Building Type	Pre R-Value	Post R-Value	ESF (kWh/SF)	PSDF (10^{-5} kW/SF)
Retail	R ≤ 13	R ≤ 13	0.73	18.84
	R ≤ 13	13 > R ≤ 20	1.03	29.57
	R ≤ 13	20 < R	1.03	31.06
	13 > R ≤ 20	13 > R ≤ 20	0.13	4.70
	13 > R ≤ 20	20 < R	0.12	5.75
	20 < R	20 < R	0.09	3.25
Education - Chiller	R ≤ 13	R ≤ 13	0.66	11.53
	R ≤ 13	13 > R ≤ 20	0.91	17.84
	R ≤ 13	20 < R	1.00	20.23
	13 > R ≤ 20	13 > R ≤ 20	0.26	4.74
	13 > R ≤ 20	20 < R	0.33	6.61
	20 < R	20 < R	0.17	3.32
Education - RTU	R ≤ 13	R ≤ 13	0.26	8.07
	R ≤ 13	13 > R ≤ 20	0.36	12.64
	R ≤ 13	20 < R	0.39	14.37
	13 > R ≤ 20	13 > R ≤ 20	0.12	4.02
	13 > R ≤ 20	20 < R	0.15	5.64
	20 < R	20 < R	0.08	2.84
Office - Chiller	R ≤ 13	R ≤ 13	0.21	6.64
	R ≤ 13	13 > R ≤ 20	0.27	4.52
	R ≤ 13	20 < R	0.28	14.56
	13 > R ≤ 20	13 > R ≤ 20	0.10	16.20
	13 > R ≤ 20	20 < R	0.10	9.46
	20 < R	20 < R	0.06	2.31
Office - RTU	R ≤ 13	R ≤ 13	0.29	7.29
	R ≤ 13	13 > R ≤ 20	0.62	12.37
	R ≤ 13	20 < R	0.75	14.35
	13 > R ≤ 20	13 > R ≤ 20	0.15	4.03
	13 > R ≤ 20	20 < R	0.28	5.68
	20 < R	20 < R	0.11	2.85

Building Type	Pre R-Value	Post R-Value	ESF (kWh/SF)	PSDF (10^{-5} kW/SF)
Hotel	R ≤ 13	R ≤ 13	0.07	1.30
	R ≤ 13	13 > R ≤ 20	0.07	1.62
	R ≤ 13	20 < R	0.07	1.74
	13 > R ≤ 20	13 > R ≤ 20	0.04	0.80
	13 > R ≤ 20	20 < R	0.04	0.92
	20 < R	20 < R	0.03	0.59
Warehouse	R ≤ 13	R ≤ 13	0.04	3.74
	R ≤ 13	13 > R ≤ 20	0.08	5.74
	R ≤ 13	20 < R	0.09	6.43
	13 > R ≤ 20	13 > R ≤ 20	0.01	1.32
	13 > R ≤ 20	20 < R	0.03	1.89
	20 < R	20 < R	0.01	0.88
Other	R ≤ 13	R ≤ 13	0.04	1.30
	R ≤ 13	13 > R ≤ 20	0.06	1.62
	R ≤ 13	20 < R	0.06	1.74
	13 > R ≤ 20	13 > R ≤ 20	0.01	0.80
	13 > R ≤ 20	20 < R	0.03	0.92
	20 < R	20 < R	0.01	0.59

Example:

Cool roof and insulation are installed in an Albuquerque retail building with a roof area of 5000 sq. ft., original R-value of 12, post R-value of 15.

Energy Savings = 5000 sq.ft. x 1.27 = 6,350 kWh

Demand Savings = 5000 sq. ft. x 36.31 x 10^{-5} = 1.82 kW

3.23.3 Energy Savings Estimation

The deemed energy and demand savings factors are used in the following formulas to calculate savings:

$$Energy\ Savings = Roof\ Area \times ESF$$

Where:

Roof Area = Total area of CRRC-rated cool roof in square feet

ESF = Energy Savings Factor from above tables by climate zone, building type, pre/post insulation levels, and heating/cooling system.

3.23.4 Demand Savings Estimation

The deemed demand savings factors are used in the following formulas to calculate savings:

$$Peak\ Summer\ Demand\ Savings = Roof\ Area \times PSDF \times 10^{-5}$$

Where:

PSDF = Peak Summer Demand Factor from above tables by climate zone, building type, pre/post insulation levels, and heating/cooling system.

10^{-5} = Scaling factor, as PSDF values are scaled up for ease of display

3.23.5 Non-energy Benefits

There are no non-energy benefits for this measure.

3.23.6 Measure Life

The estimated useful life (EUL) for cool roofs is 15 years. This value is consistent with the EUL reported in the 2014 California Database for Energy Efficiency Resources (DEER).[185]

3.23.7 Incremental Cost

Incremental cost estimates should be gathered as part of the application process if utilities wish to test the cost effectiveness of this measure using the TRC test.

3.24 ENERGY STAR® Combination Ovens

This section covers the deemed savings methodology for the installation of ENERGY STAR® combination ovens. Combination ovens are convection ovens with added capability to inject steam into the oven cavity and offers typically at least three distinct cooking modes: combination mode to roast or bake with moist heat, convection mode to operate purely as a convection oven providing dry heat, or as a straight pressure-less steamer. This deemed savings methodology determines energy and demand savings on a per-oven-basis.

[185] 2014 California Database for Energy Efficiency Resources.

3.24.1 Measure Overview

Sector	Commercial
End use	Food Cooking
Fuel	Electricity, Gas
Measure category	Food Service Equipment
Delivery mechanism	Rebate
Baseline description	Standard Commercial Combination Oven
Efficient case description	ENERGY STAR® certified Commercial Combination Oven

3.24.2 Eligiblity Criteria

Eligible units must meet ENERGY STAR® qualifications, with half-size and full-size ovens as defined by ENERGY STAR® and a pan capacity ≥ 3 and ≤ 40.[186]

- Half-size combination oven: capable of accommodating a single 12.7 x 20.8 x 2.5-inch steam table pan per rack position, loaded from front-to-back or lengthwise.
- Full-size combination oven: capable of accommodating two 12.7 x 20.8 x 2.5-inch steam table pans per rack position, loaded from front-to-back or lengthwise

Two-thirds-size combination ovens were added to the current ENERGY STAR® specification but are excluded from this measure until the ENERGY STAR® food service calculator is updated to include category specific input assumptions.

This specification is intended for commercial food-grade ovens. Ovens designed for residential, or laboratory applications cannot be certified for ENERGY STAR® under this specification. The following oven types and sub-types are ineligible for ENERGY STAR®:

The following products are excluded from the ENERGY STAR® eligibility criteria:

- Half-size gas convection ovens.
- Dual-fuel heat source combination ovens.
- Hybrid ovens not listed in Section 2.A, above, such as those incorporating microwave settings in addition to convection.

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[186] ENERGY STAR® Program Requirements for Commercial Ovens. https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Version%203.0%20Commercial%20Ovens%20Final%20Specification.pdf

- Conventional or standard ovens; conveyor; slow cook-and-hold; deck; hearth; microwave; range; rapid cook; reel-type; and rotisserie.
- Half- and full-size gas combination ovens with a pan capacity of < 5 or > 40.
- Half- and full-size electric combination ovens with a pan capacity < 3 or > 40.
- Mini and quadruple gas rack ovens. ENERGY STAR® Program Requirements for Commercial Ovens – Eligibility Criteria 5
- Electric rack ovens.

2/3-size electric combination ovens with a pan capacity greater than 5.Eligible building types include independent restaurants, chain restaurants, elementary and secondary schools, colleges and universities, corporate foodservice operations, healthcare, hospitality, and supermarkets.[187]

3.24.3 Savings

The high-efficiency combination ovens must be compliant with the current ENERGY STAR® v3 specification, effective January 12, 2023. To achieve this, they must meet the following minimum energy efficiency and idle energy rate requirements, as shown in Table 115.

Table 115. Cooking Energy Efficiency and Idle Energy Rate Requirements[188]

Electric: 5-40 Pan Capacity		
Operation	**Idle Rate, kW**	**Cooking-Energy Efficiency, %**
Steam Mode	≤ 0.133 P + 0.6400	≥ 55
Convection Mode	≤ 0.083 P + 0.35	≥ 78
Gas: 5-40 Pan Capacity		
Operation	**Idle Rate, Btu/h**	**Cooking-Energy Efficiency, %**
Steam Mode	≤ 200 P + 6,511	≥ 41
Convection Mode	≤ 140 P + 3,800	≥ 57
Electric 3-4 Pan Capacity and 2/3-size with 3-5 Pan Capacity		
Operation	**Idle Rate, kW**	**Cooking-Energy Efficiency, %**
Steam Mode	≤ 0.60P	≥ 51
Covection Mode	≤ 0.05P+0.55	≥ 70

[187] CEE Commercial Kitchens Initiative's overview of the Food Service Industry: https://forum.cee1.org/system/files/library/4203/CEE_CommKit_InitiativeDescription_Aug2021.pdf

[188] ENERGY STAR Version 3.0 Commercial Ovens Final Specification

3.24.4 Energy Savings Estimation

Savings are derived with the following formula.

$$Energy\ Savings\ (kWh) = kWh_{base} - kWh_{ES}$$

Baseline or Efficient case energy consumption is a Combination (addition) of Energy consumed during Convection and/or Steam mode used during the operation of the Combination oven. It is expressed in the following formulas:

$$kWh_{base} = kWh_{ph,base}kWh_{conv} + kWh_{st}$$

$$kWh_{eff} = kWh_{ph,ES} + kWh_{conv} + kWh_{st}$$

The energy consumption (kWh) in any mode (convection, steam, or combination) of oven operation is expressed as follows:

$$kWh = 〚E_{ph} + \left(W_{food} \times \frac{E_{food} \times 50\%}{\eta_{cooking}}\right) + E_{idle} \times \left(\left(t_{on} - \frac{W_{food}}{PC}\right) \times 50\%\right)\Bigg) \times \frac{t_{days}}{1000}$$

Where:

kWh_{base} = Baseline annual energy consumption kWh

kWh_{ES} = ENERGY STAR® annual energy consumption kWh

E_{ph} = Preheat energy [Wh/BTU]. See Table 116

t_{days} = Facility operating days per year. See Table 116

t_{on} = Equipment operating hours per day. See Table 116

CF = Coincident Factor, adjusts the gross kW savings to account foroverlap with the peak period. See Table 116

W_{food} = Pounds of food cooked per day, lb/day. See Table 116

E_{food} = ASTM energy to food, Wh/lb. (Differs for Convection-Mode and Steam Mode for Baseline and ENERGY STAR®. See Table 116

E_{Idle} = Idle energy rate, W. (Differs for Convection-Mode and Steam-Mode, for Baseline and ENERGY STAR®. See Table 116

$\eta_{cooking}$ = Cooking energy efficiency, %. (Differs for Convection-Mode and Steam-Mode, for Baseline and ENERGY STAR®. See Table 116

PC	= Production capacity per pan, lb/hr. (Differs for Convection-Mode. See Table 116and Steam-Mode, for Baseline and ENERGY STAR®. See Table 116
1000	= Wh to kWh conversion

3.24.5 Demand Savings Estimation

Demand savings are defined as the reduction in average kW attributable to the measure during 3:00-6:00 pm on the hottest summer weekdays.

Demand savings are derived with the following equation:

$$Peak\ Demand\ Savings\ (kW) = \frac{\triangle\ kWh}{t_{on} \times t_{days}} \times CF$$

Where:

ΔkW	=	Demand savings, in kW
t_{on}	=	Equipment operating hours per day, see Table 116
t_{days}	=	Facility operating days per year, see Table 116

CF = Coincident Factor, adjusts the gross kW savings to account for overlap with the peak period, see Table 116

Table 116. Deemed Variables for Energy and Demand Savings Calculations[189]

			Convection mode		Steam mode	
Parameter			**Baseline**	**ENERGY STAR®**	**Baseline**	**ENERGY STAR®**
E_{ph}	P < 15		3,000		1,500	
	P ≥ 15		3,750		2,000	
W_{food}	P < 15				200	
	P ≥ 15				250	
E_{food}				73.2		30.8
η_{cook}	3 ≥ P < 5	70%	70%	49%	51%	
	P ≥ 5	72%	76%	49%	55%	
Eidle	3 ≥ P < 5	1,320	(0.05P + 0.55) x 1,000	5,260	0.60P x 1,000	
	5 ≥ P < 15	1,320	(0.083P + 0.35) x 1,000	5,260	(0.133P + 0.64) x 1,000	

189 Texas Technical Reference Manual Version 10.0 Volume 3: Nonresidential Measures Program Year 2023 TRMv10.0 Volume 3 EEIP (texasefficiency.com)

	P ≥ 15	2,280	(0.083P + 0.35) x 1,000	8,710	(0.133P + 0.64) x 1,000
PC[190]	P < 15	79	119	126	177
	P ≥ 15	166	201	295	349
t_{on}		12			
t_{days}		365			
CF[189, 191]		0.90			

3.24.6 Natural Gas Savings Estimation

Natural Gas Energy Savings are derived with the following formula[192]:

$$\Delta\,Therms\ = \left(\begin{matrix}\Delta CookingEnergy_{ConvGas} + \Delta CookingEnergy_{SteamGas} + \\ \Delta IdleEnergy_{ConvGas} + \Delta IdleEnergy_{SteamGas}\end{matrix}\right) \times\ Days\ \div\ 100{,}000$$

Where:

$$\Delta CookingEnergy_{ConvGas}\ = LB_{Gas}\ x\ \left(\frac{EFOOD_{ConvGas}}{GasEFF_{ConvBase}} - \frac{EFOOD_{ConvGas}}{GasEFF_{ConvEE}}\right) x\ \%Conv$$

$$\Delta CookingEnergy_{SteamGas}\ = LB_{Gas}\ x\ \left(\frac{EFOOD_{SteamGas}}{GasEFF_{SteamBase}} - \frac{EFOOD_{SteamGas}}{GasEFF_{SteamEE}}\right) x\ \%Steam$$

$$\Delta IdleEnergy_{ConvGas} = \left[\left(GasIDLE_{ConvBase}\ \times\ \left(HOURS - \frac{LB_{Gas}}{GasPC_{ConvBase}}\right)\ \times\ \%_{Conv}\right) - \left(GasIDLE_{ConvEE}\ \times\ \left(HOURS\ -\ \frac{LB_{Gas}}{GasPC_{ConvEE}}\right)\right)\ \times\ \%_{Conv}\right]$$

[190] The 3/2021 ENERGY STAR® calculator update no longer varies Ccap by pan capacity. However, this is assumed to be an error. The values specified for pan capacity of 15 or greater are specified in the previous calculator version.

[191] Itron, Inc., "2004-2005 Database for Energy Efficiency Resources (DEER) Update Study. Final Report." Prepared for Southern California Edison. December 2005. Table 3-14, p. 3-17.

[192] Natural Gas Savings Formula and Assumptions are derived from ENERGY STAR® Commercial Kitchen Equipment Savings Calculator.

$$\Delta IdleEnergy_{SteamGas} = \left[\left(GasIDLE_{SteamBase} \times \left(HOURS - \frac{LB_{Gas}}{GasPC_{SteamBase}}\right) \times \%_{Steam}\right) - \left(GasIDLE_{SteamEE} \times \left(HOURS - \frac{LB_{Gas}}{GasPC_{SteamEE}}\right)\right) \times \%_{Steam}\right]$$

Where:

$\Delta CookingEnergy_{ConvGas}$ = Change in total daily cooking energy consumed by gas oven in convection mode

$\Delta CookingEnergy_{SteamGas}$ = Change in total daily cooking energy consumed by gas oven in steam mode

$\Delta IdleEnergy_{ConvGas}$ = Change in total daily idle energy consumed by gas oven in convection mode

$\Delta IdleEnergy_{SteamGas}$ = Change in total daily idle energy consumed by gas oven in steam mode

LB_{Gas} = Estimated mass of food cooked per day for gas oven (lbs/day)

= Custom, or if unknown:

For $P < 15$: 200 lbs

For $15 \leq P \leq 30$: 250 lbs

For $P \geq 30$: 400 lbs

$EFOOD_{ConvGas}$ = Energy absorbed by food product for gas oven in convection mode

= Custom or if unknown, use 250 Btu/lb

$GasEFF$ = Cooking energy efficiency of gas oven

= Custom or if unknown, use values from Table 117

Table 117. Cooking Efficiency of Gas Oven

Oven Type	Base	EE
$GasEFF_{Conv}$	52%	56%
$GasEFF_{Steam}$	39%	41%

$EFOOD_{SteamGas}$ = Energy absorbed by food product for gas oven in steam mode
= Custom or if unknown, use 105 Btu/lb

$GasIDLE_{Base}$ = Idle energy rate (Btu/hr) of baseline gas oven= Custom or if unknown, use values from Table 118

Table 118. Baseline Idle Energy Rate for Gas Ovens

Pan Capacity	Convection Mode ($GasIDLE_{ConvBase}$)	Steam Mode ($GasIDLE_{SteamBase}$)
< 15	8,747	18,656
15-30	10,788	24,562
>30	13,000	43,300

$GasPC_{Base}$ = Production capacity (lbs/hr) of baseline gas oven
= Custom or if unknown, use values from Table 119

Table 119. Baseline Production Capacity for Gas Ovens

Pan Capacity	Convection Mode ($GasPC_{ConvBase}$)	Steam Mode ($GasPC_{SteamBase}$)
< 15	125	195
15-30	176	211
>30	392	579

$GasIDLE_{ConvEE}$ = Idle energy rate of ENERGY STAR® gas oven in convection mode
= 150 x P + 5,425, See Table 119

$GasPC_{EE}$= Production capacity (lbs/hr) of ENERGY STAR® gas oven
= Custom or if unknown, use values from Table 120

Table 120. Production capacity of ENERGY STAR® gas oven

Pan Capacity	Convection Mode ($GasPC_{ConvEE}$)	Steam Mode ($GasPC_{SteamEE}$)
< 15	124	172
15-30	210	277
>30	394	640

$GasIDLE_{SteamEE}$	= Idle energy rate of ENERGY STAR® gas oven in steam mode = 200 x P + 6,511 See Table 120
10,000	= Conversion factor from Btu to therms

3.24.7 Deemed Energy and Demand Savings

The energy and demand savings of High Efficiency Combination Ovens in Table 121**Error! Reference source not found.** are calculated in the Savings Calculator for ENERGY STAR® Qualified Commercial Kitchen Equipment using the default parameters shown above in Table 116 Customer specific parameters can be input into the algorithms above to provide more relevant savings values when customer specific details are known

Table 121. Deemed Energy and Demand Savings Values[193]

kWh_{base}	kWh_{post}	Annual Energy Savings [kWh]	Peak Demand Savings [kW]	Annual Gas Savings [Therms]
18,282	11,914	6,368	1.338	278

3.24.8 Non-energy Benefits

There are no non-energy benefits associated with this measure.

3.24.9 Measure Life

The EUL has been defined for this measure as 12 years, consistent with the ENERGY STAR® calculator and with the DEER 2014 EUL update (EUL ID—Cook-ElecCombOven).[194]

3.24.10 Incremental Cost

The incremental cost of the ENERGY STAR® Combination Oven depends on whether the unit is electric or natural gas. The incremental cost for this measure is $2,000 for an electric combination oven or $4,000 for a natural gas combination oven[195].

[193] https://www.energystar.gov/ia/products/downloads/Commercial_kitchen_equipment_calculator_1-12-16.xlsx

[194] DEER READI. http://www.deeresources.com/index.php/readi.

[195] https://www.energystar.gov/sites/default/files/asset/document/CFS_calculator_03-02-2021.xlsx

3.25 ENERGY STAR® Electric Convection Ovens

This section covers the savings from retrofit or new installation of a full-size or half-size ENERGY STAR® electric convection ovens. Convection ovens cook their food by forcing hot dry air over the surface of the food product. The rapidly moving hot air strips away the layer of cooler air next to the food and enables the food to absorb the heat energy. The energy and demand savings are deemed and based on oven energy rates, cooking efficiencies, operating hours, production capacities, and building type. Average energy and demand consumption, used to calculate the savings, are determined using these assumed default input values on a per-oven basis.

3.25.1 Measure Overview

Sector	Commercial
End use	Food Cooking
Fuel	Electricity
Measure category	Food Service
Delivery mechanism	Prescriptive
Baseline description	Standard Commercial Electric Convection Oven
Efficient case description	ENERGY STAR® certified Commercial Electric Convection Oven

3.25.2 Savings

The energy and demand savings are deemed. These are based on minimum cooking energy efficiency, as well as a maximum idle energy rate. The cooking energy efficiency is the ratio of energy absorbed by the food item to the total energy consumed by the oven during the whole cooking process. The idle energy rate is the energy consumed by the oven while maintaining a stable temperature, without cooking any food item. Other factors like the operating hours and the capacity of the oven have an impact on the savings values of the convection oven.

The products that are included in the category of ENERGY STAR® Electric Convection Ovens as specified by the ENERGY STAR® qualification criteria are as follows:

- Full-size gas convection oven
- Full and half-size electric convection oven

The size of the oven and the corresponding pan size are shown in Table 122.

Table 122: Oven and and Pan Size

Convection Oven Size[196]	Standard Pan Size
Half	18 x 13 x 1-inch
Full	18 x 26 x 1-inch

Convection ovens eligible for rebate do not include ovens that can heat the cooking cavity with saturated or superheated steam. However, eligible convection ovens may have moisture injection capabilities (e.g., baking ovens and moisture-assist ovens). Ovens that include a "hold feature" are eligible under this specification if convection is the only method used to fully cook the food.

This specification is intended for commercial food-grade ovens. Ovens designed for residential, or laboratory applications cannot be certified for ENERGY STAR® under this specification. The products that are excluded from the category of ENERGY STAR® Electric Convection Ovens as specified by the ENERGY STAR® qualification criteria are as follows:

- Half-size gas convection ovens.
- Dual-fuel heat source combination ovens.
- Hybrid ovens not listed in Section 2.A, above, such as those incorporating microwave settings in addition to convection.
- Conventional or standard ovens; conveyor; slow cook-and-hold; deck; hearth; microwave; range; rapid cook; reel-type; and rotisserie.
- Half- and full-size gas combination ovens with a pan capacity of < 5 or > 40.
- Half- and full-size electric combination ovens with a pan capacity < 3 or > 40.
- Mini and quadruple gas rack ovens. ENERGY STAR® Program Requirements for Commercial Ovens – Eligibility Criteria 5
- Electric rack ovens.
- 2/3-size electric combination ovens with a pan capacity >5.

[196] ENERGY STAR Version 3.0 Commercial Ovens Final Specification

Energy Efficiency Requirements[197] for Convection Ovens are shown in Table 123 below.

Table 123 Cooking Energy Efficiency and Idle Rate requirements

Oven Size	Idle Rate, kW	Cooking Energy Efficiency, %
Full size ≥ 5 pans	≤ 1.40	≥ 76
Full size < 5 pans	≤ 1.00	≥ 76
Half size	≤ 1.00	≥ 71

3.25.3 Energy Savings Estimation

Savings are derived with the following equation.

$$\text{Energy Savings } [\Delta\text{kWh}] = \text{kWh}_{\text{base}} - \text{kWh}_{\text{ES}}$$

$$kWh_{base} = kWh_{ph,base} + kWh_{cook,base} + kWh_{idle,base}$$

$$kWh_{ES} = kWh_{ph,ES} + kWh_{cook,ES} + kWh_{idle,ES}$$

Where:

kWh_{base} = Baseline annual energy consumption [kWh]

kWh_{ES} = ENERGY STAR® annual energy consumption [kWh]

E_{ph} = Preheat energy [Wh/BTU]. See **Table 124**

ΔE_{ph} = Difference in baseline and ENERGY STAR® preheatenergy. See **Table 124**

E_{food} = ASTM energy to food of energy absorbed by food product during cooking [Wh/lb] . See **Table 124**

E_{Idle} = Idle energy rate [W] . See **Table 124**

W_{food} = Pounds of food cooked per day [lb/day]. See **Table 124**

η_{cook} = Cooking energy efficiency [%]. See **Table 124**

PC = Production capacity per pan [lb/hr] . See **Table 124**

197 www.energystar.gov/sites/default/files/Commercial%20Ovens%20Final%20Version%202.2%20Specification_0.pdf

t_{on} = Equipment operating hours per day [hr/day] .
See **Table 124**

t_{days} = Facility operating days per year [days/year] See **Table 124**

1,000 = Constant to convert from W to kW

3.25.4 Demand Savings Estimation

Demand savings are defined as the reduction in average kW attributable to the measure during 3:00-6:00 pm on the hottest summer weekdays.

Demand savings are derived with the following equation.

$$Peak\ Demand\ Savings\ (kW) = \frac{\Delta kWh - \left(\frac{\Delta Eph\ x\ t_{days}}{1000}\right)}{t_{on}\ \times t_{days}} \times CF$$

Where:

ΔkWh = Energy Savings
E_{ph} = Preheat energy [Wh/BTU] . See **Table 124**
t_{on} = Equipment operating hours per day [hr/day] . See **Table 124**
t_{days} = Facility operating days per year [days/year] . See **Table 124**
1,000 = Constant to convert from W to kW
CF = Peak coincidence factor. See **Table 124**

Table 124: Deemed Variables for Energy and Demand Savings Calculations[198]

	Full size ≥ 5 pans		Full size < 5 pans		Half size	
Parameter	**Baseline**	**ENERGY STAR®**	**Baseline**	**ENERGY STAR®**	**Baseline**	**ENERGY STAR®**
E_{ph}	1,563	1,389	1,563	1,389	890	700
W_{food}						100
E_{food}						73.2
η_{cook}	65%	76%	65%	76%	68%	71%
E_{idle}	2,000	1,400	2,000	1,000	1,030	1,000
PC	90	90	90	90	45	50
t_{on}						12
t_{days}						365

198 TRMv10.0 Volume 3 EEIP (texasefficiency.com)

CF[199]	0.90

3.25.5 Natural Gas Savings Estimation

Natural Gas Energy Savings are derived with the following equation[200].

$$\Delta \text{Therms} = (\Delta \text{DailyIdle Energy} + \Delta \text{DailyPreheat Energy} + \Delta \text{DailyCooking Energy}) \times \text{Days}/100{,}000$$

Where:

$$\Delta \text{DailyIdle Energy} = (\text{IdleBase} \times \text{IdleBaseTime}) - (\text{IdleENERGYSTAR} \times (\text{IdleENERGYSTARTime})$$

$$\Delta \text{DailyPreheat Energy} = (\text{PreHeatNumberBase} \times (\text{PreheatTimeBase}/60) \times \text{PreheatRateBase}) - (\text{PreHeatNumberENENRGYSTAR} \times (\text{PreheatTimeENERGYSTAR}/60) \times \text{PreheatRateENERGYSTAR})\Delta \text{DailyCooking Energy} = \left(\frac{\text{LB} \times \text{EFOOD}}{\text{EffBase}}\right) - \left(\frac{\text{LB} \times \text{EFOOD}}{\text{EffENERGYSTAR}}\right)$$

Where:

$Hoursday$ = Average daily operation
= Custom or if unknown, use 12 hours

$Days$ = Annual days of operation
= Custom or if unknown, use 365.25 days a year

$EffENERGYSTAR$ = Cooking Efficiency ENERGY STAR®
= Custom or if unknown, use 46%

$EffBase$ = Cooking Efficiency Baseline
Custom or if unknown, use 30%

$PCENERGYSTAR$ = Production Capacity ENERGY STAR®
= Custom or if unknown use 80 pounds/hr

199 Itron, Inc., "2004-2005 Database for Energy Efficiency Resources (DEER) Update Study. Final Report." Prepared for Southern California Edison. December 2005. Table 3-14, p. 3-17.

200 Natural Gas Savings Formula and Assumptions are derived from ENERGY STAR Commercial Kitchen Equipment Savings Calculator.

$PCBase$	= Production Capacity base = Custom or if unknown, use 70 pounds/hr
$PreheatNumberENERGYSTAR$	= Number of preheats per day = Custom or if unknown, use 1
$PreheatNumberBase$	= Number of preheats per day = Custom or if unknown, use 1
$PreheatTimeENERGYSTAR$	= Preheat length in time = Custom or if unknown, use 15 minutes
$PreheatTimeBase$	= Preheat length in time = Custom or if unknown, use 15 minutes
$PreheatRateEN$ERGYSTAR	= Preheat energy rate high efficiency = Custom or if unknown, use 44,000 Btu/h
PreheatRateBase	= Preheat energy rate baseline = Custom or if unknown, use 76,000 Btu/h
$IdleENERGYSTAR$	= Idle energy rate = Custom or if unknown, use 12,000 Btu/h
$IdleBase$	= Idle energy rate = Custom or if unknown, use 18,000 Btu/h
$IdleENERGYSTARTime$	= ENERGY STAR® Idle time = HOURsday – LB/PCENERGYSTAR – TimeENERGYSTAR/60 = 12 – 100/80 – 15/60 = 10.5 hours
$IdleBaseTime$	= BASE Idle Time = HOURsday – LB/PCbase – PreHeatTimeBase/60 = 12 – 100/70 – 15/60 = 10.3 hours
$EFOOD$	= ASTM energy to food = 250 Btu/pound

3.25.6 Deemed Energy and Demand Savings

The energy and demand savings of high efficiency convection ovens are deemed values based on an assumed capacity (See **Table 124**) for the average convection oven installed. **Table 125** provides these deemed values.

Table 125: Deemed Energy and Demand Savings Values

Oven Size	kWh Savings	kW Savings
Full size ≥ 5 pans	3,043	0.612
Full size < 5 pans	4,633	0.939
Half size	244	0.036

3.25.7 Non-energy Benefits

There are no non-energy benefits associated with this measure.

3.25.8 Measure Life

The EUL has been defined for this measure as 12 years, consistent with ENERGY STAR® research and with the DEER 2014 EUL update (EUL ID—Cook-ElecConvOven).[201]

3.25.9 Incremental Cost

The incremental cost of ENERGY STAR® Electric Convection Ovens is $1,000 for both the Full-Size oven and the Half-Size oven.[202]

[201] DEER READI (Remote Ex-Ante Database Interface). http://www.deeresources.com/index.php/readi.

[202] https://www.energystar.gov/sites/default/files/asset/document/CFS_calculator_03-02-2021.xlsx

3.26 ENERGY STAR® Electric Fryers

This section covers the deemed savings methodology for the installation of ENERGY STAR® electric fryers. Energy efficient fryers that have earned the ENERGY STAR® rating offer shorter cook times and higher production rates through advanced burner and heat exchanger designs. Fry pot insulation reduces standby losses resulting in a lower idle energy rate. The energy and demand savings are determined on a per-fryer basis.

3.26.1 Measure Overview

Sector	Commercial
End use	Food Cooking / Frying
Fuel	Electricity
Measure category	Food Service Equipment
Delivery mechanism	Prescriptive
Baseline description	Standard Commercial Electric Fryer
Efficient case description	ENERGY STAR® certified Commercial Electric Fryer

3.26.2 Savings

Eligible units must meet ENERGY STAR® qualifications, either counter-top or floor type designs, with standard-size and large vat fryers as defined by ENERGY STAR®.[203]

- Standard Fryer: A fryer with a vat that measures ≥ 12 inches and < 18 inches wide, and a shortening capacity ≥ 25 pounds and ≤ 65 pounds
- Large Vat Fryer: A fryer with a vat that measures ≥ 18 inches and ≤ 24 inches wide, and a shortening capacity > 50 pounds
- Split Vat Fryer: A standard or large vat fryer with an internal wall that separates the vat into two equal sides

Eligible building types include independent restaurants, chain restaurants, elementary and secondary schools, colleges and universities, corporate foodservice operations, healthcare, hospitality, and supermarkets.[204] The following products are excluded from the ENERGY STAR® eligibility criteria:

[203] Commercial Fryers Version 3.0 Specification (energystar.gov)

[204] CEE Commercial Kitchens Initiative's overview of the Food Service Industry: http://library.cee1.org/sites/default/files/library/4203/CEE_CommKit_InitiativeDescription_June2014.pdf.

- Fryers with vats measuring < 12 inches wide, or > 24 inches wide

Baseline fryers can be existing or new electric standard-size fryers ≥ 12 inches < 18 inches wide or large vat fryers > 18 inches and < 24 inches wide that do not meet ENERGY STAR® product criteria.

New electric standard fryers ≥ 12 inches and < 18 inches wide and large vat fryers > 18 inches and < 24 inches wide that meet or exceed the ENERGY STAR® requirements listed below in **Table 126**.

Table 126: High-efficiency Requirements for Electric Fryers[205]

Inputs	Standard	Large-Vat
Heavy-Load Cooking energy efficiency	≥ 83%	≥ 80%
Idle energy rate [W]	≤ 800	≤ 1,100

3.26.3 Energy Savings Estimation

The savings are determined with the following equation:

$$Energy\ Savings\ [\Delta kWh] = kWh_{base} - kWh_{ES}$$

$$kWh_{base} = kWh_{ph,base} + kWh_{cook,base} + kWh_{idle,base}$$

$$kWh_{ES} = kWh_{ph,\ ES} + kWh_{cook,ES} + kWh_{idle,ES}$$

kWh_{ph}, kWh_{cook}, and kWh_{idle} are each calculated the same for both the baseline and ENERGY STAR® cases, as shown in equation below, except they require their respective input assumptions relative to preheat, cooking, and idle operation as seen in **Table 127**

$$kWh = \left(E_{ph} + \left(\frac{W_{food} x E_{food}}{\eta_{cook}}\right) + E_{idle} x \left(t_{on} - \frac{t_{ph}}{60} - \frac{W_{food}}{PC}\right)\right) x \frac{t_{days}}{1000}$$

Where:

kWh_{base}	=	Baseline annual energy consumption [kWh]. See
kWh_{ES}	=	ENERGY STAR® annual energy consumption [kWh]
Eph	=	Preheat energy [Wh/BTU]

[205] Commercial Fryers Version 3.0 Specification (energystar.gov)

ΔE_{ph} = Difference in baseline and ENERGY STAR® preheat energy

E_{food} = ASTM energy to food of energy absorbed by foodproduct during cooking [Wh/lb]

E_{Idle} = Idle energy rate [W]

W_{food} = Pounds of food cooked per day [lb/day]

η_{cook} = Cooking energy efficiency [%]

PC = Production capacity per pan [lb/hr]

t_{on} = Equipment operating hours per day [hr/day]

t_{ph} = Preheat time [min/day]

t_{days} = Facility operating days per year [days/year]

60 = Constant to convert from min to hr

1,000 = Constant to convert from W to kW

3.26.4 Demand Savings Estimation

This section presents the deemed savings methodology for the installation of an ENERGY STAR® Electric Fryer.

The demand savings are determined with the equation below. The deemed algorithm variable inputs are show in Table 127.

$$Peak\ Demand\ Savings\ [\Delta kW] = \frac{\Delta kWh - \left(\frac{\Delta E_{ph}\ x\ t_{days}}{1000}\right)}{t_{on}\ x\ t_{days}} x\ CF$$

Where:

Demand Savings = Annual demand savings, in kW

CF = Peak coincidence factor

Table 127: Deemed Variables for Energy and Demand Savings Calculations[206]

	Standard-sized vat		Large vat	
Parameter	**Baseline**	**ENERGY STAR®**	**Baseline**	**ENERGY STAR®**
E_{ph}	2,400	1,900	2,400	1,900
W_{food}				150
E_{food}				167
η_{cook}	75%	83%	70%	80%
E_{idle}	1,200	800	1,350	1,100
PC	65	70	100	110
t_{on}		16		12
t_{ph}				15
t_{days}				365
CF[207]				0.90

3.26.5 Natural Gas Savings Estimation

The natural gas energy savings are determined with the following equation[208]:

$$\Delta Therms = (\Delta DailyIdle\ Energy + \Delta DailyCooking\ Energy) \times Days/100{,}000$$

Where:

$$\Delta DailyIdle\ Energy = \left(GasIdle_{Base} \times \left(HOURS - \frac{LB}{GasPC_{Base}}\right)\right) - \left(GasIdle_{ESTAR} \times \left(HOURS - \frac{LB}{GasPC_{ESTA}}\right)\right)$$

$$\Delta DailyCooking\ Energy = \left(\frac{LB \times EFOOD_{Gas}}{GasEff_{Base}}\right) - \left(\frac{LB \times EFOOD_{Gas}}{GasEff_{ESTAR}}\right)$$

Where:

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206 Deemed input values come from ENERGY STAR® Commercial Kitchen Equipment Calculator. https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator_0.xlsx

207 Itron, Inc., "2004-2005 Database for Energy Efficiency Resources (DEER) Update Study: FinalReport." Prepared for Southern California Edison. December 2005. Table 3-14, p. 3-17.

208 Natural Gas Savings Formula and Assumptions are derived from ENERGY STAR® Commercial Kitchen Equipment Savings Calculator.

100,000 = Btu to therms conversion factor

$GasIdle_{Base}$ = Idle energy rate of baseline gas fryer
= 14,000 Btu/hr for standard fryer and 16,000 Btu/hr for large vat fryer

$GasIdle_{ESTAR}$ = Idle energy rate of ENERGY STAR® gas fryer
= Custom or if unknown, use 9,000 Btu/hr for standard fryer and 12,000 Btu/hr for large vat fryer

$GasPC_{Base}$ = Production capacity of baseline gas fryer
= 60 lb/hr for standard fryer and 100 lb/hr for large vat fryer

$GasPC_{ESTAR}$ = Production capacity of ENERGY STAR® gas fryer
= Custom or if unknown, use 65 lb/hr for standard fryer and 110 lb/hr for large vat fryer

$EFOOD_{Gas}$ = ASTM energy to food
= 570 Btu/lb

$GasEff_{Base}$ = Cooking efficiency of baseline gas fryer
= 35% for both standard and large vat fryer

$GasEff_{ESTAR}$ = Cooking efficiency of ENERGY STAR® gas fryer
= Custom or if unknown, use 50% for both standard and large vat fryer

3.26.6 Deemed Energy and Demand Savings

Table 128 shows the energy and demand deemed savings values for each of the electric fryer sizes.

Table 128: Deemed Energy and Demand Savings Values by Fryer Type[209]

Fryer Type	kWh Savings	kW Savings
Standard	3,272	0.476
Large vat	2,696	0.516

209 Deemed energy and demand savings values come from ENERGY STAR® Commercial Kitchen Equipment Calculator.

3.26.7 Non-energy Benefits

There are no non-energy benefits associated with this measure.

3.26.8 Measure Life

The EUL has been defined for this measure as 12 years[210].

3.26.9 Incremental Cost

The incremental costs for this measure are shown in **Table 129**

Table 129: Incremental Cost of Electric Fryer[211]

Fryer Type	Incremental Cost
Standard	$ 1,500
Large Vat	$ 500

[210] The EUL has been defined for this measure as 12 years per the PUCT approved Texas EUL filing (Docket No. 36779) and by the DEER 2014 EUL update (EUL ID—Cook-ElecFryer)

[211] https://www.energystar.gov/sites/default/files/asset/document/CFS_calculator_03-02-2021.xlsx

3.27 ENERGY STAR® Electric Steam Cookers

This measure provides the savings methodology for the installation of ENERGY STAR® electric steam cookers. ENERGY STAR® certified steam cookers offer shorter cook times, higher production rates, and reduced heat loss due to better insulation and more efficient steam delivery systems.

3.27.1 Measure Overview

Sector	Commercial
End use	Food Cooking
Fuel	Electricity
Measure category	Food Service Equipment
Delivery mechanism	Rebate
Baseline description	Standard Commercial Electric Steam Cookers
Efficient case description	ENERGY STAR® certified Commercial Electric Steam Cookers

3.27.2 Savings

The energy and demand savings are determined on a per-cooker basis.

The eligible products can have 3, 4, 5, or 6 pan and larger capacity. A list of eligible equipment is found on the ENERGY STAR® list of qualified equipment[212].

Eligible baseline conditions for retrofit situations are electric steam cookers that are not ENERGY STAR® certified.

High-efficiency electric steam cookers are assumed to be ENERGY STAR® certified and have the characteristics shown in Table 130.

212 ENERGY STAR Program Requirements for Commercial Steam Cookers

Table 130: ENERGY STAR® Energy Efficiency and Idle Rate Requirements for Electric Steam Cookers[213]

Pan Capacity	Heavy Load Cooking Energy Efficiency	Idle Rate, Watts
3-Pan	50%	400
4-Pan	50%	530
5-Pan	50%	670
6-Pan and Larger	50%	800

3.27.3 Energy Savings Estimation

Savings are determined with the following equation:

$$Svgs = kWh_{base} - kWh_{eff}$$

$$kWh_{base} = W_{food} \times \frac{E_{food}}{\eta_{base}} + \left((1 - \eta_{tSteam}) \times E_{idleRate,base} + \eta_{tSteam} \times C_{pan} \times N_{pan} \times \frac{E_{food}}{\eta_{base}}\right) \times \left(t_{days} - \frac{W_{food}}{\eta_{base} \times N_{pan}}\right) \times \frac{N_{OpDays}}{1000}$$

$$kWh_{eff} = W_{food} \times \frac{E_{food}}{\eta_{eff}} + \left((1 - \eta_{tSteam}) \times E_{idleRate,eff} + \eta_{tSteam} \times C_{pan} \times N_{pan} \times \frac{E_{food}}{\eta_{base}}\right) \times \left(t_{days} - \frac{W_{food}}{\eta_{eff} \times N_{pan}}\right) \times \frac{N_{OpDays}}{1000}$$

Where:

$Svgs$ = Annual energy savings, in kWh

[213] ENERGY STAR® Program Requirements Product Specification for Commercial Steam Cookers v1.2 https://www.energystar.gov/sites/default/files/specs//private/Commercial_Steam_Cookers_Program_Requirements%20v1_2.pdf

kWh_{base} = Baseline annual energy consumption, in kWh. See Table 132

kWh_{eff} = Efficient annual energy consumption, in kWh. See Table 132

W_{food} = Pounds of food cooked per day, in lb/day. See Table 131

E_{food} = ASTM energy to food is equal to 30.8[214] in Wh/pound. See Table 131

η_{base} = Baseline Cooking energy efficiency (Differs for boiler-based or steam generator equipment). See Table 131

η_{eff} = Efficient cooking energy efficiency. See Table 131

η_{tSteam} = Percent of time in constant steam mode, in %. See Table 131

C_{pan} = Production capacity per pan, in lb/hr. See Table 131

$E_{idleRate,base}$ = Idle energy rate, in W (Differs for boiler-based or steam-generator equipment). See Table 131

$E_{idleRate,eff}$ = Idle energy rate, in W. See Table 131

N_{pan} = Number of pans. See Table 131

N_{OpDays} = Facility operating days per year. See Table 131

1000 = Wh to kWh conversion factor

3.27.4 Demand Savings Estimation

The demand savings are determined with the following equation:

$$\text{Peak Demand Savings } [\Delta\text{kW}] = \frac{kWh_{base} - kWh_{eff}}{t_{hrs} \times t_{days}} \times CF$$

Where:

ΔkW = Demand savings, in kW

[214] ENERGY STAR®. "Savings Calculator for ENERGY STAR® Qualified Commercial Kitchen Equipment." https://www.energystar.gov/ia/products/downloads/Commercial_kitchen_equipment_calculator_1-12-16.xlsx

kWh_{base}	= the annual energy usage of the baseline equipment calculated using baseline values, in kWh
kWh_{eff}	= the annual energy usage of the efficient equipment calculated using efficient values, in kWh
t_{hrs}	= Average daily operating hours per day
	= if average daily operating hours are unknown, assume default of 12 hours/day.
t_{days}	= Operating days per year
	= if annual days of operation are unknown, assume default of 365 days.
CF	= Peak coincidence factor, see Table 131

Table 131: Deemed Variables for Energy and Demand Savings Calculations[215,217]

Parameter	Baseline Value	Efficient Value
W_{food}	100	
E_{food}	30.8	
η	Boiler-based Efficiency: 26% Steam-Generator Efficiency: 30%	50%
η_{tSteam}	40%	
$E_{idleRate}$	Boiler-based Idle Rate: 1,000 Steam-Generator Idle Rate: 1,200	3-Pan: 400 4-Pan: 530 5-Pan: 670 6-Pan: 800
C_{pan}	23.3	16.7
N_{pan}	3, 4, 5 or 6	
t_{hrs}	12	
N_{OpDays}	365	
CF[216]	0.90	

3.27.5 Natural Gas Savings Estimation

The natural gas savings are determined with following equation.[217]

$$\Delta Therms = Therms_{base} - Therms_{eff}$$

Where:

$$Therms_{base} = \left[LB \times \frac{E_{FOOD}}{EFF_{base}} + \left((1 - PCT_{Steam}) \times IDLE_{base} + PCT_{Steam} \times PC_{Base} \times PANS \times \frac{E_{Food}}{EFF_{Base}}\right) \times \left(Hours_{Day} - \frac{LB}{PC_{Base} \times PANS}\right)\right] \times DAYS$$

215 https://www.energystar.gov/sites/default/files/asset/document/CFS_calculator_07-15-2021.xlsx

216 Itron, Inc., "2004-2005 Database for Energy Efficiency Resources (DEER) Update Study: Final Report." Prepared for Southern California Edison. December 2005. Table 3-14, p. 3-17.

217 Natural Gas Savings Formula and Assumptions are derived from ENERGY STAR Commercial Kitchen Equipment Savings Calculator.https://www.energystar.gov/ia/products/downloads/Commercial_kitchen_equipment_calculator_1-12-16.xlsx

$$Therms_{eff} = \left[LB \times \frac{E_{FOOD}}{EFF_{eff}} + \left((1 - PCT_{Steam}) \times IDLE_{eff} + PCT_{Steam} \times PC_{eff} \times PANS \times \frac{E_{Food}}{EFF_{Bas}}\right) \times \left(Hours_{Day} - \frac{LB}{PC_{eff} \times PANS}\right)\right] \times DAYS$$

Where:

$Therms_{base}$ calculated = The annual energy usage, in therms, of the baseline equipment using baseline values.

$Therms_{eff}$ = The annual energy usage, in therms, of the efficient equipment calculated using efficient values.

E_{FOOD} = ASTM Energy to Food (kWh/lb); the amount of energy absorbed by the food during cooking, per pound of food.
= 0.000105

$IDLE$ = Idle energy rate (kW)
= See Table 131 for default baseline values. If actual efficient values are unknown, assume default values from the Table 131.

PC = Production capacity per pan lb/hr
= Default baseline production capacity per pan is 23.3. If actual efficient production capacity per pan is unknown, assume default of 20.

$Hours_{Day}$ = Average daily operation hours.
= If average daily operating hours are unknown, assume default of 12 hrs/day

$PANS$ = Number of pans per unit.
= actual installed number of pans per unit.

PCT_{Steam} = Percent of time in constant steam mode
= Of percent of time in constant steam mode is unknown, assume default of 40%.

EFF = Heavy load cooking energy efficiency in %
= See above Table 131 for default values. If actual efficient values are unknown, assume default values from Table 131.

LB = Pounds of food cooked per day lb/day.

= If average pounds of food cooker per day is unknown, assume default of 100 lbs/day.

Days = Annual days of operation.
= If annual days of operation are unknown, assume default of 365 days.

3.27.6 Deemed Energy and Demand Savings

Table 132 provides the deemed values for energy and demand savings for the efficient steam cooker measure.

Table 132: Deemed Energy and Demand Savings Values[218]

Steam Cooker Type	N_{pan}	kWh_{base}	kWh_{eff}	Annual Energy Savings (kWh)	Peak Demand Savings (kW)	Natural Gas Savings (Therms)
Boiler Based	3-Pan	19,416	7,632	11,784	2.475	865
	4-Pan	24,330	9,777	14,553	3.057	-
	5-Pan	29,213	11,946	17,268	3.627	1,153
	6-Pan and Larger	34,080	14,090	19,990	4.199	1,291
Steam Generator	3-Pan	17,599	7,632	9,967	2.093	766
	4-Pan	21,884	9,777	12,107	2.543	-
	5-Pan	26,132	11,946	14,186	2.980	962
	6-Pan and Larger	30,360	14,090	16,270	3.417	1,054

3.27.7 Non-energy Benefits

The deemed annual water savings per steam cooker, based on ENERGY STAR® "Savings Calculator for ENERGY STAR® Qualified Commercial Kitchen Equipment," are shown in Table 133.

Table 133: Annual Water Consumption and Savings of Electric Steam Cooker

[218] The pre- and post- energy values are calculated using the ENERGY STAR® calculator https://www.energystar.gov/ia/products/downloads/Commercial_kitchen_equipment_calculator_1-12-16.xlsx

Type of Steam Cooker	Water Consumption in Conventional Steam Cooker	Water Consuption in ENERGY STAR® Steam Cooker	Annual Water Savings in Gallons
Electric	175,200	13,140	162,060

3.27.8 Measure Life

Based on ENERGY STAR® "Savings Calculator for ENERGY STAR® Qualified Commercial Kitchen Equipment," the measure life for an ENERGY STAR® Electric Steam Cooker is 12 years.

3.27.9 Incremental Cost

The incremental cost of the ENERGY STAR® Electric Steam Cooker depends on if the unit is electric or natural gas. The incremental capital cost for this measure is $1,000 for a natural gas steam cooker or $2,000 for an electric steam cooker[219].

[219] https://www.energystar.gov/sites/default/files/asset/document/CFS_calculator_03-02-2021.xlsx

3.28 ENERGY STAR® Hot Food Holding Cabinets

This measure involves installation of an ENERGY STAR® certified hot food holding cabinets, which incorporates better insulation to reduce heat loss. It offers better temperature uniformity within the cabinet from top to bottom and keeps the external cabinet cooler. In addition, many certified holding cabinets may include energy saving devices such as magnetic door gaskets, auto-door closures, or Dutch doors.

3.28.1 Measure Overview

Sector	Commercial
End use	Hot Food Storage
Fuel	Electricity
Measure category	Food Service Equipment
Delivery mechanism	Prescriptive
Baseline description	Standard Commercial Hot Food Holding Cabinet
Efficient case description	ENERGY STAR® certified Commercial Hot Food Holding Cabinet

3.28.2 Savings

The energy and demand savings are based on the interior volume range of the holding cabinets and the building type. An average wattage has been calculated for each volume range, half size, three-quarter size, and full size. The energy and demand savings are determined on a per-cabinet basis.

A commercial hot food holding cabinet is a heated, fully enclosed compartment with one or more solid or transparent doors designed to maintain the temperature of hot food that has been cooked using a separate appliance.

Eligible baseline equipment is a half-size, three-quarter size, or full-size hot food holding cabinet with a maximum idle energy rate of less than 40 watts/ft^3 for all equipment sizes[220].

This specification is intended for commercial food-grade equipment only. Hot food holding cabinets qualifying under this specification must be third-party certified to:

[220] http://www.texasefficiency.com/images/documents/RegulatoryFilings/DeemedSavings/PY2023%20TRM%2010.0%20Vol%203%20Nonresidential_2022-11-08_FINAL.pdf

- ANSI/NSF Standard 4 International Standard for Commercial Cooking, Rethermalization and Powered Hot Food Holding Transport Equipment

- ANSI/UL Standard 197 Commercial Electric Cooking Appliances.

Eligible equipment is set by ENERGY STAR® and based on the cabinet's interior volume. Table 134 summarizes idle energy rates per ENERGY STAR® v2.0 specification.

Table 134: Maximum Idle Energy Rate Requirements ENERGY STAR® Qualification[221]:

Product Interior Volume (ft³)	Idle Energy Rate (W)
0 < V < 13	≤ 21.5 V
13 ≤ V < 28	≤ 2.0 V + 254.0
28 ≤ V	≤ 3.8V + 203.5

Ineligible hot food holding cabinets include:

- Dual function equipment (e.g., "cook-and-hold" and proofing units)
- Heated transparent merchandising cabinets
- Drawer warmers

3.28.3 Energy Savings Estimation

Savings are derived with the following formula:

$$Energy\ Savings\ [\Delta kWh] = (E_{IdleBase} - E_{IdleES}) \times \frac{1}{1000} \times t_{on} \times t_{days}$$

Where:

Energy Savings = Annual energy savings, in kWh

$E_{IdleBase}$ = Baseline idle energy rate, in W. See

Table 135

E_{IdleES} = Idle energy rate after installation rate, in W.See

221 https://www.energystar.gov/sites/default/files/specs//private/Commercial_HFHC_Program_Requirements_2.0.pdf

Table 135

V[222] = Product Interior Volume, in ft^3. See Table 135

t_{on} = Equipment operating hours per day, in hours. See Table 135

t_{days} = Facility operating days per year. See Table 135

3.28.4 Demand Savings Estimation

Demand savings are calculated using the following formula:

$$\Delta kW = (E_{IdleBase} - E_{IdleES}) \times \frac{1}{1000} \times CF$$

Where:

ΔkW = Peak demand savings, in kW

$E_{IdleBase}$ = Baseline idle energy rate, in W. See Table 135

E_{IdleES} = Idle energy rate after installation, in W. See Table 135

CF =Peak Coincidence factor. See Table 135

Table 135: Deemed Variables for Energy and Demand Savings Calculations

Input Variable	Half-Size	Three-Quarter Size	Full-Size
Product Interior Volume (ft^3)	12	20	30
Baseline Equipment Idle Energy Rate ($E_{IdleBase}$)	480	800	1,200
Efficient Equipment Idle Energy Rate ($E_{IdleEff}$)	258	294	318
Operating Hours per Day (t_{on})		15	

[222] V = Interior Volume = Interior Height x Interior Width x Interior Depth

Facility Operating Days per Year (t_{days})	365
Peak Coincidence Factor (CF)[223]	0.92

3.28.5 Deemed Energy and Demand Savings Tables

The deemed energy and demand savings values for electric hot food holding cabinets are shown below in **Table 136**

Table 136: Deemed Energy and Demand Savings Values by Hot Food Holding Cabinet Size

Size	Annual Energy Savings (kWh)	Peak Demand Savings (kW)
Half	1,215	0.204
Three-Quarter	2,770	0.466
Full	4,832	0.812

3.28.6 Non-energy Benefits

There are no non-energy benefits associated with this measure.

3.28.7 Measure Life

The EUL has been defined for this measure as 12 years per ENERGY STAR®'s Savings Calculator.[224]

3.28.8 Incremental Cost

The incremental cost for this measure is $1,000.[225]

[223] California End Use Survey (CEUS), Building workbooks with load shapes by end use. http://capabilities.itron.com/CeusWeb/Chart.aspx.

[224] ENERGY STAR® measure life based on Food Service Technology Center (FSTC) research on available models, 2009. ENERGY STAR®. "Savings Calculator for ENERGY STAR® Qualified Commercial Kitchen Equipment." https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xls x

[225] https://www.energystar.gov/sites/default/files/asset/document/CFS_calculator_03-02-2021.xlsx

3.29 ENERGY STAR® Commercial Ice Makers

This measure presents energy and demand savings for automatic commercial ice makers. Commercial ice makers can be classified into batch-type (also called cube-type) and continuous-type. Batch-type ice makers harvest ice with alternating freezing and harvesting periods and are generally used to generate ice for use in beverages. Continuous-type ice makers produce ice through a continuous freeze and harvest process and include flake and nugget ice makers.

Via the use of one or more efficient features (such as the use of higher efficiency compressors, fan motors, and water pumps or increased air-cooled condenser surface area or improved evaporator insulation, etc.), an ENERGY STAR® certified commercial ice maker reduces energy and water consumption.

3.29.1 Measure Overview

Sector	Commercial
End use	Ice harvesting
Fuel	Electricity
Measure category	Food Service equipment
Delivery mechanism	Direct Install
Baseline description	An automatic air-cooled commercial ice maker with capacities between 50 and 4,000 pounds per 24-hour period manufactured on or after January 28, 2018[226]
Efficient case description	ENERGY STAR® rated automatic commercial ice maker

3.29.2 Savings

Eligible commercial ice makers include:[227]

- Air-cooled batch-type and continuous-type (i.e., flake and nugget) ice makers. Designs include ice-making head (IMH), self-contained (SCU), and remote condensing (RCU) units
- Air-cooled RCU units designed for connection to remote rack compressors that are alternately sold with a dedicated remote condensing unit are also eligible

[226] https://ecfr.io/Title-10/Section-431.132

[227] ENERGY STAR® Program Requirements Product Specifications for Commercial Ice Makes. Eligibility Criteria Version 3.0. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Final%20Draft%20Version%203.0%20Automatic%20Commercial%20Ice%20Maker%20Specification.pdf

Ineligible products include the following:

- Water-cooled ice makers
- Ice and water dispensing systems
- Air-cooled RCU units that are designed only for connection to remote rack compressors

The efficiency conditions of the baseline commercial ice makers are based on Federal Standards published in 10 CFR 431. A summary of those standards is shown in Table 137 below.

Table 137: Commercial Air-Cooled Ice Makers Baseline Efficiency[228]

Equipment Type	Harvest Rate (lbs ice per 24 Hrs)	Max Energy Use Rate (kWh/100 lb ice) H=harvest rate
	Batch - Type	
IMH	< 300	10 – 0.01233H
	≥ 300 and < 800	7.05 – 0.0025H
	≥ 800 and < 1,500	5.55 – 0.00063H
	≥ 1,500 and < 4,000	4.61
RCU (but not remote compressor)	< 988	7.97 -0.00342H
	≥ 988 and < 4,000	4.59
RCU and Remote Compressor	< 930	7.97 – 0.00342H
	≥ 930 and < 4,000	4.79
SCU	< 110	14.79 – 0.0469H
	≥ 110 and < 200	12.42 – 0.02533H
	≥ 200 and < 4,000	7.35
	Continuous-Type	
IMH	< 310	9.19 – 0.00629H
	≥ 310 and < 820	8.23 - 0.0032H
	≥ 820 and < 4,000	5.61
	< 800	9.7 - 0.0058H

[228] Code of Federal Regulations, Title 10 Part 431 for automatic commercial ice maker with capacities between 50 and 4,000 pounds per 24-hour period manufactured on or after January 28, 2018. https://ecfr.io/Title-10/Section-431.132

RCU (but not remote compressor)	≥ 800 and < 4,000	5.06
RCU and Remote Compressor	< 800	9.9 – 0.0058H
	≥ 800 and < 4,000	5.26
SCU	< 200	14.22 – 0.03H
	≥ 200 and < 700	9.47 – 0.00624H
	≥ 700 and < 4,000	5.1

The ENERGY STAR® requirements to qualify for the rating are shown in Table 138.

Table 138: Automatic Ice Makers – ENERGY STAR® Efficiency Criteria[229]

Equipment Type	Harvest Rate (lbs ice per 24 Hrs)	Max Energy Use Rate (kWh/100 lb ice) H=harvest rate	Potable Water Use (gal/100 lbs ice)
Batch - Type			
IMH	H < 300	≤ 9.20 – 0.01134H	≤ 20.0
	300 ≤ H < 800	≤ 6.49 - 0.0023H	
	800 ≤ H < 1500	≤ 5.11 - 0.00058H	
	1500 ≤ H ≤ 4000	≤ 4.24	
RCU	H < 988	≤ 7.17 – 0.00308H	≤ 20.0
	988 ≤ H ≤ 4,000	≤ 4.13	
SCU	H < 110	≤ 12.57 – 0.0399H	≤ 25.0
	110 ≤ H < 200	≤10.56 – 0.0215H	
	200 ≤ H ≤ 4,000	≤ 6.25	
Continuous-Type			
IMH	H < 310	≤ 7.90 – 0.005409H	≤ 15.0
	310 ≤ H < 820	≤ 7.08 - 0.002752H	
	820 ≤ H ≤ 4,000	≤ 4.82	
RCU	H < 800	≤ 7.76 – 0.00464H	≤ 15.0
	800 ≤ H ≤ 4,000	≤ 4.05	

229 ENERGY STAR® Commercial Ice Maker Key Product Criteria Version 3.0, https://www.energystar.gov/products/commercial_food_service_equipment/commercial_ice_makers/key_product_criteria

SCU	H < 200	≤ 12.37 – 0.0261H	≤ 15.0
	200 ≤ H < 700	≤ 8.24 – 0.005429H	
	700 ≤ H ≤ 4,000	≤ 4.44	

3.29.3 Energy Savings Estimation

Savings are derived using the following equation:

$$\Delta kWh = \frac{UseRate_{Base} - UseRate_{Eff}}{100} \times Duty\ Cycle \times Days \times H$$

Where:

ΔkWh = Annual energy savings, in kWh

$UseRate_{Base}$ = The rated energy consumption, in kWh per 100 pounds of ice, of the baseline unit. Select the most appropriate value from Table 137.

$UseRate_{Eff}$ = The rated energy consumption, in kWh per 100 pounds of ice, for the efficient unit.

H = Harvest rate (lb ice/24 hours) of the efficient equipment

Duty Cycle = Machine duty cycle, 80%[230]

Days = Number of days per year. Default is 365, based on continuous use for both batch and continuous type ice makers.

3.29.4 Demand Savings Estimation

The demand savings are derived by using the following equation:

$$\Delta kW = Annual\ Energy\ Savings\ \times PLS$$

[230] Duty cycle value of 80% is taken from a PGE Emerging Technologies study, ET Project #ET12PGE3151 Food Service Technology—Efficient Ice Machines and Load Shifting, average duty cycle of preexisting machines in tables ES1 and ES2.

Where:

ΔkW = Peak demand savings, in kW

PLS = Probability-weighted peak load share, as per Table 139

Table 139: Probability-weighted Peak Load Share - Ice Makers

Climate Zone	Summer Peak
All	0.00012

3.29.5 Deemed Energy and Demand Savings

There are no deemed energy or peak demand savings for this measure.

3.29.6 Non-energy Benefits

There are no water savings for continuous type commercial ice maker machines. The water savings for batch type commercial ice maker machines are[231] shown in Table 140.

Table 140: Annual Water Savings for Batch Type ENERGY STAR® Commercial Ice Maker

Equipment Type	Annual Water Savings in gallons
Ice Making Head	3,322
Self-Contained Unit	3,526
Remote Condensing Unit (Batch)	2,631
Remote Condensing Unit (Continuous)	0

3.29.7 Measure Life

The estimated useful life (EUL) for automatic ice makers is 8.5 years[232].

[231] Savings Calculator for ENERGY STAR Certified Commercial Kitchen Equipment. http://www.energystar.gov/buildings/sites/default/uploads/files/commercial_kitchen_equipment_calculator.xlsx

[232] Department of Energy, Energy Conservation Program: Energy Conservation Standards for Automatic Commercial Ice Makers, 80 FR 4698, https://www.federalregister.gov/d/2015-00326/p-4698

3.29.8 Incremental Cost

The incremental cost of ENERGY STAR® Ice Maker machines is $250 for both the Batch Type and the Continuous Type.[233]

3.30 Steam Trap Replacement or Repair

The measure applies to the repair or replacement of steam traps in the failed open state that allow steam to escape the steam distribution system or return to the condensate receiver leading to increased steam generation. The measure is applicable to commercial applications, commercial HVAC (low pressure steam) including multifamily buildings, low pressure industrial applications, medium pressure industrial applications, applications and high-pressure industrial applications.

3.30.1 Measure Overview

Sector	Commercial
End use	HVAC
Fuel	Electricity or Gas
Measure category	Steam Traps
Delivery mechanism	Direct Install
Baseline description	Faulty steam trap in the failed open or leaking state
Efficient case description	Repair or replacement of faulty steam traps

3.30.2 Definition of Baseline Equipment

The baseline criterion is a faulty steam trap in the failed open or leaking state. No minimum leak rate is required. Any leaking or blow through trap can be repaired or replaced. If a commercial customer chooses to repair or replace all the steam traps at the facility without verification, the savings are adjusted. Savings for commercial full replacement projects are reduced by the percentage of traps found to be leaking on average from the studies listed. If an audit is performed on a commercial site, then the leaking and blowdown can be adjusted.

233 https://www.energystar.gov/sites/default/files/asset/document/CFS_calculator_03-02-2021.xlsx

3.30.3 Definition of Efficient Equipment

Customers must have leaking traps to qualify for rebates. However, if a commercial customer opts to replace all traps without inspection, rebates and the savings are discounted to take into consideration the fact that some traps are being replaced that have not yet failed.

3.30.4 Energy Savings Estimation

Natural Gas Savings can be determined using the formula below:

$$\Delta Therms = Sa * \left(H_v + H_s * (T_1 - T_{source})\right) * Hours * L — (100{,}000 * \eta_B)$$

$$\Delta Therm = Sa * \left(\frac{Hv}{B}\right) * Hours * \frac{L}{}$$

For systems used in space heating applications that operate at 5 psig or lower, use the following equation to calculate Sa:

$$Sa = 1519.3 * P_1 * D * \left[\left(\frac{1}{T_1}\right) * \left(\frac{\gamma}{\gamma - 1}\right) * \left(\left(\frac{P_2}{P_1}\right)^{\frac{2}{\gamma}} - \left(\frac{P_2}{P_1}\right)^{\left(\frac{(\gamma+1)}{\gamma}\right)}\right)\right]^{0.5} * A * FF$$

The condensate return system pressure, P_2, will typically be atmospheric pressure, 14.696 psia.

For all other steam systems and applications, use the following equation:

$$Sa = 24.24 \, x \, P_1 \, x \, D^2 \, x \, A \, x \, FF$$

Where:

Sa	= Steam loss per leaking trap (lbs/hr), see Table 141
1519.3	= Constant lb/(hr-psia-in2)
P_1	= Average steam trap inlet pressure (absolute, psia). If not available, use defaults provided in Table 141 below (note that defaults are provided in psig, not psia).
D	= Diameter of orifice, inches. Actual value should be used wherever possible as this value has a significant impact on steam flowrate value, see Table 141
T_1	= Temperature of Saturated Steam (°R)
	= $507.89 * P_1^{0.0962}$

	Where:
	507.89 = Constant, $°R*(in^2 /lb_f)^{0.0962}$
γ	= Heat Capacity Ratio (unitless)
	= $5.071 * 10^{-4} * P_1 + 1.332$
P_2	= Average steam trap outlet pressure (absolute psia). If unknown, assume atmospheric pressure, 14.696 psia.
A	= Adjustment factor
	= 50%,[234] all steam systems. This factor accounts for reduction in the maximum theoretical steam flow to the average steam flow (the Enbridge factor), see Table 141
FF	= Flow Factor. In addition to the Adjustment factor (A), an additional 50 percent flow factor adjustment is recommended for medium and high-pressure steam systems to address industrial float and thermostatic style traps where additional blockage is possible, see Table 141
24.24	= Constant $lbm/(hr\text{-}psia\text{-}in^2)$
Hv	=Heat of vaporization of steam, (Btu/lbm), see Table 142
Hs	= Specfic heat of water, (Btu/(lbm * °R))
	= 1.001
T_{source}	= Incoming water temperature
	= 513.67°R[235]
η_B	= Boiler efficiency
	= custom, if unknown:
	= 80.7% for steam boilers, except multifamily low-pressure[236]
	= 64.8% for multifamily low-pressure steam boilers[237]
Hours	= Annual hours when steam system is pressurized

[234] Enbridge adjustment factor used as referenced in CLEAResult "Work Paper Steam Traps Revision #2" Revision 3 dated March 2, 2012 and DOE Federal Energy Management Program Steam Trap Performance Assessment.

[235] US DOE Building America Program. Building America Analysis Spreadsheet. For Chicago, IL.

[236] Ibid.

[237] Katrakis, J. and T.S. Zawacki. "Field-Measured Seasonal Efficiency of Intermediate-sized Low-Pressure Steam Boilers". ASHRAE V99, pt. 2, 1993.

	= custom, if unknown, see Table 143
L	= Leaking & blow-thru, see Table 144

Table 141: Default Steam Loss per Trap (Sa) and Average Inlet Pressure

Steam System	Average Steam Trap Inlet Pressure psig[238]	Diameter of Orifice (in)	Adjust ment Factor	Flow Fact or	Average Actual Steam Loss per Leaking Trap (lbm/hr/trap)[239]
Commercial Dry Cleaners	82.8	0.125	50%	100%	18.5
Multifamily LPS Space Heating – calculate Sa as provided above. If using default value, cap total savings at 20% of building consumption	-	-	50%	100%	6.9
Commercial LPS Space Heating	-	-	50%	100%	6.9
Industrial or Process Low Pressure, <15 psig	-	-	50%	100%	6.9
Medium Pressure >15 psig < 30 psig	16	0.1875	50%	50%	6.5
Medium Pressure ≥30 < 75 psig	47	0.25	50%	50%	23.4
High Pressure ≥75 < 125 psig	101	0.25	50%	50%	43.8
High Pressure ≥125 < 175 psig	146	0.25	50%	50%	60.9
High Pressure ≥175 < 250 psig	202	0.25	50%	50%	82.1
High Pressure ≥250 ≤ 300 psig	263	0.25	50%	50%	105.2

[238] Medium and high pressure steam trap inlet pressure based on Navigant analysis of source collected during program implementation by Nicor Gas for GPY1 through GPY4. For each steam trap project, the data provided measure savings description, operating pressure, installation Zip code, business building type, program year, and annual operating hours.

[239] For applications where inlet pressures and orifice diameters are provided in the table, default values are directly calculated using the equation above. For applications where inlet pressures and orifice diameters are not provided in the table, default values are assumptions based on engineering judgement and will be revisited in future years.

Adjustment factor and flow factor is 1.0 when applied to the replacement of an individual leaking trap. If several steam traps are replaced and the system has not been audited, the adjustment factor and flow factor are applied to reflect failed close and partially failed open traps. A custom value can be utilized if a supported by a detailed steam trap audit or evaluation research.

Table 142: System Heat of Vaporization

Steam System	Heat of Vaporization[240] (Btu/lbm)
Commercial Dry Cleaners	890
Commercial Space Heating (including Multifamily) LPS	951
Industrial and Process Low Pressure ≤15 psig	951
Medium Pressure >15 psig < 30 psig	944
Medium Pressure ≥ 30 <75 psig	915
High Pressure ≥ 75 psig <125 psig	880
High Pressure ≥ 125 psig	859
High Pressure ≥ 175 psig	837
High Pressure ≥ 250 ≤ 300 psig	816
High Pressure > 300 psig	Custom

[240] Heat of vaporization of steam at the inlet pressure to the steam trap. Implicit assumption that the average boiler nominal pressure where the vaporization occurs, is essentially that same pressure. Referenced in CLEAResult "Work Paper Steam Traps Revision #2" Revision 3 dated March 2, 2012.

Table 143: Annual Operating Hours for Steam Systems

Steam System	Zone (where applicable)	Hours/Yr[241]
Commercial Dry Cleaners	All Climate Zones	2,425
Industrial and Process Low Pressure ≤15 psig		8,282
Medium Pressure >15 psig < 30 psig		8,282
Medium Pressure ≥30 <75 psig		8,282
High Pressure ≥75 psig <125 psig		8,282
High Pressure ≥125 psig <175 psig		8,282
High Pressure ≥175 psig <250 psig		8,282
High Pressure ≥250		8,282
Commercial Space Heating (including Multifamily) LPS	Albuquerque	2,220
	Las Cruces	1,178
	Roswell	1,592
	Santa Fe	3,136

[241] Medium and high-pressure steam trap annual operating hours based on Navigant analysis of source collected during program implementation by Nicor Gas for GPY1 through GPY4. For each steam trap project, the data provided measure savings description, operating pressure, installation zip code, business building type, program year, and annual operating hours.

Table 144: Steam System Leaking & Blow-thru

Steam System	L (%)[242]
Custom	Custom
Commercial Dry Cleaners	27%
Industrial and Process Low Pressure ≤15 psig	27%
Medium Pressure >15 psig < 30 psig	16%
Medium Pressure ≥30 <75 psig	16%
High Pressure ≥75 psig <125 psig	16%
High Pressure ≥125 psig <175 psig	16%
High Pressure ≥175 psig <250 psig	16%
High Pressure > 300 psig	16%

L is 1.0 when applied to the replacement of an individual leaking trap. If several steam traps are replaced and the system has not been audited, the leaking and blow-thru is applied to reflect the assumed percentage of steam traps that were actually leaking and need to be replaced. A custom value can be utilized if a supported by a detailed steam system audit or evaluation research.

242 Dry cleaners survey data as referenced in CLEAResult "Work Paper Steam Traps Revision #2" Revision 3 dated March 2, 2012.

Table 145: Average Actual Steam Loss per Leaking Trap

Steam System	Average Actual Steam Loss per Leaking Trap (lbm/hr/trap)	Average Actual Water Volume Saved per Leaking Trap Atmospheric Venting (gal/hr/trap)
Commercial Dry Cleaners	19.1	2.29
Commercial Heating (including Multifamily) LPS	6.9	0.83
Industrial or Process Low Pressure, <15 psig	6.9	0.83
Medium Pressure >15 psig < 30 psig	6.5	0.78
Medium Pressure ≥30 <75 psig	23.4	2.81
High Pressure ≥75 <125 psig	43.8	5.26
High Pressure ≥125 <175 psig	60.9	7.31
High Pressure ≥175 <250 psig	82.1	9.86
High Pressure ≥250 ≤300 psig	105.2	12.63
High Pressure > 300 psig	Calculated	Calculated Steam Loss / 8.33

3.30.5 Non-energy Benefits

There are no non-energy benefits.

3.30.6 Measure Life

The life of this measure is 6 years[243]

[243] Source paper is the CLEAResult "Steam Traps Revision #1" dated August 2011. Primary studies used to prepare the source paper include Enbridge Steam Trap Survey, KW Engineering Steam Trap Survey, Enbridge Steam Saver Program 2005, Armstrong Steam Trap Survey, DOE Federal Energy Management Program Steam Trap Performance Assessment, Oak Ridge National Laboratory Steam System Survey Guide, KEMA Evaluation of PG&E's Steam Trap Program, Sept. 2007. Communication with vendors suggested a inverted bucket steam trap life typically in the range of 5 - 7 years, float and thermostatic traps 4- 6 years, float and thermodynamic disc traps of 1 - 3 years. Cost does not include installation.

3.30.7 Deemed Measure Cost

Table 146: Deemed Measure Cost for Steam Systems

Steam System	Cost per trap[244] ($)
Commercial Dry Cleaners	77
Commercial Heating (including Multifamily), low pressure steam	77
Industrial Medium Pressure >15 psig < 30 psig	180
Steam Trap, Industrial Medium Pressure ≥30 <75 psig	223
Steam Trap, Industrial High Pressure ≥75 <125 psig	276
Steam Trap, Industrial High Pressure ≥125 <175 psig	322
Steam Trap, Industrial High Pressure ≥175 <250 psig	370
Steam Trap, Industrial High Pressure ≥250 psig	418
Steam Trap, Industrial Medium Pressure ≥30 <75 psig	223
Steam Trap, Industrial High Pressure ≥75 <125 psig	276
Steam Trap, Industrial High Pressure ≥125 <175 psig	322
Steam Trap, Industrial High Pressure ≥175 <250 psig	370
Steam Trap, Industrial High Pressure ≥250 psig	418

3.30.8 Incremental Cost

Incremental cost estimates should be gathered as part of the application process if utilities wish to test the cost effectiveness of this measure using the TRC test.

[244] Ibid.

3.31 Computer Room Air Conditioners

This section summarizes the deemed savings methodology for the installation of computer room air conditioning (CRAC) systems. A CRAC unit is a device that monitors and maintains the temperature, air distribution, and humidity in a network room or data center. This measure covers assumptions made for baseline equipment efficiencies for early retirement (ER) based on the age of the replaced equipment and replace-on-burnout (ROB) and new construction (NC) situations based on efficiency standards. Savings calculations incorporate the use of only part-load efficiency values, as these types of units are only rated in units of seasonal COP (SCOP). For ER, the actual age of the baseline system should be determined from the equipment nameplate or other physical documentation whenever possible. If the actual age of the unit is unknown, default values are provided.

3.31.1 Measure Overview

Sector	Commercial
End use	HVAC
Fuel	Electricity
Measure category	Computer Room Air Conditioner
Delivery mechanism	Prescriptive
Baseline description	IECC 2018 efficiency
Efficient case description	Efficiency must exceed IECC 2018

3.31.2 Eligibility Criteria

For a measure to be eligible, the following conditions must be met:

- The existing and proposed cooling equipment is electric
- The climate zone is determined from the county-to-climate-zone mapping table
- The building type is a network room or data center
- Rated for sensible co-efficient of performance (SCOP)
- For early retirement projects: ER projects involve the replacement of a working system. Additionally, the ER approach cannot be used for projects involving a renovation where a major structural change or internal space remodel has occurred. A ROB approach should be used for these scenarios.

- If these conditions are not met, the deemed savings approach cannot be used, and the Simplified M&V Methodology or the Full M&V Methodology must be used.

3.31.3 Definition of Baseline Equipment

The baseline conditions related to efficiency and system capacity for early retirement and replace-on-burnout/new construction are as follows:

Early Retirement

Early retirement projects should claim savings using the replace-on-burnout/new construction baseline, as no additional savings are specified for early retirement projects. This section will not apply until the current baseline is updated, allowing the measure to refer to the existing baseline for early retirement projects.

Replace-on-Burnout (ROB) and New Construction (NC)

Baseline efficiency levels for CRACs are provided in Table 147. These baseline efficiency levels reflect the minimum efficiency requirements from IECC 2018, which uses the Sensible Coefficient of Performance (SCOP) as the standard efficiency metric.

Table 147: Baseline Efficiency Levels for ROB and NC CRACs[245]

System Type	Cooling Capacity [Btu/hr]	Baseline Efficiencies for Downflow/Upflow Units (SCOP)	Source
Air conditioners, air cooled	< 65,000	2.20 / 2.09	IECC 2018
	≥ 65,000 and < 240,000	2.10 / 1.99	
	> 240,000	1.90 / 1.79	
Air conditioners, water cooled	< 65,000	2.60 / 2.49	
	> 65,000 and < 240,000	2.50 / 2.39	
	≥ 240,000	2.40 / 2.29	
Air conditioners, water cooled with fluid economizer	< 65,000	2.55 / 2.44	
	≥ 65,000 and < 240,000	2.45 / 2.34	
	≥ 240,000	2.35 / 2.24	
Air conditioners, glycol cooled (rated at 40% propylene glycol)	< 65,000	2.50 / 2.39	
	≥ 65,000 and < 240,000	2.15 / 2.04	
	≥ 240,000	2.10 / 1.99	
Air conditioners, glycol cooled (rated at 40% propylene glycol) with fluid economizer	< 65,000	2.45 / 2.34	
	≥ 65,000 and < 240,000	2.10 / 1.99	
	≥ 240,000	2.05 / 1.94	

3.31.4 Definition of Efficient Equipment

Package and split systems must exceed the minimum efficiencies specified in **Table 147**.

3.31.5 Energy Savings Estimation

$$\Delta kWh = \left(\frac{Btu_{cool,sensible}}{hr} \times \frac{1\ kW}{3{,}412\ Btu}\right) \times \left(\frac{1}{SCOP_{base}} - \frac{1}{SCOP_{ee}}\right) \times EFLH_c$$

Where:

$Btu_{cool,sensible}$ = Rated sensible cooling capacity of the existing equipment at AHRI standard conditions [Btuh]; 1 ton = 12,000 Btuh

$SCOP_{base}$ = Sensible Cooling efficiency of baseline equipment

$SCOP_{ee}$ = Sensible cooling efficiency of the newly installed equipment (Table 147))

245 IECC 2018 TableC403.3.2(9).

DF = Seasonal peak demand factor for appropriate climate zone, building type, and equipment type (Table 149)

$EFLH_C$ = Cooling equivalent full-load hours for appropriate climate zone, building type, and equipment type [hours](Table 149)

3.31.6 Demand Savings Estimation

$$\Delta kWh = \left(\frac{Btu_{cool,sensible}}{hr} \times \frac{1\ kW}{3{,}412\ Btu}\right) \times \left(\frac{1}{SCOP_{base}} - \frac{1}{SCOP_{ee}}\right) \times DF$$

Deemed peak demand factor (DF) and equivalent full-load hour (EFLH) values are presented by building type and climate zone. A description of the building types that are eligible to use this measure is presented in Table 148. These building types are derived from the EIA CBECS study.[246]

The DF and EFLH values for CRAC units are presented in Table 149.

Table 148: Commercial CRAC Building Type Descriptions and Examples

Building Type	Principal Building Activity	Definition	Detailed Business Type Examples[247]
Data Center	Data Center	Buildings used to house computer systems and associated components.	1) Data Center

[246] The Commercial Building Energy Consumption Survey (CBECS) implemented by the US Energy Information Administration includes a principal building activity categorization scheme that separates the Commercial sector into 29 categories and 51 subcategories based on principal building activity (PBA). For its purposes, the CBECS defines Commercial buildings as those buildings greater than 1,000 square feet that devote more than half of their floorspace to activity that is neither residential, manufacturing, industrial, nor agricultural. The high-level building types adopted for the TRM are adapted from this CBECS categorization, with some building types left out and one additional building type—Large Multifamily—included.

[247] Principal Building Activities are based on sub-categories from the 2003 CBECS questionnaire.

Table 149: DF and EFLH Values for All Climate Zones[248]

Climate Zone	Building Type and Principal Building Activity	CRACs	
		DFC	$EFLH_C$
Albuquerque	Data Center	0.96	1,850
Santa Fe		0.92	975
Roswell		0.99	2,455
Las Cruces		1.00	2,595

3.31.7 Non-energy Benefits

There are no non-energy benefits.

3.31.8 Measure Life

The EUL for CRACs is 15 years, consistent with the EUL specified for split and packaged air conditioners and heat pumps.[249]

3.31.9 Incremental Cost

Incremental cost estimates should be gathered as part of the application process if utilities wish to test the cost-effectiveness of this measure using the TRC test.

[248] EFLH and CF values are derived from the values in the Texas TRM version 7

[249] The EUL of 15 years has been cited in several places - PUCT Docket No. 36779, DOE 77 FR 28928, 10 CFR Part 431, and in the DEER 2014 update.

3.32 Entrance and Exit Door Air Infiltration

This measure applies to the installation of weather stripping or door sweeps on entrance and exit doors for a contained, pressurized space. Entrance and exit doors often leave clearance gaps to allow for proper operation. The gaps around the doors allow for the infiltration of unconditioned air into the building, adding to the cooling and heating load of the HVAC system. Weatherstripping and door sweeps are designed to be installed along the bottom and jambs of exterior doors to prevent air infiltration into the conditioned space.

Weatherstripping or door sweeps must be installed on doors of a conditioned and/or heated space. Treated doors must have visible gaps of at least 1/8–3/4 inches along the outside edge of the door. A space with interior vestibule doors is not eligible.

3.32.1 Measure Overview

Sector	Commercial
End use	Space heating and cooling
Fuel	Electricity
Measure category	Building Envelope
Delivery mechanism	Prescriptive
Baseline description	Exterior doors not sealed from unconditioned space
Efficient case description	Exterior doors sealed from unconditioned space using weather stripping and/or brush style door sweeps

3.32.2 Definition of Baseline Equipment

The baseline standard for this measure is a commercial building with exterior doors that are not sealed from unconditioned space.

3.32.3 Definition of Efficient Equipment

The high-efficiency condition for this measure is a commercial building with exterior doors that have been sealed from unconditioned space using weather stripping and/or brush-style door sweeps.

3.32.4 Energy Savings Estimation

This savings methodology was derived by analyzing TMY3 weather data for each Texas weather zone representative city.

Derivation of Pre-Retrofit Air Infiltration Rate

This savings methodology was derived by analyzing TMY3 weather data for each Texas weather zone representative city.

The pre-retrofit air infiltration rate for each crack width is calculated by applying the methodologies presented in Chapter 5 of the ASHRAE Cooling and Heating Load Calculation Manual (CHLCM).[250] Building type characteristics for a typical commercial building were found in the DOE study PNNL-20026,[251] and an average building height of 20 feet is assumed for the deemed savings approach.

Because air infiltration is a function of differential pressure due to stack effect, wind speed, velocity head, and the design conditions of the building, TMY3 for each Texas weather zone reference city was applied to account for the varying weather conditions that are characteristic throughout an average year.

Figure 5.13 from the ASHRAE CHLCM provides the infiltration rate based on various crack width and the corresponding pressure difference across a door. Figures 5.1 and 5.2 (CHLCM) provide the differential pressure due to stack and wind pressure necessary to determine the total pressure difference across the door.

Applying a regression analysis to Figure 5.1 returns an equation that allows solving for the pressure difference due to stack effect, Δp_s. The aggregate curve fit for Figure 5.1 is shown below where x is based on the dry bulb temperature from the TMY3 data, and the design temperature based on the appropriate seasonal condition.

$$\frac{\Delta p_s}{C_d} = 0.0000334003x - 0.00014468$$

Where C_d is an assumed constant, 0.63, and the neutral pressure distance is 10 feet.

From Figure 5.2, $\Delta p_w/C_p$ is determined by applying a polynomial regression, which returns an equation for solving for the pressure difference due to wind, Δp_w. The curve fit for Figure 5.2 is shown below where x is the wind velocity based on TMY3 data.

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[250] ASHRAE Cooling and Heating Load Calculation Manual, p. 5.8. 1980. http://portal.hud.gov/hudportal/documents/huddoc?id=doc_10603.pdf.

[251] Cho, H., K. Gowri, and B. Liu, "Energy Saving Impact of ASHRAE 90.1 Vestibule Requirements: Modeling of Air Infiltration through Door Openings." November 2010. http://www.pnl.gov/main/publications/external/technical_reports/PNNL-20026.pdf.

$$\frac{\Delta p_w}{C_p} = 0.00047749x^2 - 0.00013041x$$

Where C_p is an assumed constant, 0.13 (average wind pressure coefficient from Table 5.5 from CHLCM).

This yields the total pressure difference across the door, Δp_{Total}:

$$\Delta p_{Total} = \Delta p_s + \Delta p_w$$

Solving for Δp_{Total} allows for the air infiltration rate per linear foot to be determined in Figure 5.13 (CHLCM). Applying a power regression analysis for each crack width (described in inches) represented in Figure 5.13 returns the equations listed below. In these equations, Q is the infiltration rate in cubic feet per minute through cracks around the door, and P is the perimeter of the door in feet.

$$\frac{Q}{P_{\frac{1}{8}"}} = (41.572x)^{0.5120}$$

$$\frac{Q}{P_{\frac{1}{4}"}} = (81.913x)^{0.5063}$$

$$\frac{Q}{P_{\frac{1}{2}"}} = (164.26x)^{0.5086}$$

$$\frac{Q}{P_{\frac{3}{4}"}} = (246.58x)^{0.5086}$$

These infiltration rates were based on TMY3 average monthly day and night conditions.

Derivation of Design and Average Outside Ambient Temperatures

Taking average daytime and nighttime outdoor temperature values, standard set points, and setbacks for daytime and nighttime design cooling and heating will yield the temperature difference needed for the sensible heat equation:

$$\Delta T = T_{design} - T_{avg\ outside\ ambient}$$

Where:

T_{design}	= Daytime and nighttime design temperature (°F, see Table 150)
$T_{avg\ outside\ ambient}$	= Average outside ambient temperature, specified by month (°F, see Table 150)

Table 150: Average Monthly Ambient Temperatures (°F)[252]

Month	Albuquerque		Santa Fe		Roswell		Las Cruces	
	Day	Night	Day	Night	Day	Night	Day	Night
Jan	42.5	30.9	36.4	25.8	47.2	33.4	46.7	36.7
Feb	45.6	33.9	41.4	30.5	54.9	42.8	52.2	41.1
Mar	54.6	41.0	54.7	39.6	61.6	46.9	57.6	43.9
April	62.7	51.4	59.5	43.3	71.2	55.2	68.0	56.3
May	69.8	58.3	68.4	53.3	80.8	64.2	79.9	64.8
June	81.2	66.3	79.2	61.2	85.1	70.4	87.6	71.9
July	84.8	71.5	77.2	64.3	86.3	73.9	92.4	78.2
Aug	81.4	69.3	77.0	62.6	88.8	75.0	87.6	74.7
Sept	75.1	62.6	67.6	54.3	77.7	64.1	83.4	70.4
Oct	62.1	51.3	58.5	43.4	71.6	54.3	69.3	57.6
Nov	48.6	40.4	43.8	32.2	57.0	45.9	57.6	44.5
Dec	39.6	31.9	35.2	24.1	51.3	38.5	53.8	39.6

Table 151: Daytime and Nighttime Design Temperatures

Temperature Description	T_{design} (°F)
Daytime Cooling Design Temperature	74
Daytime Heating Design Temperature	72
Nighttime Cooling Design Temperature[253]	78
Nighttime Heating Design Temperature[254]	68

[252] NOAA
[253] Assuming 4-degree setback.
[254] Ibid.

Savings Algorithms and Input Variables

To calculate HVAC load associated with air infiltration, the following sensible heat equation is used:

Electric Cooling Energy Savings

$$Cooling\ Energy\ Savings\ [kWh]_{Day} = \frac{CFM_{pre,day} \times CFM_{reduction} \times 1.08 \times \Delta T \times 1.0\,\frac{kW}{ton} \times Hours_{day}}{12{,}000\,\frac{Btuh}{ton}}$$

$$Cooling\ Energy\ Savings\ [kWh]_{Nig} = \frac{CFM_{pre,night} \times CFM_{reduction} \times 1.08 \times \Delta T \times 1.0\,\frac{kW}{ton} \times Hours_{night}}{12{,}000\,\frac{Btuh}{ton}}$$

$$Cooling\ Energy\ Savings\ [kWh] = Cooling\ Energy\ Savings\ [kWh]_{Day} + Cooling\ Energy\ Savings\ [kWh]_{Night}$$

Electric Heating Energy Savings

$$Heating\ Energy\ Savings\ [kWh]_{Day} = \frac{CFM_{pre,day} \times CFM_{reduction} \times 1.08 \times \Delta T \times 1.0\,\frac{kW}{ton} \times Hours_{day}}{COP \times 3{,}412\,\frac{Btuh}{kW}}$$

$$Heating\ Energy\ Savings\ [kWh]_{Night} = \frac{CFM_{pre,night} \times CFM_{reduction} \times 1.08 \times \Delta T \times 1.0\,\frac{kW}{ton} \times Hours_{night}}{COP \times 3{,}412\,\frac{Btuh}{kW}}$$

$$Heating\ Energy\ Savings\ [kWh] = Heating\ Energy\ Savings\ [kWh]_{Day} + Heating\ Energy\ Savings\ [kWh]_{Night}$$

3.32.5 Demand Savings Estimation

Electric Cooling Demand Savings (weighted by climate zone peak hour probability)

$$Summer\ Demand\ Savings\ [kW]_{Day} = \frac{CFM_{pre,day} \times CFM_{reduction} \times 1.08 \times \Delta T \times 1.0 \frac{kW}{ton}}{12{,}000 \frac{Btuh}{ton}}$$

3.32.6 Deemed Energy and Demand Savings

Deemed energy and demand savings per linear foot of installed weather stripping or door sweep are specified below in Table 152 to

Table **156** based on climate zone and existing door gap width (inches). Heating savings are specified for both electric resistance (ER) and heat pump (HP) heating. Cooling savings are available for buildings with electric cooling and gas heat, but no heating savings should be claimed for buildings with gas heat.

Table 152: Deemed Cooling Energy Savings per Linear Foot of Weather Stripping/Door Sweep

Climate Zone	Climate Zone Gap Width (inches)			
	1/8	1/4	1/2	3/4
Albuquerque	2.38	4.82	9.56	14.35
Santa Fe	1.06	2.14	4.24	6.37
Roswell	4.67	9.44	18.74	28.12
Las Cruces	5.06	10.25	20.33	30.52

Table 153: Deemed ER Heating Energy Savings per Linear Foot of Weather Stripping/Door Sweep

Climate Zone	Climate Zone Gap Width (inches)			
	1/8	1/4	1/2	3/4
Albuquerque	128.19	259.17	514.35	772.11
Santa Fe	174.55	352.70	700.12	1050.98
Roswell	87.14	176.27	349.76	525.04
Las Cruces	90.70	183.30	363.83	546.16

Table 154: Deemed HP Heating Energy Savings per Linear Foot of Weather Stripping/Door Sweep

Climate Zone	Climate Zone Gap Width (inches)			
	1/8	1/4	1/2	3/4
Albuquerque	38.85	78.54	155.86	233.97
Santa Fe	52.89	106.88	212.16	318.48
Roswell	26.41	53.42	105.99	159.10
Las Cruces	27.49	55.54	110.25	165.50

Table 155: Deemed Summer Demand Savings per Linear Foot of Weather Stripping/Door Sweep

Climate Zone	Climate Zone Gap Width (inches)			
	1/8	1/4	1/2	3/4
Albuquerque	0.002304	0.004662	0.009249	0.013884
Santa Fe	0.001714	0.003468	0.006881	0.010329
Roswell	0.00385	0.007787	0.015451	0.023195
Las Cruces	0.004563	0.009243	0.018329	0.027515

Table 156: Deemed Natural Gas Heating Savings (therms) per Linear Foot of Weather Stripping/Door Sweep

Climate Zone	Climate Zone Gap Width (inches)			
	1/8	1/4	1/2	3/4
Albuquerque	5.47	11.05	21.94	32.93
Santa Fe	7.44	15.04	29.86	44.82
Roswell	3.72	7.52	14.92	22.39
Las Cruces	3.87	7.82	15.52	23.29

3.32.7 Non-energy Benefits

There are no non-energy benefits.

3.32.8 Measure Life

The EUL for this measure is 11 years, according to the California Database of Energy Efficiency Resources (DEER 2014).[255] This measure life is consistent with the residential air infiltration measure in the Texas TRM.

3.32.9 Incremental Cost

Incremental cost estimates should be gathered as part of the application process if utilities wish to test the cost-effectiveness of this measure using the TRC test.

[255] Database for Energy Efficient Resources (2014). http://www.deeresources.com/.

3.33 Small Commercial Evaporative Cooling

This measure promotes the installation of high-efficiency evaporative cooler. This measure could apply to the replacement of an existing unit at the end of its useful life or the installation of a new unit in a new or existing building.

3.33.1 Measure Overview

Sector	Commercial
End use	HVAC
Fuel	Electricity
Measure category	Evaporative Cooling
Delivery mechanism	Rebate
Baseline description	IECC 2018 efficiency for split/packaged AC < 65,000 Btu/h
Efficient case description	Direct evaporative cooling (no expansion cooling) with the following characteristics: cooling flow is three times the flow use for the code baseline buildings, effectiveness = 0.85

3.33.2 Savings

Savings are calculated by multiplying the baseline consumption of a code-compliant split or packaged air conditioner against deemed cooling equivalent full-load hours (EFLH) and coincidence factors (CF) specified per climate zone and building type. Baseline consumption is determined according to deemed cooling load specified per climate zone and code-level efficiency requirement as described below. A reduction factor comparing evaporative and refrigerated cooling consumption is applied to deemed EFLH/CF values to represent the savings for installing evaporative cooling in lieu of refrigerated cooling.

Example:

An evaporative cooler with a saturation effectiveness of 0.85 is installed in a small office in Las Cruces.

Cooling savings = 36 kBtu/h x (1 W-hr/13 Btu) x 1,174 hours x 75%

= 2,438 kWh

$SEER_{Baseline} = -0.02 \times (13)^2 + 1.12 \times 13 = 11.18$

Demand Savings = 36 kBtu/h x (1/11.18) x 0.81 x 75%

$= 1.96 \text{ kW}$

3.33.3 Energy Savings Estimation

Savings for all unit capacities (typically 3,000-25,000 cfm)[256] are determined with the following equation:

$$Cooling\ Savings = Cooling\ Capacity \times \frac{1}{SEER_{Base}} \times Cooling\ EFLH \times CRF$$

Where:

Cooling Savings = Annual cooling energy savings, in kWh

Cooling Capacity = System cooling capacity, in kBtu/h

$SEER_{Base}$ = Baseline Seasonal Energy Efficiency Ratio, nominal rating of system, see Table 157 for baseline values, Btu/Wh

Cooling EFLH = Effective full load cooling hours, see Table 159

CRF = Consumption reduction factor = 75%[257]

Baseline efficiencies are shown in Table 157.[258]

Table 157: Packaged AC system baseline efficiency ratings

Equipment Type	Size Category	Subcategory or rating condition	Minimum Efficiency
Air Conditioners	< 65,000 Btu/h	Split system	13.0 SEER
		Single package	14.0 SEER

Table 158: Default Refrigerated Cooling Load for Evaporative Cooling

Climate Zone	Cooling Capacity kBtu/h
Santa Fe	24
Albuquerque	30
Roswell	36
Las Cruces	36

[256] Department of Energy, https://www.energy.gov/energysaver/home-cooling-systems/evaporative-coolers.

[257] Ibid.

[258] IECC 2018

Cooling EFLH values, derived from eQuest simulations of DEER building prototypes, are shown in Table 159.

Table 159: Cooling EFLH by Building Type and Climate Zone

Building Type	Albuquerque	Las Cruces	Roswell	Santa Fe
Assembly	1,471	1,343	1,576	812
Education - Primary School	436	508	554	289
Education - Relocatable Classroom	490	560	595	354
Education - Secondary School	450	479	555	213
Grocery	824	961	1,038	391
Manufacturing - Light Industrial	743	958	950	519
Office - Small	1,083	1,174	1,292	770
Restaurant - Fast-Food	1,271	1,267	1,377	754
Restaurant - Sit-Down	1,236	1,218	1,361	681
Retail - Small	1,296	1,361	1,438	847
Storage - Conditioned	492	698	697	336
Other[259]	1,033	1,109	1,213	617

3.33.4 Demand Savings Estimation

Peak savings are determined with the following equation.

$$PeakSvgs = Cooling\ Capacity \times \frac{1}{EER_{Base}} \times CF \times CRF$$

Where:

EER_{Base} = Baseline Energy Efficiency Ratio, nominal rating of system, calculated by converting from baseline SEER in Table 157[260]

[259] This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g., a medical administration building could potentially be assessed using the "Office – Small" EFLH.

[260] Code specified SEER values converted to EER using EER = -0.02 x SEER^2 + 1.12 x SEER. National Renewable Energy Laboratory (NREL) 2010, "Building America House Simulation Protocols." U.S. DOE. Revised October www.nrel.gov/docs/fy11osti/49246.pdf.

CF = Coincidence Factor, see Table 160

Other parameters are as defined above for energy savings.

Coincidence factors are shown in Table 160. These values were derived from the Texas TRM version 5. The value for El Paso was used for Las Cruces, the value for Amarillo was used for Roswell, and the average of these two values was used for Albuquerque and Santa Fe.

Table 160: CF by Building Type and Climate Zone

Building Type	Albuquerque	Las Cruces	Roswell	Santa Fe
Assembly	0.78	0.91	0.64	0.78
Education - Primary School	0.78	0.91	0.64	0.78
Education - Relocatable Classroom	0.78	0.91	0.64	0.78
Education - Secondary School	0.78	0.87	0.69	0.78
Grocery	0.74	0.80	0.68	0.74
Manufacturing - Light Industrial	0.34	0.38	0.29	0.34
Office - Small	0.76	0.81	0.72	0.76
Restaurant - Fast-Food	0.75	0.76	0.73	0.75
Restaurant - Sit-Down	0.80	0.76	0.83	0.80
Retail - Small	0.79	0.83	0.75	0.79
Storage - Conditioned	0.55	0.75	0.34	0.55
Other[261]	0.34	0.38	0.29	0.34

3.33.5 Non-energy Benefits

Evaporative coolers supply a continuous stream of fresh air. They also add moisture to the air which can be beneficial for regions with low relative humidity. This can improve occupancy comfort and productivity.

[261] This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g., a medical administration building could potentially be assessed using the "Office – Small" CF

3.33.6 Measure Life

The lifetime for this measure is 15 years.[262]

3.33.7 Incremental Cost

The assumption for this measure is that this is an end-of-life replacement. The incremental cost (Direct Evaporative Cooler cost less than SEER 13 Split System AC cost) is $0.[263]

[262] DEER 2008

[263] DEER 2005

3.34 Small Business Furnace and Rooftop Unit Tune-Up (New)

This measure is for a fossil fuel furnace or Gas-Fired Rooftop Unit that provides space heating for a Small Business facility. The tune-up will improve furnace or gas-fired rooftop unit performance by inspecting, cleaning, and adjusting the furnace or rooftop unit and appurtenances for correct and efficient operation. Additional savings may be realized through a complete system tune-up

3.34.1 Measure Overview

Sector	Commercial
End use	Space Heating
Fuel	Natural Gas
Measure category	High Efficiency Gas Furnaces
Delivery mechanism	Rebate
Baseline description	Steady state furnace efficiency before tune-up
Efficient case description	Steady state furnace efficiency after tune-up

3.34.2 Savings

The baseline equipment is a furnace or gas-fired rooftop unit assumed not to have had a tune-up in the past 3 years.

To qualify for this measure an approved technician must complete the tune-up requirements listed below:[264]

- Measure combustion efficiency using an electronic flue gas analyzer
- Check and clean blower assembly and components per manufacturer's recommendations
- Where applicable, lubricate motor and inspect and replace fan belt if required
- Inspect for gas leaks
- Clean burner per manufacturer's recommendations and adjust as needed
- Check ignition system and safety systems and clean and adjust as needed
- Check and clean heat exchanger per manufacturer's recommendations
- Inspect exhaust/flue for proper attachment and operation
- Inspect control box, wiring and controls for proper connections and performance

[264] American Standard Heating & Air Conditioning, Maintenance for Indoor Units

- Check air filter and clean or replace per manufacturer's
- Inspect duct work connected to furnace for leaks or blockages
- Measure temperature rise and adjust flow as needed
- Check for correct line and load volts/amps
- Check thermostat operation is per manufacturer's recommendations (if adjustments made, refer to 'Small Commercial Programmable Thermostat Adjustment' measure for savings estimate)
- Perform carbon monoxide test and adjust heating system until results are within standard industry acceptable limits

3.34.3 Energy Savings Estimation

Electric savings are calculated based on the following formula:

$$\Delta kWh = \Delta Therms \times F_e \times 29.3$$

Where:

$\Delta Therms$ = as calculated below

F_e = Furnace fan energy consumption as a percentage of annual fuel consumption
= 7.7%[265]

29.3 = kWh per therm of natural gas

Therm savings are calculated based on the following formula:

$$\Delta Therms = Capacity \times EFLH \times \frac{\left(\frac{Eff_{before} + E_i}{Eff_{before}} - 1\right)}{100{,}000}$$

Where:

Capacity = Furnace gas input size (Btu/hr)

EFLH = heating equivalent full load hours for the appropriate weather zone (from Table 161)

Eff_{before} = Efficiency of the furnace before the tune-up

Note: Contractors should select a mid-level firing rate that appropriately represents the average building operating condition over the course of the

[265] Fe is estimated using TRM models for the three most popular building types for programmable thermostats: low-rise office (10.2%), sit-down restaurant (8.6%), and retail – strip mall (4.4%). 7.7% reflects the average Fe of the three building types.

heating season and take readings at a consistent firing rate for pre and post tune-up.

E_i = Efficiency Improvement of the furnace tune-up measure
= Actual

100,000 = Converts Btu to therms

For example, a 100 kBtu furnace in a Santa Fe large single story retail facility records an efficiency prior to tune-up of 82% AFUE and a 1.8% improvement in efficiency after tune-up:

$$\Delta therms = \frac{\left(100{,}000 \times 1{,}202 \times \left(\left(\frac{0.82 + 0.018}{0.82}\right) - 1\right)\right)}{100{,}000} = 26.4\ therm$$

Table 161: Heating EFLH by Building Type and Climate Zone

Building Type	Albuquerque	Las Cruces	Roswell	Santa Fe
Assembly	0	0	0	0
Education - Community College	0	0	0	0
Education - Primary School	698	500	497	929
Education - Relocatable Classroom	733	528	525	975
Education - Secondary School	733	528	525	975
Education - University	0	0	0	0
Grocery	0	0	0	0
Health/Medical – Hospital	0	0	0	0
Health/Medical - Nursing Home	0	0	0	0
Lodging - Hotel	782	383	381	1,040
Manufacturing - Bio/Tech	339	179	178	450
Manufacturing - Light Industrial	339	179	178	450
Office - Small	339	179	178	450
Restaurant - Fast-Food	1,025	639	636	1,363
Restaurant - Sit-Down	1,119	751	747	1,488
Retail - Single-Story Large	903	470	468	1,202
Retail - Small	750	549	546	998

Storage - Conditioned	0	0	0	0
Warehouse - Refrigerated	0	0	0	0
Other	339	179	178	450

3.34.4 Demand Savings Estimation

N/A

3.34.5 Non-energy Benefits

There are no non-energy benefits for this measure.

3.34.6 Measure Life

The measure life for the gas furnace tune-up is 3 years.[266]

3.34.7 Incremental Cost

The incremental cost for this measure should be the actual invoiced cost of the tune-up.

[266] Assumed consistent with other tune-up measures.

3.35 High Efficiency Pool Pumps (New/Replacement)

This measure is the characterization of the purchasing and installing of a new ENERGY STAR® or CEE T1 variable speed commercial pool pump motor in place of a new baseline pump meeting the federal standard for Time of Sale and New Construction, or the early replacement of a standard single speed motor of equivalent horsepower.

3.35.1 Measure Overview

Sector	Commercial
End use	Pool Water Pumping
Fuel	Electricity
Measure category	Water Pumping
Delivery mechanism	Rebate
Baseline description	Two speed commercial pool pump meeting the Federal Standard
Efficient case description	0.5 – 3 HP ENERGY STAR® or CEE T1 qualified multi-speed or variable-speed pool pump

3.35.2 Savings

Commercial outdoor pool pumps can be single speed, two/multi speed or variable speed. A federal standard (82 FR 5650) effective July 19, 2021 effectively requires new pumps to be at least two speed.

Single speed pumps are often oversized and run frequently at constant flow regardless of load. Single speed pool pumps require that the motor be sized for the task that requires the highest speed. As such, energy is wasted performing low speed tasks at high speed. Two speed and variable speed pool pumps reduce speed when less flow is required, such as when filtering is needed but not cleaning, and have timers that encourage programming for fewer on-hours. Variable speed pool pumps use advanced motor technologies to achieve efficiency ratings of 90% while the average single speed pump will have efficiency ratings between 30% and 70%.

The high efficiency equipment is an ENERGY STAR® or CEE Tier commercial pool pump meeting the ENERGY STAR minimum qualifications in Table 308 for either in-ground or above ground pools. ENERGY STAR® version 3.0 specification takes effect on July 19, 2021. Note that for in ground pools, the CEE Tier 1 is the same as the new Federal Standard, and Tier 2 is the same as ENERGY STAR® V3 for the standard size pumps, so savings for CEE Tier 1 is only provided for above ground pools where there is an increment in efficiency.

Table 162: Minimum Qualifications for High Efficiency Pool Pumps

Pump Sub-Type	Size Class	ENERGY STAR® Version 3.0 Energy Efficiency Level (Effective 7/19/2021)	CEE Tier I	CEE Tier 2
Self-Priming (Inground) Pool Pumps	Extra Small (hhp ≤ 0.13)	WEF ≥ 13.40	N/A	N/A
	Small (hhp > 0.13 and < 0.711)	WEF ≥ -2.45 x ln (hhp) + 8.40	WEF ≥ -1.30 x ln (hhp) + 4.95	WEF ≥ -2.83 x ln (hhp) + 8.84
	Standard Size (hhp ≥ 0.711)	WEF ≥ -2.45 x ln (hhp) + 8.40	WEF ≥ -2.3 x ln (hhp) + 6.59	WEF ≥ -2.45 x ln (hhp) + 8.4
Non-Self Priming (Aboveground) Pool Pumps	Extra Small (hhp ≤ 0.13)	WEF ≥ 4.92	N/A	N/A
	Standard Size (hhp > 0.13)	WEF ≥ -1.00 x ln (hhp) + 3.85	WEF ≥ -1.60 x ln (hhp) + 9.10	N/A

Baseline equipment is a two-speed commercial pool pump meeting the Federal Standard, effective July 19, 2021 provided in Table 309:

Table 163: Federal Standard for Baseline Pool Pumps

Pump Sub-Type	Size Class	Baseline (Effective 7/19/2021)
Self-Priming (Inground) Pool Pumps	Extra Small (hhp ≤ 0.13)	WEF ≥ 5.55
	Small (hhp > 0.13 and < 0.711)	WEF ≥ -1.30 x ln (hhp) + 2.90
	Standard Size (hhp ≥ 0.711)	WEF ≥ -2.30 x ln (hhp) + 6.59
Non-Self Priming (Aboveground) Pool Pumps	Extra Small (hhp ≤ 0.13)	WEF ≥ 4.60
	Standard Size (hhp > 0.13)	WEF ≥ -0.85 x ln (hhp) + 2.87

For early replacement, the baseline equipment is the existing single speed commercial pool pump.

3.35.3 Energy Savings Estimation[267]

For Time of Sale and New Construction:

$$\Delta kWh = \frac{\left(Gallons * Turnovers * \left(\frac{1}{WEF_{base}} - \frac{1}{WEF_{ESTAR}}\right) * Days\right)}{1000}$$

For Early Replacement:

$$\Delta kWh = \frac{\left(Gallons * Turnovers * \left(\frac{1}{EF_{Exist}} - \frac{1}{WEF_{ESTAR}}\right) * Days\right)}{1000}$$

Where:

Gallons = *Capacity of the pool*

= *Actual. If unknown assume:*

Pool Type	Gallons
In ground	22,000[268]
Above ground	7,540[269]

Turnovers = *Desired number of pool water turnovers per day*

= *2*[270]

WEF_{base} = *Weighted Energy Factor of baseline pump (gal/Wh)*[271]*:*

Pool Type	WEF_{Base}
In ground	4.63

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[267] The methodology followed is consistent with the most recent version of the 2020 ENERGY STAR calculator (Pool_Pump_Calculator_2020.05.05_FINAL.xls), however this has not been updated to account for the new federal standard.

[268] Consistent with assumption in the 2020 ENERGY STAR calculator.

[269] Based on typical pool sizes from "Evaluation of Potential Best Management Practices - Pools, Spas, and Fountains, The California Urban Water Conservation Council", 2010.

[270] Consistent with assumption in the 2020 ENERGY STAR calculator.

[271] Based on applying the federal standard specifications to the average Curve-C rated hydraulic horsepower (hhp) from the ENERGY STAR Qualified Products List, accessed 3/31/2021.

Above ground	2.57

WEF_{ESTAR} = *Weighted Energy Factor of ENERGY STAR® pump (gal/Wh):*[272]

Pool Type	WEF_{ESTAR}	
	ENERGY STAR®	**CEE Tier 1**
In ground	6.31	N/A
Above ground	3.49	8.53

EF_{Exist} = *Energy Factor of existing single speed pump (gal/Wh)*

= *2.3273*[274]

Days = *Number of days per year that the swimming pool is operational*

= *122*[275]

1,000 = *Conversion factor from Wh to kWh*

Based on the defaults provided above, the annual energy savings (ΔkWh) are detailed in the table below:

Pool Type	ΔkWh			
	TOS/NC		**Retrofit**	
	ENERGY STAR®	**CEE T1**	**ENERGY STAR®**	**CEE T1**
In ground	307.7	N/A	1512.1	N/A
Above ground	189.5	499.5	283.7	593.6

272 Based on applying the ENERGY STAR and CEE Tier 1 specifications to the average Curve-C rated hydraulic horsepower (hhp) from the ENERGY STAR Qualified Products List, accessed 3/31/2021.

274 Consistent with assumption in the 2020 ENERGY STAR calculator, assuming 1.5 HP pump.

275 Consistent with assumption in the 2020 ENERGY STAR calculator.

3.35.4 Demand Savings Estimation

For Time of Sale and New Construction:

$$\Delta kW = \left(\frac{\frac{kWh}{day_{base}}}{\frac{Hrs}{day_{base}}}\right) - \left(\frac{\frac{kWh}{day_{ESTAR}}}{\frac{Hr}{day_{ESTAR}}}\right) * CF$$

For Early Replacement:

$$\Delta kW = \left(\frac{\frac{kWh}{day_{Exist}}}{\frac{Hrs}{day_{Exist}}}\right) - \left(\frac{\frac{kWh}{day_{ESTAR}}}{\frac{Hr}{day_{ESTAR}}}\right) * CF$$

Where:

kWh/day = *daily energy consumption of pool pump, as defined above.*

= *Actual, defaults provided below:*

	ΔkWh/day			
Pool Type	**Base**	**ENERGY STAR®**	**CEE T1**	**Exist**
In ground	9.5	7	N/A	19.4
Above ground	5.9	4.3	1.8	6.6

Hrs/day_{base} = *daily run hours of pool pump*

= *(Gallons * Turnover) / GPM*

		Weighted Average GPM	**Hours/Day**
In ground	Base	43.6	16.8
	Efficient	32.2	22.8
	Exist	78	9.4
Above ground	Base	44.7	5.6
	Efficient	27.3	9.2
	Exist	78.1	3.2

CF =*Summer Peak Coincidence Factor for measure*

= *0.831*[276]

Based on defaults provided above:

Pool Type	ΔkW			
	TOS/NC		Retrofit	
	ENERGY STAR®	CEE T1	ENERGY STAR®	CEE T1
In ground	0.2152	N/A	1.4641	N/A
Above ground	0.4793	0.7094	1.3285	1.5586

3.35.5 Non-energy Benefits

N/A

3.35.6 Measure Life

The estimated useful life for a two speed or variable speed pool pump is 7 years.[277]

3.35.7 Deemed Measure Cost

For early replacement, the full replacement costs shall be used. A deferred new baseline cost (after 4 years) of replacing the existing equipment should also be included.

3.35.8 Incremental Cost

For time of sale and new construction, the incremental costs for ENERGY STAR® in-ground pool pumps are estimated as $314[278] and for above ground pool pumps are estimated as $930.[279]

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276 Based on assumptions of daily load pattern through pool season. Assumption was developed for Efficiency Vermont but is considered a reasonable estimate for New Mexico.

277 As recommended in Navigant 'ComEd Effective Useful Life Research Report', May 2018.

278 ENERGY STAR Pool Pump Calculator and represent the difference between the two/multi speed incremental cost and the variable speed incremental cost.

279 CEE Efficient Residential Swimming Pool Initiative, December 2012, page 18 and represent the difference between the two/multi speed incremental cost and the variable speed incremental cost.

3.36 High Efficiency Bathroom Exhaust Fans (New)

This market opportunity measure is for the purchase of a new bathroom fan to be used in either a typical usage or continuous usage application (i.e. to meet the need for continuous mechanical ventilation due to reduced air-infiltration from a tighter building shell.)

3.36.1 Measure Overview

Sector	Residential
End use	Building Shell
Fuel	Electric
Measure category	Exhaust Fans
Delivery mechanism	Rebate
Baseline description	New standard efficiency exhaust-only ventilation fan
Efficient case description	New efficient ENERGY STAR® or ENERGY STAR® Most Efficient exhaust-only ventilation fan, quiet (<2.0 sones) operating in accordance with recommended ventilation rate indicated by ASHRAE 62.2 – 2016.[280]

3.36.2 Savings

ENERGY STAR® specifications (effective October 1, 2015) and 2018 ENERGY STAR® Most Efficient specifications are provided below:

Efficiency Level	Fan Capacity	Minimum Efficacy Level (CFM/Watts)	Maximum Allowable Sound Level (sones)
ENERGY STAR®	10 – 89 CFM	2.8	2.0
	90 – 200 CFM	3.5	
ENERGY STAR® Most Efficient	All	10	

This measure applies to Standard Usage and Continuous Usage categories. The default savings are provided in Table 164 and Table 165.

[280] Bi-level controls may be used by efficient fans larger than 50 CFM

Table 164: High Efficiency Bathroom Exhaust Fan savings (kWh per year)[281]

					Energy Star®		Energy Star® Most Efficient	
Application	Min CFM	Max CFM	Average CFM	Base CFM/Watts	CFM/Watts	ΔkWh Savings	CFM/Watts	ΔkWh Savings
Standard Usage	10	89	70.6	1.7	4.9	28.9	12.0	38.2
	90	200	116.1	2.6	5.6	25.3	13.9	38.7
	Unknown		92.4	2.2	5.3	27.4	12.9	38.6
Continuous Usage	N/A		50	1.7	5.1	170.7	11.2	216.9

Table 165: High Efficiency Bathroom Exhaust Fan savings (kW per year)

Application	Min CFM	Max CFM	Average CFM	Energy Star® ΔkW Savings	Energy Star® Most Efficient ΔkW Savings
Standard Usage	10	89	70.6	0.0036	0.0047
	90	200	116.1	0.0031	0.0048
	Unknown		92.4	0.0034	0.0048
Continuous Usage	N/A		50	0.0195	0.0247

3.36.3 Energy Savings Estimation

Savings are derived with the following formula.

$$Svgs = CFM \times \frac{\left(\frac{1}{\eta_{Baseline}} - \frac{1}{\eta_{Efficient}}\right)}{1000} \times Hours$$

Where:

Svgs = Annual energy savings, in kWh

CFM = Nominal Capacity of the exhaust fan

[281] Based on review of Bathroom Exhaust Fan product available on CEC Appliance Database, accessed 6/18/2018. See 'CEC Bath Fan.xls' for more information.

= Actual or use defaults provided below

= Assume 50 CFM for Continuous Ventilation[282]

$\eta_{Baseline}$ = Average efficacy for Baseline fan (CFM/Watt)

= See Table 164

$\eta_{Efficient}$ = Average efficacy for Efficient fan (CFM/Watt)

= See Table 164

Hours = assumed annual hours

= 1,089 for standard usage[283]

= 8,766 for continuous usage

3.36.4 Demand Savings Estimation

Demand Savings are calculated as below.

$$PeakSvgs = CFM \times \frac{\left(\frac{1}{\eta_{Baseline}} - \frac{1}{\eta_{Efficient}}\right)}{1000} \times CF$$

Where:

CF = Summer Peak Coincidence Factor

= 0.135 for standard usage

= 1.0 for continuous usage

3.36.5 Non-energy Benefits

There are no non-energy benefits associated with this measure.

[282] 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.

[283] Assumed to be consistent with Residential Indoor Lighting hours of use.

3.36.6 Measure Life

The expected measure life is assumed to be 19 years.[284]

3.36.7 Deemed Measure Cost

NA

3.36.8 Incremental Cost

Incremental cost per installed fan is $43.50 for quiet, efficient fans.[285]

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[284] Conservative estimate based upon GDS Associates Measure Life Report "Residential and C&I Lighting and HVAC measures" 25 years for whole-house fans, and 19 for thermostatically controlled attic fans.

[285] VEIC analysis using cost data collected from wholesale vendor.

3.37 Irrigation Pump VFD (New)

This measure applies to variable speed drives (VSD) installed on irrigation pump motors for the agriculture industry.

3.37.1 Measure Overview

Sector	Commercial
End use	Water
Fuel	Electric
Measure category	Variable Frequency Drive (VFD)
Delivery mechanism	Rebate
Baseline description	Irrigation Pump not controlled by VFD
Efficient case description	Irrigation Pump controlled by VFD

3.37.2 Savings

The baseline is an irrigation pump with no VFD installed and has no controls. . The baseline must be an existing motor operating as is. The existing irrigation pump may or may not include bypass damper, guide vanes, throttling valves, or other methods of control. This information shall be collected from the customer.

Efficient case involves the installation of VFD to the existing pump. The VFD will modulate the speed of the motor when it does not need to run at full load. Since the power of the motor is proportional to the cube of the speed for these types of applications, significant energy savings will result. This law does not apply to positive displacement pumps.

Example:

A 20 HP TEFC 1800 rpm irrigation pump is installed with a VFD. The pump efficiency is 65%. The operation data points are given below. The pump runs for 4 hours every day throughout the year (1,460 hours). The required system flow rate is 100 gallons per minute.

Electric Savings is calculated for every data point and then added.

Sr. No.	Flow	Head	$Head_{VFD}$	%Hours	HP	HP_{VFD}	kWh_{Base}	kWh_{VFD}
1	250	130	130	0	13.6	14.0	0.0	0.0
2	225	155	105.3	5	14.6	10.2	793.4	555.7

Sr. No.	Flow	Head	$Head_{VFD}$	%Hours	HP	HP_{VFD}	kWh_{Base}	kWh_{VFD}
3	200	175	83.2	10	14.6	7.2	1592.5	780.5
4	175	190	63.7	10	13.9	4.8	1512.8	522.9
5	150	210	46.8	30	13.2	3.0	4299.6	987.8
6	125	215	32.5	20	11.2	1.7	2445.6	381.1
7	100	220	20.8	20	9.2	0.9	2001.9	195.1
8	75	227.5	11.7	5	7.1	0.4	388.2	20.6
9	50	230	5.2	0	4.8	0.1	0.0	0.0
10	25	232.5	1.3	0	2.4	0.0	0.0	0.0

kWh_{Base} = 13,034 kWh; kWh_{VFD} = 3,444 kWh

$\Delta kWh = kWh_{Base} - kWh_{VFD}$ = 9,590 kWh

3.37.3 Energy Savings Estimation

Savings are derived with the following formula.

$$Svgs = kWh_{Base} - kWh_{VFD}$$

$$kWh_{Base} = \sum_{1}^{n} HP_n \times 0.746 \frac{kW}{HP} \times Hours_{year} \times \%Hours_n$$

$$kWh_{VFD} = \sum_{1}^{n} HP_{VFD,n} \times 0.746 \frac{kW}{HP} \times Hours_{year} \times \%Hours_n$$

$$HP_n = \frac{Flow_n \times Head_n}{3960 \times (Eff_{pump} \times Eff_{motor})}$$

$$HP_n = \frac{Flow_n \times Head_{VFD,n}}{3960 \times (Eff_{pump} \times Eff_{VFD} \times Eff_{motor})}$$

$$Hours_{year} = \frac{Acres \times Irrigation}{12 \frac{in}{ft} \times 60 \frac{min}{hr} \times GPM_{system} \Big/ \left(7.481 \frac{gal}{ft^3} \times 43{,}560 \frac{ft^2}{acre}\right)}$$

Where:

Svgs = Annual energy savings, in kWh

kWh_{base}	= Annual energy required for the baseline pump condition
kWh_{base}	= Annual energy required with a VFD pump installed
HP_n	= Baseline horsepower required for a given flow rate
$HP_{VFD,n}$	= Horsepower required for a given flow rate with the VFD installed
$Hours_{year}$	= Annual Hours of irrigation
$\%Hours_n$	= Percent of time irrigation pump will be operating at a given flow rate
n	= Number of data points needed or collected
$Flow_n$	= Flow rate at a given data point in gallons per minute, use actual values
$Head_n$	= Pressure head at a given data point in feet, use actual values
$Head_{VFD,n}$	= Pressure head at a given data point in feet with a VFD
Eff_{pump}	= Percent efficiency of the pump, taken from manufacturers pump curve
Eff_{motor}	= Percent efficiency of the pump motor

Table 166: NEMA Premium Efficiency Motors Default Efficiencies[286]

	Open Drip Proof (ODP)			Totally Enclosed Fan-Cooled (TEFC)		
	# of Poles			# of Poles		
	6	4	2	6	4	2
	Speed (RPM)			Speed (RPM)		
Size HP	1200	1800 (Default)	3600	1200	1800	3600
1	0.825	0.855	0.77	0.825	0.855	0.77
1.5	0.865	0.865	0.84	0.875	0.865	0.84
2	0.875	0.865	0.855	0.885	0.865	0.855
3	0.885	0.895	0.855	0.895	0.895	0.865
5	0.895	0.895	0.865	0.895	0.895	0.885
7.5	0.902	0.91	0.885	0.91	0.917	0.895
10	0.917	0.917	0.895	0.91	0.917	0.902
15	0.917	0.93	0.902	0.917	0.924	0.91
20	0.924	0.93	0.91	0.917	0.93	0.91
25	0.93	0.936	0.917	0.93	0.936	0.917
30	0.936	0.941	0.917	0.93	0.936	0.917
40	0.941	0.941	0.924	0.941	0.941	0.924
50	0.941	0.945	0.93	0.941	0.945	0.93
60	0.945	0.95	0.936	0.945	0.95	0.936
75	0.945	0.95	0.936	0.945	0.954	0.936
100	0.95	0.954	0.936	0.95	0.954	0.941
125	0.95	0.954	0.941	0.95	0.954	0.95
150	0.954	0.958	0.941	0.958	0.958	0.95
200	0.954	0.958	0.95	0.958	0.962	0.954
250	0.954	0.958	0.95	0.958	0.962	0.958
300	0.954	0.958	0.954	0.958	0.962	0.958
350	0.954	0.958	0.954	0.958	0.962	0.958
400	0.958	0.958	0.958	0.958	0.962	0.958

[286] Douglass, J. (2005). Induction Motor Efficiency Standards. Washington State University and the Northwest Energy Efficiency Alliance, Extension Energy Program, Olympia, WA, October 2005.

	Open Drip Proof (ODP)			Totally Enclosed Fan-Cooled (TEFC)		
	# of Poles			# of Poles		
	6	4	2	6	4	2
	Speed (RPM)			Speed (RPM)		
Size HP	**1200**	**1800 (Default)**	**3600**	**1200**	**1800**	**3600**
450	0.962	0.962	0.958	0.958	0.962	0.958
500	0.962	0.962	0.958	0.958	0.962	0.958

Eff_{VFD} = Percent efficiency of the VFD

= 97%[287]

Acres = Size of the field that is being irrigated in acres

Irrigation = Gross irrigation required in inches per year

GPM_{system} = Required system flow rate in gallons per minute

3.37.4 Demand Savings Estimation

The installation of a VFD on an irrigation pump should not cause any energy reduction during peak runtimes.

3.37.5 Non-energy Benefits

While there may be water savings from the installation of a VFD on an irrigation pump, they are not being included at this time. Any water savings calculations should be calculated using site specific details.

3.37.6 Measure Life

The expected measure life is 15 years.[288]

[287] Estimated typical VFD efficiency, as sourced from; "Chapter 18: Variable Frequency Drive Evaluation Protocol", The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures, NREL, December 2014 (pg. 2)

[288] DEER 2008.

3.37.7 Deemed Measure Cost

Customer provided costs will be used when available. Default measure costs[289] are noted below for up to 75 hp motors. Custom costs must be gathered from the customer for motor sizes not listed below.

HP	Cost
1-9 HP	$1,874
10-19 HP	$2,967
20-29 HP	$4,060
30-39 HP	$5,154
40-49 HP	$6,247
50-59 HP	$7,340
60-69 HP	$8,433
70-75 HP	$9,526

3.37.8 Incremental Cost

[289] Average from IPL and MidAmerican VFD reported costs from rebate forms. IPL & MIdA VFD Costs.xls

3.38 Kitchen Demand Control Ventilation Controls (New)

Installation of commercial kitchen demand ventilation controls that vary the ventilation based on cooking load and/or time of day.

3.38.1 Measure Overview

Sector	Commercial
End use	Food Cooking / Frying
Fuel	Electricity & Natural Gas
Measure category	Food Service Equipment
Delivery mechanism	Rebate
Baseline description	Kitchen ventilation that has constant speed ventilation motor
Efficient case description	Kitchen demand ventilation motor controls

3.38.2 Savings

IECC 2018 specifies that Kitchen Demand Control Ventilation is a mandatory compliance pathway for systems over 5,000 CFM of exhaust airflow. As stated, each kitchen exhaust hood shall comply with one of the following:

- Not < 50% of all replacement air shall be transfer air that would otherwise be exhausted.
- Demand ventilation systems on not < 75% of the exhaust air that are configured to provide not less than 50% reduction in exhaust and replacement air system airflow rates including controls necessary to modulate airflow in response to appliance operation and maintain full capture and containment of smoke, effluent, and combustion products during cooking and idle.
- Listed energy recovery devices with a sensible heat recovery effectiveness not < 40% on not < 50% of the total exhaust airflow.

If one of these alternate compliance options is met, kitchen demand ventilation controls would not be required by code; however, in these situations the demand ventilation controls would be considered redundant and the energy savings would likely be reduced. As a result, this measure is only applicable to new kitchens/systems under 5,000 CFM of exhaust airflow.

To qualify for this measure the installed equipment must be a control system that varies the exhaust rate of kitchen ventilation (exhaust and/or makeup air fans) based on the energy and effluent output from the cooking appliances (i.e., the more heat and smoke/vapors generated, the more ventilation needed). There are three main demand control ventilation systems available that can achieve this type of modulation:

• Temperature sensors only. These systems ramp ventilation up and down based solely on the temperature from the cooking activity as measured in the ductwork or capture tank of the hood.
• Temperature and optical sensors. These systems offer the same functionality as systems with only temperature sensors plus the ability to change the ventilation rate based on the presence of smoke or steam.
• Temperature and infrared cooking sensors. These systems offer the same functionality as systems with only temperature sensors plus the ability to measure ventilation up and down based on when cooking starts.

3.38.3 Energy Savings Estimation

Electric savings are calculated based on the following:

kWh savings are assumed to be 4,966 kWh per horsepower of the fan.[290]

Therm savings are calculated based on the following formula:

$$\Delta Therms = CFM \times HP \times \frac{AHL}{Eff_{Heat} \times 100{,}000}$$

Where:

CFM = the average airflow reduction with ventilation controls per hood
= 430 cfm/HP[291]

HP = actual if known, otherwise assume 7.75 HP[292]

AHL = Annual heating energy required to heat fan exhaust make-up air, Btu/cfm dependent on location specified in Table 167:[293]

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290 Based on data provided in PGE Workpaper, Commercial Kitchen Demand Ventilation Controls, PGECOFST116, June 1, 2009. See 'Kitchen DCV.xls' for details

291 Based on data provided in PGE Workpaper, Commercial Kitchen Demand Ventilation Controls, PGECOFST116, June 1, 2009. See 'Kitchen DCV.xls' for details.

292 Average of units in PGE Workpaper, Commercial Kitchen Demand Ventilation Controls, PGECOFST116, June 1, 2009

293 Food Service Technology Center Outside Air Load Calculator, with inputs of one cfm, and hours from Commercial Kitchen Demand Ventilation Controls (Average 17.8 hours a day 4.45 am to 10.30 pm. Regression analysis was used to calculate the annual heating loads for New Mexico based on HDD for the applicable climate zones and annual heating loads as published in the IL TRM v10.0.

Table 167: Annual Heating Loads for New Mexico climate zones

Zone (where applicable)	Annual Heating Load (AHL), Btu/cfm
Santa Fe	120,971
Albuquerque	94,751
Roswell	76,774
Las Cruces	64,923

Eff_Heat = Heat Efficiency

= actual if known, otherwise assume 80%[294]

100,000 = Converts Btu to therms

3.38.4 Demand Savings Estimation

Electric demand savings are calculated based on the following:

kW savings are assumed to be 0.68 kW per horsepower of the fan.[295]

3.38.5 Non-energy Benefits

3.38.6 Measure Life

The expected measure life is assumed to be 20 years.[296]

3.38.7 Incremental Cost

The incremental capital cost for this measure is $1,992 per HP of fan for DVC Control - Retrofit and $1,180 per HP of fan for DVC Control - New.[297]

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294 Work Paper WPRRSGNGRO301 CLEAResult "Boiler Tune-Up" which cites Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0, PA Consulting, KEMA, March 22, 2010.

295 Based on data provided in PGE Workpaper, Commercial Kitchen Demand Ventilation Controls, PGECOFST116, June 1, 2009. See 'Kitchen DCV.xls' for details.

296 "Commercial Kitchen Ventilation: An Energy Efficiency Program Administrator's Guide to Demand Control Ventilation", CEE, October 2010 (pg. 9). The 20-year measure life estimate is based on interviews with manufacturer and industry experts.

297 The incremental costs were derived from Southern California Edison (SCE) program data on 72 demand control kitchen ventilation project installations between 2013 and 2017 "SCE13CC008._Exhaust_Hood_DCKV_Exhaust_CFM_and_Cost_Field_Data.xlsx"). For reference, the baseline

measure costs were factored out accordingly, being obtained from costs for five kitchen exhaust fans from RSMeans online in 2017. For more detail on the source of these cost estimates, please see the California eTRM – Exhaust Hood Demand Controlled Ventilation, Commercial measure (SWFS012-01), March 4, 2020.

3.39 Refrigerated Walk-in and Reach-in Permanent Magnet Synchronous Motor (PMSM) Evaporator Fan Motor (New)

This measure covers replacement of single-phase shaded pole (SP) or permanent split capacitor (PSC) evaporator fan motors with electronically commutated (EC) motors in walk-in and reach-in refrigerated cases.

3.39.1 Measure Overview

Sector	Commercial
End use	Walk-in and Reach-in Refrigerated cases
Fuel	Electric
Measure category	Grocery store
Delivery mechanism	Rebate
Baseline description	Single-phase Shaded Pole (SP) or Permanent Split Capacitor (PSC) or Electronically Commutated (EC) evaporator fan motors
Efficient case description	Permanent Magnet Synchronous Motor (PMSM) evaporator fan motors

3.39.2 Savings

The high-efficiency motors save energy by reducing evaporator fan power and through interactive effects with the system's compressor. PMSMs provide increased efficiency over other motors requiring less energy to operate and introducing less heat into the refrigerated case, which reduces the total refrigeration load.

The baseline condition for walk-in coolers or freezers manufactured on or after January 1, 2009 is an EC motor298 with full load efficiency as prescribed by federal energy conservation standards for electric motors in 10 CFR 431.446 and 10 CFR 431.25, as applicable. The baseline condition for walk-in coolers or freezers manufactured before January 1, 2009 and reach-in refrigerated display cases is equivalent to the equipment being replaced (shaded pole or PSC motor). Baseline equipment shall be assumed to be of equivalent speed and horsepower to the efficient case.

298 10 CFR 431.306

The compliance condition is a PMSM installed in a commercial refrigerated reach-in display case or walk-in cooler/freezer with full-load efficiency exceeding that prescribed by federal energy conservation standards for electric motors in 10 CFR 431.446 or 10 CFR 431.25, as applicable.

3.39.3 Energy Savings Estimation

Annual electric energy savings can calculated using the following algorithm:

$$\Delta kWh = units \times \left(\frac{W_{ee}}{1{,}000}\right) \times \left(\frac{1}{Eff_{baseline}} - \frac{1}{Eff_{ee}}\right) \text{x} \left(1 + \frac{1}{COP_{ref}}\right) \text{x}\ hrs$$

where:

ΔkWh	= Annual electric energy savings
units	= Number of measures installed under the program
W_{ee}	= Rated motor wattage (energy efficient)
Eff	= Motor efficiency
hrs	= Annual operating hours
COP_{ref}	= Coefficient of performance of refrigeration equipment
1,000	= Conversion factor, one kW equals 1,000 W

Summary of Variable and Data Sources

Variable	Value	Source
W_{ee}		From application
hrs (Walk-In)	Control Type: On/Off Control: 5,571 Multistep Control: 6,062 No Cooler Control: 8,567	Based on refrigeration control type[299]
hrs (Refrigerated Case)	8,573	PG&E Workpaper[300]
$Eff_{Baseline}$	Shaded Pole: 0.20 PSC: 0.29 EC: 0.66	For replacement of motors in reach-in cases, look up based on existing motor type.[301] For new construction,

[299] Cadmus, Commercial Refrigeration Loadshape Project, October 2015, Table 4. Average Parameters – EF Motors pg. 6. The study analyzes reach-in and walk-in coolers and freezers. The annual operating hours of a walk-in cooler or freezer evaporator fan motor without controls is derived as 97.8% x 8,760 = 8,567 hours. The effective full load annual run time of evaporator fans with on/off control are assumed to be 63.6% x 8,760 = 5,571 hours, while the effective full load annual run time of evaporator fans with multispeed control are assumed to be 69.2% x 8,760 = 6,062 hours.

[300] PG&E Work Paper PGE3PREF124 Revision 2. Average of operating hours of medium temperature applications and low temperature applications

[301] U.S. DOE, Technical Support Document Commercial Refrigeration Equipment, Chapter 5, Table 5.6.4: Details for Evaporator Fan Motor Design Option

		unknown existing conditions and walk-in coolers and freezers, use value associated with EC motors
Eff_{ee}	0.73	Oak Ridge National Laboratory[302]
COP_{ref}		From application; COP = 3.517/(kW/ton), where kW/ton is the rated efficiency of the compressor in input kW per ton of refrigeration capacity

3.39.4 Demand Savings Estimation

Summer peak coincident demand savings can be calculated using the following algorithm:

$$\Delta kW = \frac{\Delta kWh}{hrs} \times CF$$

where:

CF = 1.0[303]

3.39.5 Non-energy Benefits

There are no non-energy benefits.

3.39.6 Measure Life

The measure equipment effective useful life (EUL) is estimated at 15 years[304].

3.39.7 Incremental Cost

The measure cost is assumed to be $230.94 (EC Motor equipment) plus $73.65 (EC Motor labor) = $304.59 per motor for a walk in cooler and walk in freezer.[305]

302 ORNL, Q-Sync Motors in Commercial Refrigeration: Preliminary Test Results and Projected Benefits

303 It is safe to assume evaporator fans will be operational in active facilities during peak period

304 DEER 2014 EUL ID: GrocDispFEvapFanMtr

305 DEER, Work Paper PGE3PREF126 ECM for Walk-In Evaporator with Fan Controller Revision # 2

3.41 Commercial Solid and Glass Door Refrigerators & Freezers (New)

This measure relates to the installation of a new reach-in commercial refrigerator or freezer meeting ENERGY STAR® efficiency standards. ENERGY STAR® labeled commercial refrigerators and freezers are more energy efficient than non-ENERGY STAR® certified equipment because they are designed with components such as ECM evaporator and condenser fan motors, hot gas anti-sweat heaters, or high-efficiency compressors. The efficient equipment is assumed to be a new ENERGY STAR® certified vertical closed solid or glass door refrigerator or freezer meeting energy consumptions requirements as determined by door type (solid or glass) and refrigerated volume (V).

3.41.1 Measure Overview

Sector	Commercial
End use	Food Refrigeration
Fuel	Electricity
Measure category	Food Service Equipment
Delivery mechanism	TOS and NC
Baseline description	New NON-ENERGY STAR® Certified Refrigerator and Freezer
Efficient case description	ENERGY STAR® Certified Refrigerator and Freezer

3.41.2 Energy Savings Estimation

ELECTRIC ENERGY SAVINGS (ΔkWh)

$$\Delta kWh = (kWh_{base} - kWh_{ee}) * 365.25$$

Where

kWh_{base} = baseline maximum daily energy consumption in kWh

= calculated using actual chilled or frozen compartment volume (V) of the efficient unit as shown in the Table 168 below.

Table 168. Baseline maximum daily energy consumption in kWh

Type	kWhbase[306]
Solid Door Refrigerator	0.05 * V + 1.36
Glass Door Refrigerator	0.1 * V + 0.86
Solid Door Freezer	0.22 * V + 1.38
Glass Door Freezer	0.29 * V + 2.95

kWh_{ee}[307] = efficient maximum daily energy consumption in kWh

= calculated using actual chilled or frozen compartment volume (V) of the efficient unit as shown in theTable 168.

Table 169. ENERGY STAR® Requirements (Version 4.0, Effective March 27, 2017)

Maximum Daily Energy Consumption (kWh/day)		
Volume (ft³)	**Refrigerator**	**Freezer**
Vertical Closed		
Solid Door		
0 < V < 15	≤ 0.022V + 0.97	≤ 0.21V + 0.9
15 ≤ V < 30	≤ 0.066V + 0.31	≤ 0.12V + 2.248
30 ≤ V < 50	≤ 0.04V + 1.09	≤ 0.285V -2.703
V ≥ 50	≤ 0.024V + 1.89	≤ 0.142V + 4.445
Glass Door		
0 < V < 15	≤ 0.095V + 0.445	≤ 0.232V + 2.36
15 ≤ V < 30	≤ 0.05V + 1.12	
30 ≤ V < 50	≤ 0.076V + 0.34	
V ≥ 50	≤ 0.105V – 1.111	

3.41.3 Demand Savings Estimation

SUMMER COINCIDENT PEAK DEMAND SAVINGS

306 Federal standards for equipment manufactured on or after March 27, 2017: 10 CFR §431.66 - Energy Conservation Standards for Commercial Refrigerators, Freezers and Refrigerator-Freezers.

307 ENERGY STAR Program Requirements for Commercial Refrigerators and Freezers Partner Commitments Version 4.0, effective March 27, 2017

$$\Delta kW = \frac{\Delta kWh}{Hours} \; x \; CF$$

Where:

HOURS = annual operating hours. Equipment is assumed to operate continuously, 24 hours per day, 365.25 days per year.

= 8,766

CF = Summer Peak Coincidence Factor for measure

= 0.937[308]

3.41.4 Non Energy Benefits

There are no non-energy benefits associated with this measure.

3.41.5 Measure Life

The expected measure life is assumed to be 12 years.[309]

3.41.6 Incremental Cost

The incremental capital cost per cubic foot of chilled or frozen compartment volume for this measure is provided Table 170 below.[310]

Table 170. Incremental Cost ($/ft³)

Equipment Type	Incremental Cost per Cubic Foot (ft³)
Solid Door	
Refrigerator	$24.21
Freezer	$30.41
Glass Door	
Refrigerator	$24.77
Freezer	$33.01

[308] The CF for Commercial Refrigeration was calculated based upon the Ameren provided eShapes

[309] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008.

[310] Incremental costs are based on the Northwest Regional Technical Forum, ENERGY STAR Version 4.0 Analysis. For cost calculation details, see the CostData&Analysis tab within the file Commercial Refrigerators & Freezers_Costs_Nov 2017.xlsm.

3.42 Commercial Smart Thermostats (New)

This measure characterizes the energy savings from the installation of either a Programmable or an advanced Thermostat to reduce heating and cooling consumption in a small commercial building.

The thermostat must be installed to control a single-zone HVAC system. This measure is limited to packaged HVAC units 10 tons or less. This measure does not apply when HVAC systems are being replaced, in new construction applications, or whenever code compliance is required.

3.42.1 Measure Overview

Sector	Commercial
End use	HVAC
Fuel	Electricity and Natural Gas
Measure category	Commercial Smart Thermostats
Delivery mechanism	Rebate
Baseline description	Manual or programmable thermostat
Efficient case description	Advanced Thermostat

3.42.2 Savings

The savings for this measure are based on studies as summarized in Illinois Statewide Technical Reference Manual for Energy Efficiency (Version 11.0).

Heating savings are based upon a percentage of savings from the Residential version of this measure.

Cooling savings are based on research on small commercial programmable thermostat installations[311].

Future research on heating savings percentages for small commercial applications, and heating and cooling savings percentages for Advanced Thermostat applications should be conducted to improve these assumptions.

311 See "Small Commercial Thermostats Research," memorandum from Guidehouse to ComEd dated May 15, 2020

3.42.3 Energy Savings Estimation

Savings are derived with the following formula.

$$\Delta kWh = \Delta kWh_{heati} \quad + \Delta kWh_{cooling}$$

$$\Delta kWh_{heating} = \left(\%ElecHeat * \frac{kBtu}{hr}_{heat} * \frac{1}{HSPF} * EFLH_{heat} * Heating_{Reduction} * BAF\right) + (\Delta Therms * Fe * 29.3)$$

$$\Delta kWh_{cool} = \frac{kBtu}{hr}_{cool} * \frac{1}{SEER} * EFLH_{cool} * Cooling_{Reduction} * BAF$$

Where:

%ElecHeat = Percentage of heating savings assumed to be electric

= 1 if electric heat, 0 if gas heat. If unknown, assume 0.08[312].

$kBtu/hr_{heat}$ = Capacity of the heating equipment in kBtu per hour.

= Actual. If unknown assume 114.5[313]

HSPFbase = Heating Seasonal Performance Factor of the baseline equipment

= Actual, if unknown efficiency assume Code baseline for equipment type. Refer to Table 173. If equipment type unknown, determine efficiency through evalulation.

EFLHheat = Heating mode equivalent full load hours. Refer to Table 171.

Heating_Reduction = Assumed percentage reduction in total building heating

energy consumption due to thermostat

= 8.8%[314]

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312 Based on percentage of customers in ComEd Small Business Thermostat program with electric heat.

313 Average capacity of 705 installs of thermostats in Ameren Illinois territory installed from 2015-2020.

314 Assumed equal to assumption for Residential Advanced Thermostats with manual thermostat baseline, before adding savings from Thermostat Optimization (which is not applicable to small commercial customers). Note that a Guidehouse billing study in CY2020 did not find a statistically significant basis for adjusting this assumption for commercial applications, see "Small Commercial Thermostats TRM Research" memo. April 21, 2021.

Fe = Furnace Fan energy consumption as a percentage of annual fuel consumption

= 7.7%[315]

29.3 = kWh per therm

kBtu/hrcool = Capacity of the cooling equipment actually installed in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/hr)

= Actual. If unknown assume 61.0[316]

SEER = Seasonal Energy Efficiency Ratio of the cooling equipment

= Actual, is unknown assume Code baseline. Refer to Table 173

$EFLH_{cool}$ = Equivalent Full Load Hours for cooling. Refer to Table 172

Cooling_Reduction = Average percentage reduction in total building cooling energy consumption due to installation of thermostat:

= 17.7%[317]

BAF = Baseline adjustment factor.

= 1.0, if the baseline thermostat was manual type

Estimates of heating and cooling reduction factors are based on consumption data analyses with matching to non-participants and are therefore net with respect to participant spillover and between net and gross with respect to free ridership. Like all consumption data analyses, they are gross with respect to non-participant spillover. For more detail, see Table 5-3 in Volume 4 of the IL-TRM. Consistent with Section 7.2 of the Illinois EE Policy Manual, applicable net-to-gross adjustments to these factors will be determined as part of the annual SAG net-to-gross process.

[315] Fe is estimated using TRM models for the three most popular building types for programmable thermostats: low-rise office (10.2%), sit-down restaurant (8.6%), and retail – strip mall (4.4%). 7.7% reflects the average Fe of the three building types. See "Fan Energy Factor Example Calculation 2021-06-23.xlsx" for reference.

[316] Average capacity of 639 installs of thermostats on units <=10tons in Ameren Illinois territory installed from 2015-2020 and 706 installs on units <=10tons in ComEd territory in 2021.

[317] Based on research conducted by Guidehouse on a sample of IL Small Commercial programmable thermostat installations, which found a range of savings values depending on the modeling assumptions used. Guidehouse recommended selecting the midpoint of this range, which it deemed preferable to continuing to rely on Residential assumptions, while also accounting for the relative uncertainties involved. See "Small Commercial Thermostats Research" memo completed in 2020. Estimates of heating and cooling reduction factors are based on consumption data analyses with matching to non-participants and are therefore net with respect to participant spillover and between net and gross with respect to free ridership. Like all consumption data analyses, they are gross with respect to non-participant spillover. For more detail, see Table 5-3 in Volume 4 of the IL-TRM. Consistent with Section 7.2 of the Illinois EE Policy Manual, applicable net-to-gross adjustments to these factors will be determined as part of the annual SAG net-to-gross process.

= 0.6, if the baseline thermostat was programmable type[318]

= 0.8, if the baseline is unknown[319]

ΔTherms = Therm savings if Natural Gas heating system

$$= (1 - \%ElectricHeat) * EFLH_{heat} * Capacity * \frac{1}{AFUE} * Heating_{Reduction} * BAF * \frac{1}{100{,}000}$$

Capacity = Nominal Heating Input Capacity (Btu/hr) of heating system

= Actual

AFUE = Annual Fuel Utilization Efficiency Rating

= Actual, if unknown use 80% for natural gas water heaters

100,000 = Conversion from Btu to Therms

Heating EFLH values are shown in Table 171. Heating EFLH values are derived from the Texas TRM version 5, adjusting the Texas values based on heating degree-days comparisons between Amarillo, Albuquerque, and Santa Fe, and El Paso, Las Cruces, and Roswell. Values that are blank in the Texas TRM were entered as zero in Table 171.

Table 171: Heating EFLH by building type and climate zone

Building Type	Albuquerque	Las Cruces	Roswell	Santa Fe
Assembly	0	0	0	0
Education - Community College	0	0	0	0
Education - Primary School	698	500	497	929
Education - Relocatable Classroom	733	528	525	975
Education - Secondary School	733	528	525	975
Education - University	0	0	0	0

318 This factor represents the ratio of thermostat adjustment savings to thermostat replacement savings. It is based on actual thermostat algorithm data (i.e., degrees of setback, hours values, fan modes) from two years of ComEd AirCare Plus Program data (PY9+ and CY2018), including 382 thermostat adjustment installations and 3,847 thermostat replacement installations. An analysis of the data showed that on average, thermostat adjustments saved 61% and 59% of the thermostat replacement cooling savings and heating savings, respectively. For simplicity, a value of 0.6 was selected for both cooling and heating savings adjustment. See IL TRM Workpaper "4.4.48 Small Commercial Thermostats", Guidehouse, 6/23/2021 for details.

319 4 Review of ComEd's 2020 Baseline Study and 2019-2020 Program Data indicates that approximately half of installs are in buildings with existing manual thermostats, and half with existing programmable thermostats

Grocery	0	0	0	0
Health/Medical – Hospital	0	0	0	0
Health/Medical - Nursing Home	0	0	0	0
Lodging - Hotel	782	383	381	1,040
Manufacturing - Bio/Tech	339	179	178	450
Manufacturing - Light Industrial	339	179	178	450
Office - Small	339	179	178	450
Restaurant - Fast-Food	1,025	639	636	1,363
Restaurant - Sit-Down	1,119	751	747	1,488
Retail - Single-Story Large	903	470	468	1,202
Retail - Small	750	549	546	998
Storage - Conditioned	0	0	0	0
Warehouse - Refrigerated	0	0	0	0
Other[320]	339	179	178	450

Cooling EFLH values, derived from eQuest simulations of DEER building prototypes, are shown in Table 172.

Table 172: Cooling EFLH by building type and climate zone

Building Type	Albuquerque	Las Cruces	Roswell	Santa Fe
Assembly	1,471	1,343	1,576	812
Education - Community College	1,085	1,290	1,360	629
Education - Primary School	436	508	554	289
Education - Relocatable Classroom	490	560	595	354
Education - Secondary School	450	479	555	213
Education - University	1,032	1,233	1,324	643
Grocery	824	961	1,038	391
Health/Medical – Hospital	1,189	1,181	1,387	604
Health/Medical - Nursing Home	984	958	1,206	481

320 This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g. a medical administration building could potentially be assessed using the "Office – Small" EFLH

Lodging - Hotel	1,521	1,679	1,797	974
Manufacturing - Bio/Tech	1,115	1,238	1,332	795
Manufacturing - Light Industrial	743	958	950	519
Office - Small	1,083	1,174	1,292	770
Restaurant - Fast-Food	1,271	1,267	1,377	754
Restaurant - Sit-Down	1,236	1,218	1,361	681
Retail - Single-Story Large	1,437	1,470	1,603	885
Retail - Small	1,296	1,361	1,438	847
Storage - Conditioned	492	698	697	336
Warehouse - Refrigerated	1,477	1,498	1,596	745
Other[321]	1,033	1,109	1,213	617

Baseline efficiencies are shown in Table 173.[322]

Table 173: Packaged AC system baseline efficiency ratings

Equipment Type	Size Category	Subcategory or rating condition	Minimum Efficiency[b,c]
Air Conditioners and Heat Pumps, Air cooled	< 65,000 Btu/h	Split system	13.0 SEER
		Single package	14.0 SEER
	≥65,000 Btu/h and <135,000 Btu/h	Split system and single package	11.2 EER 12.8 IEER
	≥135,000 Btu/h and <240,000 Btu/h	Split system and single package	11.0 EER 12.4 IEER
	≥240,000 Btu/h and <760,000 Btu/h	Split system and single package	10.0 EER 11.6 IEER
	≥760,000 Btu/h	Split system and single package	9.7 EER 11.2 IEER
Heat Pumps, Air cooled (Heating mode)	< 65,000 Btu/h (cooling capacity)	Split system	8.2 HSPF
		Single package	8.0 HSPF

321 This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g. a medical administration building could potentially be assessed using the "Office – Small" EFLH.

322 IECC 2018 Table C403.3.2(1) and Table C403.3.2(2)

≥65,000 Btu/h and <135,000 Btu/h (cooling capacity)	47-F db/43-F wb Outdoor air	3.3 COP
≥135,000 Btu/h (cooling capacity)	47-F db/43-F wb Outdoor air	3.2 COP

[b] IPLVs are only applicable to equipment with capacity modulation
[c] Deduct 0.2 from the required EERs and IPLVs for units with a heating section other than electric resistance heat

For Example, if a small Retail shop in Santa Fe retrofits a programmable thermostat with a smart thermostat the estimated savings can be calculated using :

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

$$\Delta kWh = (0.08 * 114.5 * 1/3.412 * 998 * 0.088 * 0.6) + ((0.92 * (0.92 * 998 * 114500 * 1/0.8 * 0.088 * 0.6/100{,}000) * 0.077 * 29.3) + (24 * 1/13 * 847 * 0.177 * 0.6)$$

$$= 256.7 + 166.1 = 422.8 \text{ kWh}$$

3.42.4 Demand Savings Estimation

$$\Delta kW = \frac{kBtu}{hr}_{cool} * \frac{1}{EER} * Cooling_{Reduction} * BAF * CF$$

Where:

EER = Energy Efficiency Ratio of the equipment

= Actual, if unknown assume Code baseline. For air-cooled units

<65 kBtu/hr, assume the following conversion from SEER to EER

for calculation of peak savings:[323]

*EER = (-0.02 * SEER2) + (1.12 * SEER)*

CF = Coincidence Factor, see Table 174

[323] Based on Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder. Note this is appropriate for single speed units only.

Remaining variables are defined in the kWh savings section above.

Coincidence factors are shown in Table 174. These values were derived from the Texas TRM version 5. The value for El Paso was used for Las Cruces, the value for Amarillo was used for Roswell, and the average of these two values was used for Albuquerque and Santa Fe.

Table 174: CF by building type and climate zone

Building Type	Albuquerque	Las Cruces	Roswell	Santa Fe
Assembly	0.78	0.91	0.64	0.78
Education - Community College	0.78	0.87	0.69	0.78
Education - Primary School	0.78	0.91	0.64	0.78
Education - Relocatable Classroom	0.78	0.91	0.64	0.78
Education - Secondary School	0.78	0.87	0.69	0.78
Education - University	0.78	0.87	0.69	0.78
Grocery	0.74	0.80	0.68	0.74
Health/Medical – Hospital	0.77	0.81	0.72	0.77
Health/Medical - Nursing Home	0.78	0.88	0.68	0.78
Lodging - Hotel	0.61	0.63	0.58	0.61
Manufacturing - Bio/Tech	0.34	0.38	0.29	0.34
Manufacturing - Light Industrial	0.34	0.38	0.29	0.34
Office - Small	0.76	0.81	0.72	0.76
Restaurant - Fast-Food	0.75	0.76	0.73	0.75
Restaurant - Sit-Down	0.80	0.76	0.83	0.80
Retail - Single-Story Large	0.80	0.80	0.80	0.80
Retail - Small	0.79	0.83	0.75	0.79
Storage - Conditioned	0.55	0.75	0.34	0.55
Warehouse - Refrigerated	0.55	0.75	0.34	0.55
Other[324]	0.34	0.38	0.29	0.34

[324] This building type may be used for facilities which cannot be adequately classified by the other listed building types. Before using this building type, care should be taken to consider if any of the other building types reasonably represent the operation of the facility in question (e.g. a medical administration building could potentially be assessed using the "Office – Small" CF

For the above-mentioned example,

$$\Delta kW = 24 * \frac{1}{((-0.02 * 132) + (1.12 * 13))} * 0.177 * 0.6 * 0.79 = 0.18\, kW$$

3.42.5 Non-energy Benefits

There are no non-energy benefits for this measure.

3.42.6 Measure Life

The expected measure life is assumed to be 11 years.[325]

3.42.7 Deemed Measure Cost

For DI and other programs for which installation services are provided, the actual material, labor, and other costs should be used. If unknown, then the average incremental cost for the new installation measure is assumed to be $175.

3.42.8 Incremental Cost

[325] Based on 2017 Residential Smart Thermostat Workpaper, prepared by SCE and Nest for SCE (Work Paper SCE17HC054, Revision #0). Estimate ability of smart systems to continue providing savings after disconnection and conduct statistical survival analysis which yields 9.2-13.8 year range.

3.43 Hand Dryer (New)

This measure consists of installing efficient hand dryers that save energy by drying with air movement, using motion sensors, and reducing drying time. Energy efficient hand dryers use less energy per dry than standard hand dryers. Hand dryers are applicable in retail, commercial, and industrial settings.

To qualify for this measure, existing hand dryer equipment must currently utilize more than 5 watt-hour (Wh) or more per use and replacement hand dryers must consume no more than 5 Wh per use. This measure is applicable in retail, commercial and industrial settings.

3.43.1 Measure Overview

Sector	Commercial
End use	Hand Drying
Fuel	Electricity
Measure category	Commercial Hand Dryer
Delivery mechanism	Direct Install
Baseline description	5 or more Wh per use. Usually, these hand dryers are push-button activated.
Efficient case description	Installing efficient hand dryers that use less energy per dry

3.43.2 Savings

Allowable methods of deriving savings are described below:

3.43.3 Energy Savings Estimation

Electric Energy Savings

The energy savings from the installation of efficient hand dryers are a result of savings due to decrease in power and or runtime of the efficient hand dryers over the pre-retrofit equipment. The energy savings are calculated using the following equations:

$$\Delta kWh = \frac{UPD * DPY * (\Delta Wh)}{1000}$$

Where:

UPD = Number of uses per day.

= If not known, use assumption from the table below.

DPY = Number of days the facility operates per year.

= If not known, use assumption from the table below

Building Type	**Usage**	**Uses per day**[326]	**Days per year** [327]
Office / Warehouse	Low	50	250
Restaurant / Small Grocery / Retail	Medium/Moderate	250	365
School/University / Theater / Conference Center	High	500	200
Large Grocery / Retail	High-Grocery	500	365
Transportation Center / Stadium / Airport	Heavy Duty/ Extreme	2500	365

ΔWh = Change in Watt-hours from baseline to efficient.

$$\Delta Wh = \frac{(Power * Cycle\ Time)_{Baseline} - (Power * Cycle\ Time)_{Efficient}}{3600\,\frac{Sec}{Hr}}$$

Where:

Power = Unit wattage.

= If not known, use assumption from the table below.

Cycle Time = Runtime seconds per use.

= If not known, use assumption from the table below.

Assumption	**Power (Watts)**	**Cycle Time (Seconds)**

326 Industry Standard. Medium/Moderate Uses per day is supported by both Excel Dryer Data (Cost Savings with Hand Dryers vs Average Cost of Paper Towels https://www.exceldryer.com/calculator-dial/) and World Dryer Data (http://staging.worlddryer.com/savings-calculator)

327 Illinois TRM v9.0, Days per year, from 4.3.2 Low Flow Faucet Aerators

Baseline[328]	2036	37
Efficient[329]	1066	12

3.4

For example, a new efficient hand dryer replacing a baseline hand dryer at a large grocery store, with unknown uses per day and unknown days per year:

ΔkWh = (500 * 365 * (((2036*37) - (1066*12)) /3600)) /1000

= 3,170.4 kWh

3.43.5 Demand Savings Estimation

$$\Delta kW = \frac{\Delta kWh}{HOU} * CF$$

Where:

HOU = Use building hours, if known.

= If hours not known, hours are selected from the fixture hours column of the lighting reference table in section 3.3 for each building type.

CF = Coincident Factor, use 1.0.

For example, a new efficient hand dryer replacing a baseline hand dryer at a large grocery store, with unknown uses per day and unknown days per year:

ΔkW = 3,170.4 / 5,468 * 1.0

= 0.58 kW

3.43.6 Non-energy Benefits

There are no non-energy benefits for this measure.

3.43.7 Measure Life

The measure life for a new energy efficient hand dryer is 10 years [330]

[328] CLEAResult survey of 24 hand dryers in convenience stores in Arkansas. See Hand_Dryer_Analysis.xlsx. 1567

[329] CLEAResult cost/specification survey of 10 unique efficient hand dryers. See Hand_Dryer_Analysis.xlsx

[330]Based on studies conducted by two separate parties; Comparative Environmental Life Cycle Assessment of Hand Drying Systems by Quantis (pg 2) and Guidelines to Reduce/Eliminate Paper Towel Use by Installing Electric Hand Dryers by Partners in Pollution Prevention P3 (pg 17)

3.43.8 Deemed Measure Cost

The incremental cost is $483. The baseline cost for a hand dryer is $368. Efficient cost for an efficient hand dryer is $851.

3.44 Building Operator Certificate (New)

Building Operator Certification (BOC) is a training and certification program for commercial and public sector building operators. The curriculum teaches participants how to improve building comfort and efficiency by optimizing the building's systems. BOC curriculums 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.

3.44.1 Measure Overview

Sector	Commercial
End use	Building Management System
Fuel	Electric and Natural Gas
Measure category	BOC
Delivery mechanism	Rebate
Baseline description	Building operations before participant completed BOC course
Efficient case description	Facilities operated by participants who completed a BOC course

3.44.2 Savings

Building operator certification program evaluations began in 200331. Evaluations from across the country show that BOC programs deliver tangible net energy savings to participant facilities. 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.

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 I

BOC Level II

331 [1] https://www.theboc.info/why-boc/energy-savings-evaluation-reports/

- 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
- 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. Average net savings per participant from the evaluations referenced. See table of evaluations referenced below in Table 175.

Table 175 Summary of BOC studies referenced to calculate savings

Sponsor	Year	Participants	MWh per Participant	kW per Participant	Therms per Participant	Building Square Footage	Costs
NEEA	2014	212	234	-	6,059	432,768	-
MEEA	2011	50	46	-	2,529	194,500	-
NEEP	2005	94	111	-	4,312	616,045	-
NEEP	2002	49	121	-	13,436	671,804	-
NEEP	2001	107	90	-	0	645,461	-
Ameren Illinois[332]	2020	10	60	0.8	987	140,137	$253.94

[332] Opinion Dynamics, 'Ameren Illinois Company 2020 Business Program Impact Evaluation Report, Final', April 28th 2021

Ameren Illinois[333]	2019	12	64	12.8	3,615	408,309	$114.93
ComEd[334]	2020	33	133	14.7	0	319,068	$8,878.79
Ameren Illinois[335]	2021	8	24	0.0	0	502,944	$0.00
Nicor Gas[336]	2021	3	0	0.0	234	517,250	0
ComEd[337]	2021	2	21	1.6	0	517,250	$9,310.50

3.44.3 Energy Savings Estimation

$\Delta kWh = C_e * Area$

Where

Area = Building area operated by the participant. The maximum eligible area per participant is 500,000 ft2. In the event there are multiple participants who operate the same building (i.e. service address), or group of buildings, the program administrator can only claim savings on building square footage once (i.e., they cannot claim savings based on the same square footage for multiple participants), unless the managed square footage exceeds 500,000 ft2; in which case, the program administrator can continue to claim savings up to the 500,000 ft2 per participant cap until the total building square footage has been accounted for.

C_e = unit area kWh savings constant per participant, 0.336 kWh/ft^2/participant

3.44.4 Demand Savings Estimation

Summer peak demand savings can be calculated using the following formula:

333 Opinion Dynamics, 'Ameren Illinois Company 2019 Business Program Impact Evaluation Report, Final', April 30th 2020.

334 The ComEd evaluation includes both 2018 and 2019 participants. The interview sample did not stratify by program year, so the savings per participant are the same for each year. Guidehouse, 'ComEd Building Operator Certification Pilot Impact Evaluation Report', April 12th, 2021.

335 Opinion Dynamics, 'Ameren Illinois Company 2019 Business Program Impact Evaluation Report, Final', April 29th 2022

336 Guidehouse completed follow-up interviews with 2018 – 2020 participants from ComEd's program which also had gas service. Three interviews were completed, and all were Nicor Gas customers who completed no cost scheduling and usage tracking. The savings for these participants was calculated following the methodology used to determine the savings for ComEd's CY2022 Building Operator Certification Pilot.

337 Guidehouse, 'ComEd Building Operator Certification Pilot Impact Evaluation Report', April 19th, 2022.

$kW = C_d * Area / 1000$

Where

C_d = Unit demand savings constant, 0.028 W/ft^2 (capped)/participant

Average net demand savings per participant calculated from the evaluations referenced. See table of evaluations referenced above in Table 175.

1000 = unit conversion from W to kW

3.44.5 Natural Gas Savings

Natural gas savings can be calculated using the formula below.

$\Delta Therms = C_g * Area$

Where

Cg = Unit gas savings constant, 0.01 therms/ft^2 (capped)/participant

3.44.6 Non-energy Benefits

This measure does not carry any deemed non-energy benefits.

3.44.7 Measure Life

BOC typically involves capital and O&M measures, each of which has a different expected useful life. The lifetime of capital measures from the researched studies was 13 years. Based on analyzed research, 42% of BOC savings are derived from O&M measures with a four-year measure life. Therefore, the overall weighted average useful life for BOC savings is 9.2 years.

3.44.8 Deemed Measure Cost

The measure cost for BOC is the tuition cost paid by the participant.

3.44.9 Incremental Cost

In addition, the incremental cost of capital and O&M measures should also be included. If unknown, use an incremental measure cost of $0.011/ft^2[338].

[338] Based on evaluated measure incremental costs, net of O&M adjustments when available, from NEEA, NEEP, MEEA and BOC programs in Illinois mentioned in Table 175.

3.45 Indoor Agriculture Lighting (New)

3.45.1 Measure Overview

This measure is designed for interior horticultural applications that use artificial light stimulation in an indoor conditioned space.

Sector	Commercial
End use	Lighting
Fuel	Electricity
Measure category	Agriculture
Delivery mechanism	Rebate
Baseline description	HID/T5 fixtures
Efficient case description	LED fixtures

3.45.2 Savings

LED lamp technology offers reduced energy and maintenance costs when compared with conventional light sources. LED technology has a significantly longer useful life lasting 30,000 hours or more and significantly reduces maintenance costs. The savings and costs for this measure are evaluated with the replacement of HID grow lights with LED fixtures. LED lamps offer a more robust lighting source, longer lifetime, and greater electrical efficiency than conventional supplemental grow lights.

The baseline equipment is the industry established grow light based on the horticultural application, as detailed in the table below. HID fixtures are assumed for flowering and vegetative crops. T5 high-output fixtures are assumed for seedling and microgreen crops. Table 176 lists the baseline PPE and wattage values for various crop types.

Efficient LED fixtures must have a reduced wattage, be listed on the Design Lights Consortium (DLC) qualified products list[339], be UL Listed, have a power factor (PF) ≥0.90, a photosynthetic photon efficacy (PPE) of no less than 1.9 micromoles per joule, a minimum rated lifetime of 50,000 hours, and a minimum warranty of 5 years. If DLC PPE requirements for LED grow lighting exceeds the current requirements, the new PPE will become the efficient equipment standard.

[339] Design Light Consortium – Horticultural Lighting, Testing and Reporting Requirements for LED-Based Horticultural Lighting, version 2.1, effective September 1, 2021. To date, all horticultural lamps certified by the DLC specification are LEDs.

Table 176 Baseline PPE and Fixture Wattages

Crop Type	Baseline Technology Type	Baseline PPE (μmol/J)[340]	Baseline Fixture Wattage[341]
Flowering Crops (Tomatoes and Peppers)	High Pressure Sodium	1.7	1,100 W
Vegetative Growth	Metal Halide	1.25[342]	640 W
Microgreens[343]	T5 HO Fixture	1.0[344]	358 W
Propagation[345]	T5 HO Fixture	1.0[346]	234 W
Medical/Recreational Cannabis – Flowering Stage	High Pressure Sodium	1.7	1,100 W
Medical/Recreational Cannabis – Vegetative Stage	Metal Halide	1.25[347]	640 W
Medical/Recreational Cannabis – Cloning, Seeding and Propagation	T5 HO Fixture	1.0[348]	234 W

3.45.3 Energy Savings Estimation

PPF Equivalence Method:

$$\Delta \text{kWh} = \left[\left(\frac{PPF_{Total,i}}{PPE_{BL,i} \times 1000}\right) - kW_{ee,i}\right] \times Hours \times WHF_e$$

340 Erik Runkle and Bruce Bugbee "Plant Lighting Efficiency and Efficacy: μmols per joule". Acces234 Wsed 4/21/2020.

341 Jesse Remillard and Nick Collins, "Trends and Observations of Energy Use in the Cannabis Industry," ACEEE, accessed April 17, 2020. Baseline watts per square foot were taken by using typical fixture technology by crop type and dividing by 16 sqft per fixture (a 4'x4' area is a typical coverage amount for one grow light fixture).

342 Jacob A. Nelson, Bruce Bugbee, "Economic Analysis of Greenhouse Lighting: Light Emitting Diodes vs. High Intensity Discharge Fixtures." Utah State University. Accessed 5/6/2020

343 Microgreens T5 fixture is based on a 6-lamp high output fixture, based on IL TRM v11.0.

344 D.S. de Villiers, L.D. Albright, and R. Tuck, "Next Generation, Energy Efficient, Uniform Supplemental Lighting for ClosedSystem Plant Production." International Society for Horticultural Science

345 Propagation T5 fixture is based on a 6-lamp high output fixture, based on IL TRM v11.0

346 D.S. de Villiers, L.D. Albright, and R. Tuck, "Next Generation, Energy Efficient, Uniform Supplemental Lighting for ClosedSystem Plant Production." International Society for Horticultural Science.

347 Jacob A. Nelson, Bruce Bugbee, "Economic Analysis of Greenhouse Lighting: Light Emitting Diodes vs. High Intensity Discharge Fixtures." Utah State University. A

348 D.S. de Villiers, L.D. Albright, and R. Tuck, "Next Generation, Energy Efficient, Uniform Supplemental Lighting for ClosedSystem Plant Production." International Society for Horticultural Science.

$$PPF_{Total,i} = PPF_{Fixture,i} \times Qty_i$$

Where:

$PPF_{Total,i}$ = Total Photosynthetically-active Photon Flux output of the installed efficient fixtures for a specific growth phase, i in units of µmol/s. Equal to the number of fixtures installed multiplied by the PPF output per fixture.

$PPE_{BL,i}$ = Photosynthetically-active Photon Flux Efficiency of the assumed baseline fixture for a specific growth phase, i in units of µmol/J. Can be found in the table above.

$PPF_{Fixture,i}$ = The Photosynthetically-active Photon Flux output of an individual fixture installed for a specific growth phase, i in units of µmol/s.[349]

Qty_i = The installed quantity of efficient fixtures.

i = An indicator used to separate growth phases of products or different plants. "i" can be used to separate "Flowering" and "Vegetative", or different crop types, such as "Flowering Crops (tomatoes and peppers)" and "Microgreens".

1000 = Watts to kilowatts conversion factor

$kW_{ee,i}$ = Total power of the installed fixtures for a specific growth phase, i.

Hours = Annual operating hours. See Table 177 below for typical hours of operation breakdown by crop type.

WHFe = 1.21[350] if cooling or unknown or 1.00 if none; waste heat factor for energy to account for cooling savings from efficient lighting in cooled buildings.

Table 177 Hours of Use by Crop Type

Crop Types	Annual Hours of Operation[351]

[349] Individual fixture PPF can be sourced directly from the DLC horticulture qualified products list, Design Light Consortium – Horticultural Lighting, Testing and Reporting Requirements for LED-Based Horticultural Lighting, version 2.1, effective September 1, 2021.

[350] Waste heat factor for cooling savings calculation as per Indoor agriculture loadshapes in IL TRM v11.0

[351] Historical custom grow lighting projects from 2020. 54 spaces and over 5500 proposed fixtures. SPS Workpaper NM Grow Lighting.

Flowering Crops (Tomatoes/Peppers)	4,255
Vegetative/Propagation Growth	6,498
Microgreens	6,300
Medical Cannabis – Flower Stage	4,255
Recreational Cannabis – Flowering Stage	4,255

3.45.4 Demand Savings Estimation

Summer coincident peak demand savings

$$\Delta \text{kW} = \left[\left(\frac{PPF_{Total,i}}{PPE_{BL,i} \times 1000} \right) - kW_{ee,i} \right] \times CF \times WHF_d$$

Where:

WHF_d = 1.22[352] if cooling or 1.00 if none; waste heat factor for demand to account for cooling savings from efficient lighting in cooled buildings.

CF = 0.89 for vegetative crops or 0.68 for flowering crops[353]

3.45.5 Non-energy Benefits

There are no non-energy benefits associated with the measure.

3.45.6 Measure Life

The expected measure life is 9.5 years (average rated life of 50,000 hours)[354].

Microgreens HOU calculated by multiplying 18 hours per day (Sole-Source Lighting of Plants. Technically Speaking by Erik Runkle. Michigan State University Extension. September 2017) by 350 operating days per year. Assuming 5 crop cycles with 3 days of downtime between each cycle

[352] Waste heat factor for cooling savings calculation as per Indoor agriculture loadshapes in IL TRM v11.0

[353] Historical custom grow lighting projects from 2020. 54 spaces and over 5500 proposed fixtures. SPS Workpaper NM Grow Lighting.

[354] Based on 50,000 hours lifetime and 5,250 hours per year of use (average hours of use per year using flowering and vegetative rooms).

3.45.7 Deemed Measure Cost

LED Fixture Costs[355]

Efficient Wattage ≤ 250 Watts = $ 325.87 per fixture

Efficient Wattage > 250 Watts = $ 535.04 per fixture

[355] Focus on Energy Evaluation Business Programs: Measure Life Study Final Report: August 25, 2009

4. Residential Measures

4.1 Ceiling Insulation

This measure saves space heating and cooling energy by reducing heat transfer through the ceiling.

4.1.1 Measure Overview

Sector	Residential
End use	Space heating and cooling
Fuel	Electricity and Natural Gas
Measure category	Insulation
Delivery mechanism	Rebate (retrofit)
Baseline description	Retrofit: Existing insulation level New Construction[356]: • Albuquerque: R-49 • Santa Fe: R-49 • Roswell: R-38 • Las Cruces: R-38
Efficient case description	Insulation level higher than baseline level

4.1.2 Savings

Savings are derived as better ceiling insulation will lead to reduced consumption of heating and cooling during winter and summer months. A better R-value of the insulation being installed will achieve higher savings.

Projects may claim heating energy savings even if cooling energy savings are not claimed e.g., in the case of homes with evaporative cooling.

[356] IECC 2018 Code Requirements for Climate Zones 3 (Las Cruces, Roswell), 4 (Albuquerque) and 5 (Santa Fe)

4.1.3 Energy Savings Estimation

Savings are calculated based on the following formulas.

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

Cooling energy savings are calculated using:

$$\Delta kWh_{Cooling} = \frac{\left(\frac{1}{R_{Old}} - \frac{1}{R_{New}}\right) * A_{Ceiling} * \left(1 - FF_{Ceiling}\right) * CDD * 24}{1000 * \eta_{Cooling}}$$

Where:

R_{Old} = R-value of existing insulation

(Default R-value of R-5 for uninsulated assemblies, assumed thermal resistance of roof materials, ft^2 °F.h/Btu; Lower R-value allowed if evidence provided, down to an allowable minimum of R-2)

R_{New} = R-Value of new ceiling insulation (ft^2 - °F.h/Btu)

$A_{Ceiling}$ = Total area of insulated ceiling (ft^2)

$FF_{Ceiling}$ = Adjustment to account for area of framing, 7%[357]

CDD = Cooling Degree Days, as listed in Table 179

24 = Converting Days to Hours

1000 = Converting Btu to kBtu

$\eta_{Cooling}$ = Seasonal Energy Efficiency Ratio of Cooling System (kBtu/kWh)

= Nameplate ratings wherever possible, if unavailable use the following efficiencies listed in Table 178

Table 178: Cooling Efficiency (Federal Standards)

Age of Equipment	SEER Ratings
Before 2006	10.0
2006 - 2014	13.0
Central AC after 1/1/2015	13.0
Heat Pump after 1/1/2015	14.0

357 ASHRAE, 2001, "Characterization of Framing Factors for New Low-Rise Residential Building Envelopes (904-RP)," Table 7.1

Heating energy savings for electric resistance and heat pump systems can be calculated using:

$$\Delta kWh_{Heating} = \frac{\left(\frac{1}{R_{Old}} - \frac{1}{R_{New}}\right) * A_{Ceiling} * \left(1 - FF_{Ceiling}\right) * HDD * 24}{1000 * \eta_{Heating}}$$

Where:

HDD = Heating Degree Days, as listed in Table 179

Table 179: Cooling Degree Days and Heating Degree Days

City (Climate Zone)	CDD	HDD
Albuquerque	1,322	4,180
Santa Fe	645	5,417
Roswell	1,790	3,289
Las Cruces	1,899	2,816

$\eta_{Heating}$= Efficiency of heating system (kBtu/kWh)

= Nameplate ratings wherever possible, if unavailable use the following efficiencies listed in Table 180

Table 180: Heating Efficiency (Federal Standards)

Age of Equipment	HSPF Ratings
Heat Pump; Before 2006	6.8
Heat Pump; 2006 - 2014	7.7
Heat Pump; After 1/1/2015	8.2
Electric Resistance	3.412

Heating energy savings for gas heat systems can be calculated using:

$$\Delta therms_{Heating} = \frac{\left(\frac{1}{R_{Old}} - \frac{1}{R_{New}}\right) * A_{Ceiling} * \left(1 - FF_{Ceiling}\right) * HDD * 24}{10^5 * \eta_{Heating}}$$

Where:

$\eta_{Heating}$ = AFUE of gas heating system

= Nameplate ratings wherever possible, if unavailable use 0.8

For example, a house in Las Cruces underwent a ceiling insulation retrofit i.e., from R-10 to R-32. The total area of the ceiling is 550 sq. ft. and is cooled using an air conditioner (installed June 2016) and heated using a gas furnace (installed June 2016). Savings generated from this measure can be calculated using:

$$\Delta kWh_{Cooling} = \frac{\left(\frac{1}{R_{Old}} - \frac{1}{R_{New}}\right) * \ A_{Ceiling} * \left(1 - FF_{Ceiling}\right) * CDD * 24}{1000 * \ \eta_{Cooling}}$$

and

$$\Delta therms_{Heating} = \frac{\left(\frac{1}{R_{Old}} - \frac{1}{R_{New}}\right) * \ A_{Ceiling} * \left(1 - FF_{Ceiling}\right) * HDD * 24}{10^5 * \eta_{Heating}}$$

i.e.,

$$\Delta kWh_{Cooling} = \frac{\left(\frac{1}{10} - \frac{1}{32}\right) * \ 550 * (1 - 0.07) * 1{,}899 * 24}{1000 * \ 13.0} = 124\ kWh$$

and

$$\Delta therms_{Heating} = \frac{\left(\frac{1}{10} - \frac{1}{32}\right) * \ 550 * (1 - 0.07) * 2{,}816 * 24}{10^5 * 0.8} = 30\ therms$$

4.1.4 Demand Savings Estimation

Demand savings are defined as the reduction in average kW attributable to the measure during 3:00-6:00 pm on the hottest summer weekdays. It is assumed that the time spent in the hottest temperature bin is likely during the peak time. Which bin is the hottest depends on the climate zone. Based on these assumptions, the demand savings for homes with standard DX cooling are derived with the following equation.[358]

$$Peak\ Demand\ Savings = \frac{\Delta kWh_{Cooling}}{EFLH_{Cool}} * CF$$

Where:

Peak Demand Savings = Summer peak kW savings, kW

$\Delta kWh_{Cooling}$ = Cooling energy savings, kWh

[358] Based on ADM ceiling insulation calculator spreadsheet

$\text{EFLH}_{\text{Cool}}$ = Effective Full Load Cooling Hours, Table 181

Table 181: Effective Full Load Cooling Hours

City	$EFLH_{Cool}$
Albuquerque	1,038
Santa Fe	629
Roswell	1,355
Las Cruces	1,290

CF = Coincidence Factor, 0.87[359]

4.1.5 Non-energy Benefits

There are no non-energy benefits.

4.1.6 Measure Life

The lifetime for this measure is 30 years.[360]

4.1.7 Incremental Cost

The actual installed cost for this measure should be used in screening.[361]

[359] For residential coincidence factors, Frontier used the Air Conditioning Cheat pontractors of America (ACCA) Manual S, which recommends that residential HVAC systems be sized at 115% of the maximum cooling requirement of the house. Assuming that the house's maximum cooling occurs during the hours 3 to 6 pm, this sizing guideline leads to a coincidence factor for residential HVAC of 1.0/1.15 = 0.87

[360] US Department of Energy, WPN 19-4: Revised Energy Audit Approval Procedures, Related Audit, and Material Approvals, Attachment 9, January 17, 2019.

[361] State of Illinois Energy Efficiency Technical Reference Manual, version 10.0

4.2 Low-flow Showerheads

This measure saves water heating energy by reducing consumption of hot water.

4.2.1 Measure Overview

Sector	Residential
End use	Water heating
Fuel	Electricity and Natural Gas
Measure category	Low-flow Showerheads
Delivery mechanism	Rebate, Direct install
Baseline description	2.0 gpm, 2.5 gpm or greater
Efficient case description	2.0, 1.75,1.5, 1.25 gpm

4.2.2 Savings

The measure applies to both single and multifamily residences. For kit-based programs and programs for which the water heating fuel is unknown, multiply the savings listed below with the type of water-heating system fuel type percentage and the in-service rates provided in the next section. The savings listed in Table 182 and Table 183 do NOT include the Fuel% or ISR parameters.

Table 182: Energy Savings in kWh

	Albuquerque		**Las Cruces**		**Roswell**		**Santa Fe**	
	SF	**MF**	**SF**	**MF**	**SF**	**MF**	**SF**	**MF**
Baseline Case: 2.0 gpm								
1.25 gpm	192.5	222.1	159.3	183.8	163.0	188.0	218.3	251.8
1.5 gpm	128.3	148.1	106.2	122.5	108.7	125.4	145.5	167.9
1.75 gpm	64.2	74.0	53.1	61.3	54.3	62.7	72.8	83.9
Baseline Case: 2.5 gpm								
1.25 gpm	320.8	370.1	265.5	306.3	271.6	313.4	363.8	419.7
1.5 gpm	256.6	296.1	212.4	245.1	217.3	250.7	291.0	335.8
1.75 gpm	192.5	222.1	159.3	183.8	163.0	188.0	218.3	251.8
2.0 gpm	128.3	148.1	106.2	122.5	108.7	125.4	145.5	167.9

Table 183: Energy Savings in therms

	Albuquerque		Las Cruces		Roswell		Santa Fe	
	SF	MF	SF	MF	SF	MF	SF	MF
Baseline Case: 2.0 gpm								
1.25 gpm	8.6	9.9	7.1	8.2	7.3	8.4	9.7	11.2
1.5 gpm	5.7	6.6	4.7	5.5	4.8	5.6	6.5	7.5
1.75 gpm	2.9	3.3	2.4	2.7	2.4	2.8	3.2	3.7
Baseline Case: 2.5 gpm								
1.25 gpm	14.3	16.5	11.8	13.7	12.1	14.0	16.2	18.7
1.5 gpm	11.4	13.2	9.5	10.9	9.7	11.2	13.0	15.0
1.75 gpm	8.6	9.9	7.1	8.2	7.3	8.4	9.7	11.2
2.0 gpm	5.7	6.6	4.7	5.5	4.8	5.6	6.5	7.5

4.2.3 Energy Savings Estimation

Savings are derived with the following formula.[362]

$$Svgs = (Pre_F - Post_F) \times (TempUsage - TempCold) \times Mins \times HtrEnergy\ x\ Fuel\%\ x\ ISR$$

Where:

Svgs = Annual energy savings, in therms

PreF = Baseline flow rate, nominal flow rate adjusted by an in situ flow percentage (90%), see Table 184

PostF = Measure flow rate, nominal flow rate adjusted by an in situ flow percentage (90%), see Table 184

$Temp_{Usage}$ = Temperature of water coming out of showerhead , 101°F[363]

$Temp_{Cold}$ = Water heater inlet temperature, refer to Table 8

[362] Derived based on the data provided in version 2.1 of the Residential: DHW – Showerheads UES Measures calculator created by the Regional Technical Forum (RTF), https://rtf.nwcouncil.org/measure/showerheads/

[363] Cadmus and Opinion Dynamics Evaluation Team. Showerhead and Faucet Aerator Meter Study. For Michigan Evaluation Working Group. June 2013. Temperature sensors provided the mixed water temperature readings resulting in an average of 101ºF

Mins	= Annual minutes showerhead is used; for single family: 2979.8, for multifamily: 3438.21 . Calculated from data shown in Table 185
$Heater_{Energy}$	= Water heater heating energy, 0.0001112 therm per °F per gallon. Factor composed of thermal efficiency of water heater, 0.75 and therms per gallon degF, 0.0000834 (from heat capacity and density of water, and a conversion from Btu to therms). For electric it is .002493 kWh per °F per gallon. Factor composed of thermal efficiency of water heater, 0.98 and therms per gallon degF, 0.0000834 (from heat capacity and density of water, and a conversion from Btu to therms) divided by the conversion factor of .03413 therm/kWh
Fuel%	= Percentage split between gas, electric and propane water heating. When water heating fuel is known, used 100%. For kit-based and other program types for which the water heating fuel is not known, use territory-specific percentages. If territory-specific values are not known, use default values of 55% gas, 36% electricity and 9% propane[364].
ISR	= In-service rate, representing the proportion of distributed showerheads which are actually installed. For direct-install and downstream programs, use 1. For kit-based programs, use a territory-specific value. If a territory-specific value is not known, use a default value of 0.6[365]

Varying parameters are shown in Table 184.

Table 184: Residential Low-flow Showerhead Flow Rate Dependent Parameters

Nominal Flow Rate (gpm)	Flow Rate (gpm)	Nominal Flow Rate (gpm)	Flow Rate (gpm)
Baseline Case		Baseline Case	
2.0	1.8	2.5	2.25
Efficient Case		Efficient Case	

364 US Energy Information Administration. https://www.eia.gov/consumption/residential/data/2015/hc/php/hc8.8.php. The percentages shown are based on the West Mountain South Region.

365 El Paso Electric New Mexico LivingWise® Program Summary Report Fall 2017

1.25	1.13	1.25	1.13
1.50	1.35	1.50	1.35
1.75	1.58	1.75	1.58
		2.00	1.80

The annual minutes value is calculated by taking the product of the four parameters listed in Table 185.

Table 185: Residential Low-flow Showerhead Minutes Parameters[366]

Parameter	Value	Source
Daily showers per Person, weighted average between primary and secondary showerheads (showers per person per day)	Single Family: 0.39 Multifamily: 0.45	Average of values from Arkansas TRM version 7 and Illinois TRM version 7
Annualized Occupancy (days per year)	365	All annual days
Persons per residence (people per housing unit)	2.67	U.S. Census Bureau: State and County QuickFacts. Data derived from Population Estimates, American Community Survey, Census of Population and Housing, State and County Housing Unit Estimates, County Business Patterns, Nonemployer Statistics, Economic Census, Survey of Business Owners, Building Permits Last Assessed: 4 October, 2018
Average Shower Length (min per shower)	7.84	"Seattle Home Water Conservation Study"; Seattle Public Utilities and the U.S. E.P.A. (December 2000), Water and Energy Savings from High Efficiency Fixtures and Appliances in Single Family Homes, US EPA Combined Retrofit Report, 2005

Parameter values are based on the following sources.[367]

Table 186: Residential Low-flow Showerhead Parameter Sources

Baseline flow rate	10 CFR 430.32(p)

[366]As reported in ibid., except persons per residence, which uses data specific for New Mexico households.

[367] As reported in ibid362, except baseline flow rate.

Hot Water %	Percentage hot water is calculated using the heat balance equation considering hot water temperature as 127.5^{0}F, cold water from Table 8 and the usage temperature as 101^{0}F.
Measure flow rate (With adjustment from nominal to actual)	RTF, informed by (1) "Seattle Home Water Conservation Study"; Seattle Public Utilities and the U.S. E.P.A. (December 2000) and (2) "Single Family 2007 Showerhead Kit Impact Evaluation". SBW Consulting; Seattle City Light. October 2008
Heater Energy	Heater efficiency is based on RTF decision informed by "Energy Efficient Showerhead and Faucet Aerator Metering Study" (PSE/BPA/SBW 1994) and "Single Family 2007 Showerhead Kit Impact Evaluation". Seattle City Light. October 2008

4.2.4 Demand Savings Estimation

There are no demand savings associated with this measure.

4.2.5 Non-energy Benefits

Water savings are shown in Table 187. Local water and wastewater rates need to be applied to these values to monetize savings.

Table 187: Residendial Low-Flow Showerhead Water Savings (in gallons)

Nominal Flow Rate	Single Family	Multi Family
Baseline Case: 2.0 gpm		
1.25 gpm	2011	2321
1.5 gpm	1341	1547
1.75 gpm	670	774
Baseline Case: 2.5 gpm		
1.25 gpm	3352	3868
1.5 gpm	2682	3094
1.75 gpm	2011	2321
2.0 gpm	1341	1547

4.2.6 Measure Life

The lifetime for this measure is 10 years.[368]

4.2.7 Incremental Cost

The incremental cost for this measure is the total cost. Actual costs (including labor if applicable) should be utilized. If unknown, assume the cost per direct-installed residential showerhead is $12.[369]

4.3 Low-flow Faucet Aerator

This measure saves water heating energy by reducing consumption of hot water.

4.3.1 Measure Overview

Sector	Residential
End use	Water heating
Fuel	Electricity and Natural Gas
Measure category	Low-flow faucet aerators
Delivery mechanism	Direct Install
Baseline description	Federal standard 2.2 GPM or greater
Efficient case description	0.5 or 1.0 gpm (bathrooms) 1.5 gpm (kitchens)

4.3.2 Savings

The measure applies to both single and multifamily residences. The savings below are per aerator for different climate zones in New Mexico. For kit-based programs and programs for which the water heating fuel is unknown, multiply the savings listed below with the type of water-heating system fuel type percentage and the in-service rates provided in the next section. The savings listed in Table 188 do NOT include the Fuel% or ISR parameters.

Table 188: Residential Low-flow Faucet Aerator Savings

Location	Flow	Albuquerque	Las Cruces	Roswell	Santa Fe
In therms					

[368] State of Illinois Energy Efficiency Technical Reference Manual, version 10.0

[369] Ibid.

Location	Flow	Albuquerque	Las Cruces	Roswell	Santa Fe
Bathroom	0.5 gpm	2.56	1.84	1.92	3.12
Bathroom	1.0 gpm	1.81	1.30	1.35	2.20
Kitchen	1.5 gpm	1.37	1.07	1.11	1.60
In kWh					
Bathroom	0.5 gpm	57.51	41.29	43.01	70.04
Bathroom	1.0 gpm	40.60	29.15	30.36	49.44
Kitchen	1.5 gpm	30.76	24.09	24.79	35.93

4.3.3 Energy Savings Estimation

Savings are derived with the following formula.[370]

$$Svgs = \frac{(FlowPre - FlowPost) \times (TempUsage - TempCold) \times Minutes \times Days \times HeatCapacity \times Density \times Const\ X\ Fuel\%\ X\ ISR}{EffDHW}$$

Where:

Svgs = Annual energy savings, in therms

$Flow_{Pre}$ = Baseline flow rate, 2.2 gpm

$Flow_{Post}$ = Measure flow rate, 0.5, 1.0, or 1.5 gpm

$Temp_{Usage}$ = Temperature of water coming out of aerator, see Table 189

$Temp_{Cold}$ = Water heater inlet temperature, refer to Table 8

MinutesOf Use = Minutes per faucet per day faucet is used, 1.59 mins/faucet/day[371]

Days = Days per year faucet is used, 365

HeatCapacity = Heat capacity of water, 1 Btu per pound per °F

370 ADM Associates, Evaluation of 2011 DSM Portfolio, New Mexico Gas Company, 2012, citing CLEAResult Workpaper, "Low Flow Aerators – 0.5[1.0] gpm"

371 Value derived using 2.67 persons/household, 2.34 minutes/person/day, 3.93 faucets/household. Persons/household derived from US Census Bureau: State and County QuickFacts. Minutes/person/day taken from TX TRM v6, derived from Cadmus and Opinion Dynamics Evaluation Team, "Memorandum: Showerhead and Faucet Aerator Meter Study". Prepared for Michigan Evaluation Working Group. Faucets/household taken from TX TRM v6, based on the 2009 Residential Energy Consumption Survey (RECS), Table HC2.10.

Density = Density of water, 8.33 pounds per gallon

Const = Constant, 1 therm/100,000 Btus, 1therm/0.03413 kWh

EffDHW = Thermal efficiency of water heater. For Natural gas 0.75, for electric 0.98

Fuel% = Percentage split between gas, electric and propane water heating. When water heating fuel is known, used 100%. For kit-based and other program types for which the water heating fuel is not known, use territory-specific percentages. If territory-specific values are not known, use default values of 55% gas, 36% electricity and 9% propane[372].

ISR = In-service rate, representing the proportion of distributed aerators which are actually installed. For direct-install and downstream programs, use 1. For kit-based programs, use a territory-specific value. If a territory-specific value is not known, use a default value of 0.6[373].

Table 189: Residential Low-flow Faucet Aerator Usage Temperatures

Location	Usage Temperature (°F) [374]
Kitchen	93.0
Bathroom	86.0

372 US Energy Information Administration. https://www.eia.gov/consumption/residential/data/2015/hc/php/hc8.8.php. The percentages shown are based on the West Mountain South Region.

373 El Paso Electric New Mexico LivingWise® Program Summary Report Fall 2017

374 Cadmus and Opinion Dynamics Evaluation Team. Showerhead and Faucet Aerator Meter Study. For Michigan Evaluation Working Group. June 2013. The study finds that the average mixed water temperature flowing from the kitchen and bathroom faucets is 93ºF and 86ºF, respectively. The "Location Unknown" values are the average temperatures between all faucets in the household, assuming 2.83 bathrooms per single family residence, and 1.5 bathrooms per multifamily residence, based on findings from a 2009 ComEd residential survey of 140 sites provided by Cadmus

Parameter values are based on the following sources.

Table 190: Residential Low-flow Faucet Aerator Parameter Sources

Baseline flow rate	Maximum flow rate federal standard for lavatories and aerators set in Federal Energy Policy Act of 1992 and codified at 2.2 gpm at 60 psi in 10CFR430.32.
Thermal efficiency of water heater	Heater efficiency is based on RTF decision informed by "Energy Efficient Showerhead and Faucet Aerator Metering Study" (PSE/BPA/SBW 1994) and "Single Family 2007 Showerhead Kit Impact Evaluation". Seattle City Light. October 2008

4.3.4 Demand Savings Estimation

There are no demand savings associated with this measure.

4.3.5 Non-energy Benefits

Water savings per faucet are shown in Table 191. Local water and wastewater rates need to be applied to these values to monetize savings.

Table 191: Residendial Low-flow Faucet Aerator Water Savings (gallons)

Flow	Savings
0.5	986.6
1.0	696.4
1.5	406.2

4.3.6 Measure Life

The lifetime for this measure is 10 years.[375]

4.3.7 Incremental Cost

The incremental cost for this measure is the total cost. The cost per direct-installed residential aerator is $10.[376]

375 DEER 2014 EUL Table

376 SBW Consulting, Direct-install program operator, 2013

4.4 Residential Lighting

This measure replaces halogen lamps and fixtures with CFL or LED lamps and fixtures.

4.4.1 Measure Overview

Sector	Residential
End use	Lighting
Fuel	Electricity
Measure category	CFL and LED Lighting
Delivery mechanism	Upstream buy-down Give-away Direct Install Retail coupons
Baseline description	Federal minimum wattage
Efficient case description	Efficient lamp wattage

In 2012, the Energy Independence and Security Act of 2007 (EISA) requirements began to phase-in, requiring all general-purpose light bulbs between 40 watts and 100 watts to have ~30% increased efficiency. The EISA legislation also contained a backstop provision, which required all lamps to have an efficacy of 45 lumens/watt by 1/1/2020. During December 2019, the DOE determined that this backstop efficiency was not economically justified. However, the DOE reversed course in May 2022 and issued a final rule[377] for broadening the definition of General Service Lamps and implementing the 45 lumens/watt requirement.

The DOE indicated that there is a grace period for the remainder of 2022 to allow the import and manufacture of noncompliant lamps. The DOE also specified a sell through period of six months, ending in July 2023, by which date noncopliant lamps should not be available. The New Mexico TRM has not historically implemented code shifts midway through program years to avoid introducing market confusion, as well as allowing for additional sell through. Therefore, the TRM assumes the 45 lumens/watt baselines are effective beginning January 1, 2024.

[377] Energy Conservation Program: Definitions for General Service Lamps; Final rule. 10 CFR Part 430. https://www.regulations.gov/document/EERE-2021-BT-STD-0012-0022

Additional considerations for applying lighting baselines depends on the type of program delivery, as well as the target participants.

- Market rate programs should use the existing EISA Tier 1 baselines for lamps incented through programs until January 1, 2024. After this date, the baseline for incented GSLs would need to be 45 lumens/watt. Lifetime savings calculations should shift the baseline to 45 lumens/watt starting January 1, 2027.
- Market rate direct install programs can use the EISA Tier 1 baseline after January 1, 2024 if it can be demonstrated that the program lamp is replacing an existing, fully functional halogen lamp. Lifetime savings calculations should shift the baseline to 45 lumens/watt two years after the installed program year.
- Income-eligible programs should use the existing EISA Tier 1 baselines for lamps incented through programs until January 1, 2026 to allow additional time to deplete existing stockpiles in the marketplace. After this date, the baseline for incented GSLs would need to be 45 lumens/watt. Lifetime savings calculations should shift the baseline to 45 lumens/watt starting January 1, 2029.
- Income eligible direct install programs can use the EISA Tier 1 baseline after January 1, 2026 if it can be demonstrated that the program lamp is replacing an existing, fully functional halogen lamp. Lifetime savings calculations should shift the baseline to 45 lumens/watt two years after the installed program year.

4.4.2 Savings

The savings depend on baseline wattage, as shown in Table 192. Tier 1 became effective January 1st, 2014. The GSL backstop provision becomes effective in the TRM January 1, 2024, following the guidance in the Measure Overview of this characterization.

Table 192: Residential Lighting Baseline – General Service

Lumen Range	EISA Status	EISA Baseline: 1st Tier (W)	DOE GSL Baseline: after 1/1/2024 (W)
250-309	Exempt	25	25
310-749	Non-exempt	29	11.8
750-1,049	Non-exempt	43	20.0
1,050-1,489	Non-exempt	53	28.2
1,490-2,600	Non-exempt	72	45.4
2,601-2,999	Exempt	150	150

3,000-5,279	Exempt	200	200
5,280-6,209	Exempt	300	300

Table 193 details wattage equivalence EISA specifications and expanded GSL baselines for reflector lamps. Program administrators should use model-specific wattages within these categorizations. The expanded definition of GSLs includes medium sized directional lamps (BR30, BR40, and ER40).

Table 193: Baseline Wattage – Reflector Lamps

Lamp Type	Pre-EISA Incandescent Equivalent (W)	Baseline Wattage – Post-EISA (W)	DOE GSL Baseline: after 1/1/2024 (W)
PAR20	50	35	11.6
PAR30	50	35	11.6
R20	50	45	14.2
PAR38	60	45	17.2
BR30	65	Exempt	17.8
BR40	65	Exempt	17.8
ER40	65	Exempt	17.8
BR40	75	65	22.8
BR30	75	65	22.8
PAR30	75	55	21.7
PAR38	75	55	21.7
R30	75	65	21.7
R40	75	65	21.7
PAR38	90	70	25.0
PAR38	120	70	30.0
R20	≤ 45	Exempt	Exempt
BR30	≤ 50	Exempt	Exempt
BR40	≤ 50	Exempt	Exempt
ER30	≤ 50	Exempt	Exempt
ER40	≤ 50	Exempt	Exempt

There are 22 incandescent lamps exempt from EISA 2007.[378] However, the expanded defintion of GSLs includes many of these lamps. The new baselines become effective after January 1, 2024, in accordance with the guidance in the Measure Overview section of this characterization. Wattage for other specialty lamps is detailed in Table 194.

Table 194: Baseline Wattage – Other Speciality Lamps

Bulb Type	Lumen Range	Baseline Watts	DOE GSL Baseline: after 1/1/2024 (W)
3-Way	250-449	25	25
	450-799	40	13.9
	800-1,099	60	21.1
	1,100-1,599	75	30.0
	1,600-1,999	100	40.0
	2,000-2,549	125	50.5
	2,550-2,999	150	61.7
Globe (medium & intermediate base, ≤ 750 lumens)	90-179	10	10
	1810-249	15	15
	250-349	25	25
	350-749	40	12.2
Decorative (shapes B, BA, C, CA, DC, F, G, medium base, ≤ 750 lumens)	70-89	10	10
	90-149	15	15
	150-299	25	25
	300-499	40	8.9
	500-1,049	60	17.2
Globe (Candelabra base, ≤ 1,049 lumens)	90-179	10	10
	180-249	15	15
	250-349	25	25
	350-499	40	9.4
	500-1,049	60	17.2
	70-89	10	10

Decorative (shapes B, BA, C, CA, DC, F, G, candelabra base, ≤ 1,050 lumens)	90-149	15	15
	150-299	25	25
	300-499	40	8.9
	500-1,049	60	17.2

4.4.3 Energy Savings Estimation

Savings are calculated per lamp with the following formula.

$$Svgs = \frac{(Watts_{Baseline} - Watts_{Efficient})}{1000} \times HoursOfUse \times HVAC_{Energy}Factor$$

Where:

Svgs = Annual energy savings, in kWh

$Watts_{Baseline}$ = Wattage of baseline incandescent lamp

$Watts_{Efficient}$ = Wattage of corresponding efficient lamp

HoursOfUse = Annual average hours of use, see below

HVAC_Energy Factor = Adjustment to lighting savings to account for the decreased heating and cooling load, see below

Baseline and efficient lamp watts are determined using the wattages shown in Table 192, Table 193, and Table 194.

A method for deriving lifetime savings by implementing a Dual Baseline methodology to address a reduced useful life is presented below.

Example:

Installation date: 1/1/2023

Installation location: Albuquerque, NM

HVAC type: Heat Pump

Hours of use: 817.6

HVAC Energy Factor: 0.76

Existing PAR 20 lamp wattage (1/1/2023 – 1st Baseline) = 45 W (310-749 Lumens)

Backstop PAR 20 lamp wattage (1/1/2024 – 2nd Baseline) = 11.8 W

Installed LED lamp wattage = 5 W (450 Lumens)

Full savings can be claimed until 1/1/2027, then need to change baseline to 45 lumens per watt for market rate programs. This would be different for Direct Install and Low-Income projects where the baseline shifts after 1/1/2029, the baseline changes to 45 lumen per watt for GSLs. Use Table 192 for GSLs.

$$Lifetime\ Svgs = [\left(\frac{(Watts_{1^{st}Baseline} - Watts_{Efficient})}{1000} \times HoursOfUse \times HVAC_{Energy}Factor\right) \times 1^{st}Baseline_{NumberOfYears}] + \left(\frac{(Watts_{2^{nd}Baseline} - Watts_{Efficient})}{1000} \times HoursOfUse \times HVAC_{Energy}Factor\right) \times 2^{nd}Baseline_{NumberOfYears}]$$

$$Lifetime\ Svgs = [\left(\frac{(40-5)}{1000} \times 817.6 \times 0.76\right) \times 4] + \left(\frac{(11.8-5)}{1000} \times 817.6 \times 0.76\right) \times 20.5] = 173.6\ kWh$$

Where:

Lifetime Svgs = Lifetime annual energy savings, in kWh

$Watts_{1stBaseline}$ = Wattage of baseline lamp consistent with EISA Tier 1.

$Watts_{2ndBaseline}$ = Wattage of baseline lamp

$Watts_{Efficient}$ = Wattage of corresponding efficient lamp

HoursOfUse = Annual average hours of use

HVAC_Energy Factor = Adjustment to lighting savings to account for the decreased heating and cooling load, see below

1st Baseline_#ofYears = Remaining useful life (years) prior to 1/1/2024

2nd Baseline_#ofYears = Remaining useful life (years) post 1/1/2024

Table 195: HVAC Energy Factor[379]

HVAC Type	Albuquerque	Roswell	Santa Fe	Las Cruces
Gas heat with AC	1.05	1.10	1.03	1.12
Gas heat with no AC	1.00	1.00	1.00	1.00
Heat Pump	0.76	0.94	0.73	0.97

379 Values derived from TX TRM values, adjusted based on a comparison of CDD between Texas Cities and New Mexico cities.

Electric Resistance Heat with AC	0.67	0.86	0.70	0.88
Electric Resistance Heat with no AC	0.57	0.70	0.66	0.70
No heat with AC	1.05	1.10	1.03	1.12
Unconditioned space	1.00	1.00	1.00	1.00
Heating cooling unknown	0.91	1.02	0.89	1.04
Upstream lighting	0.91	1.02	0.89	1.04

Hours of use were derived from the 2011 evaluations of New Mexico programs by ADM Associates.[380] Hours are shown in Table 196. The weighted average hours are based on actual installations in 2011 in New Mexico.

Table 196: Residential Lighting Daily Hours of Use by Room Type

Room Type	Hours of Use
Kitchen	3.5
Living Room	3.3
Outdoor	3.1
Family Room	2.5
Garage	2.5
Utility Room	2.4
Dining Room	2.3
Office	1.9
Bedroom	1.6
Bathroom	1.5
Hall/Entry	1.5
Laundry Room	1.2
Closet	1.4
Other	1.2
Weighted Average	**2.24**

4.4.4 Demand Savings Estimation

Demand savings are defined as the reduction in average kW attributable to the measure during 3:00-6:00 pm on the hottest summer weekdays. Demand savings are derived with the following equation.[381]

$$Svgs = \frac{(Watts_{Baseline} - Watts_{Efficient})}{1000} \times CoincidentFactor \times HVAC_{Demand}Factor$$

[380] ADM based the hours of use on KEMA, "CFL Metering Study", prepared for the California Public Utilities Commission, 2009, and US DOE, US Lighting Market Characterization, Navigant Consulting, 2002. Number of days per year is assumed to be 365 days.

[381] Coincidence factors were derived from the ADM 2011 evaluations of the New Mexico utilities. ADM cited the KEMA 2009 study and DEER 2008.

Where:

Svgs = Summer peak kW savings

$\text{Watts}_{\text{Baseline}}$ = Baseline Wattage of lamp, as determined from table above

$\text{Watts}_{\text{Efficient}}$ = Installed Wattage of lamp

CoincidentFactor = 0.1017 for residences, 0.18 for dormitories

HVAC_Demand Factor = Adjustment to lighting demand savings to account for the decreased heating and cooling load

Table 197: HVAC Demand Factor[382]

Room Type	Albuquerque	Roswell	Santa Fe	Las Cruces
Gas heat with AC	1.41	1.38	1.19	1.44
Gas heat with no AC	1.00	1.00	1.00	1.00
Heat Pump	1.24	1.32	1.12	1.37
Electric Resistance Heat with AC	1.00	1.17	1.00	1.36
Electric Resistance Heat with no AC	1.00	1.00	1.00	1.00
No heat with AC	1.41	1.38	1.19	1.44
Unconditioned space	1.00	1.00	1.00	1.00
Heating cooling unknown	1.28	1.32	1.13	1.41
Upstream lighting	1.28	1.32	1.13	1.41

4.4.5 Non-energy Benefits

There is added benefit from deferred replacement cost, as a CFL or LED lamp has a significantly longer rated life than an incandescent or halogen equivalent. Program staff may endeavor to quantify this.

4.4.6 Measure Life

The addition of the backstop requirement after January 1, 2024 requires that the useful life for LEDs reflect the time available for which a noncompliant lamp could be used as an

[382] Values derived from TX TRM values, adjusted based on a comparison of CDD between Texas Cities and New Mexico cities.

alternative. Therefore, the measure life for LED lamps installed through the program depends on the type of target participant, in order to align with the baseline selection.

Market rate programs should claim halogen baselines until January 1, 2027[383], then shift the baseline to 45 lumens/watt for the remainder of the measure life values in Table 198.

Market rate direct install programs where it can be demonstrated that the program lamp is replacing an existing, fully functional halogen lamp, should claim halogen baselines for three years after installation. The savings for the remainder of the measure life from Table 198 should be versus a 45 lumens/watt baseline.

Income-eligible should claim halogen baselines until January 1, 2029[384], then shift the baseline to 45 lumens/watt for the remainder of the measure life values in Table 198.

Income eligible direct install programs where it can be demonstrated that the program lamp is replacing an existing, fully functional halogen lamp, should claim halogen baselines for three years after installation. The savings for the remainder of the measure life from Table 198 should be versus a 45 lumens/watt baseline.

Table 198: Residential Lighting Measure Lives

Measure	Rated Life	Expected Useful Life
CFL	8,000	5.1
	10,000	6.4
	12,000	7.7
LED	17,000	20.8[385]
	20,000	24.5[386]
	25,000	30.6[387]

[383] Halogen lamps have 2000 hour lives, at 818 hours per year, is 2.4 years. This was rounded up to three years for lifetime savings calculations.

[384] Three years of remaining eligibility until 2026, plus three years of halogen life.

[385] The average rated life for Decorative lamps on the ENERGY STAR Qualified Products list (accessed 6/16/2020) is approximately 17,000 hours, the expected useful life calculated using the weighted average of 2.24 daily hours by room type.

[386] The average rated life for Omnidirectional lamps on the ENERGY STAR Qualified Products list (accessed 6/16/2020) is approximately 20,000 hours, the expected useful life calculated using the weighted average of 2.24 daily hours by room type.

[387] The average rated life for Directional lamps on the ENERGY STAR Qualified Products list (accessed 6/16/2020) is approximately 25,000 hours, the expected useful life calculated using the weighted average of 2.24 daily hours by room type.

4.4.7 Incremental Cost

The incremental cost is the difference between the retail cost of an incandescent lamp and the program cost of a program lamp. The retail cost of EISA-compliant halogen incandescent lamps is $1.48 per lamp. The CFL/LED cost is determined by the program.

4.5 Duct Sealing

This measure saves energy by reducing the quantity of conditioned air which leaks from residential supply and return ducts.

4.5.1 Measure Overview

Sector	Residential
End use	HVAC
Fuel	Electricity and Natural Gas
Measure category	Duct Sealing
Delivery mechanism	Rebate
Baseline description	Ducts with a leakage factor assumed to be 35% or less
Efficient case description	Final leakage rate, which must be less than 10% of fan CFM

4.5.2 Savings

A method for deriving savings is described. Savings depend on pre and post leakage rates, which must be measured with DuctBlaster™ or other pressurization equipment, and also on in-home HVAC equipment type. The baseline leakage rate cannot exceed 35% of the total fan flow of the system and should be capped at 35% of total fan flow to use the algorithms presented in this measure.

Example:

Conditioned air leakage from the duct is reduced from 50 CFM to 10 CFM. This system is installed in Albuquerque and the efficiency of the cooling system installed is SEER 14.

Energy savings = (50 CFM – 10 CFM) x 0.77 x 1038 hours x (29 Btu/lb x 0.0742 lb/ft^3 - 25 Btu/lb x 0.0756 lb/ft^3) x 60/(1000 x 14)

= 35.87 kWh

Demand savings = (50 CFM – 10 CFM) x 0.77 x (29 Btu/lb x 0.0742 lb/ft^3 - 25 Btu/lb x 0.0756 lb/ft^3) x 60/(1000 x 14) x 0.87

= 0.03 kW

4.5.3 Energy Savings Estimation

Total savings are the sum of cooling and heating savings. Cooling savings are derived with the following equation.[388]

$$Svgs = (DL_{Baseline} - DL_{Post}) \times 0.77 \times EFLH \times (h_{Out} \times \rho_{Out} - h_{In} \times \rho_{In}) \times \frac{60}{1000 \times SEER}$$

Where:

Svgs	= Annual cooling savings, kWh
$DL_{baseline}$	= Duct leakage, baseline, measured at 25 Pascals, CFM. Cannot exceed 35% of total fan flow.
DL_{post}	= Duct leakage, after installation, measured at 25 Pascals, CFM
0.77	= Adjustment factor to account for the fact that people do not always operate their air conditioning systems when outside temperature is greater than 75° F
EFLH	= Effective Full Load Hours for residential cooling, see below
h_{out}	= Outdoor air design specific enthalpy = 29 (Btu/lb) - ANSI/ASHRAE Standard 152-2004, Table 6.3b (El Paso)
ρ_{out}	= Density of outdoor air at 95°F = 0.0742 (lb/ft3) - ASHRAE Fundamentals 2009, Chapter 1: Psychometrics, Equation 11, Equation 41, Table 2
h_{in}	= Indoor air design specific enthalpy = 25 (Btu/lb) - ANSI/ASHRAE Standard 152-2004, Table 6.3b (El Paso)
ρ_{in}	= Density of conditioned air at 75°F = 0.0756 (lb/ft3) - ASHRAE Fundamentals 2009, Chapter 1: Psychometrics, Equation 11, Equation 41, Table 2
60	= Conversion factor from minutes to hours
1000	= Conversion factor from Wh to kWh
SEER	= Seasonal Energy Efficiency Ratio of Cooling System (kBtu/kWh)
	= Nameplate ratings wherever possible, if unavailable use the following efficiencies listed in Table 199

388 Frontier Associates, Deemed Savings based on El Paso Specific Climate Data, Filing with TX Regulatory Commission, 2012.

Table 199: Cooling Efficiency (Federal Standards)

Age of Equipment	SEER Ratings
Before 2006	10.0
2006 - 2014	13.0
Central AC after 1/1/2015	13.0
Heat Pump after 1/1/2015	14.0

Pre and post duct leakage parameters are provided on a per site basis. These values should be measured at a positive pressure of 25 Pascals with a DuctBlaster™ or similar equipment.

EFLH are shown in Table 200. Full-load hours for Albuquerque and Roswell were derived from the ENERGY STAR® Calculator for residential air conditioning.[389] EFLH for Las Cruces and Santa Fe were taken from eQuest simulations for the Community College building type performed by SBW Consulting as part of the development of the commercial air conditioning measure in this manual. The hours for this building type most closely matched the residential hours for the two New Mexico cities included in the ENERGY STAR® Calculator.

Table 200: Residential Full Load Cooling Hours for New Mexico Climate Zones

Location	$EFLH_C$
Albuquerque	1,038
Las Cruces	1,290
Roswell	1,355
Santa Fe	629

Cooling system SEER is entered on a per-household basis, if available. If this value is not available, a value of 10 should be used for cooling systems installed prior to 2006, and a value of 13 should be used for systems installed in 2006 or later.

Heating savings are derived with the following equation.[390]

$$Svgs = (DL_{Baseline} - DL_{Post}) \times 0.77 \times HDD \times 24 \times 60 \times \frac{0.018}{ConvFactor \times Efficiency}$$

[389] http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=CA

[390] Frontier Associates, Deemed Savings based on El Paso Specific Climate Data, Filing with TX Regulatory Commission, 2012.

Where:

Svgs	= Annual heating savings, kWh or therms
DLbaseline	= Duct leakage, baseline, measured at 25 Pascals, CFM
DLpost	= Duct leakage, after installation, measured at 25 Pascals, CFM
0.77	= Adjustment factor to account for the fact that people do not always operate their heating systems when outside temperature is less than 65°F
HDD	= Heating Degree Days for New Mexico climate zones, see below, days-°F
24	= Conversion factor, days to hours
0.018	= Volumetric heat capacity of air (Btu/ft^3°F)
60	= Conversion factor from minutes to hours
ConvFactor	= Conversion factor which yields either kWh or therms, see below
Efficiency	= Heating system efficiency, see Table 201

Table 201: Heating Efficiency (Federal Standards)

Age of Equipment	HSPF Ratings
Heat Pump; Before 2006	6.8
Heat Pump; 2006 - 2014	7.7
Heat Pump; After 1/1/2015	8.2
Electric Resistance	3.412

HDD are shown in Table 202[391] for each climate zone in New Mexico.

Table 202: Heating Degree Days for New Mexico Climate Zones

Location	HDD
Albuquerque	4,180
Las Cruces	2,816
Roswell	3,289
Santa Fe	5,417

[391] http://www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-datasets/climate-normals

Equipment and conversion factor depend on the type of heating system, as shown in Table 203.

Table 203: Heating System Type Conversion Factors and Efficiencies

Heating System Type	Description	Value
Heat Pump	Adjusted HSPF; Btu to kWh	1,000 x adjusted HSPF
Electric Resistance	100% efficiency; Btu to kWh	3,412
Gas furnace	78% efficiency; Btu to Therms	0.78 x 100,000

The adjusted HSPF is derived with the following formula.[392]

$$adjHSPF = HSPF \times \left(1 - \left(0.1392 + (-0.00846 * DTemp) + (-0.0001074 * (DTemp)^2) + (0.0228 * HSPF)\right)\right)$$

Where:

adjHSPF = HSPF adjusted for location

HSPF = Nominal HSPF, taken to be 7.7

DTemp = Design temperature for the location

ASHRAE Design temperatures for New Mexico locations are shown in Table 204.

Table 204: Residential Heating Design Temperatures for New Mexico Locations

Location	Design Temperature (°F)
Albuquerque	18
Las Cruces	20
Roswell	20
Santa Fe	10

[392] http://www.fsec.ucf.edu/en/publications/html/fsec-pf-413-04/

4.5.4 Demand Savings Estimation

Demand savings are defined as the reduction in average kW attributable to the measure during 3:00-6:00 pm on the hottest summer weekdays. Demand savings are derived with the following equation.

$$Svgs = (DL_{Baseline} - DL_{Post}) \times 0.77 \times (h_{Out} \times \rho_{Out} - h_{In} \times \rho_{In}) \times \frac{60}{1000 \times SEER} \times CF$$

Where:

Svgs = Peak cooling savings, kW

CF = Coincident Factor, 0.87

The Coincident Factor is derived as follows.[393] For residential coincidence factors, Frontier Associates used the Air Conditioning Contractors of America (ACCA) Manual S, which recommends that residential HVAC systems be sized at 115% of the maximum cooling requirement of the house. Assuming that the house's maximum cooling occurs during the peak period hours 1 to 7 pm, this sizing guideline leads to a coincidence factor for residential HVAC of 1.00/1.15 = 0.87.

4.5.5 Non-energy Benefits

There are currently no non-energy benefits quantified for this measure. These benefits can be added during future TRM updates.

4.5.6 Measure Life

The lifetime for this measure is 18 years.[394]

4.5.7 Incremental Cost

The actual duct sealing measure cost should be used.[395]

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393 Frontier Associates, Deemed Savings based on El Paso Specific Climate Data, Filing with TX Regulatory Commission, 2012.

394 DEER 2008, RTF

395 State of Illinois Energy Efficiency Technical Reference Manual, version 10.0

4.6 High Efficiency Air Conditioner

This measure involves residential HVAC high efficiency central air conditioning systems, including packaged systems, and split systems consisting of a remote condensing unit and one or more indoor units.

4.6.1 Measure Overview

Sector	Residential
End use	Air Conditioning
Fuel	Electricity
Measure category	High Efficiency Air Conditioner – retrofit and new construction
Delivery mechanism	Rebate
Baseline description	New Construction/Replace-on-Burnout: Federal Minimum Early Retirement: Existing Conditions
Efficient case description	More efficient than baseline

4.6.2 Savings

Newly installed units must have a cooling capacity of less than 65,000 Btu/hour (5.4 tons) to be eligible for the measure. For multi-split systems which have multiple indoor units connected to a single outdoor unit, the system cooling capacity will be considered to be whichever is lower: the outdoor unit capacity, or the total capacity of the installed indoor units. Federal minimum standard as defined by 42 U.S.C. 6291(16) are specified in the Code of Federal Regulations at CFR 430.32(c)(3):[396]

As per the Department of Energy (DOE) Docket: EERE-2014-BT-STD-0048[397], the new testing procedure M1 will be incorporated from January 1, 2023, in the Southwest Region. The M1 testing procedure is a new method of product testing designed to better reflect current field conditions. During this test, the systems' external static pressure is increased from the current SEER (0.1 in. of water) to SEER2 (0.5 in, of water). SEER2 stands for Seasonal Energy Efficiency Ratio 2. Specifically, SEER2 is the total heat removed from the conditioned space during the annual cooling season. The new M1 testing procedure will increase systems' external static pressure by a factor of five to better reflect field conditions

[396] Consumer Central Air Conditioner and Heat Pump Efficiency Standards (DOE): https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=48&action=viewlive#current_standards

[397] https://www.regulations.gov/document/EERE-2014-BT-STD-0048-0103

of installed equipment. With this change, new nomenclature will be used to denote M1 ratings (including EER2 and HSPF2)[398]. Baseline efficiencies as per the new standards and their respective unit conversions are provided below:

Table 205 Baseline Efficiencies for Residential Central Air-Conditioners[399]

System Type	Manufactured After January 1,2023			
	SEER	EER	SEER2	EER2
Split System AC (cooling capacity<45,000 Btu/h)	15.0	12.2*	14.3	11.7**
Split System AC (cooling capacity≥45,000 Btu/h)	14.5	11.7	13.8	11.2**
Packaged ACs	14		13.4	10.6

* 10.2 EER if SEER ≥ 16.0 SEER/** 9.8 EER2 if SEER2 ≥ 15.2 SEER2[400]

Table 206 Efficiency Unit Conversions[401]

Rating	Conversion
SEER2 to SEER	SEER = 1.2476 × SEER2 – 2.8674
EER2 to EER	EER = 1.0578 ×EER2 – 0.1769
HSPF2 to HSPF	HSPF = 1.1702 ×HSPF2 + 0.0700

398 https://www.energy.gov/sites/prod/files/2016/08/f33/Central%20Air%20Conditioners%20and%20Heat%20Pumps%20TP%20SNOPR_4.pdf

399 https://www.energy.gov/sites/prod/files/2016/12/f34/CAC_HP_DFR_NOPR.pdf

400 https://www.energy.gov/sites/prod/files/2016/12/f34/CAC_HP_DFR_NOPR.pdf

401 From PECO SWE Memo for TRM Measure 2.2.1 dated 08/12/2022. SWE conducted an analysis and modeled trendlines developed from equivalent values as stated in the Federal Code for Consumer Products (10 CFR 430.32(c) Energy and water conservation standards and their compliance dates. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C#p-430.32(c)) and ENERGY STAR criteria (ENERGY STAR Program Requirements for Central Air Source Heat Pumps and Central Air Conditioners)

Table 207: Baseline Efficiencies for Residential Central Air-Conditioners

	Manufactured Before January 2006	Manufactured Between January 2015 and 2006	Manufactured After January 2015
System Type	**SEER**	**SEER**	**SEER**
Split Air Conditioner	10.0	13.0	13.0
Packaged Air Conditioner	9.7	13.0	14.0

Table 208: Baseline Efficiencies for Residential Packaged Terminal Air-Conditioner and Heat Pump

	Manufactured Before January 2006		Manufactured Between January 2015 and 2006	
System Type	**SEER**	**HSPF**	**SEER**	**HSPF**
Packaged Terminal Air Conditioner (PTAC)	9.7	-	10.6	-
	Manufactured After January 2015			
System Type	**SEER**[402]			**HSPF**
Packaged Terminal Air Conditioner (PTAC)	12.5 - (0.213 * Capacity/1,000); New Construction 10.9 - (0.213 * Capacity/1,000); Replace on Burnout			-

Air conditioning equipment shall be properly sized to the dwelling, based on ASHRAE or ACCA Manual J standards. Manufacturer data sheets on installed air conditioning equipment or the AHRI reference number must be provided to the utility. The installed central air conditioning equipment must be AHRI certified.

Example:

A new packaged central air conditioner of 24,000 Btu/hour capacity (SEER = 16) will be installed for a newly constructed home in Albuquerque.

$kWh_{Savings}$ = 24000 Btu/hr x 1/1000 x 1038 hours x (1/14 – 1/16)

402 Capacity is the rated cooling capacity of the product in Btu/hr. If the unit's capacity is less than 7,000 Btu/hr then use 7,000 Btu/hr and if more than 15,000 Btu/hr, use 15,000 Btu/hr in the calculation (IECC 2018).

= 222 kWh

EER_{base} = - 0.02 x (14)^2 + 1.12 x 14 = 11.76

EER_{eff} = - 0.02 x (16)^2 + 1.12 x 16 = 12.8

$kW_{Savings}$ = 24000 Btu/hr x 1/1000 x (1/11.76 – 1/12.8) x 0.87

= 0.144 kW

4.6.3 Energy Savings Estimation

New Construction and Replace-on-Burnout

$$kWh_{Savings} = Capacity_{Cool} * \frac{1}{1000} * EFLH_C * \left(\frac{1}{SEER_{base}} - \frac{1}{SEER_{eff}}\right)$$

Where:

$kWh_{Savings}$ = Annual energy savings

$Capacity_{Cool}$ = Cooling capacity of product in Btu/hr. For multi-split systems which have multiple indoor units connected to a single outdoor unit, the system capacity is whichever is lower: the capacity of the outdoor unit, or the total capacity of the installed indoor units

$EFLH_C$ = Residential Effective Full Load Cooling Hours for New Mexico (Table 209)

$SEER_{base}$ = Seasonal Energy Efficiency Rating of the baseline cooling equipment (Table 207 & Table 208)

$SEER_{eff}$ = Seasonal Energy Efficiency Rating of the efficient cooling equipment (AHRI Certificate)

Table 209: Residential Full Load Cooling Hours for New Mexico Climate Zones

Location	$EFLH_C$
Albuquerque	1,038
Las Cruces	1,290
Roswell	1,355

Santa Fe	629

Early Retirement

- Annual kWh and kW should be calculated for two different time periods:Table 210), and
- The remaining time in the EUL period, (i.e., EUL-RUL)

For Remaining Useful Life (RUL):

$$kWh_{Savings,RUL} = Capacity_{Cool} * \frac{1}{1000} * EFLH_C * \left(\frac{1}{SEER_{existing}} - \frac{1}{SEER_{eff}}\right)$$

Where:

$kWh_{Savings,RUL}$ = Annual energy savings during RUL

$SEER_{existing}$ = Seasonal Energy Efficiency Rating of the existing cooling equipment. Use actual rated efficiency of existing unit. If existing efficiency cannot be obtained, select the federal minimum value corresponding to year of manufacture (Table 207)

$SEER_{eff}$ = Seasonal Energy Efficiency Rating of the efficient cooling equipment (from AHRI Certificate)

For remaining time in the Estimated Useful period (EUL – RUL):

$$kWh_{Savings,EUL-R} \quad = Capacity_{Cool} * \frac{1}{1000} * EFLH_C * \left(\frac{1}{SEER_{base}} - \frac{1}{SEER_{eff}}\right)$$

Hence,

$$Lifetime\ Energy\ Savings = kWh_{Savings,RUL} * RUL + kWh_{Savings,EUL-RUL} * (EUL - RUL)$$

Where:

RUL = Remaining Useful Life (Table 210)

EUL = Estimate Useful Life

= 18 Years

Table 210: Remaining Useful Life (Years) of Replaced Air Conditioner Unit[403]

Age of Equipment	Remaining Useful Life	Age of Equipment	Remaining Useful Life
1	16.8	13	9
2	15.8	14	8.6
3	14.9	15	8.2
4	14.1	16	7.9
5	13.3	17	7.6
6	12.6	18	7
7	11.9	19	6
8	11.3	20	5
9	10.8	21	4
10	10.3	22	3
11	9.8	23	2
12	9.4	24	1
		25	0

4.6.4 Demand Savings Estimation

To calculate demand savings for this measure, the baseline SEER will need to be converted to EER (Energy Efficiency Rating) using the formula.[404]

$$EER = -0.02 * SEER^2 + 1.12 * SEER$$

Peak demand savings are calculated with the following formula.

$$kW_{Savings} = Capacity_{Cool} * \frac{1}{1000} * \left(\frac{1}{EER_{base}} - \frac{1}{EER_{eff}}\right) * CF$$

403 Ward, B., Bodington, N., Farah, H., Reeves, S., and Lee, L. "Considerations for early replacement of residential equipment." Prepared by the Evaluation, Measurement, and Verification (EM&V) team for the Electric Utility Marketing Managers of Texas (EUMMOT). January 2015. Use of the early retirement baseline is capped at 25 years, representing the age at which 75 percent of existing equipment is expected to have failed. Systems older than 25 years should use the ROB baseline.

404 Code specified SEER values converted to EER using EER = -0.02 x $SEER^2$ + 1.12 x SEER. National Renewable Energy Laboratory (NREL) 2010, "Building America House Simulation Protocols." U.S. DOE. Revised October 2010 www.nrel.gov/docs/fy11osti/49246.pdf

Where:

$kW_{Savings}$	= Peak Demand Savings
$Capacity_{Cool}$	= Cooling capacity of product in Btu/hr. For multi-split systems which have multiple indoor units connected to a single outdoor unit, the system capacity is whichever is lower: the capacity of the outdoor unit, or the total capacity of the installed indoor units
CF	= Coincidence Factor for residential HVAC measures, 0.87[405]
EER_{base}	= Full-Load Energy Efficiency Rating of the baseline cooling equipment
EER_{eff}	= Full-load Energy Efficiency Rating of the efficient cooling equipment (from AHRI Certificate)

4.6.5 Non-energy Benefits

Well-designed HVAC systems increase occupant comfort and productivity.

4.6.6 Measure Life

The lifetime for this measure is 18 years.[406]

4.6.7 Incremental Cost

It is assumed that this is an end-of-life replacement. The incremental cost for this measure is the incremental cost of the more efficient unit. Incremental costs are shown in Table 211.[407]

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[405] For residential coincidence factors, Frontier used the Air Conditioning Contractors of America (ACCA) Manual S, which recommends that residential HVAC systems be sized at 115% of the maximum cooling requirement of the house. Assuming that the house's maximum cooling occurs during the hours 3 to 6 pm, this sizing guideline leads to a coincidence factor for residential HVAC of 1.0/1.15 = 0.87

[406] Texas TRM v6.0 Volume 2: Residential Measure

[407] State of Illinois Energy Efficiency Technical Reference Manual, version 10.0

Table 211: High Efficiency Air Conditioner Incremental Cost per Ton Cooling Capacity

Model	Incremental cost per ton
14 SEER	$104
15 SEER	$108
16 SEER	$221
17 SEER	$620
18 SEER	$620

4.7 Evaporative Cooling

This measure involves a residential evaporative cooler. The cooler is a direct evaporative cooler, which is in place of a vapor-compression, split system air conditioner. Direct evaporative cooling (open circuit) is used to lower the temperature of air by using latent heat of evaporation, changing liquid water to water vapor. The heat of the outside air is used to evaporate water, and warm dry outside air is changed to cool moist air to directly cool the indoors. This measure does not include indirect evaporative cooling (i.e., closed circuit with heat exchanger) or indirect-direct hybrid systems.

4.7.1 Measure Overview

Sector	Residential
End use	Air Conditioning
Fuel	Electricity
Measure category	Direct Evaporative Cooler
Delivery mechanism	Rebate
Baseline description	Federal Minimum: 13 SEER (11.09 EER) Split System Air Conditioner
Efficient case description	Direct evaporative cooling (no expansion cooling) with the following characteristics: cooling flow is three times the flow use for the code baseline buildings, effectiveness = 0.85.

4.7.2 Savings

The annual energy and demand savings per residence are shown in Table 212 for the four New Mexico climate zones.

Table 212: Evaporative Cooling Energy and Demand Savings

Location	Energy Savings (kWh)	Demand Savings (kW)
Albuquerque	2,233	1.77
Roswell	3,332	2.38
Santa Fe	1,471	1.38
Las Cruces	3,878	2.46

4.7.3 Energy Savings Estimation

Savings are derived with the following assumptions:

- The baseline cooling load is met by DX A/C systems with the following capacities:
    - Albuquerque: 2.5 tons
    - Roswell: 3 tons
    - Santa Fe: 2 tons
    - Las Cruces: 3 tons
- Baseline = 13 SEER (11.09 EER) Split System Air Conditioner
- The evaporative cooling system is two-speed, using 400 watts at low speed and 800 watts at high speed
- The evaporative cooler has runtime hours as follows according to temperature bin

Table 213: Evaporative Cooler Runtime Percentage

Temperature range	Fan speed	Runtime percentage
70 – 75	Low	0%
75 – 80	Low	50%
80 – 85	50% low/50% high	75%
85 – 90	50% low/50% high	85%
90 – 95	High	95%
95 – 100	High	95%
100+	High	95%

- Baseline energy usage is derived as for the Residential High Efficiency A/C measure

4.7.4 Demand Savings Estimation

Demand savings are defined as the reduction in average kW attributable to the measure during 3:00-6:00 pm on the hottest summer weekdays. Demand savings are the difference in usage in the hottest TMY3 temperature bin with more than 9 hours.

4.7.5 Non-energy Benefits

There are currently no non-energy benefits defined for this measure. These benefits may be added during future TRM updates.

4.7.6 Measure Life

The lifetime for this measure is 15 years.[408]

4.7.7 Incremental Cost

The assumption here is that this is an end-of-life replacement. The incremental cost (Direct Evaporative Cooler cost less than SEER 13 Split System A/C cost) is $0.[409]

[408] DEER 2008

[409] DEER 2005

4.8 Infiltration Reduction

This measure reduces air infiltration into the residence, using pre- and post-treatment blower door air pressure readings to confirm air leakage reduction.

4.8.1 Measure Overview

Sector	Residential
End use	HVAC
Fuel	Electricity and Natural Gas
Measure category	Air Sealing - Reduce Infiltration
Delivery mechanism	Qualified professional installation
Baseline description	Upper limit of 4.00 CFM50 per square foot of house floor area
Efficient case description	A minimum air leakage reduction of 10% of the pre-installation reading is required

4.8.2 Savings

A method for deriving savings is described. Savings are site specific, based on blower door test readings and HVAC system efficiencies.

Example:

Pre treatment air infiltration = 4,000 CFM50

Post treatment air infiltration = 2,000 CFM50

SEER rating of the AC equipment = 13

$\Delta kWh_{Cooling}$ = ((4,000 CFM-2,000 CFM)/21.5) x 60 mins/hour x 31,728 hours x 0.018/(1000 x 13)

= 245 kWh

$\Delta kWh_{Heating}$ = ((4,000 CFM-2,000 CFM)/21.5) x 60min/hour x 24 hour/day x 4180 days x 0.018/(100,000 x 1 x 0.80)

= 126 kWh

Total energy savings = 371 kWh

Demand savings (Cooling only) = 245 kWh/1038 hours x 0.87 = 0.205 kW

4.8.3 Energy Savings Estimation

Savings are derived using the methodology in the State of Ohio Energy Efficiency Technical Reference Manual, August 6, 2012.

Annual cooling energy savings are derived with the following formula.

$$\Delta \mathrm{kWh}_{Cooling} = \frac{\left(\frac{CFM50exist - CFM50new}{Nfactor}\right) \times 60 \times CDH \times 0.018}{(1000 \times \eta Cool)}$$

Where:

$\Delta \mathrm{kWh}_{\mathrm{Cooling}}$	= Annual cooling energy savings, kWh
CFM50exist	= Existing Cubic Feet per Minute at 50 Pascal pressure differential as measured by the blower door before air sealing.
CFM50new	= New Cubic Feet per Minute at 50 Pascal pressure differential as measured by the blower door after air sealing.
Nfactor	= Conversion factor to convert 50-pascal air flows to natural airflow
	= 21.5[410]
60	= Constant to convert cubic feet per minute to cubic feet per hour
CDH	= Cooling Degree Hours, see Table 214
0.018	= Volumetric heat capacity of air (Btu/ft^3°F)
$\eta Cool$	= Efficiency of Air Conditioning equipment (i.e., SEER rating), see Table 215

410 Nfactor from methodology developed by the Lawrence Berkeley Laboratory (LBL) for Zone 3 (as defined by LBL), single story, normal exposure.

Table 214: Cooling Degree Hours for New Mexico Climate Zones

	Cooling Degree Hours[411] (65°F Reference Temp)
Albuquerque	31,728
Las Cruces	45,600
Roswell	42,936
Santa Fe	15,504

Table 215: Cooling Efficiency (Federal Standards)

Age of Equipment	SEER Ratings
Before 2006	10.0
2006 - 2014	13.0
Central AC after 1/1/2015	13.0
Heat Pump after 1/1/2015	14.0

Annual space heating savings are derived with the following formulas.

$$Svgs\ Gas\ Heating = \frac{\left(\frac{CFM50exist - CFM50new}{Nfactor}\right) \times 60 \times 24 \times HDD \times 0.018}{(100{,}000 \times \eta Heat \times \eta Dist)}$$

$$Svgs\ Electric\ Heating = \frac{\left(\frac{CFM50exist - CFM50new}{Nfactor}\right) \times 60 \times 24 \times HDD \times 0.018 \times 29.31}{(100{,}000 \times \eta Heat \times \eta Dist)}$$

Where:

Svgs Gas Heating = Annual space heating energy savings, therms

Svgs Electric Heating = Annual space heating energy savings, kWh

CFM50exist = Existing Cubic Feet per Minute at 50 Pascal pressure differential as measured by the blower door before air-sealing.

411 www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-datasets/climate-normals

CFM50new	= New Cubic Feet per Minute at 50 Pascal pressure differential as measured by the blower door after air-sealing.
Nfactor	= Conversion factor to convert 50-pascal air flows to natural airflow
	= 21.5[412]
60	= Constant to convert cubic feet per minute to cubic feet per hour
24	= Constant to convert days to hours
HDD	= Heating Degree Days, see Table 216
0.018	= Volumetric heat capacity of air (Btu/ft^3°F)
$\eta Heat$	= Heating Equipment Efficiency (AFUE or COP; convert HSPF to COP using COP = HSPF/3.412)
$\eta Dist$	= Distribution Efficiency [413] (default = 80%)
29.31	= Constant to convert therms to kWh

Table 216: Heating Degree Days for New Mexico Climate Zones

	Heating Degree Days[414] (65°F Reference Temp)
Albuquerque	4,180
Las Cruces	2,816
Roswell	3,289
Santa Fe	5,417

412 Nfactor from methodology developed by the Lawrence Berkeley Laboratory (LBL) for Zone 3 (as defined by LBL), single story, normal exposure.

413 The System Efficiency can be obtained either by recording the AFUE of the unit, or performing a steady state efficiency test. The Distribution Efficiency can be estimated via a visual inspection and by referring to a look up table such as that provided by the Building Performance Institute: (http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf) or by performing duct blaster testing. In the case of electric heat use 1.0 as the heating system efficiency, and for heat pumps use COP (HSPF/3.412).

414 www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-datasets/climate-normals

4.8.4 Demand Savings Estimation

Demand savings are defined as the reduction in average kW attributable to the measure during 3:00-6:00 pm on the hottest summer weekdays. Demand savings are derived with the following equation.

$$kW = \frac{\Delta kWh_{Cooling}}{EFLH_{Cooling}} \times CF$$

Where:

$\Delta kWh_{Cooling}$ = Annual Cooling energy savings, kWh

$EFLH_{Cooling}$ = Effective Full Load Hours for residential cooling

CF = Summer peak Coincidence Factor for measure = 0.87

Full load cooling hours ($EFLH_{Cooling}$) are shown in Table 217. EFLH for Albuquerque and Roswell were derived from the ENERGY STAR® Calculator for residential air conditioning.[415] EFLH for Las Cruces and Santa Fe were taken from eQuest simulations for the Community College building type performed by SBW Consulting as part of the development of the commercial air conditioning measure in this manual. The hours for this building type most closely matched the residential hours for the two New Mexico cities included in the ENERGY STAR® Calculator.

Table 217: Full Load Cooling Hours for New Mexico Climate Zones

	Full Load Cooling Hours ($EFLH_{Cooling}$)
Albuquerque	1,038
Las Cruces	1,290
Roswell	1,355
Santa Fe	629

The Coincidence Factor, CF, is derived as follows.[416] For residential coincidence factors, Frontier Associates used the Air Conditioning Contractors of America (ACCA) Manual S, which recommends that residential HVAC systems be sized at 115% of the maximum cooling requirement of the house. Assuming that the house's maximum cooling occurs

[415] Full Load Hour assumptions taken from the ENERGY STAR® calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls)

[416] Frontier Associates, Deemed Savings based on El Paso Specific Climate Data, Filing with TX Regulatory Commission, 2012.

during the peak period hours 1 to 7 pm, this sizing guideline leads to a coincidence factor for residential HVAC of 1.00/1.15 = 0.87.

4.8.5 Non-energy Benefits

There are currently no non-energy benefits defined for this measure. These benefits may be added during future TRM updates.

4.8.6 Measure Life

The estimated useful life is 11 years for this measure.[417]

4.8.7 Incremental Cost

The incremental cost is the complete measure cost. This cost should be determined on a site-by-site basis according to actual costs.

[417] DEER 2008 (low-income weatherization)

4.9 Efficient Water Heaters

This measure saves water heating energy due to an increase in efficiency beyond federal standards.

4.9.1 Measure Overview

Sector	Residential
End use	Water Heating
Fuel	Electricity and Natural Gas
Measure category	Efficient water heaters
Delivery mechanism	Rebate
Baseline description	Federal standard minimum efficiencies for gas and electric storage and instantaneous water heaters
Efficient case description	Efficiencies meeting ENERGY STAR® standards

4.9.2 Savings

Savings depend on the technology, fuel, and the date of implementation, as shown below. The tables below list savings for electric and gas-fired water heaters including the storage and instantaneous types.[418]

[418] The savings below are derived using the average Uniform Energy Factors across the draw patterns.

Table 218: Electric Water Heater Energy Savings (kWh)

Number of Bedrooms	1	2			3		4		5	6
Storage capacity	**20**	**30**	**40**	**50**	**40**	**50**	**50**	**66**	**66**	**80**
Electric storage water heater										
Albuquerque	1,845	1,742	2,339	2,944	2,494	3,140	2,842	272	273	327
Las Cruces	1,657	1,564	2,100	2,644	2,240	2,820	2,553	244	246	293
Roswell	1,677	1,584	2,127	2,677	2,268	2,855	2,585	248	249	297
Santa Fe	1,991	1,880	2,524	3,177	2,692	3,389	3,068	294	295	353

The baseline equipment for electric water heaters with storage tank capacity greater than 55 gallons is a heat pump water heater, which has a much higher efficiency. This explains the significant drop in energy savings for electric water heaters once storage tank capacities exceed 55 gallons.

Table 219: Electric Water Heater Demand Savings (kW)

Number of Bedrooms	1	2			3		4		5	6
Storage capacity	**20**	**30**	**40**	**50**	**40**	**50**	**50**	**66**	**66**	**80**
Electric storage water heater										
Albuquerque	0.162	0.153	0.205	0.258	0.219	0.275	0.249	0.024	0.024	0.029
Las Cruces	0.145	0.137	0.184	0.232	0.196	0.247	0.224	0.021	0.022	0.026
Roswell	0.147	0.139	0.186	0.235	0.199	0.250	0.227	0.022	0.022	0.026
Santa Fe	0.175	0.165	0.221	0.279	0.236	0.297	0.269	0.026	0.026	0.031

Table 220: Gas-fired Water Heater Savings (therms)

Number of Bedrooms	1	2		3			4		5	6
Storage capacity	**20**	**30**	**40**	**30**	**40**	**50**	**40**	**50**	**50**	**50**
Gas-fired storage water heater										
Albuquerque	35.2	44.7	69.6	47.0	73.1	105.3	75.8	109.2	112.3	126.4
Las Cruces	31.6	46.9	62.5	42.2	65.6	94.6	68.0	98.1	100.9	113.5
Roswell	32.0	47.4	63.3	42.7	66.4	95.8	68.9	99.3	102.1	114.9
Santa Fe	38.0	56.3	75.1	50.7	78.8	113.6	81.8	117.9	121.2	136.4
Instantaneous gas-fired water heater[419]										
Albuquerque	9.4	11.7		14.0			16.4		18.7	21.1
Las Cruces	8.4	10.5		12.6			14.7		16.8	18.9
Roswell	8.5	10.6		12.8			14.9		17.0	19.2
Santa Fe	10.1	12.6		15.2			17.7		20.2	22.7
Gas-fired storage water heater to Instantaneous gas-fired water heater[420]										
Albuquerque	75.2	87.5	126.6	91.9	133.0	180.2	137.9	186.9	192.2	216.2
Las Cruces	67.5	78.6	113.7	82.5	119.4	161.8	123.8	167.8	172.6	194.2
Roswell	68.4	79.6	115.2	83.6	120.9	163.9	125.4	169.9	174.8	196.6
Santa Fe	81.1	94.5	136.7	99.2	143.5	194.5	148.8	201.7	207.4	233.4

4.9.3 Energy Savings Estimation

Savings are determined with the following equations.

$$Savings = EnergyInWater * \left(\frac{1}{UEF_{Base}} - \frac{1}{UEF_{Measure}}\right)$$

Where:

Savings = Annual energy savings, kWh or therms

EnergyInWater = Derived with the equation below

[419] These savings are for replacing a baseline instantaneous gas-fired water heater with a high-efficiency instantaneous gas-fired water heater.

[420] These savings are for replacing a baseline storage gas-fired water heater with a high-efficiency instantaneous gas-fired water heater.

UEF_{Base} = Baseline uniform energy factor, see below

$UEF_{Measure}$ = Efficient uniform energy factor, see below

= Rated efficiency of the incented unit, if unknown use values in Table 223.

$$EnergyInWater = GallonsPerDay * 365 * Density * C_p * (Temp_{Hot} - Temp_{Cold}) * ConversionConstant$$

Where:

EnergyUse = Annual energy use due to change in water temperature, kWh or therms

GallonsPerDay = Daily hot water usage, see below

Density = Density of water, 8.33 lbs/gallon

C_p = Heat capacity of water, 1.0 Btu/lb/°F

$Temp_{Hot}$ = Temperature of water in tank, 127.5 °F

$Temp_{Cold}$ = Temperature of inlet water, see Table 8[421]

ConversionConstant = Converts Btus into kWh or therms: 0.0002932972 kWh/Btu, 0.00001 therms/Btu

Table 221: Daily Hot Water Usage[422]

Number of bedrooms	1	2	3	4	5	6
Clothes Washer	10.0	12.5	15.0	17.5	20.0	22.5
Dishwasher	3.3	4.2	5.0	5.8	6.7	7.5
Shower	18.7	23.3	28.0	32.7	37.4	42.0
Bath	4.7	5.8	7.0	8.2	9.4	10.5
Sinks	16.7	20.8	25.0	29.1	33.3	37.5
Total	**53.3**	**66.7**	**80.0**	**93.3**	**106.7**	**120.0**

Efficient case UEF's are shown in the table below.

421 Inlet water temperature is calculated using NREL report "Building America Performance Analysis Procedures for Existing Homes". Ambient temperature for Albuquerque, Las Cruces, Roswell and Santa Fe are taken from the TMY data.

422 Hot water consumption is calculated based on different uses of water in a house as given in the Building America Research Benchmark report. https://www.nrel.gov/docs/fy10osti/47246.pdf

Table 222: Baseline UEF for Electric and Gas-fired Water Heaters[423]

Product Class	Rated Storage Volume	Draw pattern[424]	Uniform Energy Factor*
Electric storage	≥20 gal and ≤55 gal	Very Small	0.8808 – (0.0008 × Vr)
		Low	0.9254 – (0.0003 × Vr)
		Medium	0.9307 – (0.0002 × Vr)
		High	0.9349 – (0.0001 × Vr)
	>55 gal and ≤100 gal	Very Small	1.9236 – (0.0011 × Vr)
		Low	2.0440 – (0.0011 × Vr)
		Medium	2.1171 – (0.0011 × Vr)
		High	2.2418 – (0.0011 × Vr)
Gas-fired storage	≥20 gal and ≤55 gal	Very Small	0.3456 – (0.0020 × Vr)
		Low	0.5982 – (0.0019 × Vr)
		Medium	0.6483 – (0.0017 × Vr)
		High	0.6920 – (0.0013 × Vr)
	>55 gal and ≤100 gal	Very Small	0.6470 – (0.0006 × Vr)
		Low	0.7689 – (0.0005 × Vr)
		Medium	0.7897 – (0.0004 × Vr)
		High	0.8072 – (0.0003 × Vr)
Instantaneous Gas-fired	<2 gal & >50,000 Btu/h	Very Small	0.8
		Low	0.81
		Medium	0.81
		High	0.81
Instantaneous Electric	<2 gal	Very Small	0.91
		Low	0.91
		Medium	0.91
		High	0.92

*Vr is volume of the water heater in gallons

423 Water heater uniform energy factors are taken from the Code of Federal Regulation 10 CFR 430.32 Energy and water conservation standards. https://www.ecfr.gov/cgi-bin/text-idx?SID=80dfa785ea350ebeee184bb0ae03e7f0&mc=true&node=se10.3.430_132&rgn=div8

424 The draw pattern is governed by 10 CFR 429.17- Water Heaters. Maximum gallons per minute for different draw patterns are as follows: Very Small- 1.7 gal/min, Low- 2.8 gal/min, Medium-4 gal/min, High-No upper limit.

Efficient case UEF's are shown in the table below.

Table 223: Measure UEF for Electric and Gas-fired Water Heaters[425]

Product Class	Rated Storage Volume	Uniform Energy Factor
Electric	≤ 55 gallons	3.50[426]
	> 55 gallons	3.57[427]
Gas-fired storage	≤ 55 gallons, Medium Draw Pattern	0.64
	≤ 55 gallons, High Draw Pattern	0.68
	> 55 gallons, Medium Draw Pattern	0.78
	> 55 gallons, High Draw Pattern	0.80
Gas-fired instantaneous	-	0.87

4.9.4 Demand Savings Estimation

Demand savings are calculated using:

$$kW_{savings} = kWh_{savings} \ X \ Ratio_{Annual\ kWh}^{Peak\ kW}$$

Where:

$kW_{savings}$ = Annual demand savings, in kW

$kWh_{savings}$ = Annual energy savings as calculated above

$Ratio_{Annual\ kW}^{Peak\ kW}$ = Peak kW to annual energy kWh ratio, 0.0000877[428]

4.9.5 Non-energy Benefits

Higher efficiency water heaters generally have a longer lifespan.

425 Measure efficiency of water heaters based on the ENERGY STAR requirements. https://www.energystar.gov/sites/default/files/Water%20Heaters%20Final%20Version%203.2_Program%20Requirements.pdf

426 Average efficiency of listed electric ENERGY STAR water heaters with rated storage volume. https://www.energystar.gov/productfinder/product/certified-water-heaters/

427 Ibid

428 US Department of Energy's "Building America Performance Analysis Procedures for Existing Homes" combined domestic hot water use profile (http://www.nrel.gov/docs/fy06osti/38238.pdf).

4.9.6 Measure Life

The measure life for this equipment is shown in Table 224.[429]

Table 224: Residential Water Heater Measure Life (years)

Measure	Measure Life
Gas storage	11
Gas Instantaneous	20
Electric (HPWH)	10

4.9.7 Incremental Cost

The incremental cost for this measure is the difference between the cost of an efficient water heater and a standard water heater, as shown in the following table. The incremental costs reflect current CA DEER values, subtracting the average expected cost increase associated with the more advanced code.

Table 225: Residential Water Heater Incremental Measure Cost[430]

Measure	Incremental cost
Gas storage	$117
Condensing gas storage	$627
Tankless	$547
Electric (HPWH)	$995

[429] IL TRM, DEER, NW Power Council, NREL National Database of Energy Efficiency measures - http://www.nrel.gov/ap/retrofits/measures.cfm?gId=6&ctId=270&scId=4142&acId=4142

[430] DEER 2008, with adjustments for expected average cost increase specified in DOE Rulemaking 10 CFR part 430

4.10 High Efficiency Gas Furnace (Condensing)

This measure involves the installation of a new high efficiency, gas-fired condensing furnace for residential space heating, instead of a new baseline gas furnace. The measure could be installed in either an existing or new home.

4.10.1 Measure Overview

Sector	Residential
End use	Space Heating
Fuel	Natural Gas
Measure category	High Efficiency Gas Furnaces
Delivery mechanism	Rebate
Baseline description	Federal standard minimum efficiency for gas furnace, effective May 1, 2013. AFUE = 0.80
Efficient case description	AFUE ≥ 0.90

4.10.2 Savings

Savings are a function of the baseline and as-installed furnace efficiency (AFUE), input capacity (CAP_{Input}), and effective full load hours (EFLH) of operation. The efficiency and the CAP_{Input} values are application-specific, whereas the EFLH is deemed according to weather zone. A de-rating factor is also applied to account research indicating a nominal discrepancy between rated efficiency and actual operating efficiency for both the baseline and efficient cases.

4.10.3 Energy Savings Estimation

The savings for the installation of a high efficiency furnace are calculated using the formula shown below.

$$Therm_{Savings} = \frac{\frac{EFLH_H \times CAP_{Input}}{(1 - Derating_{eff})} \times \left(\frac{AFUE_{eff} \times (1 - Derating_{eff})}{AFUE_{base} \times (1 - Derating_{base})} - 1 \right)}{100{,}000}$$

Where:

$Therm_{Savings}$ = Annual gas savings

CAP_{Input} = Gas Furnace input capacity, Btu/hr

$EFLH_H$ = Effective Full Load Hours of the furnace for the climate region, Table 226

$AFUE_{base}$ = Baseline Furnace Annual Fuel Utilization Efficiency rating, 0.80

$AFUE_{eff}$ = Efficient Furnace Annual Fuel Utilization Efficiency rating, actual

$Derating_{base}$ = Baseline furnace AFUE derating, 0.064[431]

$Derating_{eff}$ = Efficient furnace AFUE derating

= 0.000 if verified quality installation is performed

= 0.064[432] if verified quality installation is not performed or unknown

Table 226: Residential Full Load Heating Hours for New Mexico Climate Zones

Location	$EFLH_H$
Albuquerque	1,358
Las Cruces	899
Roswell	921
Santa Fe	1,447

4.10.4 Demand Savings Estimation

There are no demand savings for this measure.

4.10.5 Non-energy Benefits

Higher efficiency furnaces generally have a longer lifespan.

4.10.6 Measure Life

The measure life for this equipment is 20 years.[433]

431 Brand, L., Yee, S., and Baker, J. "Improving Gas Furnace Performance: A Field and Laboratory Study at End of Life." Building Technologies Office. National Renewable Energy Laboratory. 2015

432 Ibid

433 US Department of Energy, WPN 19-4: Revised Energy Audit Approval Procedures, Related Audit, and Material Approvals, Attachment 9, January 17, 2019.

4.10.7 Incremental Cost

The incremental cost (retail equipment cost plus installation cost) for this measure is the difference between the cost of a high efficiency condensing gas furnace and a standard gas furnace, as shown in Table 227.

Table 227: High Efficiency Gas Furnace Incremental Measure Cost[434]

AFUE (%)	Incremental cost
80	n/a
90	$630
91	$716
92	$802
93	$1,014
94	$1,226
95	$1,438
96	$1,650
97	$1,862

[434] State of Illinois Energy Efficiency Technical Reference Manual, 2020

4.11 High Efficiency Gas Boiler (Condensing)

This measure involves the installation of a new residential sized ENERGY STAR®qualified high efficiency gas-fired condensing boiler for residential space heating, instead of a new baseline gas boiler. The measure could be installed in either an existing or new home, or an existing or new multifamily building.

4.11.1 Measure Overview

Sector	Residential
End use	Space Heating
Fuel	Natural Gas
Measure category	High Efficiency Gas Boilers
Delivery mechanism	Rebate
Baseline description	For single-family: Federal standard minimum efficiency for gas boiler, effective May 1, 2013. AFUE = 0.82 For multifamily: Hot water boiler (300 - 2500 kBtuh, 80.0 Et) Hot water boiler (> 2500 kBtuh, 80.0 Et, 82.0Ec) Hot water boiler (< 300 kBtuh, 82.0 AFUE) Steam boiler (300 - 2500 kBtuh, 79.0 Et) Steam boiler (> 2500 kBtuh, 79.0 Et, 82.0Ec) Steam boiler (< 300 kBtuh, 80.0 AFUE)
Efficient case description	For single-family: ENERGY STAR® qualified, AFUE > or = 0.90 For multifamily: Greater efficiency than baseline boiler

4.11.2 Savings

Savings is a function of the baseline and as-installed boiler efficiency (EF), output capacity (CAP), and effective full load hours (EFLH) of operation. The efficiency and the CAP values are application-specific, whereas the EFLH is deemed according to weather zone. A de-rating factor is also applied to take into account research indicating a nominal discrepancy between rated efficiency and actual operating efficiency for both the baseline and efficient cases.

Example:

Energy star® qualified boiler is installed in place of existing minimum efficiency boiler. The rated capacity of the boiler is 200 kBtuh with 90% boiler efficiency.

$$Savings = 200\ kBtuh\ x\ \left[\left(\frac{1}{0.967 \times 0.82}\right) - \left(\frac{1}{0.941 \times 0.90}\right)\right] x\ 1250\ hours\ x\ 0.01$$

Answer: 200.88 therms

4.11.3 Energy Savings Estimation

Savings are determined with the following equation.

$$Savings = CAP * \left(\frac{1}{C_B * 0.82} - \frac{1}{C_E * EF_{AE}}\right) * \ EFLH_{CR} * 0.01$$

Where:

Savings	= Annual energy savings, therms
CAP	= Efficient boiler rated output capacity, MBH
EF_E	= Efficient boiler rated efficiency
C_B	= De-rating factor for baseline boiler, 0.967[435]
C_E	= De-rating factor for efficient boiler, 0.941[436]
$EFLH_{CR}$	= Effective full load hours of boiler operation for the climate region
0.01	= Conversion factor from kBtu to therms, 0.01 therms/kBtu

CAP and EF_E are variable according to the application. $EFLH_{CR}$ is determined with the following equation.

$$EFLH_{CR} = \left(24 * \left(\frac{1}{Sizing\ Factor}\right) * HDD_{CR}\right)/(55 - T_{CR})$$

[435] High Efficiency Heating Equipment Impact Evaluation (Cadmus, 2015)

[436] Ibid.

Where:

Sizing Factor = Sizing factor to account for the difference between net and gross output, given piping losses and initial pickup, 1.15[437]

HDD_{CR} = Heating Degree Days at base 55°F for the climate zone[438]

T_{CR} = 99% Heating Design Outdoor Air Temperature for the climate zone[439]

Table 228 shows the HDD_{CR}, T_{CR}, and $EFLH_{CR}$ for each of the four New Mexico climate regions.

Table 228: Climate Region Parameters

Parameter	Albuquerque	Las Cruces	Roswell	Santa Fe
HDD_{CR}	2,213	1,508	1,588	3,121
T_{CR}	21	20	19	10
$EFLH_{CR}$	1,358	899	921	1,447

4.11.4 Demand Savings Estimation

No demand savings are associated with this measure.

4.11.5 Non-energy Benefits

There are no non-energy benefits.

4.11.6 Measure Life

The measure life for this equipment is 20 years.[440]

4.11.7 Incremental Cost

The incremental cost for this measure is the difference between the cost of a high efficiency condensing gas furnace and a standard gas furnace, as shown in the following table.

[437] 2016 ASHRAE Handbook – HVAC Systems and Equipment, Chapter 32 Section 5.

[438] An Analysis of Representative Heating Load Lines for Residential HSPF Ratings (ORNL, July 2015)

[439] Energy-Star Certified Homes Design Temperatures by County

[440] US Department of Energy, WPN 19-4: Revised Energy Audit Approval Procedures, Related Audit, and Material Approvals, Attachment 9, January 17, 2019.

Table 229: High Efficiency Gas Boiler Incremental Measure Cost[441]

AFUE (%)	Incremental cost
90	$1,272
92	$1,443
94	$1,614
96	$1,785

[441] Costs derived from Page E-13 of Appendix E of Residential Furnaces and Boilers Final Rule Technical Support Document: http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/fb_fr_tsd/appendix_e.pdf

4.12 Advanced Power Strips

Advanced power strips (APS) reduce "vampire" load in home entertainment or home office environments by sensing when the controlling device, assumed to be either a TV or a computer, is turned off or switches into low power mode, and shutting off power at that point to peripheral devices plugged into the APS.

4.12.1 Measure Overview

Sector	Residential
End use	Plug Load
Fuel	Electricity
Measure category	Advanced Power Strips
Delivery mechanism	Rebate/Direct Install/Leave-behind/Mail-by-request
Baseline description	Standard power strip, or no power strip
Efficient case description	Load sensing Advanced Power Strip (APS) - power to peripheral devices is shut off when the controlling device is turned off or enters low power mode - in one of the following applications 1. Home Entertainment 2. Home Office 3. Unspecified application

4.12.2 Savings

Deemed energy and demand savings for the measure are shown in Table 230.

Table 230: Advanced Power Strip Energy and Demand Savings

Application	Energy Savings (kWh)	Demand Savings (kW)
Home Entertainment	62	0.0068
Home Office	36	0.0039
Unspecified	52	0.0057

4.12.3 Energy Savings Estimation

Savings are based on the following equation.[442]

$$kWh_{Savings} = IdlePower_{App} \times DailyIdleHours_{App} \times 365 \times ISR$$

Parameters are described in Table 231. The values are for the 5-outlet APS rather than the 7-outlet APS, based on program evaluation findings that the number of connected peripheral devices was not high enough to justify the higher savings.[443]

Table 231: Energy Savings Estimation Variable & Sources

Variable	Definition	Value
$IdlePower_{TV}$	Idle power draw of home entertainment peripheral devices, kW	0.0085[444,445]
$DailyIdleHours_{TV}$	Number of hours per day the home entertainment system is not in use	20444
$IdlePower_{Comp}$	Idle power draw of home office peripheral devices, kW	0.0049444,445[446]
$DailyIdleHours_{Comp}$	Number of hours per day the home office system is not in use	20444
ISR	In-service-rate	Provided by implementer, according to delivery mechanism

Where the installed application is unknown, the probabilities of installation application are shown in Table 232.[447] These weightings are used to derive the "Unspecified" measure application.

442 PNM/Ecova "Advanced Power Strips Savings Brief," 2015 PNM Whole House Program. This report cites the 2014 Pennsylvania Technical Reference Manual (PA TRM) as the source of savings, and equations from the 2015 PA TRM are used as the basis of savings here: "Technical Reference Manual," Pennsylvania PUC, June 2015, http://www.puc.pa.gov/pcdocs/1333318.docx

443 PNM/Ecova Savings Brief, citing ADM evaluation

444 PNM/Ecova Savings Brief, citing "Electricity Savings Opportunities for Home Electronics and Other Plug-In Devices in Minnesota Homes", Energy Center of Wisconsin, May 2010.

445 PNM/Ecova Savings Brief, citing "Advanced Power Strip Research Report", NYSERDA, August 2011

446 PNM/Ecova Savings Brief, citing "Smart Plug Strips", ECOS, July 2009.

447 Northwest Power & Conservation Council, Regional Technical Forum, https://rtf.nwcouncil.org/measure/residential-advanced-power-strips/(The PA TRM just uses a 50/50 installation split with no source cited.)

Table 232: Advanced Power Strip Installation Weightings

Application	Weighting
Home Entertainment	61%
Home Office	39%

The in-service-rate (ISR) is a combination of the installation rate and the removal rate. This value will vary according to delivery mechanism and should be determined by the program implementer according to evaluation results of this or similar measures.

4.12.4 Demand Savings Estimation

Savings are derived with the following equation.

$$Demand\ kW_{Savings} = kWSavings_{App} \times CoincidenceFactor$$

Parameters in this equation are described in Table 233.

Table 233: APS Peak Demand Savings Estimation Variable & Sources

Variable	Definition	Value & source
$kWSavings_{TV}$	The power savings when the home entertainment peripheral devices are shut off	$IdlePower_{TV}$, above
$kWSavings_{Comp}$	The power savings when the home office peripheral devices are shut off	$IdlePower_{Comp}$, above
CoincidenceFactor	Fraction which describes the overlap between the measure and peak hours	0.8[448]

4.12.5 Non-energy Benefits

There are no non-energy benefits.

4.12.6 Measure Life

The measure life for this equipment is 7 years.[449]

[448] PNM/Ecova Savings Brief, citing "Efficiency Vermont coincidence factor for smart strip measure – in the absence of empirical evaluation data, this was based on the assumptions of the typical run pattern for televisions and computers in homes."

[449] State of Illinois Energy Efficiency Technical Reference Manual, version 10.0

4.12.7 Incremental Cost

The cost for an APS is $16.46,[450] based on the TrickleStar 7-outlet APS 1080 Joules.

[450] PNM/Ecova Savings Brief, citing "EFI Quote November 2014." An online search on Nov. 11, 2022 found the same power strip for a retail price starting at $29.99.

4.13 Heat Pumps

This measure involves residential HVAC high efficiency central heat pump systems, including packaged systems, and split systems consisting of a remote condensing unit and one or more indoor units.

4.13.1 Measure Overview

Sector	Residential
End use	Heating and Cooling
Fuel	Electricity
Measure category	Residential heat pumps – Electric only
Delivery mechanism	Rebate
Baseline description	New Construction/Replace-on-Burnout: Federal Minimum Early Retirement: Existing Conditions
Efficient case description	More efficient than baseline

4.13.2 Savings

Newly installed units must have a cooling capacity of less than 65,000 Btu/hour (5.4 tons) to be eligible for the measure. For multi-split systems which have multiple indoor units connected to a single outdoor unit, the total cooling capacity should be determined by choosing the lower of outdoor units or the sum of all indoor units. Federal minimum standards as defined by 42 U.S.C. 6291(16) are specified in the Code of Federal Regulations at 10 CFR 430.32(c)(3):[451]

As per the Department of Energy (DOE) Docket: EERE-2014-BT-STD-0048[452], the new testing procedure M1 will be incorporated from January 1, 2023, in the Southwest Region. The M1 testing procedure is a new method of product testing designed to better reflect current field conditions. During this test, the systems' external static pressure is increased from the current SEER (0.1 in. of water) to SEER2 (0.5 in, of water). SEER2 stands for Seasonal Energy Efficiency Ratio 2. Specifically, SEER2 is the total heat removed from the conditioned space during the annual cooling season. The new M1 testing procedure will

451 Consumer Central Air Conditioner and Heat Pump Efficiency Standards (DOE): https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=48&action=viewlive#current_standards

452 https://www.regulations.gov/document/EERE-2014-BT-STD-0048-0103

increase systems' external static pressure by a factor of five to better reflect field conditions of installed equipment. With this change, new nomenclature will be used to denote M1 ratings (including EER2 and HSPF2)[453]. Baseline efficiencies as per the new standards and their respective unit conversions are listed below:

Table 234 Baseline Efficiencies for Residential Heat Pumps[454]

	Manufactured After January 1,2023			
System Type	**SEER**	**HSPF**	**SEER2**	**HSPF2**
Split Heat Pump	15.0	8.8	14.3	7.5
Packaged Heat Pump	14.0	8.0	13.4	6.7

Table 235 Efficiency Unit Conversions[455]

Rating	Conversion
SEER2 to SEER	SEER = 1.2476 × SEER2 – 2.8674
EER2 to EER	EER = 1.0578 ×EER2 – 0.1769
HSPF2 to HSPF	HSPF = 1.1702 ×HSPF2 + 0.0700

Table 236: Baseline Efficiencies for Residential Heat Pumps

System Type	Manufactured Before January 2006	Manufactured Between January 2006 and January 2015	Manufactured After January 2015

[453] https://www.energy.gov/sites/prod/files/2016/08/f33/Central%20Air%20Conditioners%20and%20Heat%20Pumps%20TP%20SNOPR_4.pdf

[454] The 2023 federal standards (10 CFR 430.32(c)(5)) are in terms of an updated metric, depicted as SEER2, EER2, and HSPF2 and manufacturers must certify their products meet the standard according to the new test procedure and new metrics. The updated test method as well as the updated energy conservation standards were negotiated under the appliance standards and rulemaking federal advisory committee (ASRAC) in accordance with the Federal Advisory Committee Act (FACA) and the negotiated rulemaking act. An equivalent stringency of these new standards for split system heat pumps are 15 SEER and 8.8 HSPF and for single-package heat pumps are 14 SEER and 8 HSPF, as detailed in: Federal Code of Regulations, Energy Conservation Program: Energy Conservations Standards for residential Central Air Conditioners and Heat Pumps; Confirmation of effective date and compliance date for direct final rule, May 26, 2017, Docket: EERE-2014-BT-STD-0048 (https://www.regulations.gov/document/EERE-2014-BT-STD-0048-0200)

[455] From PECO SWE Memo for TRM Measure 2.2.1 dated 08/12/2022. SWE conducted an analysis and modeled trendlines developed from equivalent values as stated in the Federal Code for Consumer Products (10 CFR 430.32(c) Energy and water conservation standards and their compliance dates. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C#p-430.32(c)) and ENERGY STAR criteria (ENERGY STAR Program Requirements for Central Air Source Heat Pumps and Central Air Conditioners)

	SEER	HSPF	SEER	HSPF	SEER	HSPF
Split Heat Pump	10.0	6.8	13.0	7.7	14.0	8.2
Packaged Heat Pump	9.7	6.6	13.0	7.7	14.0	8.0
Split Air Conditioner with Electric Furnace	10.0	3.41	13.0	3.41	13.0	3.41
Packaged Air Conditioner with Electric Furnace	9.7	3.41	13.0	3.41	14.0	3.41

Table 237: Baseline Efficiencies for Residential Packaged Terminal Heat Pump

	Manufactured Before January 2006		Manufactured Between January 2006 and January 2015	
System Type	**SEER**	**HSPF**	**SEER**	**HSPF**
Packaged Terminal Heat Pump (PTHP)	9.7	6.6	10.6	7.0

	Manufactured After January 2015	
System Type	**SEER**[456]	**HSPF**
Packaged Terminal Heat Pump (PTHP)	12.3 - (0.213 * Capacity/1000); New Construction 10.8 - (0.213 * Capacity/1000); Replace on Burnout	3.2 - (0.026 * Capacity/1000); New Construction 2.9 - (0.026 * Capacity/1000); Replace on Burnout

Air conditioning equipment shall be properly sized to the dwelling, based on ASHRAE or ACCA Manual J standards. Manufacturer data sheets on installed air conditioning equipment or the AHRI reference number must be provided to the utility. The installed central air conditioning equipment must be AHRI certified.

[456] Capacity is the rated cooling capacity of the product in Btu/hr. If the unit's capacity is less than 7,000 Btu/hr then use 7,000 Btu/hr and if more than 15,000 Btu/hr, use 15,000 Btu/hr in the calculation (IECC 2018).

4.13.3 Energy Savings Estimation

New Construction and Replace-on-Burnout

$$kWh_{Savings} = Capacity_{Cool} * \frac{1}{1000} * EFLH_C * \left(\frac{1}{SEER_{base}} - \frac{1}{SEER_{eff}}\right) +$$

$$Capacity_{Heat} * \frac{1}{1000} * EFLH_H * \left(\frac{1}{HSPF_{base}} - \frac{1}{HSPF_{eff}}\right)$$

Where:

$kWh_{Savings}$ = Annual energy savings

$Capacity_{Cool}$ = Cooling capacity of product in Btu/hr. For multi-split systems which have

multiple indoor units connected to a single outdoor unit, the system capacity is whichever is lower: the capacity of the outdoor unit, or the total capacity of the installed indoor units

$EFLH_C$ = Residential Effective Full Load Cooling Hours for New Mexico (Table 238)

$SEER_{base}$ = Seasonal Energy Efficiency Rating of the baseline cooling equipment, use "Manufactured after January 2015" column of

Table 235 Efficiency Unit Conversions

Rating	Conversion
SEER2 to SEER	SEER = 1.2476 × SEER2 – 2.8674
EER2 to EER	EER = 1.0578 ×EER2 – 0.1769
HSPF2 to HSPF	HSPF = 1.1702 ×HSPF2 + 0.0700

Table 236 &

Table 237

$SEER_{eff}$ = Seasonal Energy Efficiency Rating of the efficient cooling equipment (AHRI Certificate)

$Capacity_{Heat}$ = Heating capacity of product in Btu/hr. For multi-split systems which have multiple indoor units connected to a single outdoor unit, the system capacity is whichever is lower: the capacity of the outdoor unit, or the total capacity of the installed indoor units

$EFLH_H$ = Residential Effective Full Load Heating Hours for New Mexico (Table 238)

$HSPF_{base}$ = Heating System Performance Factor of the baseline cooling equipment, use "Manufactured after January 2015" column of

Table 235 Efficiency Unit Conversions

Rating	Conversion
SEER2 to SEER	SEER = 1.2476 × SEER2 – 2.8674
EER2 to EER	EER = 1.0578 ×EER2 – 0.1769
HSPF2 to HSPF	HSPF = 1.1702 ×HSPF2 + 0.0700

Table 236 &

Table 237

$HSPF_{eff}$ = Heating System Performance Factor of the efficient cooling equipment (AHRI Certificate)

Table 238: Residential Full Load Cooling and Heating Hours for New Mexico Climate Zones[457]

Location	$EFLH_C$	$EFLH_H$
Albuquerque	1,038	2,162
Las Cruces	1,290	1,909
Roswell	1,355	1,596
Santa Fe	629	2,490

Early Retirement

Annual kWh and kW should be calculated for two different time periods:

1. The estimated remaining life of the equipment that is being removed, designated the Remaining Useful Life (RUL; see Table 239), and
2. The remaining time in the EUL period, i.e. (EUL-RUL)

For Remaining Useful Life (RUL):

$$kWh_{Savings,RUL} = Capacity_{Cool} * \frac{1}{1000} * EFLH_C * \left(\frac{1}{SEER_{existing}} - \frac{1}{SEER_{eff}}\right) +$$

457 Derived from ENERGY STAR® Air-Source Heat Pump Calculator. Las Cruces and Santa Fe values derived from El Paso and Amarillo values, respectively, with a comparison of degree-days.

$$Capacity_{Heat} * \frac{1}{1000} * EFLH_H * \left(\frac{1}{HSPF_{existing}} - \frac{1}{HSPF_{eff}}\right)$$

Where:

$kWh_{Savings,RUL}$ = Annual energy savings during RUL

$SEER_{existing}$ = Seasonal Energy Efficiency Rating of the existing cooling equipment. Use actual rated efficiency of existing unit. If existing efficiency cannot be obtained, select the federal minimum value corresponding to year of manufacture (Newly installed units must have a cooling capacity of less than 65,000 Btu/hour (5.4 tons) to be eligible for the measure. For multi-split systems which have multiple indoor units connected to a single outdoor unit, the total cooling capacity should be determined by choosing the lower of outdoor units or the sum of all indoor units. Federal minimum standards as defined by 42 U.S.C. 6291(16) are specified in the Code of Federal Regulations at 10 CFR 430.32(c)(3):

As per the Department of Energy (DOE) Docket: EERE-2014-BT-STD-0048, the new testing procedure M1 will be incorporated from January 1, 2023, in the Southwest Region. The M1 testing procedure is a new method of product testing designed to better reflect current field conditions. During this test, the systems' external static pressure is increased from the current SEER (0.1 in. of water) to SEER2 (0.5 in, of water). SEER2 stands for Seasonal Energy Efficiency Ratio 2. Specifically, SEER2 is the total heat removed from the conditioned space during the annual cooling season. The new M1 testing procedure will increase systems' external static pressure by a factor of five to better reflect field conditions of installed equipment. With this change, new nomenclature will be used to denote M1 ratings (including EER2 and HSPF2). Baseline efficiencies as per the new standards and their respective unit conversions are listed below:

Table 234 Baseline Efficiencies for Residential Heat Pumps

	Manufactured After January 1,2023			
System Type	**SEER**	**HSPF**	**SEER2**	**HSPF2**
Split Heat Pump	15.0	8.8	14.3	7.5
Packaged Heat Pump	14.0	8.0	13.4	6.7

Table 235 Efficiency Unit Conversions

Rating	Conversion
SEER2 to SEER	SEER = 1.2476 × SEER2 – 2.8674
EER2 to EER	EER = 1.0578 ×EER2 – 0.1769
HSPF2 to HSPF	HSPF = 1.1702 ×HSPF2 + 0.0700

Table 236 &

Table 237)

$SEER_{eff}$ = Seasonal Energy Efficiency Rating of the efficient cooling equipment (AHRI Certificate)

$HSPF_{existing}$ = Heating System Performance Factor of the existing cooling equipment. Use actual rated efficiency of existing unit. If existing efficiency cannot be obtained, select the federal minimum value corresponding to year of manufacture (

Table 235 Efficiency Unit Conversions

Rating	Conversion
SEER2 to SEER	SEER = 1.2476 × SEER2 – 2.8674
EER2 to EER	EER = 1.0578 ×EER2 – 0.1769
HSPF2 to HSPF	HSPF = 1.1702 ×HSPF2 + 0.0700

Table 236 &

Table 237)

$HSPF_{eff}$	= Heating System Performance Factor of the efficient cooling equipment (AHRI Certificate; Heat Pump only)

For remaining time in the Estimated Useful period (EUL – RUL):

$$kWh_{Savings,EUL-R} = Capacity_{Cool} * \frac{1}{1000} * EFLH_C * \left(\frac{1}{SEER_{base}} - \frac{1}{SEER_{ef}}\right) + Capacity_{Heat} * \frac{1}{1000} * EFLH_H * \left(\frac{1}{HSPF_{base}} - \frac{1}{HSPF_{eff}}\right)$$

Hence,

$$Lifetime\ Energy\ Savings = kWh_{Savings,RUL} * RUL + kWh_{Savings,EUL-R} * (EUL - RUL)$$

Where:

RUL = Remaining Useful Life (Table 239)

EUL = Estimate Useful Life

= 15 Years

Table 239: Remaining Useful Life (Years) of Replaced Central Heat Pump Unit[458]

Age of Equipment	Remaining Useful Life	Age of Equipment	Remaining Useful Life
1	13.7	13	7.6
2	12.7	14	7
3	12	15	6
4	11.3	16	5
5	10.7	17	4
6	10.2	18	3
7	9.7	19	2
8	9.3	20	1
9	8.9	21	0
10	8.5		

458 Ward, B., Bodington, N., Farah, H., Reeves, S., and Lee, L. "Considerations for early replacement of residential equipment." Prepared by the Evaluation, Measurement, and Verification (EM&V) team for the Electric Utility Marketing Managers of Texas (EUMMOT). January 2015. RULs are capped at the 75th percentile of equipment age, 21 years, as determined based on DOE survival curves. Systems older than 21 years should use the ROB baseline.

11	8.2
12	7.9

4.13.4 Demand Savings Estimation

To calculate demand savings for this measure, the baseline SEER will need to be converted to EER (Energy Efficiency Rating) using the formula:[459]

$$EER = -0.02 * SEER^2 + 1.12 * SEER$$

Peak demand savings:

$$kW_{Savings} = Capacity_{Cool} * \frac{1}{1000} * \left(\frac{1}{EER_{base}} - \frac{1}{EER_{eff}}\right) * CF$$

Where:

$kW_{Savings}$ = Peak Demand Savings

$Capacity_{Cool}$ = Cooling capacity of product in Btu/hr. For multi-split systems which have multiple indoor units connected to a single outdoor unit, the system capacity is whichever is lower: the capacity of the outdoor unit, or the total capacity of the installed indoor units

CF = Coincidence Factor for residential HVAC measures, 0.87[460]

EER_{base} = Full-Load Energy Efficiency Rating of the baseline cooling equipment

EER_{eff} = Full-load Energy Efficiency Rating of the efficient cooling equipment (AHRI Certificate)

[459] Code specified SEER values converted to EER using EER = -0.02 x SEER^2 + 1.12 x SEER. National Renewable Energy Laboratory (NREL) 2010, "Building America House Simulation Protocols." U.S. DOE. Revised October www.nrel.gov/docs/fy11osti/49246.pdf

[460] For residential coincidence factors, Frontier used the Air Conditioning Contractors of America (ACCA) Manual S, which recommends that residential HVAC systems be sized at 115% of the maximum cooling requirement of the house. Assuming that the house's maximum cooling occurs during the hours 3 to 6 pm, this sizing guideline leads to a coincidence factor for residential HVAC of 1.0/1.15 = 0.87

4.13.5 Non-energy Benefits

Well-designed HVAC systems increase occupant comfort and productivity.

4.13.6 Measure Life

This measure life is 15 Years.[461]

4.13.7 Incremental Cost

This manual does not include cost of electric heat in heat pump conversions, following the approach of the Northwest Power & Conservation Council's Regional Technical Forum.[462] This is reasonable since units rarely need complete replacement, but if a cost is desired for forced air furnace or baseboard heat conversions, typical costs per ton can be estimated from local HVAC retailers.

If the install cost of the efficient heat pump is unknown, assume the following in Table 240. These assumptions do not include additional costs associated with fuel switch scenarios.

Table 240: High Efficiency Heat Pump Incremental Cost Per Ton Cooling Capacity[463]

SEER	Heat Pump Per Ton Cooling (including labor)
14.5	$1,381 + $123
15	$1,381 + $303
16	$1,381 + $438
17	$1,381 + $724
18	$1,381 + $724

[461] Texas TRM v6.0 Volume 2: Residential Measures

[462] http://rtf.nwcouncil.org/measures/res/ResSFExistingHVAC_v3_2.xlsm

[463] State of Illinois Energy Efficiency Technical Reference Manual, version 10.0

4.14 ENERGY STAR® Clothes Dryer

This measure involves the installation of a residential ENERGY STAR® clothes dryer in a new construction or replacement-on-burnout. This measure applies to all residential applications.

4.14.1 Measure Overview

Sector	Residential
End use	Efficient Laundry
Fuel	Electricity and Natural Gas
Measure category	Efficient Laundry Appliances
Delivery mechanism	Prescriptive
Baseline description	Non-Energy Star® Clothes Dryer
Efficient case description	Energy Star® Clothes Dryer

4.14.2 Savings

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 electric and gas clothes dryers.

The baseline condition is a clothes dryer meeting the minimum federal requirements for units manufactured on or after January 1, 2015.

As per federal regulations, dryers should comply with these efficiency standards as shown in Table 241:

Table 241: Federal Standards for Clothes Dryers (manufactured after Jan 1st 2015)[464]

Product class	Combined Energy Factor (lbs/kWh)
Vented Electric, Standard (4.4 cu. ft. or greater capacity)	3.73
Vented Electric, Compact (120V) (less than 4.4 cu. ft. capacity)	3.61
Vented Electric, Compact (240V) (less than 4.4 cu. ft. capacity)	3.27
Ventless Electric, Compact (240V) (less than 4.4 cu. ft capacity)	2.55
Ventless Electric, Combination Washer-Dryer	2.08
Vented Gas	3.30

In the efficient case, the clothes dryer must meet ENERGY STAR® criteria, as stated in Table 242:

Table 242: ENERGY STAR® Clothes Dryer Efficiency Standards[465]

Product class	Combined Energy Factor (lbs/kWh)
Vented Electric, Standard (4.4 cu. ft. or greater capacity)	3.93
Vented Electric, Compact (120V) (less than 4.4 cu. ft. capacity)	3.80
Vented Electric, Compact (240V) (less than 4.4 cu. ft. capacity)	3.45
Ventless Electric, Compact (240V) (less than 4.4 cu. ft capacity)	2.68
Ventless Electric, Combination Washer-Dryer	3.93
Vented Gas	3.48

[464] Code of Federal Regulations 10 CFR 430.32(h)
https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-C/section-430.32
[465] ENERGY STAR® Clothes Dryer Key Product Criteria
https://www.energystar.gov/products/appliances/clothes_dryers/key_product_criteria

Table 243: ENERGY STAR® Clothes Dryer Cycle Time Standards[466]

Maximum Test Cycle Time	80 Minutes

Example:

Standard vented electric dryer is replaced with ENERGY STAR® vented electric dryer.

$kWh_{savings}$= (8.45 lbs/ 3.73 lbs/kWh – 8.45 lbs/3.93 lbs/kWh) x 283 cycles/year x 100%

= 32.62 kWh

$kW_{savings}$= 32.62/ (283 x 80) x 0.07 = 0.0001 kW

4.14.3 Energy Savings Estimation

Electric savings can be determined using the formula below.

$$kWh_{savings} = \left(\frac{Load}{CEF_{Baseline}} - \frac{Load}{CEF_{ES}}\right) * N_{Cycles} * \%Electric$$

Where:

$Load$ = The average total weight (lbs) of clothes per drying cycle. If dryer size is unknown, assume Standard dryer size.

Table 244: Average Load of Clothes Per Drying Cycle

Dryer Size	Load (lbs)[467]
Standard	8.45
Compact	3

[466] ENERGY STAR® Clothes Dryer Key Product Criteria https://www.energystar.gov/products/appliances/clothes_dryers/key_product_criteria

[467] Based on ENERGY STAR® Dryer Test Criteria https://www.energystar.gov/products/appliances/clothes_dryers/key_product_criteria

$CEF_{Baseline}$ = Combined Energy Factor in lbs/kWh of the baseline unit. If dryer is electric but product class is unknown, assume vented electric standard.

CEF_{ES} = Combined Energy Factor in lbs/kWh of the ENERGY STAR® unit. If dryer is electric but product class is unknown, assume vented electric standard.

N_{Cycles} = Number of dryer cycles per year. Use actual data if available. If unknown, use 283 cycles per year[468]

$\%Electric$ = Percent of overall savings coming from electricity (100% for Electric, 16% for Gas)[469]

Natural Gas Savings can be determined using the formula below.

$$Therm_{savings} = \left(\frac{Load}{CEF_{Baseline}} - \frac{Load}{CEF_{ES}}\right) * N_{Cycles} * Conversion\ Factor * \%Gas$$

Where:

$Conversion\ Factor$ = Conversion Factor from kWh to Therms
= 0.03413 therm/kWh

$\%Gas$ = Percent of overall savings coming from natural gas (0% for Electric, 84% for Gas)

4.14.4 Demand Savings Estimation

Demand savings are calculated using the following equation.

$$kW_{savings} = \frac{kWh_{savings}}{AOH} * CF$$

Where:

468 10 CFR Chapter II, Subchapter D, Part 430, Subpart B, Appendix D1– Uniform Test Method for Measuring the Energy Consumption of Clothes Dryers.

469 %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.

AOH = Annual Operating Hours

$= N_{Cycles} * \frac{d}{60\ min/hr}$ (where d is the Average Duration of a Drying cycle, 80 minutes)

CF = Coincidence Factor = 0.07[470]

4.14.5 Non-energy Benefits

There are no non-energy benefits.

4.14.6 Measure Life

The average lifetime of this measure is 14 years according to the US DOE.[471]

4.14.7 Incremental Cost

The incremental cost for this measure is estimated to be $152.[472]

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470 Value from Clothes Washer Measure, Mid Atlantic TRM 2014. 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, p. 36.

471 Based on an average estimated range of 12-16 years. ENERGY STAR® Market & Industry Scoping Report. Residential Clothes Dryers. November 2011

http://www.energystar.gov/ia/products/downloads/ENERGY_STAR_Scoping_Report_Residential_Clothes_Dryers.pdf

472 Based on the difference in installed cost for an efficient dryer ($716) and standard dryer ($564).

http://www.aceee.org/files/proceedings/2012/data/papers/0193-000286.pdf

4.15 ENERGYSTAR® Clothes Washer

This measure involves the installation of a residential ENERGYSTAR® clothes washer in new construction or replacement-on-burnout. This measure applies to all residential applications.

4.15.1 Measure Overview

Sector	Residential
End use	Efficient Laundry
Fuel	Electricity and Natural Gas
Measure category	Efficient Laundry Appliances
Delivery mechanism	Prescriptive
Baseline description	Non-ENERGY STAR® Clothes Washer
Efficient case description	ENERGY STAR® Clothes Washer

4.15.2 Savings

The baseline standard for deriving savings from this measure is the current federal minimum efficiency levels.[473]

Table 245: Baseline Efficiency for Clothes Washer Configurations

Clothes Washer Configuration	Baseline Efficiency (Federal)
Top Loading (Standard, 1.6 cu. ft. or greater)	IMEF ≥ 1.57 WF ≤ 6.5
Top Loading (Compact, 1.6 cu. ft. or less)	IMEF ≥ 1.15 WF ≤ 12.0
Front Loading (Standard, 1.6 cu. ft. or greater)	IMEF ≥ 1.84 WF ≤ 4.7
Front Loading (Compact, 1.6 cu. ft. or less)	IMEF ≥ 1.13 WF ≤ 8.3

For a washer installed in new construction or replacing an existing washer at the end of its useful life, the baseline efficiency levels shall correspond to the configuration of the new

473 Current federal standards for clothes washers can be found on the DOE website at: https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=68&action=viewlive

washer. For a washer replacing an existing washer that is not at the end of its useful life, the baseline efficiency levels may correspond to the configuration of the existing washer, even if it does not match that of the new washer.

Efficiency performance for clothes washers are characterized by Integrated Modified Energy Factor (IMEF) and Integrated Water Factor (IWF). The units for IMEF are cu. ft./kWh/cycle. Units with higher IMEF values are more efficient. The units for IWF are gallons/cycle/cu. ft. Units with lower IWF values will use less water and are therefore more efficient.

The efficiency standard is the ENERGY STAR® requirements for clothes washers.[474]

Table 246: ENERGY STAR® Efficiency for Clothes Washer Configurations

Clothes Washer Configuration	ENERGY STAR Efficiency
Top Loading (Greater than 2.5 cu. ft.)	IMEF ≥ 2.06 WF ≤ 4.3
Washer 2.5 cu. ft. or less	IMEF ≥ 2.07 WF ≤ 4.2
Front Loading (Greater than 2.5 cu. ft.)	IMEF ≥ 2.76 WF ≤ 3.2

4.15.3 Energy Savings Estimation

Energy savings for this measure were derived using the ENERGY STAR® Clothes Washer Savings Calculator.[475] Unless otherwise specified, all savings assumptions are extracted from the ENERGY STAR® calculator. The baseline and ENERGY STAR® efficiency levels are set to those matching Table 245 and Table 246. The ENERGY STAR® calculator determines savings based on whether or not an electric or gas water heater is used. Calculations are also conducted based on whether or not the dryer is electric or gas.

For applications using an electric water heater and an electric dryer, the savings are calculated as follows:

$$kWh_{savings} = (E_{conv,machine} + E_{conv,WH} + E_{conv,dryer}) - (E_{ES,machine} + E_{ES,WH} + E_{ES,dryer})$$

[474] Current ENERGY STAR® criteria for clothes washers can be found on the ENERGY STAR® website at: http://www.energystar.gov/index.cfm?c=clotheswash.pr_crit_clothes_washers

[475] The ENERGY STAR® Clothes Washer Savings Calculator can be found on the ENERGY STAR® website https://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx

Where:

$E_{conv,machine}$ = Conventional Machine Energy (kWh)

$E_{conv,WH}$ = Conventional Water Heater Energy (kWh)

$E_{conv,dryer}$ = Dryer Energy needed in combination with a conventional washer (kWh)

$E_{ES,machi}$ = ENERGY STAR® Machine Energy (kWh)

$E_{ES,WH}$ = ENERGY STAR® Water Heater Energy (kWh)

$E_{ES,dryer}$ = Dryer Energy needed in combination with an ENERGY STAR® washer (kWh)

Energy consumption for the above factors can be determined using the following algorithms.

$$E_{conv,machine} = \frac{MCF * RUEC_{conv} * LPY}{RLPY}$$

$$E_{conv,WH} = \frac{WHCF * RUEC_{conv} * LPY}{RLPY}$$

$$E_{conv,dryer} = \left[\left(\frac{CAP * LPY}{IMEF_{FS}} - \frac{RUEC_{conv} * LPY}{RLPY}\right)\right] * \frac{DU_{DW}}{DUF}$$

$$E_{ES,machine} = \frac{MCF * RUEC_{ES} * LPY}{RLPY}$$

$$E_{ES,WH} = \frac{WHCF * RUEC_{ES} * LPY}{RLPY}$$

$$E_{ES,dryer} = \left[\left(\frac{CAP * LPY}{IMEF_{ES}} - \frac{RUEC_{ES} * LPY}{RLPY}\right)\right] * \frac{DU_{DW}}{DUF}$$

If the water heater is gas, the following equation is used to determine therms savings from water heating:

$$therms_{savings,WH} = \frac{WHCF * LPY}{RLPY * \eta_{gas\ WH}} * \frac{0.03412\ therms}{kWh} * (RUEC_{conv} - RUEC_{ES})$$

If the dryer is gas, the following equation is used to determine therms savings from reduced time for drying:

$$therm_{savings,dryer} =$$

$$\left[\left[\left(\frac{CAP * LPY}{IMEF_{FS}} - \frac{RUEC_{conv} * LPY}{RLPY}\right)\right] - \left[\left(\frac{CAP * LPY}{IMEF_{ES}} - \frac{RUEC_{ES} * LPY}{RLPY}\right)\right]\right]$$

$$* \frac{0.03412\ therms}{kWh} * \frac{DU_{DW}}{DUF}$$

Where:

MCF = Machine Electricity Consumption Factor = 20%

$WHCF$ = Water Heater Electricity Consumption Factor = 80%

$RUEC_{conv}$ = Rated Unit Electricity Consumption (kWh/year) =

381 (Top Loading, > 2.5 cu. ft.);

169 (Front Loading, > 2.5 cu. ft.);

163 (≤ 2.5 cu. ft.)

$RUEC_{ES}$ = Rated Unit Electricity Consumption (kWh/year) =

230 (Top Loading, > 2.5 cu. ft.);

127 (Front Loading, > 2.5 cu. ft.);

108 (≤ 2.5 cu. ft.)

CAP = Clothes Washer Capacity, cu. ft.

$IMEF_{FS}$ = Federal Standard Integrated Modified Energy Factor (cu. ft./kWh/cycle)

$IMEF_{ES}$ = ENERGY STAR® Integrated Modified Energy Factor (cu. ft./kWh/cycle)

LPY = Loads per year = 295

$RLPY$ = Reference Loads per year = 392

DU_{DW} = Dryer Use in households with both a washer and dryer = 95%

DUF = Dryer Use Factor = 91%

$\eta_{gas\ WH}$ = Gas water heater efficiency = 75%

All the assumed factors and utilization factors in the measure has been sourced from ENERGY STAR® Appliance Calculator[476].

4.15.4 Demand Savings Estimation

Demand savings are calculated using the following equation:

$$kW_{savings} = \frac{kWh_{savings}}{AOH} * CF$$

Where:

AOH = Annual Operating Hours = $LPY * d$, where d is the Average wash cycle duration (1 hour)

CF = Coincidence Factor = 0.07[477]

4.15.5 Non-energy Benefits

There are no non-energy benefits.

4.15.6 Measure Life

The estimated useful life (EUL) of an ENERGY STAR® clothes washer is established at 11 years based on the Technical Support Document for the current DOE Final Rule standards for residential clothes washers.[478]

[476] The ENERGY STAR® Clothes Washer Savings Calculator can be found on the ENERGY STAR® website https://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx

[477] Value from Clothes Washer Measure, Mid Atlantic TRM 2014. 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, p. 36.

[478] The median lifetime was calculated using the survival function outlined in the DOE Technical Support Document. Final Rule: Standards, Federal Register, 77 FR 32308 (May 31, 2012) and associated Technical Support Document. Accessed 10/07/2014. http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/39 Download TSD at: http://www.regulations.gov/#!documentDetail;D=EERE-2008-BT-STD-0019-0047

4.15.7 Incremental Cost

The incremental cost for this measure is estimated to be $400.[479]

[479] Focus on Energy Evaluation Residential Technologies Incremental Cost Review https://www.focusonenergy.com/sites/default/files/residentialtechnologiesincrementalcostreview_evaluationreport.pdf

4.16 Floor Insulation

Floor insulation is installed on the underside of floor areas sitting below conditioned space. Typically, it is installed in ventilated crawlspaces. Savings are presented per square foot of treated floor area.

4.16.1 Measure Overview

Sector	Residential
End use	Insulation
Fuel	Electricity and Gas
Measure category	Building Envelope
Delivery mechanism	Prescriptive, Retrofit
Baseline description	No Floor Insulation
Efficient case description	R-19 or Greater Floor Insulation*

**A minimum of 24-inch clearance from bottom of the insulation to the ground is required by Occupational Safety and Health Association (OSHA).*

4.16.2 Savings

Calibrated simulation modeling for Texas climate zones 1-5 was used to develop these deemed savings values as listed in the Texas Technical Reference Manual.[480]

Deemed savings estimates were calculated using BEopt 2.6, running Energy Plus 8.1 for the Texas climate zones and adjusted for weather for New Mexico climate zones. The deemed cooling and heating savings from Texas Climate Zone 5 were adjusted as per the cooling degree days and heating degree days for all the New Mexico climate zones.

The baseline for this measure is an existing floor space with no insulation. This measure is not eligible for new construction homes.

4.16.3 Energy Savings Estimation

The tables below (Table 247 - Table 250) present energy savings on a kWh per square foot of insulation installed basis for all four New Mexico climate zones. Annual energy savings are the sum of cooling and heating savings for the appropriate equipment types.

[480] Texas Technical Reference Manual, Version 5.0, Volume 2: Residential Measures, Program Year 2018 (Pg. 2-355 to 2-358)

Table 247: Albuquerque - Residential Floor Insulation Deemed Annual Energy Saving (kWh/sq.ft.)

Home Type	Cooling Savings		Heating Savings		
	Refrigerated Air	Evaporated Cooling	Electric Resistance	Heat Pump	Natural Gas (Therms)
Site-Built Home	-0.16	-0.07	1.35	0.53	0.0577
Manufactured Home	-0.13	-0.06	1.19	0.47	0.0509

Table 248: Roswell - Residential Floor Insulation Deemed Annual Energy Saving (kWh/sq.ft.)

Home Type	Cooling Savings		Heating Savings		
	Refrigerated Air	Evaporated Cooling	Electric Resistance	Heat Pump	Natural Gas (Therms)
Site-Built Home	-0.14	-0.06	1.34	0.52	0.0572
Manufactured Home	-0.12	-0.05	1.18	0.46	0.0504

Table 249: Las Cruces - Residential Floor Insulation Deemed Annual Energy Saving (kWh/sq.ft.)

Home Type	Cooling Savings		Heating Savings		
	Refrigerated Air	Evaporated Cooling	Electric Resistance	Heat Pump	Natural Gas (Therms)
Site-Built Home	-0.16	-0.07	1.35	0.53	0.0575
Manufactured Home	-0.13	-0.06	1.19	0.47	0.0507

Table 250: Santa Fe - Residential Floor Insulation Deemed Annual Energy Saving (kWh/sq.ft.)

Home Type	Cooling Savings		Heating Savings		
	Refrigerated Air	Evaporated Cooling	Electric Resistance	Heat Pump	Natural Gas (Therms)
Site-Built Home	-0.06	-0.03	2.91	1.14	0.1241
Manufactured Home	-0.05	-0.02	2.57	1.01	0.1095

4.16.4 Demand Savings Estimation

The tables below present peak demand savings on a kW per square foot for all four New Mexico climate zones.

Table 251: Albuquerque - Residential Floor Insulation Deemed Peak Demand Saving (kW/sq.ft.)

Home Type	Refrigerated Air	Evaporated Cooling
Site-Built Home	6.32E-05	-1.35E-06
Manufactured Home	8.34E-07	1.86E-07

Table 252: Roswell - Residential Floor Insulation Deemed Peak Demand Saving (kW/sq.ft.)

Home Type	Refrigerated Air	Evaporated Cooling
Site-Built Home	5.65E-05	-1.20E-06
Manufactured Home	7.46E-07	1.66E-07

Table 253: Las Cruces - Residential Floor Insulation Deemed Peak Demand Saving (kW/sq.ft.)

Home Type	Refrigerated Air	Evaporated Cooling
Site-Built Home	6.19E-05	-1.32E-06
Manufactured Home	8.17E-07	1.82E-07

Table 254: Santa Fe - Residential Floor Insulation Deemed Peak Demand Saving (kW/sq.ft.)

Home Type	Refrigerated Air	Evaporated Cooling
Site-Built Home	2.32E-05	-4.95E-07
Manufactured Home	3.06E-07	6.83E-08

4.16.5 Non-energy Benefits

There are no non-energy benefits.

4.16.6 Measure Life

The EUL for this measure is 30 years.[481]

4.16.7 Incremental Cost

The actual installed cost for this measure should be used in screening.[482]

[481] US Department of Energy, WPN 19-4: Revised Energy Audit Approval Procedures, Related Audit, and Material Approvals, Attachment 9, January 17, 2019.

[482] State of Illinois Energy Efficiency Technical Reference Manual, version 10.0

4.17 Water Heater Pipe Insulation

This measure requires the installation of pipe insulation on un-insulated domestic water heater pipes.

4.17.1 Measure Overview

Sector	Residential (DHW only)
End use	Insulation
Fuel	Electric, Natural Gas
Measure category	Water Heater
Delivery mechanism	Prescriptive
Baseline description	Uninsulated Hot Water Pipe
Efficient case description	Insulated Hot Water Pipe

4.17.2 Savings

The baseline is assumed to be a typical electric/gas/heat pump water heater with no heat traps and no insulation on water heater pipes.

New construction and retrofits involving the installation of new water heaters are not eligible for this new measure.

The efficiency standard requires an insulation thickness R-3. The International Residential Code (IRC) 2009 section N1103.3: Mechanical system piping insulation requires R-3 insulation. All visible hot water piping must be insulated. Savings are based on a maximum allowable insulation length of 6 feet of piping.

Example:

Insulation (R-3) added to an uninsulated natural gas storage water heater pipe with diameter 0.5 inches and 20 feet total length.

Annual Energy Savings = [(1/(2.03 + 0) – 1/(2.03 + 0 + 3)] Btu/hr sq. ft. °F x (0.13 x 20) sq. ft. x (127.5 – 61.6) °F x 1/0.80 x 8760 hours x 1/(100,000 BTU/Therm)

= 5.5 Therms

4.17.3 Energy Savings Estimation

Hot water pipe insulation energy savings are calculated using the formula:

Energy Savings per Year:

$$Annual\ Energy\ Savings = (U_{Pre} - U_{Post}) * A * (T_{Pipe} - T_{Ambient}) * \left(\frac{1}{Eff}\right) * Hours_{otal} * \frac{1}{Conversion\ Factor}$$

Where:

U_{Pre}[483] = 1/(2.03 + R_{Pipe}) Btu/hr sq. ft. °F (R_{Pipe} is considered to be 0 given the high conductivity of bare metal pipe)

U_{Post} = 1/(2.03+$R_{insulation}$) Btu/hr sq. ft. °F

$R_{insulation}$ = R-value of insulation

A = Pipe surface area insulated in square feet (πDL) with L (length) and D (pipe diameter) in feet. The maximum length allowable for insulation is 6 feet. If the pipe area is not known, use Table 255: Pipe Diameter and Pipe Surface Area below

Table 255: Pipe Diameter and Pipe Surface Area

Pipe Diameter (inches)	Pipe Surface Area (sq. ft.)
0.5	0.13 * Pipe Length Insulated (in feet)
0.75	0.20 * Pipe Length Insulated (in feet)
1.0	0.26 * Pipe Length Insulated (in feet)
1.25	0.33 * Pipe Length Insulated (in feet)
1.5	0.39 * Pipe Length Insulated (in feet)
2.0	0.52 * Pipe Length Insulated (in feet)

T_{Pipe} = Average temperature of the pipe, use 127.5 °F[484]

$T_{Ambient}$ = Average annual temperature, use table below

[483] 2.03 is the R-value representing the film coefficients between water and the inside of the pipe, and between the surface and air. Mark's Standard Handbook for Mechanical Engineers, 8th edition.

[484] Preliminary visits to schools in New Mexico has shown water heater temperatures set at 125 – 130°F, within typical range for domestic hot water. Average of 127.5°F used.

Table 256: Temperature Unconditioned and Conditioned Area

Climate Zone	$T_{Ambient}$ (Unconditioned)[485]	$T_{Ambient}$ (Conditioned)
Albuquerque	61.6°F	72.7 °F[486]
Roswell	67.5°F	
Santa Fe	56.5°F	
Las Cruces	68.2 °F	

Eff = System Efficiency (in the case of heat pump water heaters, COP; AFUE for gas water heater) of installed water heater. If unknown, use 0.98 as a default for electric resistance water heaters or 2.2 for heat pump water heaters[487] or 0.80 for natural gas storage water heaters and 0.82 for natural gas tankless water heaters[488]

$Hours_{Total}$ = 8,760 hours per year

$Conversion\ Factor$ = 3,412 Btu/kWh, for Electric Water Heater
= 100,000 BTU/Therm, for Gas Water Heater

4.17.4 Demand Savings Estimation

Tank insulation demand savings (kW, only for electric and heat pump water heater):

$$Demand\ Savings = \frac{Annual\ Energy\ Savings}{8760}$$

485 Average ambient temperatures were taken from TMY3 data (adjusted for interior unconditioned spaces)

486 Weighted average reported thermostat set points from RECS. Times associated with these set points are assumed to be the same as those assumed by ENERGY STAR®: http://www.energystar.gov/index.cfm?c=thermostats.pr_thermostats_guidelines

487 Default values based on median recovery efficiency of residential water heaters by fuel type in the AHRI database, at http://www.ahrinet.org

488 ENERGY STAR® Residential Water Heaters: Final Criteria Analysis https://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/water_heaters/WaterHeaterAnalysis_Final.pdf

4.17.5 Non-energy Benefits

There are no non-energy benefits.

4.17.6 Measure Life

As per 2014 California Database for Energy Efficiency Resources (DEER), the EUL for this measure is listed as 13 years.[489]

4.17.7 Incremental Cost

The measure cost is the actual cost of material and installation. If the actual cost is unknown, assume a default cost of $4 per linear foot[490] including material and installation.

[489] 2014 California Database for Energy Efficiency Resources.

[490] Consistent with DEER 2008 Measure Cost Summary, Revised June 2, 2008

4.18 Programmable Thermostat

This measure characterizes the household energy savings from the installation of a new or reprogramming of an existing programmable thermostat. This allows for reduced heating and cooling energy consumption through temperature setback during unoccupied or reduced demand times.

4.18.1 Measure Overview

Sector	Residential
End use	HVAC
Fuel	Electricity, Natural Gas
Measure category	Programmable Thermostat
Delivery mechanism	Prescriptive
Baseline description	Manual Thermostat, Programmable Thermostat verified to be operated as a manual thermostat, or No Thermostat
Efficient case description	Properly-Programmed Programmable Thermostat

4.18.2 Savings

Savings in this measure are achieved by installing a programmable thermostat capable of temperature setback during unoccupied periods. The baseline can be a manual thermostat which requires manual intervention to change temperature, a programmable thermostat operated in override mode, or no thermostat at all.

As per ENERGY STAR® guidelines, the following control scheme is ideal for a residential programmable thermostat:[491]

[491] A Guide to Energy-Efficient Heating and Cooling https://www.energystar.gov/ia/partners/publications/pubdocs/HeatingCoolingGuide%20FINAL_9-4-09.pdf

Table 257: Setpoint Temperature for Different Time Settings

Setting	Time	Setpoint Temperature (Heat)	Setpoint Temperature (Cool)
Wake	6:00 AM	< 70 °F	> 78 °F
Day	8:00 AM	Setback at least 8 °F	Setup at least 7 °F
Evening	6:00 PM	< 70 °F	> 78 °F
Sleep	10:00 PM	Setback at least 8 °F	Setup at least 4 °F

4.18.3 Energy Savings Estimation

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

$$\Delta kWh_{cooling} = \frac{Capacity_{cool}}{1000\,\frac{W}{kW}} \times \frac{1}{SEER \times Eff_{duct}} \times EFLH_{Cool} \times Reduction_{Cool}$$

$$\Delta kWh_{heat.heatpump} = \frac{Capacity_{heat}}{1000\,\frac{W}{kW}} \times \frac{1}{HSPF_{heat\ pump} \times Eff_{duct}} \times EFLH_{Heat} \times Reduction_{Heat} \times \%HeatPump$$

$$\Delta kWh_{hea\ .electricfurn} = \frac{Capacity_{heat}}{1000\,\frac{W}{kW}} \times \frac{1}{HSPF_{elec\ furn} \times Eff_{duct}} \times EFLH_{Heat} \times Reduction_{Heat} \times \%ElecFurn$$

$$\Delta kWh_{heat.gasfurn} = \frac{HP_{motor} \times \left(746\,\frac{W}{HP}\right) \times EFLH_{Heat}}{\eta_{motor} \times 1000\,\frac{W}{kW}} \times Reduction_{Heat} \times \%GasFurn$$

Where:

$Capacity_{Cool}$ = Cooling equipment's rated cooling capacity, Btu/h (36,000 Btu/h, if unknown)[492]

$Capacity_{Heat}$ = Heating equipment's rated heating capacity, Btu/h (34,560 Btu/h, if unknown)[493]

$EFLH_{Cool}$ = Estimate of annual residential cooling hours for air conditioning equipment, see Table 258

$EFLH_{Heat}$ = Estimate of annual residential heating hours, see Table 258

Table 258: Residential Full Load Cooling and Heating Hours for New Mexico Climate Zones[494]

City	$EFLH_{Cool}$	$EFLH_{Heat}$
Albuquerque	1,038	1,358
Las Cruces	1,290	899
Roswell	1,355	921
Santa Fe	629	1,447

$1{,}000$ = Conversion between W and kW

$SEER$ = Cooling equipment's Seasonal Energy Efficiency Ratio Rating, Btu/Wh (Nameplate Data; default = 13.0)

$Reduction_{Cool}$ = Assumed percentage reduction in total household cooling energy consumption due to installation of a programmable thermostat, 5.6%[495]

$Reduction_{Heat}$ = Assumed percentage reduction in total household heating energy consumption due to installation of a programmable thermostat, 6.2%[496]

492 Conservative estimate based on program data from Texas IOUs showing average cooling capacity

493 Based on Frontier assumptions that heating capacity is 96% of cooling capacity, based on an analysis of AHRI-rated systems

494 Derived from ENERGY STAR® Air-Source Heat Pump Calculator. Las Cruces and Santa Fe values derived from El Paso and Amarillo values, respectively, with a comparison of degree-days.

495 Cooling reduction estimated based on multiplying smart thermostat cooling reduction by ratio of programmable thermostat heating reduction to smart thermostat heating reduction (manual thermostat baseline); 8% x (6.2% / 8.8%) = 5.6%

496 Value published in Illinois Technical Resource Manual v7.0, Volume 3: Residential Measures, a conservative estimate based on studies done in various regions

$HSPF$	= Heating equipment's Heating Seasonal Performance Factor, Btu/Wh (Nameplate Data; default Heat Pump = 7.7, Electric Furnace = 3.412)
Eff_{duct}	= Duct System Efficiency, 0.8[497]
$\Delta kWh_{heat.gasfurn}$	= Fan energy savings in a gas heat furnace, kWh
HP_{motor}	= Gas furnace blower motor horsepower, HP (default = 0.5 HP)
η_{motor}	= Efficiency of furnace blower motor horsepower (default = 50%)
%HeatPump	= % of homes using heat pump heat. For upstream programs, default = 20%[498]. If heating type is known to be heat pump, use 100%.
%ElecFurn	= % of homes using electric resistance heat. For upstream programs, default = 23%[499]. If heating type is known to be electric resistance, use 100%.
%GasFurn	= % of homes using gas heat. For upstream programs, default = 57%[500]. If heating type is known to be gas, use 100%.

Natural Gas Energy Savings:

$$\Delta Therms = \frac{Capacity_{Heat} \times EFLH_{Heat}}{AFUE \times Eff_{duct}} \times Reduction_{Heat} \times \%GasFurn$$

Where:

$AFUE$	= Heating equipment's Annual Fuel Utilization Efficiency, (Nameplate Data; default = 80%)

For example, if a house in Las Cruces installed a new programmable thermostat which has an electric heat furnace, the savings can be determined using the formula:

$$\Delta kWh_{cooling} = \frac{36{,}000\frac{Btu}{h}}{1000\frac{W}{kW}} \times \frac{1}{13.0 \times 0.8} \times 1{,}290 \times 5.6\% = 250 \text{ kWh}$$

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497 2014 Energy Trust of Oregon Nest Thermostat Heat Pump Control Pilot Evaluation

498 US Energy Information Administration. https://www.eia.gov/consumption/residential/data/2015/hc/php/hc6.8.php. The heating type split is considered for West Mountain South Region.

499 Ibid.

500 Ibid.

$$\Delta kWh_{heat} = \frac{34{,}560\frac{\text{Btu}}{\text{h}}(\text{default})}{1000\frac{W}{kW}} \times \frac{1}{3.412(\text{default}) \times 0.8} \times 1{,}909 \times 6.2\% = 1{,}498\ \text{kWh}$$

$$\Delta kWh = 250 + 1{,}498 = 1{,}748\ \text{kWh}$$

4.18.4 Demand Savings Estimation

Demand savings can be defined as:

$$Demand\ Savings = \frac{Annual\ Energy\ Savings}{Hours_{Thermostat}} * CF$$

Where: $Hours_{Thermostat}$ are the annual hours the HVAC is controlled by the thermostat (listed below).

Table 259: Operational Hours

City	$Hours_{Thermostat}$
Roswell	5,424
Las Cruces	5,035
Santa Fe	6,474
Albuquerque	5,876

CF = Coincidence Factor, 100%

4.18.5 Non-energy Benefits

There are no non-energy benefits.

4.18.6 Measure Life

The expected measure life of a programmable thermostat is assumed to be 10 years[501] based upon equipment life only.[502]

[501] Table 1, HVAC Controls, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

[502] Future evaluation is strongly encouraged to inform the persistence of savings to further refine measure life assumption. As this characterization depends heavily upon a large scale but only 2-year study of the energy impacts of programmable thermostats, the longer-term impacts should be assessed.

4.18.7 Incremental Cost

Actual material and labor costs should be used if the implementation method allows. If unknown, the capital cost for the new installation measure is assumed to be $30.[503] The cost for reprogramming is assumed to be $10 to account for the auditor’s time to reprogram and educate the homeowner.

[503] Market prices vary significantly in this category, generally increasing with thermostat capability and sophistication. The basic functions required by this measure's eligibility criteria are available on units readily available in the market for the listed price.

4.19 Smart Thermostats

This measure estimates the annual energy savings from the installation of a new smart thermostat(s). This allows for reduced heating and cooling consumption through a configurable schedule of temperature setpoints and automatic variations to that schedule. This is to better match HVAC system runtimes to meet occupant comfort needs.

These schedules may be defaults, established through user interaction, and changed manually at the device or remotely through a web or mobile app. Automatic variations to that schedule could be driven by local sensors and software algorithms, and/or through connectivity to an internet software service. Data triggers to automatic schedule changes might include, for example: occupancy/activity detection, arrival & departure of conditioned spaces, optimization based on historical or population-specific trends, weather data and forecasts.

4.19.1 Measure Overview

Sector	Residential
End use	HVAC
Fuel	Electricity, Natural Gas
Measure category	Smart Thermostat
Delivery mechanism	Prescriptive, Mail-in, Online
Baseline description	Manual or Programmable Thermostat
Efficient case description	Smart Thermostat

4.19.2 Savings

The savings for this measure are based on studies as summarized in Illinois Statewide Technical Reference Manual for Energy Efficiency (Version 7.0). The document analyzed consumption for residences which underwent a retrofit from a manual or programmable thermostat to a smart one. The study was conducted by Navigant Energy for the Illinois Stakeholder Advisor Group.[504]

The results summarized in the referenced study were found to be the most conservative and hence most reliable.

504 'Residential Smart Thermostats: Impact Analysis – Gas Preliminary Findings', December 2015

4.19.3 Energy Savings Estimation

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

$$\Delta kWh_{cooling} = \frac{Capacity_{cool}}{1000\frac{W}{kW}} \times \frac{1}{SEER \times Eff_{duct}} \times EFLH_{Cool} \times Reduction_{Cool}$$

$$\Delta kWh_{heat.heatpump} = \frac{Capacity_{heat}}{1000\frac{W}{kW}} \times \frac{1}{HSPF_{heat\ pump} \times Eff_{duct}} \times EFLH_{Heat} \times Reduction_{Heat} \times \%HeatPump$$

$$\Delta kWh_{heat.electricfurn} = \frac{Capacity_{heat}}{1000\frac{W}{kW}} \times \frac{1}{HSPF_{elec\ furn} \times Eff_{duct}} \times EFLH_{Heat} \times Reduction_{Heat} \times \%ElecFurn$$

$$\Delta kWh_{heat.gasfurn} = \frac{HP_{motor} \times \left(746\frac{W}{HP}\right) \times EFLH_{Heat}}{\eta_{motor} \times 1000\frac{W}{kW}} \times Reduction_{Heat} \times \%GasFurn$$

Where:

$Capacity_{Cool}$	= Cooling equipment's rated cooling capacity, Btu/h (36,000 Btu/h, if unknown)[505]
$Capacity_{Heat}$	= Heating equipment's rated heating capacity, Btu/h (34,560 Btu/h, if unknown)[506]
$EFLH_{Cool}$	= Estimate of annual residential cooling hours for air conditioning equipment, see Table 260
$EFLH_{Heat}$	= Estimate of annual residential heating hours, see Table 260

505 Conservative estimate based on program data from Texas IOUs showing average cooling capacity

506 Based on Frontier assumptions that heating capacity is 96% of cooling capacity, based on an analysis of AHRI-rated systems

Table 260: Residential Full Load Cooling and Heating Hours for New Mexico Climate Zones

City	$EFLH_{Cool}$	$EFLH_{Heat}$
Albuquerque	1,038	1,358
Las Cruces	1,290	899
Roswell	1,355	921
Santa Fe	629	1,447

$1{,}000$ = Conversion between W and kW

$SEER$ = Cooling equipment's Seasonal Energy Efficiency Ratio Rating, Btu/Wh (Nameplate Data; default = 13.0)

$Reduction_{Cool}$ = Assumed percentage reduction in total household cooling energy consumption due to installation of a smart thermostat, 8%[507]

$Reduction_{Heat}$ = Assumed percentage reduction in total household heating energy consumption due to installation of a smart thermostat

Manual to Smart Thermostat: 8.8%

Programmable to Smart Thermostat: 5.6%

Unknown (default) to Smart Thermostat: 7.0%[508]

$HSPF$ = Heating equipment's Heating Seasonal Performance Factor, Btu/Wh (Nameplate Data; default Heat Pump = 7.7, Electric Furnace = 3.412)

Eff_{duct} = Duct System Efficiency, 0.8[509]

HP_{motor} = Gas furnace blower motor horsepower, 0.5 HP

η_{motor} = Efficiency of furnace blower motor horsepower, 50%

[507] Value published in Illinois Technical Resource Manual v7.0, Volume 3: Residential Measures, a conservative estimate based on studies done in various regions

[508] Value published in Illinois Technical Resource Manual v7.0, Volume 3: Residential Measures, a conservative estimate based on studies done in various regions

[509] 2014 Energy Trust of Oregon Nest Thermostat Heat Pump Control Pilot Evaluation

%HeatPump = % of homes using heat pump heat. For upstream programs, default = 20%[510]. If heating type is known to be heat pump, use 100%.

%ElecFurn = % of homes using electric resistance heat. For upstream programs, default = 23%[511]. If heating type is known to be electric resistance, use 100%.

%GasFurn = % of homes using gas heat. For upstream programs, default = 57%[512]. If heating type is known to be gas, use 100%.

Natural Gas Energy Savings:

$$\Delta Therms = \frac{Capacity_{Heat} \times EFLH_{Heat}}{AFUE \times Eff_{duct} \times 100{,}000 \frac{BTU}{Therm}} \times Reduction_{Heat} \times \%GasFurn$$

Where:

$AFUE$ = Heating equipment's Annual Fuel Utilization Efficiency, (Nameplate Data; default = 80%)

100,000 = Conversion between BTU and Therms

For example, if a house (packaged air conditioning, natural gas furnace) in Santa Fe retrofits a programmable thermostat with a smart thermostat the estimated savings can be calculated using these:

$$\Delta kWh_{cooling} = \frac{36{,}000 \frac{Btu}{h}}{1000 \frac{W}{kW}} \times \frac{1}{13.0 \times 0.8} \times 629 \times 8\% = 174 \text{ kWh}$$

$$\Delta kWh_{heat.gasfurn} = \frac{0.5\ HP \times \left(746 \frac{W}{HP}\right) \times 2{,}490}{50\% \times 1000 \frac{W}{kW}} \times 5.6\% = 105 \text{ kWh}$$

$$Therms = \frac{34{,}560 \frac{Btu}{h} \times 2{,}490}{80\% \times 0.8} \times 10^{-5} \times 5.6\% = 75 \text{ therms}$$

[510] US Energy Information Administration. https://www.eia.gov/consumption/residential/data/2015/hc/php/hc6.8.php. The heating type split is considered for West Mountain South Region.

[511] Ibid.

[512] Ibid.

4.19.4 Demand Savings Estimation

Conventional programmable thermostats likely do not lead to coincident demand savings because most of the savings occur during off-peak hours. There is no strong evidence that smart thermostats save coincident demand any differently than programmable thermostats.

4.19.5 Non-energy Benefits

There are no non-energy benefits.

4.19.6 Measure Life

The expected measure life for advanced thermostats is assumed to be like that of a programmable thermostat, i.e., 10 years.[513]

4.19.7 Incremental Cost

Actual material and labor costs should be used when possible. If unknown, the average incremental cost for the new installation measure is assumed to be $125.[514]

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513 Table 1, HVAC Controls, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

514 State of Illinois Energy Efficiency Technical Reference Manual, version 10.0

4.20 Water Heater Tank Insulation

This measure saves electric consumption by insulating an uninsulated water heater tank located in a conditioned or unconditioned space.

4.20.1 Measure Overview

Sector	Residential
End use	Insulation
Fuel	Electric, Natural Gas
Measure category	Water Heater
Delivery mechanism	Prescriptive
Baseline description	Uninsulated Water Heater Tank
Efficient case description	Insulated Water Heater Tank

4.20.2 Savings

The baseline condition is assumed to be a typical electric or gas water heater with no insulation. There is no minimum insulation requirement. Manufacturer's instructions on the water heater jacket and water heater itself should be followed. Thermostat and heating element access panels must be left uncovered.

Example:

Water tank insulation of $R_{insulation} = 5$ is added to a natural gas water heater of 50 gallons capacity in Albuquerque. The variables are as follows:

Savings = [1/5 – 1/(5+(5 x 1.4))] Btu/hr sq. ft. °F x 22.63 sq. ft. x [127.5 – 61.6] °F x (1/0.8) x 8760 hours x (1/100,000 BTU/Therm)

= 19 therms

4.20.3 Energy Savings Estimation

Hot water tank insulation energy savings are calculated using the formula below.

Energy Savings per Year:

$$Annual\ Energy\ Savings = (U_{Pre} - U_{Post}) * A * (T_{Tank} - T_{Ambient}) * \left(\frac{1}{Eff}\right) * Hours_{Total} * \frac{1}{Conversion\ Factor}$$

Where:

U_{Pre} = 1/(5) Btu/hr sq. ft. °F[515]

U_{Post} = 1/(5+$R_{insulation}$) Btu/hr sq. ft. °F

$R_{insulation}$ = R-value of insulation (Multiplied by a factor of 1.4 to adjust for increase in perceived tank radius; determined using estimated average tank diameter of 22" and insulation thickness of 1.5")[516]

A = Tank surface area insulated in square feet (πDL) with L (length) and D (tank diameter) in feet. If the tank area is not known, use Table 261 below

Table 261: Hot Water Gallons and Tank Surface Area

Volume (gallons)	A (sq. ft.)[517]
30	17.45
40	21.81
50	22.63
60	26.94
80	30.36
120	38.73

T_{Tank} = Average temperature of the tank, use 127.5 °F[518]

$T_{Ambient}$ = Average annual temperature, use Table 262 below

515 Baseline R value as per Texas Technical Reference Manual V9.0, Volume 2: Residential Measures

516 True R-Values of Round Residential Ductwork, https://aceee.org/files/proceedings/2006/data/papers/SS06_Panel1_Paper18.pdf

517 Texas Technical Reference Manual V9.0, Volume 2: Residential Measures

518 Preliminary visits to schools in New Mexico has shown water heater temperatures set at 125 – 130°F, within typical range for domestic hot water. Average of 127.5°F used.

Table 262: Temperature Unconditioned and Conditioned Area

Climate Zone	$T_{ambient}$ (Unconditioned)[519]	$T_{ambient}$ (Conditioned)
Albuquerque	61.6°F	72.7 °F[520]
Roswell	67.5°F	
Santa Fe	56.5°F	
Las Cruces	68.2 °F	

Eff = System Efficiency (in the case of heat pump water heaters, COP; AFUE for gas water heater) of installed water heater. If unknown, use 0.98 as a default for electric resistance water heaters or 2.2 for heat pump water heaters[521] or 0.80 for natural gas water heaters

$Hours_{Total}$ = 8,760 hours per year

$Conversion\ Factor$ = 3,412 Btu/kWh, for Electric Water Heater
= 100,000 Btu/Therm, for Gas Water Heater

4.20.4 Demand Savings Estimation

Tank insulation demand savings (kW, only for electric and heat pump water heater):

$$Demand\ Savings = \frac{Annual\ Energy\ Savings}{8760}$$

[519] Average ambient temperatures were taken from TMY3 data. 5-F was added to each average to approximate the difference between outdoor temperature and unconditioned interior temperature.

[520] Weighted average reported thermostat set points from RECS. Times associated with these set points are assumed to be the same as those assumed by ENERGY STAR®: http://www.energystar.gov/index.cfm?c=thermostats.pr_thermostats_guidelines

[521] Default values based on median recovery efficiency of residential water heaters by fuel type in the AHRI database, at http://www.ahrinet.org

4.20.5 Non-energy Benefits

There are no non-energy benefits.

4.20.6 Measure Life

As per 2014 California Database for Energy Efficiency Resources (DEER), the EUL for this measure is listed as 7 years.[522]

4.20.7 Incremental Cost

As per 2008 California Database for Energy Efficiency Resources (DEER) Measure Cost Summary, the incremental cost for this measure is $79.[523]

[522] 2014 California Database for Energy Efficiency Resources.

[523] Consistent with DEER 2008 Measure Cost Summary, Revised June 2, 2008

4.21 ENERGY STAR® Windows

This measure achieves energy and demand savings by installing ENERGY STAR® windows which are more energy efficient. ENERGY STAR® windows savings are calculated on per square foot of window basis, inclusive of frame and sash.

4.21.1 Measure Overview

Sector	Residential
End use	Single-family, duplex and triplex; Multifamily; Manufactured
Fuel	Electricity and Natural Gas
Measure category	Building Envelope
Delivery mechanism	Retrofit, Prescriptive
Baseline description	Single-Pane/Double-Pane Windows
Efficient case description	ENERGY STAR® rated Windows

4.21.2 Savings

Cooling savings in this measure apply to customers with central or mini-split electric refrigerated air conditioning in their homes, or to customers who have evaporated cooling systems. Homes must be heated with either a furnace (gas or electric resistance) or a heat pump to claim heating savings.

For the baseline condition the U-Values and SHGCs stated in Table 263 should be assumed:[524]

Table 263: Baseline Windows

Number of Panes	U-Factor Btu/(h sq.ft.°F)	Solar Heat Gain Coefficient (SHGC)
1 (Single)	1.16	0.76
2 (Double)	0.76	0.67

For the efficient condition, windows must satisfy ENERGY STAR® criteria.[525]

[524] Baseline value for U-Factor and SHGC as per Texas Technical Resource Manual v9.0, Volume 2: Residential Measures
[525] ENERGY STAR® criteria for U.S. South-Central Region effective January 2015

Table 264: ENERGY STAR® Windows Specification[526]

Climate Zone	U-Factor Btu/(h sq.ft.°F)	Solar Heat Gain Coefficient (SHGC)
Albuquerque	≤ 0.30	≤ 0.40
Santa Fe	U-factor ≤ 0.27 and Any SHGC U-factor ≤ 0.28 and SHGC ≥ 0.32 U-factor ≤ 0.29 and SHGC ≥ 0.37 U-factor ≤ 0.30 and SHGC ≥ 0.42	
Roswell	≤ 0.30	≤ 0.25
Las Cruces	≤ 0.30	≤ 0.25

4.21.3 Energy Savings Estimation

Deemed savings values have been estimated using calibrated simulation models for the El Paso region of Texas and then adjusted for New Mexico climate zones based on weather.[527]

In the base case homes were fitted with single-pane and double-pane windows and in the retrofit case homes were equipped with windows meeting ENERGY STAR® criteria. A weighted single- and double-pane baseline is also provided, assuming a standard distribution of 46 percent single-pane and 54 percent double-pane based on 2020 RECS survey data.[528] This baseline may be used exclusively if applied consistently for all projects.

Based on the cooling and heating equipment utilized in a particular residence, total deemed savings per square foot can be calculated using the formula below.

$$Total\ Deemed\ Savings\ \left(\frac{kWh}{sq}.ft.\right) = Deemed\ Heating\ Svgs. + Deemed\ Cooling\ Svgs.$$

Deemed heating and cooling savings for ENERGY STAR® single pane windows are listed in Table 265:

526 Windows, Doors, and Skylights Climate Zone Finder: https://www.energystar.gov/index.cfm?fuseaction=windows_doors.search_climate

527 Deemed Savings for El Paso (Texas Climate Zone 5) from the ENERGY STAR® Windows Measure provided in Texas Technical Reference Manual v5.0, Volume 2: Residential Measures. The savings were adjusted comparing the Heating Degree Days and Cooling Degree Days of New Mexico climate zones with that of Texas Climate Zone 5.

528 2020 Residential Energy Consumption Survey (RECS). Structural and geographic characteristics in the South and West regions (HC2.8). Analysis based on West South-Central census region. https://www.eia.gov/consumption/residential/data/2020/

Table 265: ENERGY STAR® Windows Replacing Single Pane Windows, Deemed Annual Energy Savings

Climate Zone	Cooling Savings (kWh/sq.ft.)		Heating Savings		
	Refrigerated Air	Evaporated Cooling	Gas Heat (therms/sq.ft.)	Electric Resistance (kWh/sq.ft.)	Heat Pump (kWh/sq.ft.)
Albuquerque	5.69	1.91	0.05	1.22	0.85
Santa Fe	2.09	0.70	0.11	2.62	1.83
Roswell	5.10	1.71	0.05	1.21	0.84
Las Cruces	5.58	1.87	0.05	1.21	0.84

Deemed heating and cooling savings for ENERGY STAR® double pane windows are listed in Table 266:

Table 266: ENERGY STAR® Windows Replacing Double Pane Windows, Deemed Annual Energy Savings

Climate Zone	Cooling Savings (kWh/sq.ft.)		Heating Savings		
	Refrigerated Air	Evaporated Cooling	Gas Heat (therms/sq.ft.)	Electric Resistance (kWh/sq.ft.)	Heat Pump (kWh/sq.ft.)
Albuquerque	4.26	1.47	-0.01	-0.22	0.20
Santa Fe	1.56	0.54	-0.02	-0.48	0.42
Roswell	3.81	1.31	-0.01	-0.22	0.20
Las Cruces	4.18	1.44	-0.01	-0.22	0.20

Deemed heating and cooling savings for ENERGY STAR® weighted single and double pane windows are listed in Table 266:

Table 243: ENERGY STAR® Windows Replacing Weighted Single and Double Pane Windows, Deemed Annual Energy Savings

	Cooling Savings (kWh/sq.ft.)		Heating Savings		
Climate Zone	**Refrigerated Air**	**Evaporated Cooling**	**Gas Heat (therms/sq.ft.)**	**Electric Resistance (kWh/sq.ft.)**	**Heat Pump (kWh/sq.ft.)**
Albuquerque	4.92	1.67	0.02	0.44	0.50
Santa Fe	1.80	0.61	0.04	0.95	1.07
Roswell	4.40	1.49	0.02	0.44	0.49
Las Cruces	4.82	1.64	0.02	0.44	0.49

Therefore,

$$Annual\ Energy\ Svgs\ (kWh) = Total\ Deemed\ Svgs\ \left(\frac{kWh}{sq}.ft.\right) \times Area\ of\ Windows\ (sq.ft.)$$

4.21.4 Demand Savings Estimation

Deemed peak demand savings for installing ENERGY STAR® single pane windows are listed in Table 267:

Table 267: ENERGY STAR® Windows Replacing Single Pane Windows, Deemed Peak Demand Savings

	Cooling Savings (kW/sq.ft.)	
Climate Zone	**Refrigerated Air**	**Evaporated Cooling**
Albuquerque	5.49E-03	1.84E-03
Santa Fe	3.33E-03	1.11E-03
Roswell	3.76E-03	1.26E-03
Las Cruces	4.33E-03	1.45E-03

Deemed peak demand savings for installing ENERGY STAR® double pane windows are listed in Table 268.

Table 268: ENERGY STAR® Windows Replacing Double Pane Windows, Deemed Peak Demand Savings (kW/sq.ft.)

Climate Zone	Cooling Savings (kW/sq.ft.)	
	Refrigerated Air	**Evaporated Cooling**
Albuquerque	4.10E-03	4.32E-03
Santa Fe	2.49E-03	2.62E-03
Roswell	2.81E-03	2.96E-03
Las Cruces	3.24E-03	3.40E-03

Deemed peak demand savings for installing ENERGY STAR® double pane windows are listed in Table 268.

Table 269: ENERGY STAR® Windows Replacing Weighted Single and Double Pane Windows, Deemed Peak Demand Savings (kW/sq.ft.)

Climate Zone	Cooling Savings (kW/sq.ft.)	
	Refrigerated Air	**Evaporated Cooling**
Albuquerque	4.74E-03	3.18E-03
Santa Fe	2.88E-03	1.93E-03
Roswell	3.25E-03	2.18E-03
Las Cruces	3.74E-03	2.50E-03

Therefore,

$$Peak\ Demand\ Savings\ (kW) = Deemed\ Cooling\ Savings\ \left(\frac{kW}{sq}.ft.\right) \times Area\ of\ Vertical\ Windows\ (sq.ft.)$$

4.21.5 Non-energy Benefits

There are no non-energy benefits.

4.21.6 Measure Life

According to the GDS Associates Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures (2007), the Estimated Useful Life is 25 years for ENERGY STAR® windows.

4.21.7 Incremental Cost

Incremental cost estimates should be gathered as part of the application process if utilities wish to test the cost effectiveness of this measure using the TRC test.

4.22 Solar Screens

Savings are presented for the installation of solar screens on west and/or south-facing windows or glass doors. Deemed savings are calculated per square foot of treated window or door opening.

4.22.1 Measure Overview

Sector	Residential
End use	Building Envelope
Fuel	Electricity
Measure category	Solar Screens
Delivery mechanism	Direct Install, Rebate
Baseline description	Single pane, clear, unshaded glass on fenestration
Efficient case description	Solar screens reducing solar heat gain by at least 80%

4.22.2 Savings

Cooling savings in this measure apply to customers with central or mini-split electric refrigerated air conditioning or evaporative cooling in their homes. The heating savings penalty applies to homes that are centrally heated with either a furnace (gas or electric resistance) or a heat pump.

The baseline is a single pane, clear glass, unshaded, west-, or south-facing window. Double-paned windows are not eligible for this measure. Baseline window area is assumed to be 7.5 percent of the total wall area.

Solar screens must be installed on windows or glass doors that face west or south and receive significant direct sun exposure. Solar screens must block at least 80 percent of the solar heat gain and are not recommended for homes with electric resistance heat.

Deemed savings values were derived using the savings values from the Texas TRM, version 5. The Texas savings values were adjusted based on a comparison of annual solar radiation for the Texas representative cities and the New Mexico representative cities. Solar radiation values were taken from NREL's PVWatts tool, with inputs representing a vertical surface (i.e., tilt = 90 degrees) and south and west orientations (i.e., azimuth = 180 degrees, 270 degrees). Cooling energy savings were adjusted using radiation for the months of April through October, and heating energy savings were adjusted using radiation for the months of January through March and November through December.

Peak demand savings were adjusted using radiation for the months of June through August.

The savings values in the Texas TRM were estimated using calibrated simulation models. Specifically, these deemed savings estimates were developed using BEopt 2.6, running EnergyPlus 8.4 as the underlying simulation engine. A single modification was made to the prototype models for the various climate zone-HVAC type combinations to create the base case models for estimating savings for the solar screens measure. Windows facing all directions are assumed to be single-pane windows with U-Values of 1.16 BTU/h-ft2-R and Solar Heat Gain Coefficients (SHGC) of 0.76.[529]

For the change case models, an 80 percent reduction was applied to the solar heat gain coefficient for the south and west-facing windows.

Summer peak demand savings are estimated by taking the difference in demand for the 20 hours identified from the TMY3 datasets in which the summer and winter peaks are most likely to occur as described in Texas TRM Volume 1 Section 4.

The model assumes the average solar screen installed blocks 80 percent of the solar heat gain attributed to the south and west facing windows based on performance data from solar screens analyzed at sun angles of 30, 45 and 75 degrees to the window.[530]

While it is recommended that solar screens be removed during winter to allow the advantage of free heat from the sun, often they are not removed seasonally. This may be due to solar screens serving as an insect screen in addition to blocking the sun or simply that they're installed in difficult-to-reach areas such as second floor windows. The savings estimates presented herein assume that the installed solar screens remain in place year-round.

Thermal Performance Improvement

Manual J and other studies researched indicate a thermal improvement to a window with a solar screen due to reduced air infiltration. The National Certified Testing Laboratories provided a report stating a 15 percent reduction in the thermal transmittance of a single pane, ¼" clear glass window with a solar screen added to the exterior.

Another study that was conducted for NFRC indicated between a 22 percent and 4 percent improvement to the U-value of a window with a solar screen. A single pane, clear window has a 22 percent improvement with the addition of a solar screen, whereas a double pane,

[529] BEopt default values for single-paned windows with metal frames.

[530] Performance data from Matrix, Inc., Mesa, Arizona testing facility for Phifer Wire Products' SunTex screen, blocks 80 percent of solar heat gain.

spectrally selective low-E window may only have a 4 percent improvement. The deemed savings models assume an average 10 percent improvement in thermal performance with the addition of a solar screen.

Window Frame

The window frame accounts for 10-30 percent[531] of the window area and since it is opaque and blocks sunlight from entering the home, it is factored into the model. An average of 15 percent frame area was incorporated into the performance of the window.

4.22.3 Energy Savings Estimation

Table 270 presents the deemed energy savings value per square foot of solar screen installed. Annual energy savings are the sum of cooling and heating savings for the appropriate equipment types.

Table 270: Deemed Energy (kWh) Savings per Square Foot of Solar Screen

	Cooling Savings (kWh/sq. ft.)		Heating Savings		
Climate Zone	Refrigerated Air	Evaporative Cooling	Gas Heat (therms/sq. ft.)	Electric Resistance (kWh/sq. ft.)	Heat Pump (kWh/sq. ft.)
Albuquerque	3.77	1.38	-0.65	-13.51	-4.79
Las Cruces	5.74	2.03	-0.45	-10.81	-3.93
Roswell	5.73	2.03	-0.43	-10.26	-3.73
Santa Fe	3.64	1.33	-0.64	-13.32	-4.72

4.22.4 Demand Savings Estimation

Table 271 presents the deemed summer peak demand savings value per square foot of solar screen installed.

Table 271: Deemed Summer Peak Demand (kW) Savings per Square Foot of Solar Screen

Climate Zone	Refrigerated Air	Evaporative Cooling
Albuquerque	0.00277	0.00130
Las Cruces	0.00322	0.00110
Roswell	0.00327	0.00112

531 Residential Windows – A Guide to New Technologies and Energy Performance, 2000.

Santa Fe	0.00264	0.00123

4.22.5 Non-energy Benefits

There are no non-energy benefits.

4.22.6 Measure Life

The estimated useful life (EUL) for solar screens is 10 years. This value is consistent with the EUL reported in the 2014 California Database for Energy Efficiency Resources (DEER).[532]

4.22.7 Incremental Cost

Incremental cost estimates should be gathered as part of the application process if utilities wish to test the cost effectiveness of this measure using the TRC test.

[532] 2014 California Database for Energy Efficiency Resources.

4.23 Cool Roofs

This section presents the deemed savings methodology for the installation of an ENERGY STAR® certified roof. The installation of an ENERGY STAR® roof decreases the roofing heat transfer coefficient and reduces the solar heat transmitted to the building space. During hours when cooling is required in the building, this measure decreases the cooling energy use. During hours when heating is required in the building, this measure increases the heating energy use.

4.23.1 Measure Overview

Sector	Residential
End use	Building Envelope
Fuel	Electricity and Natural Gas
Measure category	Cool Roofs
Delivery mechanism	Direct Install, Rebate
Baseline description	Existing home with a standard medium- or dark-colored roof
Efficient case description	Roof products that have been rated by the Cool Roof Rating Council and compliance with ENERGY STAR® certified roof product performance specifications for the relevant roof application

4.23.2 Savings

Cooling savings in this measure apply to customers with central or mini-split electric refrigerated air conditioning, or evaporative cooling in their homes. Homes must be centrally heated with either a furnace (gas or electric resistance) or a heat pump to claim heating savings.

The ENERGY STAR® program classifies roofs with slope greater than 2/12 as having a steep slope and roofs with slope less than or equal to 2/12 as low slope roofs. ENERGY STAR® performance specifications for cool roof products for use on roofs with steep slopes and low slopes are provided in Table 272.

Table 272: ENERGY STAR® Solar Reflectance Specification for Cool Roof Products

Roof Slope	Characteristic	Performance Specification
Low Slope ≤ 2/12	Initial Solar Reflectance	≥ 0.65
	3-Year Solar Reflectance	≥ 0.50
High Slope > 2/12	Initial Solar Reflectance	≥ 0.25
	3-Year Solar Reflectance	≥ 0.15

In the event that a cool roof is installed concurrent with changes to attic insulation levels, savings should be claimed for the reflective roof according to the post-retrofit (ceiling or roof deck) insulation levels. Savings for changes in insulation levels should be claimed separately according to the ceiling insulation or attic encapsulation measures, assuming the retrofit performed meets the requirements of those measures.

Deemed savings values were derived using the savings values from the Texas TRM, version 5. The Texas savings values were adjusted based on a comparison of annual solar radiation for the Texas representative cities and the New Mexico representative cities. Solar radiation values were taken from NREL's PVWatts tool, with inputs representing a horizontal surface (i.e., tilt = 0 degrees). Cooling energy savings were adjusted using radiation for the months of April through October, and heating energy savings were adjusted using radiation for the months of January through March and November through December. Peak demand savings were adjusted using radiation for the months of June through August.

Calibrated simulation modeling was used to develop the deemed savings values in the Texas TRM. Specifically, the deemed savings estimates were developed using BEopt 2.6, running EnergyPlus 8.4 as the underlying simulation engine. To model this measure, the prototype home models for each climate zone were modified as follows. Roof slopes were modified to reflect representative levels for the low slope and steep slope roofs. A 1/12 slope was selected for modeling low slope roofs (defined as having slope <= 2/12), and a 4/12 slope was selected for modeling steep slope roofs (slope > 2/12). Based on the performance criteria and review of the rated 3-year reflectance of rated products listed in the CRRC database, four reflectance levels were selected for modeling: 0.2, 0.4, 0.6 and 0.8, representing 20 to 80 percent reflectance.

Because of the interplay between the performance of insulation and attic/roof deck temperatures, which are directly affected by the installation of a cool roof, savings were estimated for a range of different attic insulation scenarios: a range of ceiling insulation levels from no insulation (R-0) to R-30, and two roof deck insulation levels, R-19 and R-38, were modeled. The model runs calculated energy use for the prototypical home prior to encapsulating the attic. Next, change-case models were run to calculate energy use with the floor insulation measure in place with either R-30 or R-38 insulation. Modeled prototypical home characteristics are shown in Table 273.

Table 273: Prototypical Home Characteristics

Shell Characteristic	Value	Source
Base Case Roof Material	Medium Asphalt Shingle, Reflectance = 0.15	Prototype home default
Change Case Roof Material	Medium Asphalt Shingle, Reflectance = 0.2 Reflectance = 0.4 Reflectance = 0.6 Reflectance = 0.8	Lower reflectance levels only relevant for steep slope roofs. Modeled reflectance levels reflect midpoints of ranges: 0.15 ≤ R < 0.3 0.3 ≤ R < 0.5 0.5 ≤ R < 0.7 0.7 ≤ R
Roof Slope: Low-Slope Roof	1/12	Not modified between base and change cases
Roof Slope: Steep-Slope Roof	4/12	Not modified between base and change cases
Ceiling (attic floor) Insulation Levels	R-0 R1-R4 R5-R8 R9-R14 R-15-R22 R-30	Not modified between base and change cases
Roof Deck (underside) Insulation Levels	R-19 R-38	Not modified between base and change cases

The following tables list energy and demand savings for cool roofs according to the rated 3-year reflectance of the installed cool roof product and the type of roof (low-slope, high-slope) on which it is installed. Separate tables of energy and demand savings are provided for each climate zone, and for insulation type (ceiling or roof deck). Savings are per-square foot of installed roofing.

Table 274: Energy Savings for Homes with Ceiling Insulation, Albuquerque

Ceiling Insulation R-value	Installed Roof Material 3-Year Reflectance	Cooling Savings		Heating Savings		
		Refrigerated Air (kWh/SF)	Evaporative Cooling (kWh/SF)	Gas Heat (Therms/SF)	Electric Resistance (kWh/SF)	Heat Pump (kWh/SF)
Steep Slope						
R-0	0.15 - 0.29	0.05	0.02	-0.01	-0.08	-0.03
R-0	0.3 – 0.49	0.26	0.09	-0.02	-0.45	-0.17
R-0	0.5 – 0.69	0.47	0.18	-0.05	-0.84	-0.32
R-0	≥ 0.7	0.68	0.25	-0.08	-1.28	-0.47
R-1 to R-4	0.15 - 0.29	0.04	0.02	0.00	-0.07	-0.03
R-1 to R-4	0.3 – 0.49	0.22	0.08	-0.02	-0.37	-0.14
R-1 to R-4	0.5 – 0.69	0.40	0.15	-0.04	-0.70	-0.26
R-1 to R-4	≥ 0.7	0.58	0.21	-0.07	-1.05	-0.39
R-5 to R-8	0.15 - 0.29	0.02	0.01	0.00	-0.04	-0.01
R-5 to R-8	0.3 – 0.49	0.13	0.04	-0.02	-0.21	-0.07
R-5 to R-8	0.5 – 0.69	0.22	0.08	-0.03	-0.38	-0.15
R-5 to R-8	≥ 0.7	0.32	0.13	-0.05	-0.57	-0.21
R-9 to R-14	0.15 - 0.29	0.02	0.01	0.00	-0.03	-0.01
R-9 to R-14	0.3 – 0.49	0.08	0.03	-0.01	-0.14	-0.05
R-9 to R-14	0.5 – 0.69	0.16	0.06	-0.03	-0.26	-0.09
R-9 to R-14	≥ 0.7	0.23	0.08	-0.04	-0.39	-0.15
R-15 to R-22	0.15 - 0.29	0.01	0.00	0.00	-0.02	-0.01
R-15 to R-22	0.3 – 0.49	0.06	0.02	-0.01	-0.09	-0.04
R-15 to R-22	0.5 – 0.69	0.10	0.04	-0.02	-0.18	-0.06
R-15 to R-22	≥ 0.7	0.16	0.06	-0.03	-0.26	-0.11
R-30	0.15 - 0.29	0.01	0.00	0.00	-0.01	0.00
R-30	0.3 – 0.49	0.04	0.01	-0.01	-0.06	-0.02
R-30	0.5 – 0.69	0.07	0.02	-0.02	-0.12	-0.04
R-30	≥ 0.7	0.10	0.04	-0.03	-0.17	-0.06
Low Slope						

Ceiling Insulation R-value	Installed Roof Material 3-Year Reflectance	Cooling Savings		Heating Savings		
		Refrigerated Air (kWh/SF)	Evaporative Cooling (kWh/SF)	Gas Heat (Therms/SF)	Electric Resistance (kWh/SF)	Heat Pump (kWh/SF)
R-0	0.5 – 0.69	0.50	0.19	-0.05	-0.91	-0.35
R-0	≥ 0.7	0.72	0.26	-0.08	-1.37	-0.52
R-1 to R-4	0.5 – 0.69	0.43	0.16	-0.05	-0.75	-0.28
R-1 to R-4	≥ 0.7	0.62	0.23	-0.07	-1.14	-0.42
R-5 to R-8	0.5 – 0.69	0.24	0.09	-0.03	-0.42	-0.16
R-5 to R-8	≥ 0.7	0.36	0.14	-0.05	-0.62	-0.23
R-9 to R-14	0.5 – 0.69	0.17	0.06	-0.03	-0.28	-0.11
R-9 to R-14	≥ 0.7	0.24	0.09	-0.04	-0.43	-0.16
R-15 to R-22	0.5 – 0.69	0.12	0.04	-0.02	-0.20	-0.07
R-15 to R-22	≥ 0.7	0.18	0.07	-0.03	-0.30	-0.12
R-30	0.5 – 0.69	0.08	0.03	-0.02	-0.14	-0.05
R-30	≥ 0.7	0.13	0.05	-0.03	-0.20	-0.07

Table 275: Energy Savings for Homes with Roof Deck Insulation, Albuquerque

Roof Deck Insulation R-value	Installed Roof Material 3-Year Reflectance	Cooling Savings		Heating Savings		
		Refrigerated Air (kWh/SF)	Evaporative Cooling (kWh/SF)	Gas Heat (Therms/SF)	Electric Resistance (kWh/SF)	Heat Pump (kWh/SF)
Steep Slope						
R-19	0.15 - 0.29	0.00	0.00	0.00	0.00	0.00
R-19	0.3 – 0.49	0.06	0.02	-0.01	-0.14	-0.05
R-19	0.5 – 0.69	0.14	0.04	-0.01	-0.30	-0.12
R-19	≥ 0.7	0.21	0.07	-0.02	-0.44	-0.17
R-38	0.15 - 0.29	0.01	0.00	0.00	-0.02	-0.01
R-38	0.3 – 0.49	0.05	0.02	-0.01	-0.12	-0.04
R-38	0.5 – 0.69	0.09	0.03	-0.01	-0.21	-0.08
R-38	≥ 0.7	0.14	0.04	-0.02	-0.32	-0.13
Low Slope						

Roof Deck Insulation R-value	Installed Roof Material 3-Year Reflectance	Cooling Savings		Heating Savings		
		Refrigerated Air (kWh/SF)	Evaporative Cooling (kWh/SF)	Gas Heat (Therms/SF)	Electric Resistance (kWh/SF)	Heat Pump (kWh/SF)
R-19	0.5 – 0.69	0.14	0.04	-0.01	-0.28	-0.12
R-19	≥ 0.7	0.21	0.07	-0.02	-0.44	-0.17
R-38	0.5 – 0.69	0.09	0.03	-0.01	-0.21	-0.08
R-38	≥ 0.7	0.14	0.04	-0.02	-0.31	-0.12

Table 276: Energy Savings for Homes with Ceiling Insulation, Las Cruces

Ceiling Insulation R-value	Installed Roof Material 3-Year Reflectance	Cooling Savings		Heating Savings		
		Refrigerated Air (kWh/SF)	Evaporative Cooling (kWh/SF)	Gas Heat (Therms/SF)	Electric Resistance (kWh/SF)	Heat Pump (kWh/SF)
Steep Slope						
R-0	0.15 - 0.29	0.09	0.03	0.00	-0.08	-0.03
R-0	0.3 – 0.49	0.44	0.17	-0.02	-0.43	-0.16
R-0	0.5 – 0.69	0.80	0.30	-0.03	-0.84	-0.32
R-0	≥ 0.7	1.19	0.44	-0.05	-1.32	-0.49
R-1 to R-4	0.15 - 0.29	0.07	0.03	0.00	-0.07	-0.03
R-1 to R-4	0.3 – 0.49	0.37	0.14	-0.01	-0.35	-0.13
R-1 to R-4	0.5 – 0.69	0.68	0.26	-0.03	-0.68	-0.26
R-1 to R-4	≥ 0.7	1.01	0.38	-0.05	-1.07	-0.40
R-5 to R-8	0.15 - 0.29	0.04	0.02	0.00	-0.04	-0.01
R-5 to R-8	0.3 – 0.49	0.21	0.08	-0.01	-0.20	-0.07
R-5 to R-8	0.5 – 0.69	0.39	0.15	-0.02	-0.38	-0.14
R-5 to R-8	≥ 0.7	0.58	0.23	-0.03	-0.59	-0.22
R-9 to R-14	0.15 - 0.29	0.03	0.01	0.00	-0.03	-0.01
R-9 to R-14	0.3 – 0.49	0.15	0.06	-0.01	-0.14	-0.05
R-9 to R-14	0.5 – 0.69	0.27	0.11	-0.01	-0.27	-0.10
R-9 to R-14	≥ 0.7	0.41	0.16	-0.02	-0.41	-0.15
R-15 to R-22	0.15 - 0.29	0.02	0.01	0.00	-0.02	-0.01

Ceiling Insulation R-value	Installed Roof Material 3-Year Reflectance	Cooling Savings		Heating Savings		
		Refrigerated Air (kWh/SF)	Evaporative Cooling (kWh/SF)	Gas Heat (Therms/SF)	Electric Resistance (kWh/SF)	Heat Pump (kWh/SF)
R-15 to R-22	0.3 – 0.49	0.10	0.04	-0.01	-0.10	-0.04
R-15 to R-22	0.5 – 0.69	0.19	0.08	-0.01	-0.18	-0.07
R-15 to R-22	≥ 0.7	0.29	0.12	-0.02	-0.28	-0.10
R-30	0.15 - 0.29	0.01	0.01	0.00	-0.01	-0.01
R-30	0.3 – 0.49	0.07	0.03	0.00	-0.06	-0.02
R-30	0.5 – 0.69	0.13	0.05	-0.01	-0.12	-0.04
R-30	≥ 0.7	0.20	0.08	-0.01	-0.18	-0.07
Low Slope						
R-0	0.5 – 0.69	0.90	0.34	-0.04	-0.94	-0.36
R-0	≥ 0.7	1.32	0.49	-0.06	-1.49	-0.56
R-1 to R-4	0.5 – 0.69	0.77	0.29	-0.03	-0.77	-0.29
R-1 to R-4	≥ 0.7	1.13	0.43	-0.05	-1.23	-0.45
R-5 to R-8	0.5 – 0.69	0.45	0.18	-0.02	-0.44	-0.16
R-5 to R-8	≥ 0.7	0.66	0.26	-0.03	-0.68	-0.25
R-9 to R-14	0.5 – 0.69	0.32	0.13	-0.02	-0.31	-0.12
R-9 to R-14	≥ 0.7	0.47	0.19	-0.03	-0.47	-0.18
R-15 to R-22	0.5 – 0.69	0.23	0.09	-0.01	-0.21	-0.08
R-15 to R-22	≥ 0.7	0.34	0.14	-0.02	-0.32	-0.12
R-30	0.5 – 0.69	0.17	0.07	-0.01	-0.14	-0.06
R-30	≥ 0.7	0.25	0.10	-0.02	-0.22	-0.08

Table 277: Energy Savings for Homes with Roof Deck Insulation, Las Cruces

Roof Deck Insulation R-value	Installed Roof Material 3-Year Reflectance	Cooling Savings		Heating Savings		
		Refrigerated Air (kWh/SF)	Evaporative Cooling (kWh/SF)	Gas Heat (Therms/SF)	Electric Resistance (kWh/SF)	Heat Pump (kWh/SF)
Steep Slope						
R-19	0.15 - 0.29	0.00	0.00	0.00	0.00	0.00
R-19	0.3 – 0.49	0.11	0.04	-0.01	-0.14	-0.05
R-19	0.5 – 0.69	0.22	0.08	-0.01	-0.28	-0.11
R-19	≥ 0.7	0.35	0.12	-0.02	-0.45	-0.17
R-38	0.15 - 0.29	0.02	0.01	0.00	-0.02	-0.01
R-38	0.3 – 0.49	0.09	0.03	0.00	-0.11	-0.04
R-38	0.5 – 0.69	0.16	0.05	-0.01	-0.20	-0.08
R-38	≥ 0.7	0.23	0.08	-0.01	-0.31	-0.12
Low Slope						
R-19	0.5 – 0.69	0.23	0.08	-0.01	-0.29	-0.11
R-19	≥ 0.7	0.36	0.12	-0.02	-0.46	-0.18
R-38	0.5 – 0.69	0.16	0.05	-0.01	-0.21	-0.08
R-38	≥ 0.7	0.24	0.08	-0.01	-0.32	-0.12

Table 278: Energy Savings for Homes with Ceiling Insulation, Roswell

Ceiling Insulation R-value	Installed Roof Material 3-Year Reflectance	Cooling Savings		Heating Savings		
		Refrigerated Air (kWh/SF)	Evaporative Cooling (kWh/SF)	Gas Heat (Therms/SF)	Electric Resistance (kWh/SF)	Heat Pump (kWh/SF)
Steep Slope						
R-0	0.15 - 0.29	0.09	0.03	0.00	-0.07	-0.03
R-0	0.3 – 0.49	0.43	0.17	-0.02	-0.40	-0.15
R-0	0.5 – 0.69	0.78	0.29	-0.03	-0.78	-0.30
R-0	≥ 0.7	1.15	0.43	-0.05	-1.22	-0.46
R-1 to R-4	0.15 - 0.29	0.07	0.03	0.00	-0.07	-0.03
R-1 to R-4	0.3 – 0.49	0.36	0.14	-0.01	-0.33	-0.12

Ceiling Insulation R-value	Installed Roof Material 3-Year Reflectance	Cooling Savings		Heating Savings		
		Refrigerated Air (kWh/SF)	Evaporative Cooling (kWh/SF)	Gas Heat (Therms/SF)	Electric Resistance (kWh/SF)	Heat Pump (kWh/SF)
R-1 to R-4	0.5 – 0.69	0.66	0.25	-0.03	-0.63	-0.24
R-1 to R-4	≥ 0.7	0.98	0.37	-0.05	-1.00	-0.37
R-5 to R-8	0.15 - 0.29	0.04	0.02	0.00	-0.04	-0.01
R-5 to R-8	0.3 – 0.49	0.20	0.08	-0.01	-0.19	-0.07
R-5 to R-8	0.5 – 0.69	0.38	0.15	-0.02	-0.35	-0.13
R-5 to R-8	≥ 0.7	0.56	0.22	-0.03	-0.55	-0.21
R-9 to R-14	0.15 - 0.29	0.03	0.01	0.00	-0.03	-0.01
R-9 to R-14	0.3 – 0.49	0.15	0.06	-0.01	-0.13	-0.05
R-9 to R-14	0.5 – 0.69	0.26	0.11	-0.01	-0.25	-0.09
R-9 to R-14	≥ 0.7	0.40	0.16	-0.02	-0.38	-0.14
R-15 to R-22	0.15 - 0.29	0.02	0.01	0.00	-0.02	-0.01
R-15 to R-22	0.3 – 0.49	0.10	0.04	-0.01	-0.09	-0.04
R-15 to R-22	0.5 – 0.69	0.18	0.08	-0.01	-0.17	-0.07
R-15 to R-22	≥ 0.7	0.28	0.12	-0.02	-0.26	-0.09
R-30	0.15 - 0.29	0.01	0.01	0.00	-0.01	-0.01
R-30	0.3 – 0.49	0.07	0.03	0.00	-0.06	-0.02
R-30	0.5 – 0.69	0.13	0.05	-0.01	-0.11	-0.04
R-30	≥ 0.7	0.19	0.08	-0.01	-0.17	-0.07
Low Slope						
R-0	0.5 – 0.69	0.87	0.33	-0.04	-0.88	-0.34
R-0	≥ 0.7	1.27	0.48	-0.06	-1.38	-0.52
R-1 to R-4	0.5 – 0.69	0.75	0.28	-0.03	-0.72	-0.27
R-1 to R-4	≥ 0.7	1.10	0.42	-0.05	-1.14	-0.42
R-5 to R-8	0.5 – 0.69	0.44	0.17	-0.02	-0.41	-0.15
R-5 to R-8	≥ 0.7	0.64	0.25	-0.03	-0.63	-0.23

Ceiling Insulation R-value	Installed Roof Material 3-Year Reflectance	Cooling Savings		Heating Savings		
		Refrigerated Air (kWh/SF)	Evaporative Cooling (kWh/SF)	Gas Heat (Therms/SF)	Electric Resistance (kWh/SF)	Heat Pump (kWh/SF)
R-9 to R-14	0.5 – 0.69	0.31	0.13	-0.02	-0.29	-0.11
R-9 to R-14	≥ 0.7	0.46	0.18	-0.03	-0.44	-0.17
R-15 to R-22	0.5 – 0.69	0.22	0.09	-0.01	-0.20	-0.07
R-15 to R-22	≥ 0.7	0.33	0.14	-0.02	-0.30	-0.11
R-30	0.5 – 0.69	0.17	0.07	-0.01	-0.13	-0.06
R-30	≥ 0.7	0.24	0.10	-0.02	-0.21	-0.07

Table 279: Energy Savings for Homes with Roof Deck Insulation, Roswell

Roof Deck Insulation R-value	Installed Roof Material 3-Year Reflectance	Cooling Savings		Heating Savings		
		Refrigerated Air (kWh/SF)	Evaporative Cooling (kWh/SF)	Gas Heat (Therms/SF)	Electric Resistance (kWh/SF)	Heat Pump (kWh/SF)
Steep Slope						
R-19	0.15 - 0.29	0.00	0.00	0.00	0.00	0.00
R-19	0.3 – 0.49	0.11	0.04	-0.01	-0.13	-0.05
R-19	0.5 – 0.69	0.21	0.08	-0.01	-0.26	-0.10
R-19	≥ 0.7	0.34	0.12	-0.02	-0.42	-0.16
R-38	0.15 - 0.29	0.02	0.01	0.00	-0.02	-0.01
R-38	0.3 – 0.49	0.09	0.03	0.00	-0.10	-0.04
R-38	0.5 – 0.69	0.16	0.05	-0.01	-0.19	-0.07
R-38	≥ 0.7	0.22	0.08	-0.01	-0.29	-0.11
Low Slope						
R-19	0.5 – 0.69	0.22	0.08	-0.01	-0.27	-0.10
R-19	≥ 0.7	0.35	0.12	-0.02	-0.43	-0.17
R-38	0.5 – 0.69	0.16	0.05	-0.01	-0.20	-0.07
R-38	≥ 0.7	0.23	0.08	-0.01	-0.30	-0.11

Table 280: Energy Savings for Homes with Ceiling Insulation, Santa Fe

Ceiling Insulation R-value	Installed Roof Material 3-Year Reflectance	Cooling Savings		Heating Savings		
		Refrigerated Air (kWh/SF)	Evaporative Cooling (kWh/SF)	Gas Heat (Therms/SF)	Electric Resistance (kWh/SF)	Heat Pump (kWh/SF)
Steep Slope						
R-0	0.15 - 0.29	0.05	0.02	-0.01	-0.08	-0.03
R-0	0.3 – 0.49	0.25	0.09	-0.02	-0.44	-0.16
R-0	0.5 – 0.69	0.45	0.17	-0.05	-0.82	-0.31
R-0	≥ 0.7	0.65	0.24	-0.08	-1.25	-0.46
R-1 to R-4	0.15 - 0.29	0.04	0.02	0.00	-0.07	-0.03
R-1 to R-4	0.3 – 0.49	0.21	0.08	-0.02	-0.36	-0.13
R-1 to R-4	0.5 – 0.69	0.38	0.14	-0.04	-0.68	-0.26
R-1 to R-4	≥ 0.7	0.55	0.20	-0.07	-1.03	-0.38
R-5 to R-8	0.15 - 0.29	0.02	0.01	0.00	-0.04	-0.01
R-5 to R-8	0.3 – 0.49	0.12	0.04	-0.02	-0.21	-0.07
R-5 to R-8	0.5 – 0.69	0.21	0.08	-0.03	-0.37	-0.14
R-5 to R-8	≥ 0.7	0.31	0.12	-0.05	-0.56	-0.21
R-9 to R-14	0.15 - 0.29	0.02	0.01	0.00	-0.03	-0.01
R-9 to R-14	0.3 – 0.49	0.08	0.03	-0.01	-0.13	-0.05
R-9 to R-14	0.5 – 0.69	0.15	0.06	-0.03	-0.26	-0.09
R-9 to R-14	≥ 0.7	0.22	0.08	-0.04	-0.38	-0.14
R-15 to R-22	0.15 - 0.29	0.01	0.00	0.00	-0.02	-0.01
R-15 to R-22	0.3 – 0.49	0.06	0.02	-0.01	-0.09	-0.04
R-15 to R-22	0.5 – 0.69	0.10	0.04	-0.02	-0.17	-0.06
R-15 to R-22	≥ 0.7	0.15	0.06	-0.03	-0.26	-0.10

Ceiling Insulation R-value	Installed Roof Material 3-Year Reflectance	Cooling Savings		Heating Savings		
		Refrigerated Air (kWh/SF)	Evaporative Cooling (kWh/SF)	Gas Heat (Therms/SF)	Electric Resistance (kWh/SF)	Heat Pump (kWh/SF)
R-30	0.15 - 0.29	0.01	0.00	0.00	-0.01	0.00
R-30	0.3 – 0.49	0.04	0.01	-0.01	-0.06	-0.02
R-30	0.5 – 0.69	0.07	0.02	-0.02	-0.11	-0.04
R-30	≥ 0.7	0.10	0.04	-0.03	-0.16	-0.06
Low Slope						
R-0	0.5 – 0.69	0.48	0.18	-0.05	-0.89	-0.34
R-0	≥ 0.7	0.69	0.25	-0.08	-1.34	-0.50
R-1 to R-4	0.5 – 0.69	0.41	0.15	-0.05	-0.73	-0.28
R-1 to R-4	≥ 0.7	0.59	0.22	-0.07	-1.11	-0.41
R-5 to R-8	0.5 – 0.69	0.23	0.09	-0.03	-0.41	-0.15
R-5 to R-8	≥ 0.7	0.34	0.13	-0.05	-0.61	-0.23
R-9 to R-14	0.5 – 0.69	0.16	0.06	-0.03	-0.28	-0.10
R-9 to R-14	≥ 0.7	0.23	0.09	-0.04	-0.42	-0.15
R-15 to R-22	0.5 – 0.69	0.11	0.04	-0.02	-0.20	-0.07
R-15 to R-22	≥ 0.7	0.17	0.07	-0.03	-0.29	-0.11
R-30	0.5 – 0.69	0.08	0.03	-0.02	-0.13	-0.05
R-30	≥ 0.7	0.12	0.05	-0.03	-0.20	-0.07

Table 281: Energy Savings for Homes with Roof Deck Insulation, Santa Fe

Roof Deck Insulation R-value	Installed Roof Material 3-Year Reflectance	Cooling Savings		Heating Savings		
		Refrigerated Air (kWh/SF)	Evaporative Cooling (kWh/SF)	Gas Heat (Therms/SF)	Electric Resistance (kWh/SF)	Heat Pump (kWh/SF)
Steep Slope						
R-19	0.15 - 0.29	0.00	0.00	0.00	0.00	0.00

Roof Deck Insulation R-value	Installed Roof Material 3-Year Reflectance	Cooling Savings		Heating Savings		
		Refrigerated Air (kWh/SF)	Evaporative Cooling (kWh/SF)	Gas Heat (Therms/SF)	Electric Resistance (kWh/SF)	Heat Pump (kWh/SF)
R-19	0.3 – 0.49	0.06	0.02	-0.01	-0.13	-0.05
R-19	0.5 – 0.69	0.13	0.04	-0.01	-0.29	-0.11
R-19	≥ 0.7	0.20	0.07	-0.02	-0.43	-0.16
R-38	0.15 - 0.29	0.01	0.00	0.00	-0.02	-0.01
R-38	0.3 – 0.49	0.05	0.02	-0.01	-0.11	-0.04
R-38	0.5 – 0.69	0.09	0.03	-0.01	-0.21	-0.08
R-38	≥ 0.7	0.13	0.04	-0.02	-0.31	-0.12
Low Slope						
R-19	0.5 – 0.69	0.13	0.04	-0.01	-0.28	-0.11
R-19	≥ 0.7	0.20	0.07	-0.02	-0.43	-0.16
R-38	0.5 – 0.69	0.09	0.03	-0.01	-0.21	-0.08
R-38	≥ 0.7	0.13	0.04	-0.02	-0.30	-0.11

Table 282: Demand Savings for Homes with Ceiling Insulation, Albuquerque

Ceiling Insulation R-value	Installed Roof Material 3-Year Reflectance	Low Slope		Steep Slope	
		Refrigerated Air (kW/SF)	Evaporative Cooling (kW/SF)	Refrigerated Air (kW/SF)	Evaporative Cooling (kW/SF)
R-0	0.15 - 0.29	n/a	n/a	0.0000456	0.0000189
R-0	0.3 – 0.49	n/a	n/a	0.0002357	0.0000950
R-0	0.5 – 0.69	0.0004694	0.0002069	0.0004477	0.0001853
R-0	≥ 0.7	0.0007102	0.0003006	0.0006845	0.0002872
R-1 to R-4	0.15 - 0.29	n/a	n/a	0.0000387	0.0000175
R-1 to R-4	0.3 – 0.49	n/a	n/a	0.0001935	0.0000892
R-1 to R-4	0.5 – 0.69	0.0003819	0.0001657	0.0003644	0.0001616
R-1 to R-4	≥ 0.7	0.0006011	0.0002666	0.0005908	0.0002686
R-5 to R-8	0.15 - 0.29	n/a	n/a	0.0000152	0.0000069
R-5 to R-8	0.3 – 0.49	n/a	n/a	0.0000833	0.0000460

Ceiling Insulation R-value	Installed Roof Material 3-Year Reflectance	Low Slope		Steep Slope	
		Refrigerated Air (kW/SF)	Evaporative Cooling (kW/SF)	Refrigerated Air (kW/SF)	Evaporative Cooling (kW/SF)
R-5 to R-8	0.5 – 0.69	0.0001832	0.0000948	0.0001678	0.0000773
R-5 to R-8	≥ 0.7	0.0002933	0.0001595	0.0002944	0.0001441
R-9 to R-14	0.15 - 0.29	n/a	n/a	0.0000062	0.0000082
R-9 to R-14	0.3 – 0.49	n/a	n/a	0.0000581	0.0000224
R-9 to R-14	0.5 – 0.69	0.0001204	0.0000617	0.0001112	0.0000465
R-9 to R-14	≥ 0.7	0.0001976	0.0000937	0.0001956	0.0000965
R-15 to R-22	0.15 - 0.29	n/a	n/a	0.0000024	-0.0000009
R-15 to R-22	0.3 – 0.49	n/a	n/a	0.0000365	0.0000157
R-15 to R-22	0.5 – 0.69	0.0000813	0.0000384	0.0000755	0.0000282
R-15 to R-22	≥ 0.7	0.0001348	0.0000646	0.0001410	0.0000772
R-30	0.15 - 0.29	n/a	n/a	-0.0000007	0.0000035
R-30	0.3 – 0.49	n/a	n/a	0.0000243	0.0000188
R-30	0.5 – 0.69	0.0000555	0.0000181	0.0000514	0.0000278
R-30	≥ 0.7	0.0000952	0.0000444	0.0000984	0.0000617

Table 283: Demand Savings for Homes with Roof Deck Insulation, Albuquerque

Roof Deck Insulation R-value	Installed Roof Material 3-Year Reflectance	Low Slope		Steep Slope	
		Refrigerated Air (kW/SF)	Evaporative Cooling (kW/SF)	Refrigerated Air (kW/SF)	Evaporative Cooling (kW/SF)
R-19	0.15 - 0.29	n/a	n/a	0.0000000	0.0000000
R-19	0.3 – 0.49	n/a	n/a	0.0000275	0.0000078
R-19	0.5 – 0.69	0.0000572	0.0000189	0.0000551	0.0000160
R-19	≥ 0.7	0.0001017	0.0000078	0.0000907	0.0000156
R-38	0.15 - 0.29	n/a	n/a	0.0000060	0.0000061

R-38	0.3 – 0.49	n/a	n/a	0.0000150	0.0000074
R-38	0.5 – 0.69	0.0000154	0.0000024	0.0000144	0.0000107
R-38	≥ 0.7	0.0000489	0.0000094	0.0000396	0.0000171

Table 284: Demand Savings for Homes with Ceiling Insulation, Las Cruces

Ceiling Insulation R-value	Installed Roof Material 3-Year Reflectance	Low Slope		Steep Slope	
		Refrigerated Air (kW/SF)	Evaporative Cooling (kW/SF)	Refrigerated Air (kW/SF)	Evaporative Cooling (kW/SF)
R-0	0.15 - 0.29	n/a	n/a	0.0000567	0.0000212
R-0	0.3 – 0.49	n/a	n/a	0.0002883	0.0001246
R-0	0.5 – 0.69	0.0006408	0.0002300	0.0005705	0.0002561
R-0	≥ 0.7	0.0009482	0.0003385	0.0008347	0.0003134
R-1 to R-4	0.15 - 0.29	n/a	n/a	0.0000503	0.0000192
R-1 to R-4	0.3 – 0.49	n/a	n/a	0.0002491	0.0001000
R-1 to R-4	0.5 – 0.69	0.0005444	0.0001868	0.0004882	0.0002119
R-1 to R-4	≥ 0.7	0.0008498	0.0003054	0.0007262	0.0002913
R-5 to R-8	0.15 - 0.29	n/a	n/a	0.0000273	0.0000090
R-5 to R-8	0.3 – 0.49	n/a	n/a	0.0001276	0.0000603
R-5 to R-8	0.5 – 0.69	0.0003074	0.0001346	0.0002602	0.0001386
R-5 to R-8	≥ 0.7	0.0004791	0.0002059	0.0003988	0.0001788
R-9 to R-14	0.15 - 0.29	n/a	n/a	0.0000126	0.0000093
R-9 to R-14	0.3 – 0.49	n/a	n/a	0.0000828	0.0000532
R-9 to R-14	0.5 – 0.69	0.0002079	0.0001004	0.0001738	0.0000890
R-9 to R-14	≥ 0.7	0.0003285	0.0001446	0.0002612	0.0001225
R-15 to R-22	0.15 - 0.29	n/a	n/a	0.0000062	0.0000037
R-15 to R-22	0.3 – 0.49	n/a	n/a	0.0000621	0.0000442
R-15 to R-22	0.5 – 0.69	0.0001507	0.0000766	0.0001246	0.0000652
R-15 to R-22	≥ 0.7	0.0002431	0.0001115	0.0001888	0.0000890

R-30	0.15 - 0.29	n/a	n/a	0.0000067	0.0000006
R-30	0.3 – 0.49	n/a	n/a	0.0000479	0.0000288
R-30	0.5 – 0.69	0.0001014	0.0000594	0.0000885	0.0000509
R-30	≥ 0.7	0.0001808	0.0000854	0.0001326	0.0000678

Table 285: Demand Savings for Homes with Roof Deck Insulation, Las Cruces

Roof Deck Insulation R-value	Installed Roof Material 3-Year Reflectance	Low Slope		Steep Slope	
		Refrigerated Air (kW/SF)	Evaporative Cooling (kW/SF)	Refrigerated Air (kW/SF)	Evaporative Cooling (kW/SF)
R-19	0.15 - 0.29	n/a	n/a	0.0000000	0.0000000
R-19	0.3 – 0.49	n/a	n/a	0.0000366	0.0000225
R-19	0.5 – 0.69	0.0000815	0.0000277	0.0000899	0.0000444
R-19	≥ 0.7	0.0001336	0.0000231	0.0001356	0.0000446
R-38	0.15 - 0.29	n/a	n/a	0.0000116	0.0000019
R-38	0.3 – 0.49	n/a	n/a	0.0000256	-0.0000072
R-38	0.5 – 0.69	0.0000381	-0.0000012	0.0000497	-0.0000005
R-38	≥ 0.7	0.0000996	0.0000056	0.0000844	0.0000063

Table 286: Demand Savings for Homes with Ceiling Insulation, Roswell

Ceiling Insulation R-value	Installed Roof Material 3-Year Reflectance	Low Slope		Steep Slope	
		Refrigerated Air (kW/SF)	Evaporative Cooling (kW/SF)	Refrigerated Air (kW/SF)	Evaporative Cooling (kW/SF)
R-0	0.15 - 0.29	n/a	n/a	0.0000560	0.0000209
R-0	0.3 – 0.49	n/a	n/a	0.0002850	0.0001231
R-0	0.5 – 0.69	0.0006335	0.0002274	0.0005640	0.0002532
R-0	≥ 0.7	0.0009373	0.0003346	0.0008251	0.0003098
R-1 to R-4	0.15 - 0.29	n/a	n/a	0.0000497	0.0000190
R-1 to R-4	0.3 – 0.49	n/a	n/a	0.0002462	0.0000989
R-1 to R-4	0.5 – 0.69	0.0005381	0.0001847	0.0004825	0.0002095
R-1 to R-4	≥ 0.7	0.0008400	0.0003018	0.0007178	0.0002879

Ceiling Insulation R-value	Installed Roof Material 3-Year Reflectance	Low Slope		Steep Slope	
		Refrigerated Air (kW/SF)	Evaporative Cooling (kW/SF)	Refrigerated Air (kW/SF)	Evaporative Cooling (kW/SF)
R-5 to R-8	0.15 - 0.29	n/a	n/a	0.0000270	0.0000089
R-5 to R-8	0.3 – 0.49	n/a	n/a	0.0001261	0.0000596
R-5 to R-8	0.5 – 0.69	0.0003038	0.0001330	0.0002572	0.0001370
R-5 to R-8	≥ 0.7	0.0004736	0.0002035	0.0003942	0.0001767
R-9 to R-14	0.15 - 0.29	n/a	n/a	0.0000124	0.0000092
R-9 to R-14	0.3 – 0.49	n/a	n/a	0.0000818	0.0000526
R-9 to R-14	0.5 – 0.69	0.0002055	0.0000993	0.0001718	0.0000880
R-9 to R-14	≥ 0.7	0.0003247	0.0001430	0.0002581	0.0001211
R-15 to R-22	0.15 - 0.29	n/a	n/a	0.0000061	0.0000037
R-15 to R-22	0.3 – 0.49	n/a	n/a	0.0000614	0.0000437
R-15 to R-22	0.5 – 0.69	0.0001489	0.0000758	0.0001231	0.0000644
R-15 to R-22	≥ 0.7	0.0002403	0.0001102	0.0001867	0.0000880
R-30	0.15 - 0.29	n/a	n/a	0.0000066	0.0000006
R-30	0.3 – 0.49	n/a	n/a	0.0000474	0.0000285
R-30	0.5 – 0.69	0.0001003	0.0000587	0.0000875	0.0000503
R-30	≥ 0.7	0.0001787	0.0000844	0.0001311	0.0000670

Table 287: Demand Savings for Homes with Roof Deck Insulation, Roswell

Roof Deck Insulation R-value	Installed Roof Material 3-Year Reflectance	Low Slope		Steep Slope	
		Refrigerated Air (kW/SF)	Evaporative Cooling (kW/SF)	Refrigerated Air (kW/SF)	Evaporative Cooling (kW/SF)
R-19	0.15 - 0.29	n/a	n/a	0.0000000	0.0000000
R-19	0.3 – 0.49	n/a	n/a	0.0000361	0.0000222
R-19	0.5 – 0.69	0.0000805	0.0000274	0.0000889	0.0000439

R-19	≥ 0.7	0.0001321	0.0000228	0.0001340	0.0000441
R-38	0.15 - 0.29	n/a	n/a	0.0000114	0.0000019
R-38	0.3 – 0.49	n/a	n/a	0.0000253	-0.0000071
R-38	0.5 – 0.69	0.0000376	-0.0000012	0.0000491	-0.0000005
R-38	≥ 0.7	0.0000985	0.0000056	0.0000834	0.0000062

Table 288: Demand Savings for Homes with Ceiling Insulation, Santa Fe

Ceiling Insulation R-value	Installed Roof Material 3-Year Reflectance	Low Slope		Steep Slope	
		Refrigerated Air (kW/SF)	Evaporative Cooling (kW/SF)	Refrigerated Air (kW/SF)	Evaporative Cooling (kW/SF)
R-0	0.15 - 0.29	n/a	n/a	0.0000433	0.0000180
R-0	0.3 – 0.49	n/a	n/a	0.0002238	0.0000902
R-0	0.5 – 0.69	0.0004456	0.0001964	0.0004250	0.0001759
R-0	≥ 0.7	0.0006742	0.0002853	0.0006498	0.0002726
R-1 to R-4	0.15 - 0.29	n/a	n/a	0.0000367	0.0000166
R-1 to R-4	0.3 – 0.49	n/a	n/a	0.0001837	0.0000847
R-1 to R-4	0.5 – 0.69	0.0003625	0.0001573	0.0003459	0.0001534
R-1 to R-4	≥ 0.7	0.0005706	0.0002531	0.0005609	0.0002550
R-5 to R-8	0.15 - 0.29	n/a	n/a	0.0000145	0.0000065
R-5 to R-8	0.3 – 0.49	n/a	n/a	0.0000790	0.0000437
R-5 to R-8	0.5 – 0.69	0.0001739	0.0000900	0.0001593	0.0000734
R-5 to R-8	≥ 0.7	0.0002785	0.0001515	0.0002795	0.0001368
R-9 to R-14	0.15 - 0.29	n/a	n/a	0.0000059	0.0000077
R-9 to R-14	0.3 – 0.49	n/a	n/a	0.0000551	0.0000213
R-9 to R-14	0.5 – 0.69	0.0001143	0.0000585	0.0001055	0.0000442
R-9 to R-14	≥ 0.7	0.0001876	0.0000889	0.0001857	0.0000917
R-15 to R-22	0.15 - 0.29	n/a	n/a	0.0000022	-0.0000009
R-15 to R-22	0.3 – 0.49	n/a	n/a	0.0000347	0.0000149
R-15 to R-22	0.5 – 0.69	0.0000772	0.0000364	0.0000717	0.0000268

R-15 to R-22	≥ 0.7	0.0001280	0.0000614	0.0001339	0.0000733
R-30	0.15 - 0.29	n/a	n/a	-0.0000007	0.0000033
R-30	0.3 – 0.49	n/a	n/a	0.0000231	0.0000179
R-30	0.5 – 0.69	0.0000527	0.0000172	0.0000488	0.0000264
R-30	≥ 0.7	0.0000904	0.0000421	0.0000934	0.0000585

Table 289: Demand Savings for Homes with Roof Deck Insulation, Santa Fe

Roof Deck Insulation R-value	Installed Roof Material 3-Year Reflectance	Low Slope		Steep Slope	
		Refrigerated Air (kW/SF)	Evaporative Cooling (kW/SF)	Refrigerated Air (kW/SF)	Evaporative Cooling (kW/SF)
R-19	0.15 - 0.29	n/a	n/a	0.0000000	0.0000000
R-19	0.3 – 0.49	n/a	n/a	0.0000261	0.0000074
R-19	0.5 – 0.69	0.0000543	0.0000180	0.0000523	0.0000151
R-19	≥ 0.7	0.0000965	0.0000074	0.0000861	0.0000149
R-38	0.15 - 0.29	n/a	n/a	0.0000057	0.0000058
R-38	0.3 – 0.49	n/a	n/a	0.0000143	0.0000070
R-38	0.5 – 0.69	0.0000147	0.0000023	0.0000137	0.0000102
R-38	≥ 0.7	0.0000464	0.0000089	0.0000376	0.0000162

4.23.3 Energy Savings Estimation

The deemed energy and demand savings values are used in the following formulas to calculate savings:

$$Cooling\ Energy\ Savings = Roof\ \ Area \times Deemed\ Cooling\ Savings$$

$$Heating\ Energy\ Savings = Roof\ \ Area \times Deemed\ Heating\ Savings$$

Where:

Roof Area = Total area of ENERGY STAR®roof in square feet

Deemed Cooling Savings = Per-SF cooling savings from tables above by climate zone, insulation type roof slope, insulation R-value, roof reflectance, and cooling system type

Deemed Heating Savings = Per-SF heating savings from tables above by climate zone, insulation type, roof slope, insulation R-value, roof reflectance, and heating system type

4.23.4 Demand Savings Estimation

The deemed demand savings factors are used in the following formulas to calculate savings:

$$Peak\ Summer\ Demand\ Savings = Roof\ Area \times Deemed\ Demand\ Savings$$

Where:

Deemed Demand Savings = Per-SF demand savings from tables above by climate zone, insulation type, roof slope, insulation R-value, roof reflectance, and cooling system type

4.23.5 Non-energy Benefits

There are no non-energy benefits.

4.23.6 Measure Life

The estimated useful life (EUL) for cool roofs is 15 years. This value is consistent with the EUL reported in the 2014 California Database for Energy Efficiency Resources (DEER).[533]

4.23.7 Incremental Cost

Incremental cost estimates should be gathered as part of the application process if utilities wish to test the cost effectiveness of this measure using the TRC test.

[533] 2014 California Database for Energy Efficiency Resources.

4.24 Wall Insulation

This measure saves space heating and cooling energy by reducing heat transfer through the walls.

4.24.1 Measure Overview

Sector	Residential
End use	Space heating and cooling
Fuel	Electricity and Natural Gas
Measure category	Insulation
Delivery mechanism	Rebate (retrofit)
Baseline description	Retrofit: Existing insulation level New Construction[534]: IECC 2018
Efficient case description	Insulation level higher than baseline level

4.24.2 Savings

Savings are derived as better wall insulation will lead to reduced consumption of heating and cooling during winter and summer months. A better R-value of the insulation being installed will achieve higher savings.

Baseline R-value for new construction projects are listed in Table 106:

Table 106: IECC 2018 Wall Insulation Baseline

Cities	Wood Frame Wall	Mass Wall	Basement Wall	Crawl Space Wall
Albuquerque	20 or 13+5**	8/13*	10/13*	10/13*
Santa Fe	20 or 13+5**	13/17*	15/19*	15/19*
Roswell	20 or 13+5**	8/13*	5/13*	5/13*
Las Cruces	20 or 13+5**	8/13*	5/13*	5/13*

534 IECC 2018 Code Table R402.1.2 Requirements for Climate Zones 3 (Las Cruces, Roswell), 4 (Albuquerque) and 5 (Santa Fe)

**13/17 means R-13 continuous insulated sheathing and R-17 on the interior or exterior of the wall or R-17 cavity insulation at the interior of the basement wall*
***13+5 means R-13 cavity insulation plus R-5 insulated sheathing*

4.24.3 Energy Savings Estimation

Savings are calculated based on the following formulas.

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

Cooling energy savings are calculated using:

$$\Delta kWh_{Cooling} = \frac{\left(\frac{1}{R_{Old}} - \frac{1}{R_{New}}\right) * A_{wall} * (1 - FF_{Wall}) * CDD * 24}{1000 * \eta_{Cooling}}$$

Where:

R_{Old}	= R-Value of existing insulation or baseline in case of new construction
R_{New}	= R-Value of new wall insulation (ft^2 - °F.h/Btu)
A_{wall}	= Total area of insulated wall (ft^2)
FF_{wall}	= Adjustment to account for area of framing, 25%[535]
CDD	= Cooling Degree Days, as listed in Table 291
24	= Converting Days to Hours
1000	= Converting Btu to kBtu
$\eta_{Cooling}$	= Seasonal Energy Efficiency Ratio of Cooling System (kBtu/kWh)
	= Nameplate ratings wherever possible, if unavailable use the following efficiencies listed in Table 290

Table 290: Cooling Efficiency (Federal Standards)

Age of Equipment	SEER Ratings
Before 2006	10.0
2006 - 2014	13.0
Central AC after 1/1/2015	13.0
Heat Pump after 1/1/2015	14.0

535 ASHRAE, 2001, "Characterization of Framing Factors for New Low-Rise Residential Building Envelopes (904-RP)," Table 7.1

Heating energy savings for electric resistance and heat pump systems can be calculated using:

$$\Delta kWh_{Heating} = \frac{\left(\frac{1}{R_{Old}} - \frac{1}{R_{New}}\right) * A_{wall} * (1 - FF_{wall}) * HDD * 24}{3412 * \eta_{Heating}}$$

Where:

HDD = Heating Degree Days, as listed in Table 291

Table 291: Cooling Degree Days and Heating Degree Days

City (Climate Zone)	CDD	HDD
Albuquerque	1,322	4,180
Santa Fe	645	5,417
Roswell	1,790	3,289
Las Cruces	1,899	2,816

3,412 = Converting Btu to kWh

$\eta_{Heating}$ = Efficiency of heating system (kBtu/kWh)

= Nameplate ratings wherever possible, if unavailable use the following efficiencies listed in Table 292

Table 292: Cooling Efficiency (Federal Standards)

Age of Equipment	HSPF Ratings
Heat Pump; Before 2006	6.8
Heat Pump; 2006 - 2014	7.7
Heat Pump; After 1/1/2015	8.2
Electric Resistance	1.0 (COP)

Heating energy savings for gas heat systems can be calculated using:

$$\Delta therms_{Heating} = \frac{\left(\frac{1}{R_{Old}} - \frac{1}{R_{New}}\right) * A_{wall} * (1 - FF_{wall}) * HDD * 24}{10^5 * \eta_{Heating}}$$

Where:

$\eta_{Heating}$ = AFUE of gas heating system. Use nameplate ratings wherever possible, if unavailable use 0.8

For example, a house in Las Cruces underwent a wall insulation retrofit i.e., from R-10 to R-32. The total area of the wall is 2500 sq. ft. and is cooled using an air conditioner (installed June 2016) and heated using a gas furnace (installed June 2016). Savings generated from this measure can be calculated using:

$$\Delta kWh_{Cooling} = \frac{\left(\frac{1}{R_{Old}} - \frac{1}{R_{New}}\right) * A_{wall} * (1 - FF_{wall}) * CDD * 24 * DUA}{1000 * \eta_{Cooling}}$$

and

$$\Delta therms_{Heating} = \frac{\left(\frac{1}{R_{Old}} - \frac{1}{R_{New}}\right) * A_{wall} * \left(1 - FF_{Ceiling}\right) * HDD * 24}{10^5 * \eta_{Heating}}$$

i.e.,

$$\Delta kWh_{Cooling} = \frac{\left(\frac{1}{10} - \frac{1}{32}\right) * 2500 * (1 - 0.07) * 1{,}899 * 24 * 0.75}{1000 * 13.0} = 339\ kWh$$

and

$$\Delta therms_{Heating} = \frac{\left(\frac{1}{10} - \frac{1}{32}\right) * 2500 * (1 - 0.07) * 2{,}816 * 24}{10^5 * 0.8} = 109\ therms$$

4.24.4 Demand Savings Estimation

Demand savings are defined as the reduction in average kW attributable to the measure during 3:00-6:00 pm on the hottest summer weekdays. It is assumed that the time spent in the hottest temperature bin is likely during the peak time. Which bin is the hottest depends on the climate zone. Based on these assumptions, the demand savings for homes with standard DX cooling are derived with the following equation.[536]

$$Peak\ Demand\ Savings = \frac{\Delta kWh_{Cooling}}{EFLH_{Cool}} * CF$$

Where:

$Peak\ Demand\ Savings$ = Summer peak kW savings, kW

$\Delta kWh_{Cooling}$ = Cooling energy savings, kWh

[536] Based on ADM ceiling insulation calculator spreadsheet

$EFLH_{Cool}$ = Effective Full Load Cooling Hours, Table 293

Table 293: Effective Full Load Cooling Hours

City	$EFLH_{Cool}$
Albuquerque	1,038
Santa Fe	629
Roswell	1,355
Las Cruces	1,290

CF = Coincidence Factor, 0.87[537]

4.24.5 Non-energy Benefits

There are no non-energy benefits.

4.24.6 Measure Life

The lifetime for this measure is 30 years.[538]

4.24.7 Incremental Cost

The incremental cost for this measure is the total cost. The cost is $0.035 per sq. ft. per "R" unit of insulation.[539]

537 For residential coincidence factors, Frontier used the Air Conditioning Contractors of America (ACCA) Manual S, which recommends that residential HVAC systems be sized at 115% of the maximum cooling requirement of the house. Assuming that the house's maximum cooling occurs during the hours 3 to 6 pm, this sizing guideline leads to a coincidence factor for residential HVAC of 1.0/1.15 = 0.87

538 US Department of Energy, WPN 19-4: Revised Energy Audit Approval Procedures, Related Audit, and Material Approvals, Attachment 9, January 17, 2019.

539 Public Service Company of New Mexico Commercial & Industrial Incentive Program Work Papers, 2011.

4.25 Low-E Window Film

This measure consists of adding solar film to east and west facing windows. This measure applies to all residential applications.

4.25.1 Measure Overview

Sector	Residential
End use	Building Envelope
Fuel	Electricity
Measure category	Window Treatments
Delivery mechanism	Prescriptive
Baseline description	Clear glass without existing window treatments
Efficient case description	Eligible window treatments installed on eligible windows

4.25.2 Baseline and Efficiency Standards

This measure is applicable to existing homes only. Low-E windows and tinted windows are not applicable for this measure. In order to qualify for deemed savings, solar film should be applied to east and west facing glass.

Table 294: Window Film – Baseline and Efficiency Standards

Baseline	Efficiency Standard
Single- or double-pane window with no existing solar films, solar screens, or low-e coating	Solar Film with SHGC <0.50

4.25.3 Deemed Energy and Demand Savings

From Table 295 to Table 298, savings per square foot is a factor to be multiplied by the square footage of the window area to which the films are being added. Gas Heat (no AC) kWh applies to forced air furnace systems only. Deemed savings value for single-pane, double-pane and weighted single- and double-pane windows are provided. The weighted single- and double-pane window assumes a standard distribution of 46% single-pane and 54% double-pane based on 2020 RECS survey data.[540]

Table 295: Window Film – Deemed Savings Values – Albuquerque

Existing Window Pane Type	AC/Gas Heat kWh	Gas Heat (no AC) kWh	Gas Heat Therms	AC/Electric Resistance kWh	Heat Pump kWh	AC Peak Savings kW	Peak Gas Savings Therms
	(/ sq. ft.)	(/ sq. ft.)	(/ sq. ft.)	(/ sq. ft.)	(/ sq. ft.)	(/ sq. ft.)	(/ sq. ft.)
Single Pane	2.452	-0.275	-0.409	-5.663	-1.298	0.0021	-0.0018
Double Pane	0.800	-0.089	-0.133	-2.061	-0.516	0.0000	-0.0018
Weighted	1.560	-0.175	-0.260	-3.718	-0.876	0.001	-0.002

Table 296: Window Film – Deemed Savings Values - Santa Fe

Existing Window Pane Type	AC/Gas Heat kWh	Gas Heat (no AC) kWh	Gas Heat Therms	AC/Electric Resistance kWh	Heat Pump kWh	AC Peak Savings kW	Peak Gas Savings Therms
	(/ sq. ft.)	(/ sq. ft.)	(/ sq. ft.)	(/ sq. ft.)	(/ sq. ft.)	(/ sq. ft.)	(/ sq. ft.)
Single Pane	1.843	-0.343	-0.476	-8.304	-2.720	0.0025	-0.0016
Double Pane	0.597	-0.116	-0.160	-2.941	-0.990	-0.0004	-0.0025
Weighted	1.170	-0.220	-0.305	-5.408	-1.786	0.001	-0.002

Table 297: Window Film – Deemed Savings Values – Roswell

Existing Window Pane Type	AC/Gas Heat kWh	Gas Heat (no AC) kWh	Gas Heat Therms	AC/Electric Resistance kWh	Heat Pump kWh	AC Peak Savings kW	Peak Gas Savings Therms
	(/ sq. ft.)	(/ sq. ft.)	(/ sq. ft.)	(/ sq. ft.)	(/ sq. ft.)	(/ sq. ft.)	(/ sq. ft.)
Single Pane	2.873	-0.229	-0.362	-3.838	-0.315	0.0018	-0.0020
Double Pane	0.941	-0.070	-0.114	-1.452	-0.188	0.0003	-0.0013

[540] 2020 Residential Energy Consumption Survey (RECS). Structural and geographic characteristics in the South and West regions (HC2.8). Analysis based on West South-Central census region. https://www.eia.gov/consumption/residential/data/2020/

Weighted	1.830	-0.143	-0.228	-2.550	-0.246	0.001	-0.002

Table 298: Window Film – Deemed Savings Values - Las Cruces

Existing Window Pane Type	AC/Gas Heat kWh	Gas Heat (no AC) kWh	Gas Heat Therms	AC/Electric Resistance kWh	Heat Pump kWh	AC Peak Savings kW	Peak Gas Savings Therms
	(/ sq. ft.)	(/ sq. ft.)	(/ sq. ft.)	(/ sq. ft.)	(/ sq. ft.)	(/ sq. ft.)	(/ sq. ft.)
Single Pane	2.971	-0.218	-0.351	-3.413	-0.086	0.0018	-0.0021
Double Pane	0.974	-0.066	-0.110	-1.311	-0.112	0.0003	-0.0012
Weighted	1.893	-0.136	-0.221	-2.278	-0.100	0.001	-0.002

Deemed savings values have been calculated for each of the four weather zones. The deemed savings are dependent on the SHGC of pre- and post-retrofit glazing. BEoptTM was used to estimate energy savings for a series of models using the DOE EnergyPlus simulation engine. Since window film savings are sensitive to weather, available TMY3 weather data specific to each of the four Arkansas weather regions were used for the analysis. The prototype home characteristics used in the BEopt building model are outlined in Appendix A.

4.25.4 Non-energy Benefits

There are no non-energy benefits.

4.25.5 Measure Life

The average lifetime of this measure is 10 years.[541]

4.25.6 Incremental Cost

Incremental cost estimates should be gathered as part of the application process if utilities wish to test the cost effectiveness of this measure using the TRC test.

541 DEER 2008

4.26 ENERGY STAR® Electric Vehicle Supply Equipment (EVSE)

This measure applies to the installation of ENERGY STAR® certified Level 2 electric vehicle supply equipment (EVSE) at a residential site. EVSE is the infrastructure that enables plug-in electric vehicles (PEV) to charge onboard batteries. Level 2 EVSE require 240-volt electrical service. This measure provides deemed savings for the energy efficiency improvement of an ENERGY STAR® EVSE over a standard or non-ENERGY STAR® EVSE.

4.26.1 Measure Overview

Sector	Residential
End use	Electric Vehicle Charging Equipment
Fuel	Electricity
Measure category	Appliance
Delivery mechanism	Prescriptive
Baseline description	Non-ENERGY STAR® certified Level 2 EVSE
Efficient case description	ENERGY STAR® certified Level 2 EVSE

4.26.2 Energy Savings Estimation

Energy savings for the measure is realized because of the improved operating efficiency of the ENERGY STAR® EVSE when the vehicle is plugged in but not being charged and when the vehicle is not plugged in.

Deemed savings are calculated according to the following algorithm:

$$ENERGY\ STAR\ Idle\ Consumption\ [kWh] = \frac{\left(hrs_{plug} * W_{plug} + hrs_{unp\quad C} * W_{unplug}\right) * days_C + hrs_{unplug_{NC}} * W_{unplug} * days_{NC}}{1000}$$

$$Baseline\ Idle\ Consumption\ [kWh] = \frac{ENERGY\ STAR\ Idle\ Consumption}{0.6}$$

$$Annual\ Energy\ Savings\ [kWh] = Baseline\ Idle\ Consumption\ -\ ENERGY\ STAR\ Idle\ Consumption$$

Where:

hrs_{plug} = Hours per day the vehicle is plugged into the EVSE and not charging, 9.3 hrs.[542]

W_{plug} = Wattage of the EVSE when the vehicle is plugged into the EVSE but not charging, 7.0 W.[543]

hrs_{unplug} = Hours per day the vehicle is not plugged into the EVSE on a charging day, 12.3 hrs.[544]

hrs_{unplug_NC} = Hours per day the vehicle is not plugged into the EVSE on a non-charge day, 24 hrs.

W_{unplug} = Wattage of the EVSE when the vehicle is not plugged into the EVSE, 2.9 W.[545]

$days_C$ = Number of charging days per year, 321.[546]

$days_{NC}$ = Number of non-charging days per year, 44.

1000 = Conversion from Wh to kWh

0.6 = Efficiency adjustment factor[547]

4.26.3 Demand Savings Estimation

Demand savings are calculated using the following formula:

$$Demand\ Savings\ [kW] = Annual\ Energy\ Savings * PLS$$

Where:

PLS = Probability-weighted peak load share, Table 299

Table 299 presents the deemed annual energy savings per EVSE.

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542 Idaho National Lab (INL) EV Project, June 2015, "Characterize the Demand and Energy Characteristics of Residential Electric Vehicle Supply Equipment," page 5. A vehicle plugged in for 11.7 hours and charging for 2.4 hours leaves 9.3 hours when it is plugged in and not charging.

543 Average Idle Mode Input Power from ENERGY STAR® certified EVSE product list as of August 27, 2019.

544 INL, page 5. 24 hours per day minus 11.7 hours plugged in leaves 12.3 hours unplugged.

545 Average No Vehicle Mode Input Power from ENERGY STAR® certified EVSE product list.

546 INL, page 6. 88% of PEV owners charge every day. 365 x .88 = 321.2.

547 ENERGY STAR® EVSE overview: "ENERGY STAR certified EV charger… on average use 40% less energy than a standard EV charger when the charger is in standby mode (i.e., not actively charging a vehicle)." https://www.energystar.gov/products/other/evse. Accessed August 2022.

Table 299: EVSE Peak Load Share[548]

Summer PLS	Winter PLS
0.00011	0.00016

4.26.4 Deemed Energy and Demand Savings

Table 300 presents the deemed annual energy savings per EVSE.

Table 300: EVSE Annual Energy Savings

Annual Energy Savings (kWh)
23.6

Table 301 presents the deemed summer and winter peak kW savings per EVSE.

Table 301: EVSE Peak Demand Savings

Summer Peak kW	Winter Peak kW
0.00011	0.00016

4.26.5 Non-energy Benefits

There are no non-energy benefits.

4.26.6 Measure Life

The estimated useful life (EUL) for an EVSE is assumed to be 10 years[549]

4.26.7 Incremental Cost

Incremental cost estimates should be gathered as part of the application process if utilities wish to test the cost effectiveness of this measure using the TRC test.

548 Probability weighted peak load factors are calculated according to the method in Section 4 of the Texas TRM Vol 1 using data from 3 studies: CCET Wind Integration in ERCOT, Avista Utilities SemiAnnual Report on Electric Vehicle Supply, and Xcel CO EVCS Pilot.

549 U.S. Department of Energy Vehicle Technologies Office, November 2015, "Costs Associated with Non-Residential Electric Vehicle Supply Equipment" p. 21. https://afdc.energy.gov/files/u/publication/evse_cost_report_2015.pdf, Accessed August 2022.

4.27 Solar Attic Fans

Solar attic fans increase the extraction rate of accumulated hot air in attics during the cooling season. Solar attic fans introduce no new electrical load to the home since they are powered by an attached photovoltaic panel. They save energy by reducing the load on air conditioning equipment, cooling the conditioned space directly underlying the attic, and by reducing heat exchange with supply ducts located in the attic when present. Deemed savings are provided for reduced air conditioning load.

Note: This is a new measure with limited savings information for Texas; therefore, solar attic fans should be implemented with the expectation of a savings methodology update in future TRMs as Texas-specific field information becomes available.

4.27.1 Measure Overview

Sector	Residential
End use	HVAC
Fuel	Electricity
Measure category	Building Envelope
Delivery mechanism	Direct Install
Baseline description	Attic with no solar attic fan
Efficient case description	Solar attic fans capable of removing a minimum of 400 cfm for every thousand square feet of attic floorspace

4.27.2 Definition of Baseline Equipment

The baseline condition is an existing home with refrigerated air and a vented attic.

4.27.3 Definition of Efficient Equipment

The high-efficiency condition is the installation of sufficient solar attic fans to remove 400 cfm for every thousand square feet of attic floorspace. A solar attic fan consists of an electric fan powered by an integrated photovoltaic panel installed for the exclusive purpose of powering the fan.

4.27.4 Energy Savings Estimation

Savings have been estimated by performing energy balances on the roof surface and on the attic airspace on an hourly time step. The energy balances account for heat flux from the roof into the attic and between the attic and the underlying conditioned space. Solar attic fans are assumed to operate in the cooling season in the hours of the day when there is incident solar irradiation on the panel. Deemed savings are based on replacing hot attic air with outside air using solar attic fans with a capacity of 400 cfm per thousand square feet of attic floor. Estimated savings are a function of the difference in heat transfer to conditioned space with and without solar attic fans, considering that the heat transferred to conditioned space must be removed by the air conditioning system. For homes with ducts in the attic, additional savings are estimated considering heat transfer to supply ducts.

Hourly data for the ambient conditions is from TMY3 files for the Texas TRM climate zones.

Annual energy savings are simply the sum of the hourly energy savings:

$$Annual\ Energy\ Savings\ (kWh) = \sum_{hr=1}^{8760} Hourly\ Energy\ Savings * CAF$$

Attic temperature for each hour is estimated according to the following equation for both the baseline and high-efficiency conditions.[550]

$$T_a = \frac{A_r * U_r * \frac{\alpha * I_S + h_O * T_O}{h_O + U_r} + Q * \rho * c_p * T_o + (A_c * U_c + A_d * U_d) * T_i}{\frac{A_r * U_r * h_O}{h_O + U_r} + Q * \rho * c_p + (A_c * U_c + A_d * U_d)}$$

Once hourly attic temperatures are estimated for the baseline and high-efficiency conditions, hourly energy savings are estimated as follows:

$$Hourly\ Energy\ Savings\ (kWh) = \frac{(A_c * U_c + A_d * U_d)}{1000 * EER} * \left(T_{a,b} - T_{a,he}\right) * 1\ hr$$

Where:

CAF = Cooling savings adjustment factor: set to 1.0 for homes with central refrigerated air; for homes with one or more room air conditioners set to 0.6.

[550] This equation results from solving the energy balance on the roof for Tr and inserting this value into the energy balance for the attic airspace, while solving for Ta. The equations are drawn from ASHRAE Fundamentals, Chapter 17, Residential Heat Load Guidebook. Approach originally derived by TetraTech, Inc. (see references section).

A_r	= Roof surface area (ft^2)
U_r	= U-factor of the roof between the unconditioned attic and the exterior (Btu/ft^2-hr-°F)
a	= Absorption coefficient of the roof (dimensionless)
I_s	= Solar irradiance (Btu/ft^2-hr)
h_o	= Convective heat transfer coefficient for air (Btu/ft^2-hr-°F)
T_o	= Exterior temperature (°F)
T_r	= Temperature of the roof (°F)
T_a	= Temperature of the attic (°F)
Q	= Ventilation airflow rate (CFM)
r	= Density of air (lb/ft^3)
c_p	= Specific heat of air (Btu/lb-°F)
A_c	= Ceiling surface area (ft^2)
U_c	= U-factor of the ceiling between the conditioned space and the unconditioned attic (Btu/ft^2 -hr-°F)
A_d	= Surface area of supply ducts in the attic (ft^2); set to zero if there are no supply ducts in the attic
U_d	= U-factor of the insulation on the ducts, (Btu/ft^2-hr-°F)
Ti	= Temperature of the conditioned space (°F)
EER	= Efficiency of the air conditioner (Btu/W-h)
$T_{a,b}$	= Temperature of the baseline attic, without solar powered attic fan (°F)
$T_{a,he}$	= Temperature of the attic in the high-efficiency condition, with solar powered attic fan (°F)

4.27.5 Demand Savings Estimation

The cooling adjustment factor is also applied to the demand savings:

$$Peak\ Demand\ Savings\ (kW) = Summer\ Peak\ Demand\ Savings \times CAF$$

The Summer Peak Demand Savings are the appropriate value from Table 303.

Winter peak demand savings are not estimated. Solar attic fans that operate in the winter would likely require more space heating and produce negative savings by increasing the temperature gradient between conditioned space and the cooler attic air (while potentially creating condensation issues).

4.27.6 Deemed Energy and Demand Savings

Table 302 and Table 303 present the Deemed Energy and Demand Savings for homes with ducts in the attic and for homes with no ductwork in their attics.

Table 302: Solar Attic Fans Deemed Annual Energy Savings (kWh)

Climate Zone	No Ducts in Attic	Ducts in Attic
Albuquerque	169	281
Santa Fe	137	229
Roswell	191	317
Las Cruces	196	325

Table 303: Solar Attic Fans Deemed Summer Peak Demand Savings (kW)

Climate Zone	No Ducts in Attic	Ducts in Attic
Albuquerque	0.15	0.25
Santa Fe	0.16	0.27
Roswell	0.14	0.24
Las Cruces	0.14	0.24

4.27.7 Non-energy Benefits

There are no non-energy benefits.

4.27.8 Measure Life

The EUL for solar attic fans in Texas is estimated to be 15 years.[551]

[551] The EUL of a solar attic fan is closely related to its motor. The US DOE Advanced Manufacturing Office's Motor Systems Tip Sheet #3 suggests motors should last approximately 35,000 hours. The average annual hours of operation for solar attic fans across the Texas TRM zones is about 2,300 hours.

4.27.9 Incremental Cost

Incremental cost estimates should be gathered as part of the application process if utilities wish to test the cost effectiveness of this measure using the TRC test.

4.28 Window Air Conditioner Replacement and Recycling

This measure involves replacement of an existing window air conditioner with a new window air conditioner. The characterization also includes an option for Window AC recycling. Window AC recycling is only eligible for fully functional units which are removed from the grid and not replaced with a new unit. This measure applies to all residential applications.

4.28.1 Measure Overview

Sector	Residential
End use	HVAC
Fuel	Electricity
Measure category	ENERGY STAR® Window AC
Delivery mechanism	Rebate
Baseline description	IECC 2018 efficiency
Efficient case description	Efficiency must exceed IECC 2018

4.28.2 Definition of Baseline Equipment

The baseline is assumed to be a new air conditioning unit with a combined energy efficiency ratio (CEER) rating that meets the current federal standard, which became effective on June 1, 2014.[552]

4.28.3 Definition of Efficient Equipment

Installed units must meet the current ENERGY STAR® specification of 10 percent more efficient than the federal standard for all categories. The baseline and efficiency standards are summarized in Table 304 below.

[552] 10 CFR 430.32(b). https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=52&action=viewlive#current _standards

Table 304: Window AC Replacement – Baseline and Efficiency Standard[553]

Reverse Cycle (Yes/No)	Louvered Sides (Yes/No)	Capacity (Btu/hr)	Baseline Efficiency (CEER)	Efficiency Standard (EER)
No	Yes	< 8,000	11.0	12.1
		≥ 8,000 and < 14,000	10.9	12.0
		≥ 14,000 and < 20,000	10.7	11.8
		≥ 20,000	9.4	10.3
No	No	< 8,000	10.0	11.0
		≥ 8,000	9.6	10.6
Yes	Yes	< 20,000	9.8	10.8
		≥ 20,000	9.3	10.2
Yes	No	< 14,000	9.3	10.2
		≥ 14,000	8.7	9.6

4.28.4 Energy Savings Estimation

$$kWh_{Savings} = CAP * \left(\frac{1\ kW}{1000\ W}\right) * RAF * [(EFLH)]_C * \left(\frac{1}{\eta_{base}} - \frac{1}{\eta_{post}}\right)$$

Where:

CAP = Rated equipment cooling capacity of the new or recycled unit (Btu/hr)

η_{base} = Energy efficiency rating (EER) of the baseline cooling equipment. Use Table 304 for replacements and recycling when known. For recycling where efficiency is unknown, assume 9.8 CEER[554].

η_{post} = Energy efficiency rating (EER) of the installed cooling equipment (at least equal to value from Table 304). For recycling, remove this term from the equation.

CF = Coincidence factor = 0.87 (default)

RAF = Room AC adjustment factor = 0.49 (default); derivation described in (Table 306*)*

553 Current federal standards, as well as ENERGY STAR® criteria for room air conditioners can be found on the ENERGY STAR® website at www.energystar.gov/index.cfm?c=roomac.pr_crit_room_ac.

554 Federal efficiency standard for most window AC units (less than 20,000 btu/hr with louvered sides).

$EFLH_C$ = Equivalent full-load cooling hours (Table 305)

Table 305: Room AC Replacement – Equivalent Full-Load Cooling Hours[555]

Location	$EFLH_C$
Albuquerque	1,081
Las Cruces	1,375
Roswell	1,319
Santa Fe	736

The EFLHs from the ENERGY STAR® Room AC savings are the same as those used for the ENERGY STAR® Central AC savings calculator. This is not appropriate as room AC units typically do not run as many hours as central systems. To correct this issue, an adjustment factor of 49 percent is applied to the ENERGY STAR® EFLHs.

This adjustment factor is derived by taking the ratio of average run hours from two sources to the ENERGY STAR® EFLHs. The derivation of this factor is described in Table 306.

Table 306: RAF Derivation[556]

Location	ES $EFLH_C$	RLW Adj Hours[557]	AHAM Hours	Avg. Hours	RAF
Albuquerque	1,072	358	749	553	0.49
Las Cruces	1,137	454	899	676	0.48
Roswell	1,214	436	871	653	0.48
Santa Fe	1,293	245	573	409	0.51
				Average:	**0.49**

555 EFLH values are derived from the values in the Arkansas TRM version 8.1

556 Values in table are derived from the values in the Arkansas TRM version 8.1

557 RLW Analytics: Final Report Coincidence Factor Study Residential Room Air Conditioners, https://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf. Derived by taking the average ratio of EFLH for Room ACs (from the RLW Analytics report) to EFLHs for Central ACs for the same location (from the ENERGY STAR® Central AC Calculator).

4.28.5 Demand Savings Estimation

Demand savings are derived with the following equation. When calculating demand savings from recycling, do not include the η_{post} term to determine the peak demand of only the baseline unit which was recycled.

$$Demand\ Savings\ (kW) = CAP * \left(\frac{1\ kW}{1000\ W}\right) * \left(\frac{1}{\eta_{base}} - \frac{1}{\eta_{post}}\right) * CF$$

4.28.6 Non-energy Benefits

There are no non-energy benefits.

4.28.7 Measure Life

The estimated measure life for window air conditioners is 10.5 years.[558]

4.28.8 Incremental Cost

Incremental cost estimates should be gathered as part of the application process if utilities wish to test the cost effectiveness of this measure using the TRC test.

[558] According to the DOE's Technical Support Document, Chapter 8: Life Cycle Cost and Payback Period Analyses 2011

4.29 Gas Furnace Tune-Up (New)

This measure is for a natural gas Residential furnace that provides space heating. The tune-up will improve furnace performance by inspecting, cleaning and adjusting the furnace and appurtenances for correct and efficient operation. Additional savings maybe realized through a complete system tune-up.

4.29.1 Measure Overview

Sector	Residential
End use	Space Heating
Fuel	Natural Gas
Measure category	High Efficiency Gas Furnaces
Delivery mechanism	Rebate
Baseline description	Steady state furnace efficiency before tune-up
Efficient case description	Steady state furnace efficiency after tune-up

4.29.2 Savings

The baseline equipment is a furnace or a gas-fired rooftop unit assumed not to have had a tune-up in the past 3 years.

To qualify for this measure an approved technician must complete the tune-up requirements listed below:[559]

- Measure combustion efficiency using an electronic flue gas analyzer
- Check and clean blower assembly and components per manufacturer's recommendations
- Where applicable Lubricate motor and inspect and replace fan belt if required
- Inspect for gas leaks
- Clean burner per manufacturer's recommendations and adjust as needed
- Check ignition system and safety systems and clean and adjust as needed
- Check and clean heat exchanger per manufacturer's recommendations
- Inspect exhaust/flue for proper attachment and operation
- Inspect control box, wiring and controls for proper connections and performance
- Check air filter and clean or replace per manufacturer's
- Inspect duct work connected to furnace for leaks or blockages

[559] American Standard Maintenance for Indoor Units (see 'HVAC Maintenance American Standard')

• Measure temperature rise and adjust flow as needed
• Check for correct line and load volts/amps
• Check thermostat operation is per manufacturer's recommendations (if adjustments made, refer to 'Small
Commercial Programmable Thermostat Adjustment' measure for savings estimate)
• Perform Carbon Monoxide test and adjust heating system until results are within standard industry acceptable limits

4.29.3 Energy Savings Estimation

Electric savings are calculated based on the following formula:

$$\Delta kWh = \Delta Therms \times F_e \times 29.3$$

Where:

$\Delta Therms$	= as calculated below
F_e	= Furnace Fan energy consumption as a percentage of annual fuel consumption
	= 3.14%[560]
29.3	= kWh per therm

Therm savings are calculated based on the following formulas:

$$\Delta Therms = \frac{(CAP_{InputPre} \times EFLH \times (\frac{\frac{1}{Eff_{Before}-1}}{Eff_{Before}+E_i})}{100{,}000\,\frac{BTU}{therm}}$$

$$Peak\ Day\ Therm\ Savings = \frac{\Delta Therms}{yr} \times GM$$

Where:

$CAP_{InputPre}$ = Gas Furnace input capacity pre tune-up (Btuh)
= Measured input capacity form HVAC

560 Fe is not one of the AHRI certified ratings provided for residential furnaces, but can be reasonably estimated from a calculation based on the certified values for fuel energy (Ef in MMBtu/yr) and Eae (kWh/yr). An average of a 300 record sample (non-random) out of 1495 was 3.14%. This is, appropriately, ~50% greater than the ENERGY STAR version 3 criteria for 2% Fe. See "Programmable Thermostats Furnace Fan Analysis.xlsx" for reference.

EFLH = heating equivalent full load hours for the appropriate weather zone (from Table 307)

Eff_{Before} = Efficiency of the furnace before the tune-up

= Actual

Note: Contractors should select a mid-level firing rate that appropriately represents the average building operating condition over the course of the heating season and take readings at a consistent firing rate for pre and post tune-up.

E_i = Efficiency Improvement of the furnace tune-up measure

= Actual

Table 307: Heating Equivalent Full Load Operating

City	$EFLH_{Heat}$
Albuquerque	1,358
Las Cruces	899
Roswell	921
Santa Fe	1,447

4.29.4 Demand Savings Estimation

N/A

4.29.5 Non-energy Benefits

There are no non-energy benefits for this measure.

4.29.6 Measure Life

The measure life for the clean and check tune up is 3 years.[561]

4.29.7 Incremental Cost

The incremental cost for this measure should be the actual cost of tune up.

[561] Assumed consistent with other tune-up measures.

4.30 High Efficiency Pool Pumps (New/Replacement)

This measure is the characterization of the purchasing and installing of a new ENERGY STAR® or CEE T1 variable speed residential pool pump motor in place of a pump meeting the federal standard for Time of Sale and New Construction, or the early replacement of a standard single speed motor of equivalent horsepower.

4.30.1 Measure Overview

Sector	Residential
End use	Pool Water Pumping
Fuel	Electricity
Measure category	Water Pumping
Delivery mechanism	Rebate
Baseline description	Two speed residential pool pump meeting the Federal Standard
Efficient case description	0.5-3 HP ENERGY STAR® or CEE T1 qualified multi-speed or variable-speed pool pump

4.30.2 Savings

Residential outdoor pool pumps can be single speed, two/multi speed or variable speed. A federal standard (82 FR 5650) effective July 19, 2021 effectively requires new pumps to be at least two speed.

Single speed pumps are often oversized and run frequently at constant flow regardless of load. Single speed pool pumps require that the motor be sized for the task that requires the highest speed. As such, energy is wasted performing low speed tasks at high speed. Two-speed and variable speed pool pumps reduce speed when less flow is required, such as when filtering is needed but not cleaning, and have timers that encourage programming for fewer on-hours. Variable speed pool pumps use advanced motor technologies to achieve efficiency ratings of 90% while the average single speed pump will have efficiency ratings between 30% and 70%.

The high efficiency equipment is an ENERGY STAR or CEE Tier residential pool pump meeting the ENERGY STAR minimum qualifications in Table 308 for either in-ground or above ground pools. ENERGY STAR version 3.0 specification takes effect on July 19, 2021. Note that for in-ground pools, the CEE Tier 1 is the same as the new Federal Standard, and

Tier 2 is the same as ENERGY STAR® V3 for the standard size pumps, so savings for CEE Tier 1 is only provided for above ground pools where there is an increment in efficiency.

Table 308: Minimum Qualifications for High Efficiency Pool Pumps

Pump Sub-Type	Size Class	ENERGY STAR® Version 3.0 Energy Efficiency Level (Effective 7/19/2021)	CEE Tier I	CEE Tier 2
Self-Priming (Inground) Pool Pumps	Extra Small (hhp ≤ 0.13)	WEF ≥ 13.40	N/A	N/A
	Small (hhp > 0.13 and < 0.711)	WEF ≥ -2.45 x ln (hhp) + 8.40	WEF ≥ -1.30 x ln (hhp) + 4.95	WEF ≥ -2.83 x ln (hhp) + 8.84
	Standard Size (hhp ≥ 0.711)	WEF ≥ -2.45 x ln (hhp) + 8.40	WEF ≥ -2.3 x ln (hhp) + 6.59	WEF ≥ -2.45 x ln (hhp) + 8.4
Non-Self Priming (Aboveground) Pool Pumps	Extra Small (hhp ≤ 0.13)	WEF ≥ 4.92	N/A	N/A
	Standard Size (hhp > 0.13)	WEF ≥ -1.00 x ln (hhp) + 3.85	WEF ≥ -1.60 x ln (hhp) + 9.10	N/A

Baseline equipment is a two-speed residential pool pump meeting the Federal Standard, effective July 19, 2021 provided in Table 309:

Table 309: Federal Standard for Baseline Pool Pumps

Pump Sub-Type	Size Class	Baseline (Effective 7/19/2021)
Self-Priming (Inground) Pool Pumps	Extra Small (hhp ≤ 0.13)	WEF ≥ 5.55
	Small (hhp > 0.13 and < 0.711)	WEF ≥ -1.30 x ln (hhp) + 2.90
	Standard Size (hhp ≥ 0.711)	WEF ≥ -2.30 x ln (hhp) + 6.59
Non-Self Priming (Aboveground) Pool Pumps	Extra Small (hhp ≤ 0.13)	WEF ≥ 4.60
	Standard Size (hhp > 0.13)	WEF ≥ -0.85 x ln (hhp) + 2.87

For early replacement, the baseline equipment is the existing single speed residential pool pump.

4.30.3 Energy Savings Estimation[562]

For Time of Sale and New Construction:

$$\Delta kWh = \frac{\left(\text{Gallons} * \text{Turnovers} * \left(\frac{1}{WEF_{base}} - \frac{1}{WEF_{ESTAR}}\right) * \text{Days}\right)}{1000}$$

For Early Replacement:

$$\Delta kWh = \frac{\left(\text{Gallons} * \text{Turnovers} * \left(\frac{1}{EF_{Exist}} - \frac{1}{WEF_{ESTAR}}\right) * \text{Days}\right)}{1000}$$

Where:

Gallons = *Capacity of the pool*

= *Actual. If unknown assume:*

Pool Type	Gallons
In ground	22,000[563]
Above ground	7,540[564]

Turnovers = *Desired number of pool water turnovers per day*

= *2*[565]

WEF_{base} = *Weighted Energy Factor of baseline pump (gal/Wh)*[566]

Pool Type	WEF_{Base}
In ground	4.63

562 The methodology followed is consistent with the most recent version of the 2020 ENERGY STAR calculator (Pool_Pump_Calculator_2020.05.05_FINAL.xls), however this has not been updated to account for the new federal standard.

563 Consistent with assumption in the 2020 ENERGY STAR calculator.

564 Based on typical pool sizes from "Evaluation of Potential Best Management Practices - Pools, Spas, and Fountains, The California Urban Water Conservation Council", 2010.

565 Consistent with assumption in the 2020 ENERGY STAR calculator.

566 Based on applying the federal standard specifications to the average Curve-C rated hydraulic horsepower (hhp) from the ENERGY STAR Qualified Products List, accessed 3/31/2021.

Above ground	2.57

WEF_{ESTAR} = *Weighted Energy Factor of ENERGY STAR® pump (gal/Wh)*[567]

Pool Type	WEF_{ESTAR}	
	ENERGY STAR®	CEE Tier 1
In ground	6.31	N/A
Above ground	3.49	8.53

EF_{Exist} = *Energy Factor of existing single speed pump (gal/Wh)*

= *2.3568*[569]

Days = *Number of days per year that the swimming pool is operational*

= *122*[570]

1,000 = *Conversion factor from Wh to kWh*

Based on the defaults provided above, the annual energy savings (ΔkWh) are detailed in the table below:

Pool Type	ΔkWh			
	TOS/NC		Retrofit	
	ENERGY STAR®	CEE T1	ENERGY STAR®	CEE T1
In ground	307.7	N/A	1512.1	N/A
Above ground	189.5	499.5	283.7	593.6

567 Based on applying the ENERGY STAR and CEE Tier 1 specifications to the average Curve-C rated hydraulic horsepower (hhp) from the ENERGY STAR Qualified Products List, accessed 3/31/2021.

569 Consistent with assumption in the 2020 ENERGY STAR calculator, assuming 1.5 HP pump.

570 Consistent with assumption in the 2020 ENERGY STAR calculator.

4.30.4 Demand Savings Estimation

For Time of Sale and New Construction:

$$\Delta kW = \left(\frac{\frac{kWh}{day_{base}}}{\frac{Hrs}{day_{base}}}\right) - \left(\frac{\frac{kWh}{day_{ESTAR}}}{\frac{Hr}{day_{ESTAR}}}\right) \text{ x } CF$$

For Early Replacement:

$$\Delta kW = \left(\frac{\frac{kWh}{day_{Exist}}}{\frac{Hrs}{day_{Exist}}}\right) - \left(\frac{\frac{kWh}{day_{ESTAR}}}{\frac{Hr}{day_{ESTAR}}}\right) * CF$$

Where:

kWh/day = *daily energy consumption of pool pump, as defined above.*

= *Actual, defaults provided below:*

	ΔkWh/day			
Pool Type	**Base**	**ENERGY STAR®**	**CEE T1**	**Exist**
In ground	9.5	7	N/A	19.4
Above ground	5.9	4.3	1.8	6.6

Hrs/day_{base} = *daily run hours of pool pump*

= *(Gallons * Turnover) / GPM*

		Weighted Average GPM	**Hours/Day**
In ground	Base	43.6	16.8
	Efficient	32.2	22.8
	Exist	78	9.4
Above ground	Base	44.7	5.6
	Efficient	27.3	9.2
	Exist	78.1	3.2

CF = *Summer Peak Coincidence Factor for measure*

= *0.831*[571]

Based on defaults provided above:

Pool Type	ΔkW			
	TOS/NC		Retrofit	
	ENERGY STAR®	CEE T1	ENERGY STAR®	CEE T1
In ground	0.2152	N/A	1.4641	N/A
Above ground	0.4793	0.7094	1.3285	1.5586

4.30.5 Non-energy Benefits

There are no non-energy benefits for this measure.

4.30.6 Measure Life

The estimated useful life for a two-speed or variable-speed pool pump is 7 years.[572]

4.30.7 Deemed Measure Cost

For early replacement, the full replacement costs shall be used. A deferred new baseline cost (after 4 years) of replacing the existing equipment should also be included.

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571 Based on assumptions of daily load pattern through pool season. Assumption was developed for Efficiency Vermont but is considered a reasonable estimate for New Mexico.

572 As recommended in Navigant 'ComEd Effective Useful Life Research Report', May 2018.

4.30.8 Incremental Cost

For time of sale and new construction, the incremental cost is estimated as $314[573] for an ENERGY STAR® in-ground pool pump and $930[574] for an above-ground pool pump.

573 ENERGY STAR Pool Pump Calculator and represent the difference between the two/multi speed incremental cost and the variable speed incremental cost.

574 CEE Efficient Residential Swimming Pool Initiative, December 2012, page 18 and represent the difference between the two/multi speed incremental cost and the variable speed incremental cost.

4.31 Residential Induction Cooking (New)

Residential cooking appliances include ovens, cooktops, and full ranges. A full range consists of an oven with a built-in cooktop.

An induction range is an electric oven with a built-in induction cooktop. Induction technology works on the principle of magnetic induction, where excited eddy currents in ferromagnetic cookware within the presence of an oscillating magnetic field dissipate heat through the Joule effect. This heat is directly generated by the cookware and is transmitted to the food within it, lessening thermal condition heat loss between the heating element and the cookware. Induction cooktops include a switching-power electronics circuit that delivers high-frequency current to a planar coil of wire embedded in the cooking surface. The cookware is magnetically coupled to the coil by the oscillating magnetic field. Current flows in the cooking vessel due to the low resistance of the metal. Resistance is a function of the permeability and resistivity of the cookware as well as the frequency of excitation. Typical induction cooktops operate at switching frequencies between 25 kHz and 50 kHz, which restricts coupling to ferromagnetic cookware such as cast iron, and some alloys of stainless stee.[575]

According to manufacturers, induction cooktops heat food faster, are easier to clean, are less likely to burn those using them, and have a higher cooking efficiency than electric resistance cooktops.

4.31.1 Measure Overview

Sector	Residential
End use	Appliance or Plug Load
Fuel	Electricity
Measure category	Appliances
Delivery mechanism	Prescriptive
Baseline description	Electric Resistance Cooktop
Efficient case description	Induction Cooktop

575 Sweeney, M., J. Dols, B. Fortenbery, and F. Sharp (EPRI), "Induction Cooking Technology Design and Assessment." Proceedings of the 2014 ACEEE Summer Study on Energy Efficiency in Buildings, p. 9370. https://www.aceee.org/files/proceedings/2014/data/papers/9-702.pdf

4.31.2 Savings

Energy savings are calculated as the difference between the baseline and high-efficiency condition unit energy consumption (UEC). These exclude HVAC interactive effects or savings due to reduced kitchen hood consumption. Range oven cooking efficiency varies by cooktop type. Ranges with electric resistance and induction cooktops both have electric resistance oven components. Therefore, baseline and high-efficiency condition oven cooking efficiencies are equivalent and are excluded from the savings calculation.

This measure requires the installation of an electric range with an induction cooktop or a standalone induction cooktop in a residential application. This measure assumes the use of small cookware typical of residential applications.

4.31.3 Energy Savings Estimation

Energy savings are derived as follows:

$$Energy\,Savings\,[\Delta kWh] = UEC_{base} - UEC_{IC}$$

$$UEC_{IC} = UEC_{base} \times \frac{CE_{base}}{CE_{IC}}$$

Where:

UEC_{base} = Baseline annual unit energy consumption [kWh]; See Table 1

UEC_{IC} = Induction cooking annual unit energy consumption [kWh]

CE_{base} = Baseline cooking efficiency = 75%[576]

CE_{IC} = Induction cooking efficiency = 85%[577]

The deemed energy savings for this measure is 12[578] kWh.

576"2021-2022 Residential Induction Cooking Tops," ENERGY STAR® https://www.energystar.gov/about/2021_residential_induction_cooking_tops#:~:text=The%20per%20unit%20efficiency%20of,times%20more%20efficient%20than%20gas

577 Ibid.

578 For all applications, this measure assumes a default value of four burners. Savings for 0-7+ burners only vary from 10-15 kWh

Table 310. Induction Cooking – Baseline Electric Resistance Cooktop Energy Consumption[579]

Number of burners	Electric cooktop baseline kWh
0	84
1	89
2	95
3	101
4	106
5	112
6	118
7+	124

4.31.4 Demand Savings Estimation

$$Peak\ Demand\ Savings\ [\Delta kW] = \frac{kWh_{savings}}{8760} \times CF_{s/w}$$

Where,

8760 = Total hours per year

CF_{summer} = Summer peak coincidence factor = 0.002

CF_{winter} = Winter peak coincidence factor = 0.010

The deemed summer peak demand savings is 0.000003 kW.

The deemed winter peak demand savings is 0.000014[580] kW.

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579 "Plug Loads and Lighting Modeling," Codes and Standards Enhancement Initiative (CASE). 2016 California Building Energy Efficiency Standards. June 2016. Table 35. https://www.caetrm.com/media/reference-documents/2016_T24CASE_Report__Plug_Load_and_Ltg_Modeling_-_June_2016.pdf

580 CF and deemed demand savings values are referenced from TX – PY2023 TRM 10.0 Vol 2 Residential for Climate Zone 5: El Paso

4.31.5 Non-Energy Benefits

Induction cooktops have a positive impact on the power quality of the grid. They exhibit relatively lower current harmonics for all load levels and a high power factor. However, there are no quantifiable benefits at this time.

4.31.6 Measure Life

The estimated useful life (EUL) of an induction cooktop is 16 years based on the average lifetime specified for electric cooktops in the 2016 DOE life-cycle cost tool for residential cooking products.[581]

4.31.7 Incremental Cost

The incremental cost for the installation of an Electric range with an induction cooktop is $1,294, whereas for an induction cooktop only, the incremental cost is $736.[582]

581 U.S. Department of Energy (DOE), Energy Efficiency and Renewable Energy Office (EERE). 2016. 2016 SNOPR Analytical Tools: Life-Cycle Cost and Payback Period Analysis Spreadsheet.

https://www.caetrm.com/media/reference-documents/Cooking_Pds_LCC_SNOPR_DOE_2016_publication.xlsm

582 San Diego Gas & Electric (SDG&E). 2022. https://www.caetrm.com/media/reference-documents/SWAP015-02_Costs_SJ_1_19_2022.xlsx

4.32 Residential AC Tune-Up (New)

This measure applies to central air conditioners and heat pumps. An AC tune-up, in general terms, involves checking, adjusting and resetting the equipment to factory conditions, such that it operates closer to the performance level of a new unit. This measure applies to all residential applications.

For this measure, the service technician must complete the following tasks according to industry best practices:

Air Conditioner Inspection and Tune-Up Checklist[583]

- Inspect and clean condenser, evaporator coils, and blower.
- Inspect refrigerant level and adjust to manufacturer specifications.
- Measure the static pressure across the cooling coil to verify adequate system airflow and adjust to manufacturer specifications.
- Inspect, clean, or change air filters.
- Calibrate thermostat on/off set points based on building occupancy.
- Tighten all electrical connections, and measure voltage and current on motors.
- Lubricate all moving parts, including motor and fan bearings.
- Inspect and clean the condensate drain.
- Inspect controls of the system to ensure proper and safe operation. Check the starting cycle of the equipment to assure the system starts, operates, and shuts off properly.
- Provide documentation showing completion of the above checklist to the utility or the utility's representative.

4.32.1 Measure Overview

Sector	Residential
End use	Space Cooling

[583] Based on ENERGY STAR® HVAC Maintenance Checklist. www.energystar.gov/index.cfm?c=heat_cool.pr_maintenance

Fuel	Electric
Measure category	High Efficiency Air Conditioners and Heat Pumps
Delivery mechanism	Rebate
Baseline description	Pre-tune-up measured efficiency
Efficient case description	Post tune-up measured/nameplate efficiency

4.32.2 Savings

Savings for this measure are based on direct site measurements of EER pre- and post-tune-up. Pre and post EER measurements should be conducted, and the measurements should be taken on the same site visit and under similar operating conditions using reliable, industry accepted techniques.

4.32.3 Energy Savings Estimation

Annual energy savings for unitary AC/HP tune-up should be calculated using the following formulas:

$$kWh_{savings,C} = CAP_C \times \frac{1}{1000} \times EFLH_C \times \left(\frac{1}{EER_{pre}} - \frac{1}{EER_{post}}\right)$$

$$kWh_{savings,H} = CAP_H \times \frac{1}{1000} \times EFLH_H \times \left(\frac{1}{HSPF_{pre}} - \frac{1}{HSPF_{post}}\right)$$

$$kWh_{savings,AC} = kWh_{savings,C}$$

$$kWh_{savings,HP} = kWh_{savings,C} + kWh_{savings,H}$$

Where:

CAP_C = Rated or calculated equipment cooling capacity (Btu/hr)

CAP_H = Rated or calculated equipment heating capacity (Btu/hr)

1000 = Conversion constant for watts to kilowatts

EER_{pre} = Measured efficiency of the equipment for cooling before tune-up

EER_{post} = Nameplate or Measured efficiency of the existing equipment for cooling; if unknown, use 11.2 EER (default)[584]

$HSPF_{pre}$ = Measured efficiency of the equipment for heating before tune-up

$HSPF_{post}$ = Nameplate or Measured efficiency of the existing equipment for heating; if unknown, use 7.7 HSPF (default)[585]

$EFLH_C$ = Residential Effective Full Load Cooling Hours for New Mexico climate zones, see Table 311 below

$EFLH_H$ = Residential Effective Full Load Heating Hours for New Mexico climate zones, see Table 311 below

Table 311 Residential Full Load Cooling and Heating Hours for New Mexico Climate Zones[586]

Location	$EFLH_C$	$EFLH_H$
Albuquerque	1,038	2,162
Las Cruces	1,290	1,909
Roswell	1,355	1,596
Santa Fe	629	2,490

The system capacity (CAP_C) is adjusted using the following equation:

$$CAP_C = CAP_{nameplate} \times \frac{EER_{post}}{EER_{nameplate}}$$

In cases where only a pre-tune up efficiency can be measured, then post tune-up efficiency may be estimated using the lesser of the nameplate efficiency or the results of the following equation:

584 Code specified SEER value (13 SEER from federal standard effective January 23, 2006 through January 1, 2015) converted to EER using EER = -0.02 x SEER2 + 1.12 x SEER. National Renewable Energy Laboratory (NREL). "Building America House Simulation Protocols." U.S. DOE. Revised October 2010. www.nrel.gov/docs/fy11osti/49246.pdf

585 Consumer Central Air Conditioner and Heat Pump Efficiency Standards (DOE): https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=48&action=viewlive#current_standards

586 Derived from ENERGY STAR® Air-Source Heat Pump Calculator. Las Cruces and Santa Fe values derived from El Paso and Amarillo values, respectively, with a comparison of degree-days.

$$EER_{post} = \frac{EER_{pre}}{(1 - M)^{Age}}$$

The above equation estimates the efficiency of the unit based on the age as well as typical maintenance practices of the customer.

Where:

M = Maintenance factor[587], use 0.01 if annual maintenance conducted or 0.03 if maintenance is seldom; use default value of 0.03 if maintenance history is unknown

Age = Age of equipment in years, up to a maximum of 20 years, use a default of 10 years if unknown

For heat pump systems, an additional savings credit may be calculated as follows:

$$HSPF_{pre} = HSPF_{post} \times (1 - M)^{Age}$$

4.32.4 Demand Savings Estimation

Peak demand savings for unitary AC/HP tune-up should be calculated using the following formula:

$$kW_{savings} = CAP_C \times \frac{1}{1000} \times \left(\frac{1}{EER_{pre}} - \frac{1}{EER_{post}}\right) \times CF$$

Where:

CF = Coincidence Factor for residential HVAC measures, 0.87[588]

4.32.5 Non-energy Benefits

Well-tuned HVAC systems increase occupant comfort and productivity.

587 "Building America House Simulation Protocols." U.S. DOE. Revised October 2010. Table 32. Page 40. http://www.nrel.gov/docs/fy11osti/49246.pdf

588 For residential coincidence factors, Frontier used the Air Conditioning Contractors of America (ACCA) Manual S, which recommends that residential HVAC systems be sized at 115% of the maximum cooling requirement of the house. Assuming that the house's maximum cooling occurs during the hours 3 to 6 pm, this sizing guideline leads to a coincidence factor for residential HVAC of 1.0/1.15 = 0.87

4.32.6 Measure Life

The measure life is assumed to be 3 years[589].

4.32.7 Incremental Cost

The incremental cost for this measure should be the actual cost of tune up.

589 Based on DEER 2014 EUL Table for "Clean Condenser Coils – Residential" and "Refrigerant Charge – Residential".

4.33 Heat Pump Water Heater (New)

This measure involves the installation of an ENERGY STAR® -compliant heat pump water heater (HPWH) in place of a standard electric water heater in a home. Savings are presented dependent on the heating system installed in the home due to the impact of the heat pump water heater on the heating loads.

4.33.1 Measure Overview

Sector	Residential
End use	Water Heating
Fuel	Electricity and Natural Gas
Measure category	Heat Pump Water Heaters
Delivery mechanism	Rebate
Baseline description	Federal standard minimum efficiencies for gas and electric storage water heaters
Efficient case description	ENERGY STAR® -Compliant Heat Pump Water Heater

4.33.2 Savings

The baseline condition is an electric/gas storage water heater with baseline efficiency (UEF) determined by tank size and draw pattern, according to the amended federal energy efficiency standards for residential water heaters with tank sizes 20 to 120 gallons, as published in 10 CFR Part 430.32 of the Federal Register[590].

Table 312 HPWH—Federal Standard for Residential Water Heaters

Product Class	Rated Storage Volume	Draw pattern[591]	Uniform Energy Factor*
Electric storage	≥20 gal and ≤55 gal	Very Small	0.8808 – (0.0008 × Vr)
		Low	0.9254 – (0.0003 × Vr)
		Medium	0.9307 – (0.0002 × Vr)
		High	0.9349 – (0.0001 × Vr)

[590] Code of Federal Regulation 10 CFR 430.32 Energy and water conservation standards. https://www.ecfr.gov/cgi-bin/text-idx?SID=80dfa785ea350ebeee184bb0ae03e7f0&mc=true&node=se10.3.430_132&rgn=div8

[591] The draw pattern is governed by 10 CFR 429.17- Water Heaters. Maximum gallons per minute for different draw patterns are as follows: Very Small- 1.7 gal/min, Low- 2.8 gal/min, Medium-4 gal/min, High-No upper limit.

	>55 gal and ≤100 gal	Very Small	1.9236 – (0.0011 × Vr)
		Low	2.0440 – (0.0011 × Vr)
		Medium	2.1171 – (0.0011 × Vr)
		High	2.2418 – (0.0011 × Vr)
Gas-fired storage	≥20 gal and ≤55 gal	Very Small	0.3456 – (0.0020 × Vr)
		Low	0.5982 – (0.0019 × Vr)
		Medium	0.6483 – (0.0017 × Vr)
		High	0.6920 – (0.0013 × Vr)
	>55 gal and ≤100 gal	Very Small	0.6470 – (0.0006 × Vr)
		Low	0.7689 – (0.0005 × Vr)
		Medium	0.7897 – (0.0004 × Vr)
		High	0.8072 – (0.0003 × Vr)

The same draw pattern (very small, low, medium or high draw) should be used for both baseline and efficient units. If using a deemed approach, for units less than or equal to 55 gallons, the baseline is assumed to be a resistance storage unit with efficiency represented by the equation below, assuming medium draw.

Baseline efficiency = 0.9307 – (0.0002 * *rated volume in gallons)*

For units greater than 55 gallons, assume a 50-gallon resistance tank baseline[592], i.e., 0.9299 UEF, assuming high draw.

If unknown, assume a 50-gallon resistance tank baseline, at medium draw, therefore 0.9207 UEF.

The efficient condition is a HPWH certified by ENERGY STAR[593]. Heat pump water heaters depend on adequate ventilation to properly function, including adequate space for both inlet and outlet airflow, and should be installed in spaces where the temperature does not drop below a certain level. The Department of Energy recommends installation in

[592] A 50-gallon volume tank for the baseline is assumed to capture market practice of using larger heat pump water heaters to achieve greater efficiency of the heat pump cycle and preventing the unit from going in electric resistance mode

[593] ENERGY STAR® Requirements (as of March 2022). HPWH must have a maximum current rating of 24 amperes, voltage no greater than 250 volts, and a transfer of thermal energy from one temperature to a higher temperature level for the purpose of heating water. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Version%204.0%20Water%20Heaters%20Final%20Specification%20and%20Partner%20Commitments-March2022_5.pdf

locations that remain above 40°F year-round and provide a minimum of 1,000 cubic feet of air space around the water heater[594].

4.33.3 Energy Savings Estimation

HPWH savings are calculated on a per-unit basis. Annual electric energy savings are calculated utilizing the standard algorithms outlined below:

$$kWh_{savings} = \left[\frac{\rho \times C_p \times GPD \times 365.25 \times (Temp_{Hot} - Temp_{Cold}) \times \left(\frac{1}{UEF_{Base}} - \frac{1}{UEF_{Eff}}\right)}{3{,}412} + kWh_{Cooling} - kWh_{heating} + Deh_{Reduction}\right]$$

Where:

$kWh_{savings}$ = Annual energy savings, kWh

ρ = Density of water, 8.33 lbs/gal

Cp = Specific heat of water, 1 Btu/lb*°F

GPD = Daily hot water usage, see Table 313 below

Table 313 Daily Hot Water Usage[595]

Number of bedrooms	1	2	3	4	5	6
Clothes Washer	10.0	12.5	15.0	17.5	20.0	22.5
Dishwasher	3.3	4.2	5.0	5.8	6.7	7.5
Shower	18.7	23.3	28.0	32.7	37.4	42.0
Bath	4.7	5.8	7.0	8.2	9.4	10.5
Sinks	16.7	20.8	25.0	29.1	33.3	37.5
Total	**53.3**	**66.7**	**80.0**	**93.3**	**106.7**	**120.0**

365.25 = Days per year

[594] Heat Pump Water Heaters. Department of Energy, May 2012. http://energy.gov/energysaver/articles/heat-pump-water-heaters

[595] Hot water consumption is calculated based on different uses of water in a house as given in the Building America Research Benchmark report. https://www.nrel.gov/docs/fy10osti/47246.pdf

3,412 = Constant to convert Btu to kWh

$Temp_{Hot}$ = Tank temperature, 127.5 °F

$Temp_{Cold}$ = Inlet water temperature, see Table 314 below

Table 314 Inlet Water Temperature[596]

City	Temperature Cold (°F)
Albuquerque	62.6
Las Cruces	69.2
Roswell	68.5
Santa Fe	57.5

UEF_{Base} = Baseline uniform energy factor calculated as per Table 312 using the same draw pattern as the efficient equipment.

UEF_{Eff} = Actual uniform energy factor of HPWH

$kWh_{Cooling}$ = Cooling savings from conversion of heat in home to water heat

$$kWh_{Cooling} = \left[\frac{\left(1 - \frac{1}{UEF_{Eff}}\right) * \rho \times C_p \times GPD \times 365.25 \times (Temp_{Hot} - Temp_{Cold})}{3{,}412}\right] * \frac{1}{COP_{Cool}} * LF * 27\% * LM$$

LF = Location Factor

= 1.0 for HPWH installation in a conditioned space

= 0.22 for HPWH installation in an unknown location[597]

= 0.0 for installation in an unconditioned space

596 Average annual cold-water temperatures for each city were calculated using Equation 4 in the Department of Energy's "Building America Performance Analysis Procedures for Existing Homes" (https://www.nrel.gov/docs/fy06osti/38238.pdf). Ambient temperature for Albuquerque, Las Cruces, Roswell and Santa Fe were taken from the TMY3 data.

597 West Hills Energy and Computing (2019) found 78% of HPWHs "are installed in basements that are not intentionally heated."

27% = Portion of reduced waste heat that results in cooling savings[598]

COP_{Cool} = COP of central air conditioning

= Actual, if unknown, assume 2.8[599]

LM = Latent multiplier to account for latent cooling demand

= 1.33[600]

$kWh_{Heating}$ = Heating cost from conversion of heat in home to water heat (Dependent on heating fuel)

$$kWh_{Heating} = \left[\frac{\left(1 - \frac{1}{UEF_{Eff}}\right) * \rho \times C_p \times GPD \times 365.25 \times (Temp_{Hot} - Temp_{Cold})}{3{,}412}\right] * \frac{1}{COP_{Heat}} * LF * 5\% * (1 - \%NaturalGas)$$

5% = Portion of reduced waste heat that results in increased heating load[601]

COP_{Hea} = COP of electric heating system

= actual. If not available, use:[602]

598 REMRate determined percentage (27%) of lighting savings that result in reduced cooling loads (lighting is used as a proxy for hot water heating since load shapes suggest their seasonal usage patterns are similar).

599 Starting from standard assumption of SEER 10.5 central AC unit, converted to 9.5 EER using algorithm (-0.02 * SEER2) + (1.12 * SEER) (from Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder), converted to COP = EER/3.412 = 2.8COP

600 A sensible heat ratio (SHR) of 0.75 corresponds to a latent multiplier of 4/3 or 1.33. SHR of 0.75 for typical split system from page 10 of "Controlling Indoor Humidity Using Variable-Speed Compressors and Blowers" by M. A. Andrade and C. W. Bullard, 1999

601 The operation of a HPWH causes both sensible and latent heat transfer with the surrounding air(and water vapor). The amount of sensible heat transfer is governed by the specific heat capacity of water: 4,186 J/kg ·°C (which is 4x larger than that of dry air) and the temperature change. The latent heat transfer is governed by the latent heat of vaporation for water: 22.6x105 J/kg. Only the sensible heat transfer increases the heating load, and because of the relative sizes of these parameters, the latent heat transfer is several orders of magnitude greater than the sensible heat transfer. See HPWH_CalculationSheet.xlsx for the specific example used to derive the 5% portion for sensible heat.

602 These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate. Note efficiency should include duct losses. Defaults provided assume 15% duct loss for heat pumps.

System Type	Age Of Equipment	HSPF Estimate	COPHEAT (COP Estimate) = (HSPF/3.413)*0.85
Heat Pump	Before 2006	6.8	1.70
	After 2006 - 2014	7.7	1.92
	2015 on	8.2	2.04
Resistance	N/A	N/A	1.00
Unknown[603]	N/A	N/A	1.28

$\%NaturalGas$ = Factor dependent on heating fuel:

= 100 % for Natural Gas

= 0 % for Electric Resistance or Heat Pump

$Deh\_Reduction$ = Savings resulting from reduced dehumidification

= values based on table below[604]

Dehumidifcation Status	Deh_Reduction (kWh)
If Dehumidifier is in use	359
If unknown	72

Annual Therms savings are calculated utilizing the standard algorithms outlined below:

[603] Calculation assumes 35% Heat Pump and 65% Resistance, which is based upon data from Energy Information Administration, 2009 Residential Energy Consumption Survey, see "HC6.9 Space Heating in Midwest Region.xls", using average for East North Central Region. Average efficiency of heat pump is based on assumption that 50% are units from before 2006 and 50% from 2006- 2014. Program or evaluation data should be used to improve this assumption if available.

[604] West Hills Energy and Computing (2019) found that 20% of homes had dehumidifiers in use and in interviews with homeowners found the following reductions in dehumidifier usage: 46% reported "1 month or more reduction", 32% reported "3 months or more reduction", and 15% reported removal of a dehumidifier. kWh savings assumptions are based on an average of: Federal Standard, ENERGY STAR, and ENERGY STAR Most Efficient annual energy usage. See HPWH_CalculationSheet.xlsx for calculations

$$Therms_{savings} = \left[\frac{\rho \times C_p \times GPD \times 365.25 \times (Temp_{Hot} - Temp_{Cold}) \times \left(\frac{1}{UEF_{Base}} - \frac{1}{UEF_{Eff}}\right)}{100{,}000}\right] - Therms_{heating}$$

$Therms_{heating}$ = Heating cost from conversion of heat in home to water heat for homes with Natural Gas heat[605]

$$Therms_{heating} = \left[\frac{\left(1 - \frac{1}{UEF_{Eff}}\right) * \rho \times C_p \times GPD \times 365.25 \times (Temp_{Hot} - Temp_{Cold})}{3{,}412}\right] * \frac{1}{\eta \text{Heat}} * LF * 5\% * 0.03412 * \%NaturalGas$$

0.03412 = conversion factor (therms per kWh)

ηHeat = AFUE of gas heating system. Use nameplate ratings wherever possible, if unavailable use 0.8

Other factors as defined above

4.33.4 Demand Savings Estimation

Demand savings are calculated by using:

$$kW_{savings} = \frac{kWh_{savings}}{Hours} \times CF$$

Where:

kW savings = Peak demand savings, kW

Hours = Full load hours of water heater, 2533[606]

---

605 This is the additional energy consumption required to replace the heat removed from the home during the heating season by the heat pump water heater. kWh_heating (electric resistance) is that additional heating energy for a home with electric resistance heat (COP 1.0). This formula converts the additional heating kWh for an electric resistance home to the MMBtu required in a Natural Gas heated home, applying the relative efficiencies.

606 Full load hours assumption based on Efficiency Vermont analysis of Itron eShapes.

CF = Summer Peak Coincidence Factor for measure, 0.12[607]

4.33.5 Non-energy Benefits

Heat pump water heaters have a longer lifespan compared to other types of baseline water heaters.

4.33.6 Measure Life

The measure life for HPWH is 13 years[608].

4.33.7 Incremental Cost

For Time of Sale or New Construction the incremental installation cost (including labor) should be used. Defaults are provided in Table 315 below. Actual efficient costs can also be used although care should be taken as installation costs can vary significantly due to the complexities of a particular site. For retrofit costs, the actual full installation cost should be used (default provided below if unknown).

Table 315 Residential HPWH Incremental Cost[609]

Capacity	Efficiency Range	Baseline Installed Cost	Efficient Installed Cost	Incremental Installed Cost
≤55 gal	<2.6 UEF	$1,032	$2,062	$1,030
	≥2.6 UEF	$1,032	$2,231	$1,199
>55 gal	<2.6 UEF	$1,319	$2,432	$1,113
	≥2.6 UEF	$1,319	$3,116	$1,797

607 Calculated from Figure 8 "Combined six-unit summer weekday average electrical demand" in FEMP study; 'Field Testing of Pre-Production Prototype Residential Heat Pump Water Heaters' as (average kW usage during peak period * hours in peak period) / [(annual kWh savings / FLH) * hours in peak period] = (0.1 kW * 5 hours) / [(2100 kWh / 2533 hours) * 5 hours] = 0.12

608 2010 ACEEE Summer Study on Energy Efficiency in Buildings, LBNL, "Heat Pump Water Heaters and American Homes: A Good Fit?" p 9-74. https://www.aceee.org/files/proceedings/2010/data/papers/2205.pdf.

609 Costs for <2.6 UEF are based upon averages from the NEEP Phase 3 Incremental Cost Study. The assumption for higher efficiency tanks is based upon averaged from NEEP Phase 4 Incremental Cost Study. See 'HPWH Cost Estimation.xls' for more information.

4.34 LED Nightlights (New)

This measure describes savings from LED nightlights. This characterization assumes that the LED nightlight is installed in a residential location.

4.34.1 Measure Overview

Sector	Residential
End use	Lighting
Fuel	Electricity
Measure category	LED Nightlights
Delivery mechanism	Rebate
Baseline description	The baseline condition is assumed to be an incandescent/halogen nightlight.
Efficient case description	

4.34.2 Savings

This measure describes savings from LED nightlights. This characterization assumes that the LED nightlight is installed in a residential location.

Electric Energy Savings

$\Delta kWh = ((Watts_{Base} - Watts_{EE}) / 1000) * ISR * Hours * WHF_e$

Where:

$Watts_{base}$ = Actual wattage if known, if unknown, assume 7W[610].

$Watts_{EE}$ = Actual wattage of LED purchased / installed.

ISR = In Service Rate or the percentage of nightlights rebated that get installed

[610] Based on Stanley Mertz, "LED Nightlights Energy Efficiency Retail products programs", March 2018.

Program	In Service Rate (ISR)
Retail (Time of Sale)	98.0% [611]
Direct Install	96.9% [612]
School Kits	84% [613]

Hours = Average hours of use per year

= 4,380[614]

WHFe = Waste heat factor for energy to account for cooling savings from efficient lighting

Room Type	Albuquerque	Roswell	Santa Fe	Las Cruces
Gas heat with AC	1.05	1.10	1.03	1.12
Gas heat with no AC	1.00	1.00	1.00	1.00
Heat Pump	0.76	0.94	0.73	0.97
Electric Resistance Heat with AC	0.67	0.86	0.70	0.88
Electric Resistance Heat with no AC	0.57	0.70	0.66	0.70
No heat with AC	1.05	1.10	1.03	1.12
Unconditioned space	1.00	1.00	1.00	1.00
Heating cooling unknown	0.91	1.02	0.89	1.04
Upstream lighting	0.91	1.02	0.89	1.04

4.34.3 Demand Savings Estimation

Demand savings are defined as the reduction in average kW attributable to the measure during 3:00-6:00 pm on the hottest summer weekdays. Demand savings is assumed to be zero for this measure.

611 1st year in service rate is based upon analysis of ComEd PY7, PY8, and PY9 intercept data (see 'Res Lighting ISR_2018.xlsx' for more information).

612 Consistent with assumption for standard CFLs (in the absence of evidence that it should be different for this bulb type). Based upon review of the PY2 and PY3 ComEd Direct Install program surveys. This value includes bulb failures in the 1st year to be consistent with the Commission approval of annualization of savings for first year savings claims. ComEd PY2 All Electric Single Family Home Energy Performance Tune-Up Program Evaluation, Navigant Consulting, December 21, 2010

613 1st year ISR for school kits based on ComEd PY9 data for the Elementary Energy Education program

614 Assumes nightlight is operating 12 hours per day, consistent with the 2016 Pennsylvania TRM.

Demand savings are derived with the following equation:

$\Delta kW = ((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * WHFd * CF$

Where:

WHFd = Waste heat factor for demand to account for cooling savings from efficient lighting.

Room Type	Albuquerque	Roswell	Santa Fe	Las Cruces
Gas heat with AC	1.41	1.38	1.19	1.44
Gas heat with no AC	1.00	1.00	1.00	1.00
Heat Pump	1.24	1.32	1.12	1.37
Electric Resistance Heat with AC	1.00	1.17	1.00	1.36
Electric Resistance Heat with no AC	1.00	1.00	1.00	1.00
No heat with AC	1.41	1.38	1.19	1.44
Unconditioned space	1.00	1.00	1.00	1.00
Heating cooling unknown	1.28	1.32	1.13	1.41
Upstream lighting	1.28	1.32	1.13	1.41

CF = Summer Peak Coincidence Factor for measure.

= 0

4.34.4 Non-energy Benefits

There are no non-energy benefits associated with this measure.

4.34.5 Measure Life

The estimated useful life of the is estimated is 8 years [615]

[615] The value is estimated at 1.11 (calculated as 1 + (0.66 * 0.466 / 2.8)). See footnote relating to WHFe for details. Note the 46.6% factor represents the average Residential cooling coincidence factor calculated by dividing average load during the peak hours divided by the maximum cooling load

4.34.6 Incremental Cost

Where possible, the actual cost should be used and compared to the baseline cost. If the incremental cost is unknown, assume the following[616] :

Bulb Type	Year	Incandescent	LED	Incremental Cost
Nightlights	All	$2.84	$6.19	$3.35

[616] Average cost data provided in Stanley Mertz, "LED Nightlights Energy Efficiency Retail products programs", March 2018

4.35 Tier 2 Advanced Power Strips

This measure is applicable to the installation of a Tier 2 Advanced Power Strip for household audio visual environments (Tier 2 AV APS). Tier 2 AV APS are multi-plug power strips that remove power from audio visual equipment through intelligent control and monitoring strategies.[617]

4.35.1 Measure Overview

Sector	Residential
End use	Plug Load
Fuel	Electricity
Measure category	Tier 2 Advanced Power Strips – Audio Visual
Delivery mechanism	Direct Install
Baseline description	Standard power strip, or no power strip
Efficient case description	Use of a Tier 2 AV APS in a residential AV environment that includes control of at least 2 AV devices, with one being the television.[618]

4.35.2 Savings

Energy and demand deemed savings are shown in Table 230.

Table 316: Deemed Savings[619]

Product Type	ΔkWh	ΔkW
Infrared Only	136.1	0.0249
Infrared and Occupancy Sensor	96.7	0.0177

617 State of Illinois Energy Efficiency Technical Reference Manual, version 10.0

618 Given this requirement, an AV environment consisting of a television and DVD player or a TV and home theater would be eligible for a Tier 2 AV APS installation.

619 State of Illinois Energy Efficiency Technical Reference Manual, version 10.0

4.35.3 Energy Savings Estimation

Energy savings for a Tier 2 APS are calculated using the following equation.[620]

$\Delta kWh = \text{ERP} * \text{BaselineEnergy}_{AV} * \text{ISR}$

Where:

ERP = Energy Reduction Percentage of qualifying Tier 2 AV APS product range (see Table 317)

Table 317: Energy Reduction Percentage

Product Type	ERP
Infrared Only	40%[621]
Infrared and Occupancy Sensor	25%[622]

$\text{BaselineEnergy}_{AV}$ = 466 kWh[623]

ISR = In Service Rate (see Table 318)

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620 State of Illinois Energy Efficiency Technical Reference Manual, version 10.0

621 Representative savings assumption based on the following independent field tests on Embertec's IR-only product. This includes both simulated saving results (based on recording what action the APS would have taken, but where equipment is not actually switched off allowing evaluation of the expected length of savings), and pre/post metering studies.
• AESC (page 30) - Valmiki, MM., Corradini, Antonio PE. 2015. Tier 2 Advanced Power Strips in Residential and Commercial Applications. Prepared for San Diego Gas & Electric by Alternative Energy Systems Consulting, Inc. (Simulated 50%, pre/post 32%).
• AESC- Valmiki, MM., Corradini, Antonio PE., Feb 2016. Energy Savings of Tier 2 Advanced Power Strips in Residential AV Systems. (Simulated 50%, pre/post 29%)
• CalPlug research (Page 12) - Wang, M. e. 2014. "Tier 2 Advanced Power Strip Evaluation for Energy Saving Incentive". California Plug Load Research Center (CalPlug), UC Irvine. (Simulated 51%)
• NMR Group Inc., RLPNC 17-3: Advanced Power Strip Metering Study, Revised March 18, 2019, submitted to Massachusetts Program Administrators and EEAC. (Pre/post with regression 50%, Pre/post only 20%).

622 Representative savings assumption based on the following independent field tests on TrickleStar IR-OS product and reflect both simulated and pre/post meter study results.
• AESC- Valmiki, MM., Corradini, Antonio PE., Feb 2016. Energy Savings of Tier 2 Advanced Power Strips in Residential AV Systems. (Simulated 27%, pre/post 25%)
• NMR Group Inc., RLPNC 17-3: Advanced Power Strip Metering Study, Revised March 18, 2019, submitted to Massachusetts Program Administrators and EEAC. (Pre/post with regression 37%, Pre/post only 11%)

623 Average of baseline energy in Regional Technical Form survey of Tier 2 APS pre-post methodology studies, see 'RTF_T2_APS.ppt'.

Table 318: In Service Rate

Product Type	ISR[624]
Infrared Only	73%
Infrared and Occupancy Sensor	83%

4.35.4 Demand Savings Estimation

Demand savings for a Tier 2 APS are calculated using the following equation.[625]

$\Delta kW = \Delta \text{kWh} \ / \ \text{Hours} * \text{CF}$

Where:

ΔkWh = Annual kWh energy savings calculated as defined above

Hours = Annual hours per year controlled by APS

= 4,380[626]

CF = Coincidence Factor = *0.8*[627]

4.35.5 Non-energy Benefits

There are no non-energy benefits.

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[624] Weighted average of evaluation results from AESC, Inc, "Energy Savings of Tier 2 Advanced Power Strips in Residential AC Systems", p35. These assumptions include "adjustments in weighting based on the persistence sensitivity to demographics" and NMR Group Inc., RLPNC 17-3: Advanced Power Strip Metering Study, Revised March 18, 2019.

[625] State of Illinois Energy Efficiency Technical Reference Manual, version 10.0

[626] This is estimate based on assumption that approximately half of savings are during active hours (supported by AESC study) (assumed to be 5.3 hrs/day, 1936 per year (NYSERDA 2011. "Advanced Power Strip Research Report")) and half during standby hours (8760-1936 = 6824 hours). The weighted average is 4380.

[627] PNM/Ecova Savings Brief, citing "Efficiency Vermont coincidence factor for smart strip measure – in the absence of empirical evaluation data, this was based on the assumptions of the typical run pattern for televisions and computers in homes."

4.35.6 Measure Life

The measure life for this equipment is 7 years.[628]

4.35.7 Incremental Cost

The actual installed cost, including labor, should be used.[629]

[628] There is little evaluation to base a lifetime estimate upon. Based on review of assumptions from other jurisdictions and the relative treatment of In Service Rates and persistence, an estimate of 7 years was agreed by the Technical Advisory Committee, but further evaluation is recommended.

[629] State of Illinois Energy Efficiency Technical Reference Manual, version 10.0

4.36 Refrigerator and Freezer Recyling (New)

This measure describes savings from the retirement and recycling of inefficient but operational refrigerators and freezers. This measure applies to residential grade appliances, regardless of if they are installed in a residential or commercial building. Savings are provided based on a 2013 workpaper provided by Cadmus that used data from a 2012 ComEd metering study and metering data from a Michigan study, to develop a regression equation that uses key inputs describing the retired unit**Error! Bookmark not defined.**. The savings are equivalent to the Unit Energy Consumption of the retired unit and should be claimed for the assumed remaining useful life of that unit. A part use factor is applied to account for those secondary units that are not in use throughout the entire year. The reader should note that the regression algorithm is designed to provide an accurate portrayal of savings for the population as a whole and includes those parameters that have a significant effect on the consumption. The precision of savings for individual units will vary.

4.36.1 Measure Overview

Sector	Residential/Commercial
End use	Food Service
Fuel	Electricity
Measure category	Food Service Equipment
Delivery mechanism	ERET
Baseline description	Existing inefficient unit (10-30 ft^3)
Efficient case description	N/A

4.36.2 Energy Savings Estimation

ENERGY SAVINGS[630]

Refrigerators:

[630] Based on the specified regression, a small number of units may have negative energy and demand consumption. These are a function of the unit size and age, and should comprise a very small fraction of the population. While on an individual basis this result is counterintuitive it is important that these negative results remain such that as a population the average savings is appropriate.

Energy savings for refrigerators are based upon a linear regression model using the following coefficients, see **Error! Reference source not found.**:[631]

Table 319. Coefficient Estimates for Input Variables for Refrigerators

Independent Variable Description	Coefficient Estimate
Intercept	83.324
Age (years)	3.678
Pre-1990 (=1 if manufactured pre-1990)	485.037
Size (cubic feet)	27.149
Dummy: Side-by-Side (= 1 if side-by-side)	406.779
Dummy: Primary Usage Type (in absence of the program) (= 1 if primary unit)	161.857
Interaction: Located in Unconditioned Space x CDD/365.25	15.366
Interaction: Located in Unconditioned Space x HDD/365.25	-11.067

$$\Delta kWh = [83.32 + (Age * 3.68) + (Pre - 1990 * 485.04) + (Size * 27.15) + (Side - by - side * 406.78) + (Proportion\ of\ Primary\ Appliances * 161.86) + (CDD/365.25 * unconditioned * 15.37) + (HDD/365.25 * unconditioned * -11.07)] * Part\ Use\ Factor$$

Where:

Age = Age of retired unit. See **Error! Reference source not found.**

Pre-1990 = Pre-1990 dummy (1 if manufactured pre-1990, else 0). See **Error! Reference source not found.**

Size = Capacity (cubic feet) of retired unit. See **Error! Reference source not found.**

Side-by-side = Side-by-side dummy (1 if side-by-side, else 0). See **Error! Reference source not found.**

Primary Usage = Primary Usage Type (in absence of the program) dummy (1 if Primary, else 0). See **Error! Reference source not found.**

Interaction: Located in Unconditioned Space x CDD/365.25. See **Error! Reference source not found.**

(=1 * CDD/365.25 if in unconditioned space)

631 Energy savings are based on an average 30-year TMY temperature of 51.1 degrees. Coefficients provided in July 30, 2014 memo from Cadmus: "Appliance Recycling Update no single door July 30, 2014".

CDD = Cooling Degree Days

= Dependent on location. See **Error! Reference source not found.**

Interaction: Located in Unconditioned Space x HDD/365.25. See **Error! Reference source not found.**

(=1 * HDD/365.25 if in unconditioned space)

HDD = Heating Degree Days

= Dependent on location. See **Error! Reference source not found.**

Table 320 Cooling Degree Days and Heating Degree Days[632]

City (Climate Zone)	CDD	HDD
Albuquerque	1,322	4,180
Santa Fe	645	5,417
Roswell	1,790	3,289
Las Cruces	1,899	2,816

Part Use Factor = To account for those units that are not running throughout the entire year. The most recent part-use factor participant survey results available at the start of the current program year shall be used.[633]

Freezers:

Energy savings for freezers are based upon a linear regression model using the following coefficients:[634]

Table 321. Coefficient Estimates for Input Variables for Freezers

Independent Variable Description	Estimate Coefficient
Intercept	132.122
Age (years)	12.130
Pre-1990 (=1 if manufactured pre-1990)	156.181
Size (cubic feet)	31.839

632 https://www.nm-prc.org/wp-content/uploads/2021/07/New-Mexico-TRM-2021-Final-03-09-2021.pdf

633 For example, the part-use factor that shall be applied to the current program year t (PYt) for savings verification purposes should be determined through the PYt-2 participant surveys conducted in the respective utility's service territory, if available. If an evaluation was not performed in PYt-2 the latest available evaluation should be used.

634 Energy savings are based on an average 30-year TMY temperature of 51.1 degrees. Coefficients provided in January 31, 2013 memo from Cadmus: "Appliance Recycling Update".

Chest Freezer Configuration (=1 if chest freezer)	-19.709
Interaction: Located in Unconditioned Space x CDD/365.25	9.778
Interaction: Located in Unconditioned Space x HDD/365.25	-12.755

$$\Delta kWh = [132.12 + (Age * 12.13) + (Pre-1990 * 156.18) + (Size * 31.84) + (Chest\ Freezer * -19.71) + (CDDs * unconditioned * 9.78) + (HDDs * unconditioned * -12.75)] * Part\ Use\ Factor$$

Where:

Age = Age of retired unit. See **Error! Reference source not found.**

Pre-1990 = Pre-1990 dummy (=1 if manufactured pre-1990, else 0) See **Error! Reference source not found.**

Size = Capacity (cubic feet) of retired unit. See **Error! Reference source not found.**

Chest Freezer = Chest Freezer dummy (= 1 if chest freezer, else 0). See **Error! Reference source not found.**

Interaction: Located in Unconditioned Space x CDD/365.25. See **Error! Reference source not found.**

(=1 * CDD/365.25 if in unconditioned space)

CDD = Cooling Degree Days (see table above). See **Error! Reference source not found.**

Interaction: Located in Unconditioned Space x HDD/365.25

(=1 * HDD/365.25 if in unconditioned space)

HDD = Heating Degree Days (see table above). See **Error! Reference source not found.**

Part Use Factor = To account for those units that are not running throughout the entire year. The most recent part-use factor participant survey results available at the start of the current program year shall be used.[635]

[635] Most recent freezer part-use factor from Ameren Illinois Company PY5 evaluation.

4.36.3 Demand Savings Estimation

$$\Delta kW = \frac{\Delta kWh * CF}{8{,}766}$$

Where:

kWh = Savings provided in algorithm above

CF = Coincident factor defined as summer kW/average kW

= 1.081 for Refrigerators

= 1.028 for Freezers[636]

4.36.4 Measure Life

The estimated remaining useful life of the recycling units is 6.5 years.[637]

4.36.5 Deemed Measure Cost

Measure cost includes the customer's value placed on their lost amenity, any customer transaction costs, and the cost of pickup and recycling of the refrigerator/freezer and should be based on actual costs of running the program. The payment a Program Administrator makes to the customer serves as a proxy for the value the customer places on their lost amenity and any customer transaction costs. If unknown assume $170 per unit.[638]

[636] Cadmus memo, February 12, 2013; "Appliance Recycling Update"

[637] DOE refrigerator and freezer survival curves are used to calculate RUL for each equipment age and develop a RUL schedule. The RUL of each unit in the ARCA database is calculated and the average RUL of the dataset serves as the final measure RUL. Refrigerator recycling data from ComEd (PY7-PY9) and Ameren (PY6-PY8) were used to determined EUL with the DOE survival curves from the 2009 TSD. A weighted average of the retailer ComEd data and the Ameren data results in an average of 6.5 years. See Navigant 'ComEd Effective Useful Life Research Report', May 2018.

[638] The $170 default assumption is based on $120 cost of pickup and recycling per unit and $50 proxy for customer transaction costs and value customer places on their lost amenity. $120 is cost of pickup and recycling based on similar Efficiency Vermont program. $50 is bounty, based on Ameren and ComEd program offerings as of 7/27/15.

5. Industrial Measures

5.1 Pump Off Controls (POC)

This measure category applies to pumps used to extract oil from the earth. The measure saves energy by reducing the runtime of the pump. This measure is only eligible in retrofit applications.

5.1.1 Measure Overview

Sector	Industrial
End use	Oil Production
Fuel	Electricity
Measure category	Motor controls
Delivery mechanism	Rebate
Baseline description	Pump motor with clock timer operating 80% of the time
Efficient case description	Pump motor controlled by sensor (strain gauges or other)

5.1.2 Savings

Allowable methods of deriving savings are described. The methods are derived from a calculator that was developed as a joint venture between ADM Associates and SPS, which was developed from extensive monitoring performed by ADM.

5.1.3 Energy Savings Estimation

Savings are determined with the following equation,

$$kWh_{Savings} = \left(\frac{HP * LF * .746}{Eff_{Motor} * Eff_{SurfMech}}\right) * \left(TC - \left(\frac{Run_{Const} + Run_{Coeff} * Eff_{VolPump} * TC * 100}{100}\right)\right) * 8760$$

The parameters in this equation are a combination of user defined, prescriptive, and empirically derived.

Table 322: Energy Savings Estimation Variable & Sources

Variable	Definition	Value & source
$kWh_{Savings}$	Annual kWh Savings for the installation of a POC	Calculated
HP	Motor Horsepower	Provided by customer
LF	Motor Load Factor	Ratio of average demand to maximum demand = 25%. From NYSERDA (New York State Energy Research and Development Authority), Energy $mart Programs Deemed Savings Database and adjusted based on Field measurements provided by ADM, based on 2010 custom projects.
0.746	HP to Watt conversion	Standard conversion from horsepower to kW or Horsepower to watts. 1 HP = 0.746 kW = 746 watts
Eff_{Motor}	Motor Efficiency	NEMA Standard Efficient Motor based on Deemed Plan B table from motor HP, enclosure, and RPM
$Eff_{SurfMech}$	Surface Mechanical Efficiency	Mechanical efficiency of sucker rod pump = 95%
TC	Time Clock setting observed during the site visit	Deemed Clock Timer setting based on ADM field monitoring of 2010-2013 custom projects = 70%
Run_{Const}	Run Constant	8.366: Empirically derived coefficient for run time calculation from J.E Bullock, Society of Petroleum Engineers Paper SPE 16363, "Electric Savings in Oil Production"
Run_{Coeff}	Run Coefficient	.956: Empirically derived coefficient for run time calculation from J.E Bullock, Society of Petroleum Engineers Paper SPE 16363, "Electric Savings in Oil Production"
$Eff_{VolPump}$	Volumetric pump efficiency	Average Fill level of pump cylinder at clock time percentage, provided by the customer
8760	Annual Hours	Total hours in a year

The motor efficiency in the POC calculator is pulled from the lookup table below based on motor horsepower and RPM.

Table 323: Energy Savings Estimation Variable & Sources

Motor HP	EPACT Efficiency			
	900 RPM	1200 RPM	1800 RPM	3600 RPM
1	74.0%	80.0%	82.5%	75.5%
1.5	75.5%	85.5%	84.0%	82.5%
2	85.5%	86.5%	84.0%	84.0%
3	86.5%	87.5%	87.5%	85.5%
5	87.5%	87.5%	87.5%	87.5%
7.5	88.5%	89.5%	89.5%	88.5%
10	89.5%	89.5%	89.5%	89.5%
15	89.5%	90.2%	91.0%	90.2%
20	90.2%	90.2%	91.0%	90.2%
25	90.2%	91.7%	92.4%	91.0%
30	91.0%	91.7%	92.4%	91.0%
40	91.0%	93.0%	93.0%	91.7%
50	91.7%	93.0%	93.0%	92.4%
60	92.4%	93.6%	93.6%	93.0%
75	93.6%	93.6%	94.1%	93.0%
100	93.6%	94.1%	94.5%	93.6%
125	93.6%	94.1%	94.5%	94.5%
150	93.6%	94.1%	95.0%	94.5%
200	93.6%	95.0%	95.0%	95.0%
250	94.5%	95.0%	95.0%	95.4%
300	94.5%	95.0%	95.4%	95.4%
350	94.5%	95.0%	95.4%	95.4%
400	94.9%	95.0%	95.4%	95.4%
450	95.3%	95.0%	95.4%	95.4%
500	95.3%	95.9%	95.8%	95.4%

5.1.4 Demand Savings Estimation

Savings are derived with the following equation,

$$Demand\ kW_{Savings} = \left(\frac{HP * LF * 0.746}{Eff_{Motor} * Eff_{SurfMech}}\right) * CoincidentFactor$$

The Coincident Factor is determined by subtracting the percent of annual hours the controlled pump operates from the baseline time clock setting. This assumes that the controller is equally likely to turn off the pump at all hours of the year. Subtracting the proposed case operating hours from the baseline time clock setting accounts for the probability that the pump would have been turned off by the time clock in the baseline case, thus resulting in no demand savings in the proposed case. The Coincident Factor is derived with the following equation,

$$CoincidentFactor = TC - \left(\frac{Run_{Const} + Run_{Coeff} * Eff_{VolPump} * TC * 100}{100}\right)$$

The parameters in this equation are a combination of user defined, prescriptive, and empirically derived.

Table 324: Peak Demand Savings Estimation Variable & Sources

Variable	Definition	Value & source
$kW_{Savings}$	Annual kW Savings for the installation of a POC	Calculated
HP	Motor Horsepower	Provided by customer
LF	Motor Load Factor	Ratio of average demand to maximum demand = 25%. From NYSERDA (New York State Energy Research and Development Authority), Energy $mart Programs Deemed Savings Database and adjusted based on Field measurements provided by ADM, based on 2010 custom projects.
0.746	HP to Watt conversion	Standard conversion from horsepower to kW or Horsepower to watts. 1 HP = 0.746 kW = 746 watts
Eff_{Motor}	Motor Efficiency	NEMA Standard Efficient Motor based on Deemed Plan B table from motor HP, enclosure, and RPM
$Eff_{SurfMech}$	Surface Mechanical Efficiency	Mechanical efficiency of sucker rod pump = 95%
CoincidentFactor	Adjusts the gross kW savings to account for overlap with the peak period	Derived per above equation.

Variable	Definition	Value & source
TC	Time Clock setting observed during the site visit	Deemed Clock Timer setting based on ADM field monitoring of 2010-2013 custom projects = 70%
Run_{Const}	Run Constant	8.366: Empirically derived coefficient for run time calculation from J.E Bullock, Society of Petroleum Engineers Paper SPE 16363, "Electric Savings in Oil Production"
Run_{Coeff}	Run Coefficient	.956: Empirically derived coefficient for run time calculation from J.E Bullock, Society of Petroleum Engineers Paper SPE 16363, "Electric Savings in Oil Production"
$Eff_{VolPump}$	Volumetric pump efficiency	Average Fill level of pump cylinder at clock time percentage, provided by the customer

5.1.5 Non-energy Benefits

The non-energy benefits for this measure work to decrease energy costs, but also extend the life of the equipment. The controls reduce the operating hours of the equipment, and thus reduce energy consumption; however, they also allow the pumps to only run during optimal operating conditions and thus increase the efficiency during the operating periods. This also reduces the wear and tear on the pumps and stress on the beams, thus extending the life of the equipment.

5.1.6 Measure Life

The measure life for this equipment is 13 years.[639]

5.1.7 Incremental Cost

The cost for a pump off motor controller is $5,959 per controller.[640]

639 SPS Motor and Drive Efficiency Workpaper citing: Efficiency Vermont: Technical Reference User Manual (TRM) No. 2004-31. There is no listed measure life for POCs, but the pump motors have a rated life of 20 years, and controllers have a rated life between 10 and 15 years, based on the type and application.

640 NMx Pump Off Controller Custom Projects

6 Protocols

6.1 Home Energy Reports (New)

This measure involves randomly assigning residential customers into treatment and control groups, and then having the treatment group receive regular (e.g., monthly) energy reports that show how their energy use compared with a group of peer households. If the treatment household energy consumption is higher than the peer average, then this information encourages the household to reduce their energy use. Helpful tips for reducing energy use are also included with the energy reports.

Savings is calculated by comparing the average energy use between the treatment and control groups in the post-participation period once the home energy reports are sent out. Prior to sending out the reports, the control group is adjusted as needed to match the treatment group based on key parameters; at a minimum the groups must be matched based on average energy consumption. Additional matching can occur based on participation rates in utility rebate programs if this information is being tracked.

6.1.0 Measure Overview

Sector	Residential
End use	Multiple
Fuel	Electricity
Measure category	Cross Cutting
Delivery mechanism	Email or paper energy reports on household electricity use compared with a matched peer group
Baseline description	Average electricity consumption from a randomly selected matched control group
Efficient case description	Average electricity consumption from the participating treatment group that receives the home energy reports

6.1.1 Energy Savings Estimation

Savings are determined using a fixed effects regression model and a sample that contains monthly billing data for both treatment and control group customers. The model dataset should include a minimum of 12 months of pre-participation billing data and 12 months of post-participation billing data.

The fixed effects billing regression model is specified as follows:

$$kWh_{i,t} = \alpha_i + \beta_1 Post_t + \beta_2 Treatment + \beta_3 CDD_{i,t} + \beta_4 HDD_{i,t} + \beta_5 Post_t * Treatment + \varepsilon_{i,t}$$

$Where$:

$kWh_{i,t}$ = daily electricity usage of customer i on day t

α_i = customer-specific fixed effect

$Post_t$ = indicator for post-program for year t

$Treatment$ = indicator for treatment group participants

CDD_t, HDD_t = cooling and heating degree days (base of 65°F) for customer i on day t

$\beta_1, \beta_2, \ldots$ = coefficients to be estimated by the regression

ε = random error term

The coefficient estimate on the $Post * Treatment$ interaction variable (β_5) can be interpreted as the change in daily energy consumption (i.e., savings) for a participating household in the treatment group.

Since the model includes data from both participants and non-participants, the regression results can be interpreted as net impacts.

6.1.2 Non-energy benefits

None.

6.1.3 Measure Life

The measure life for this equipment is 1 year.

6.1.4 Incremental Cost

The incremental cost is the cost of program administration; no additional rebate is provided.

6.2 Residential Lighting Guidance on EISA Backstop (New)

6.2.1 Measure Overview

Sector	Residential
End use	Lighting
Fuel	Electricity
Measure category	CFL and LED Lighting
Delivery mechanism	Upstream buy-down Give-away Direct Install Retail coupons
Baseline description	Federal minimum wattage
Efficient case description	Efficient lamp wattage

6.2.2 Savings

The baseline and efficient measure assumptions are shown in Table 192. New lamps must be ENERGY STAR labeled or equivalent to the most recent version of ENERGY STAR specifications. Note a new ENERGY STAR specification v2.1 became effective on 1/2/2017.

In 2012, Federal legislation stemming from the Energy Independence and Security Act of 2007 (EISA) will require all general-purpose light bulbs between 40 watts and 100 watts to have ~30% increased efficiency, essentially phasing out standard incandescent technology. In 2012, the 100 w lamp standards apply; in 2013 the 75 w lamp standards will apply, followed by restrictions on the 60 w and 40 w lamps in 2014. Since measures installed under this TRM all occur after 2014, baseline equipment are the values after EISA. These are shown in the baseline table below.

Additionally, an EISA backstop provision was included that would require replacement baseline lamps to meet an efficacy requirement of 45 lumens/watt or higher beginning on 1/1/2020. In December 2019, DOE issued a final determination for General Service Incandescent Lamps (GSILs), finding that this more stringent standard was not economically justified. However, in May 2022 DOE reversed this decision by issuing a Final rule for both the broadened General Service Lamp definition as well as the implementation of the 45 lumen per watt backstop. DOE stated that it will use its enforcement discretion to minimize impacts on the supply chain and effectively allow companies to continue the manufacture and import of noncompliant bulbs through the remainder of 2022, and allow retailers to continue selling them with limited enforcement until July 2023.

Non-Income Qualified Programs

This TRM assumes that non-income qualified participants would continue to have access to baseline / noncompliant bulbs through retail until 6/30/2023. The New Mexico TRM has not historically implemented code shifts midway through program years to avoid introducing market confusion, as well as allowing for additional sell through. Therefore, the TRM assumes the 45 lumens/watt baselines are effective beginning January 1, 2024. The lifetime savings for non-income qualified participants should shift the baseline to 45 lumens/watt lamps starting January 1, 2027. This accounts for the three year measure life of an installed halogen lamp.

Direct Install programs where it can be shown that the LED is replacing working inefficient lighting should continue to use the existing inefficient lighting as baseline. The program can claim full savings from halogen to LED for three years, after which the baseline should shift to 45 lumens /watt for the remaining lamp life.

Income Qualified Programs

This TRM assumes that income qualified participants would continue to have access to baseline / noncompliant bulbs through retail and existing stocks until June, 2025 (two years past market rate participants). The New Mexico TRM has not historically implemented code shifts midway through program years to avoid introducing market confusion, as well as allowing for additional sell through. Therefore, the TRM assumes the 45 lumens/watt baselines are effective beginning January 1, 2026. The lifetime savings for income qualified participants should shift the baseline to 45 lumen/watt lamps starting January 1, 2029. This accounts for the three year measure life of an installed halogen lamp.

Direct Install programs where it can be shown that the LED is replacing working inefficient lighting should continue to use the existing inefficient lighting as baseline. The program can claim full savings from halogen to LED for three years, after which the baseline should shift to 45 lumens /watt for the remaining lamp life. New Construction Programs

Since IECC 2015 energy code, there has been mandatory requirements for lighting in New Construction: "Not less than 75 percent (90 percent in IECC 2018 and 100 percent in IECC 2021) of the lamps in permanently installed lighting fixtures shall be high-efficacy lamps or not less than 75 percent (90 percent in IECC 2018 and 100 percent in IECC 2021) of the permanently installed lighting fixtures shall contain only high-efficacy lamps". To meet the 'high efficacy' requirements, lamps need to be CFL or LED, however since CFLs are no longer commonly purchased (only 1% baseline forecast) it is assumed that 75% (IECC 2015) or 90% (IECC 2018) or 100% (IECC 2021) of the New Construction baseline is an LED and therefore savings are reduced by that percentage for bulbs provided in New Construction projects. Any New Construction project utilizing IECC 2021 code should therefore not include savings from this measure.

Table 325: Residential Lighting Baseline & Efficiency Wattage – General Service

Minimum Lumens	Maximum Lumens	LED Wattage (Watts)	Baseline (Watts)	Baseline for New Construction (Watts)		Delta Watts (WattsEE)	Delta Watts for New Construction (WattsEE)	
				IECC 2015	IECC 2018		IECC 2015	IECC 2018
120	399	4	25	9.3	6.1	21	5.3	2.1
400	749	6.6	29	12.2	8.8	22.4	5.6	2.2
750	899	9.6	43	18	12.9	33.4	8.4	3.3
900	1399	13.1	53	23.1	17.1	39.9	10	4
1400	1999	16	72	30	21.6	56	14	5.6
2000	2999	21.8	150	53.9	34.6	128.2	32.1	12.8
3000	3999	28.9	200	71.7	46	171.1	42.8	17.1
4000	5000	35.7	300	101.8	62.1	264.3	66.1	26.4

Table 326 details wattage ENERGY STAR specifications for reflector lamps. Program administrators should use model-specific wattages within these categorizations.

Table 326: Baseline & Efficiency Wattage – Reflector Lamps

Bulb Type	Minimum Lumens	Maximum Lumens	LED Wattage (Watts)	Baseline (Watts)	Baseline for New Construction (Watts)		Delta Watts (WattsEE)	Delta Watts for New Construction (WattsEE)	
					IECC 2015	IECC 2018		IECC 2015	IECC 2018
Reflector lamp types with medium screw bases (PAR20, PAR30(S,L), PAR38, R40, etc.) w/ diameter >2.25" (*see exceptions below)	400	649	7	50	17.8	11.3	43	10.8	4.3
	650	899	10.7	75	26.8	17.1	64.3	16.1	6.4
	900	1049	13.9	90	32.9	21.5	76.1	19	7.6
	1050	1199	13.8	100	35.4	22.4	86.2	21.6	8.6
	1200	1499	15.9	120	41.9	26.3	104.1	26	10.4
	1500	1999	18.9	150	51.7	32	131.1	32.8	13.1
	2000	4200	27.3	250	83	49.6	222.7	55.7	22.3

Reflector lamp types with medium screw bases (PAR16, R14, R16, etc.) w/ diameter <2.25" (*see exceptions below)	280	374	4.6	35	12.2	7.6	30.4	7.6	3
	375	600	6.4	50	17.3	10.8	43.6	10.9	4.4
*BR30, BR40, or ER40	650	949	9.3	65	23.2	14.9	55.7	13.9	5.6
	950	1099	12.7	75	28.3	18.9	62.3	15.6	6.2
	1100	1399	14.4	85	32.1	21.5	70.6	17.7	7.1
	1400	1600	16.6	100	37.5	24.9	83.4	20.9	8.3
	1601	1800	22.2	120	46.7	32	97.8	24.5	9.8
*R20	450	524	6	40	14.5	9.4	34	8.5	3.4

	525	750	7.1	45	16.6	10.9	37.9	9.5	3.8
*MR16	250	324	3.8	20	7.9	5.4	16.2	4.1	1.6
	325	369	4.8	25	9.9	6.8	20.2	5.1	2
	370	400	4.9	25	9.9	6.9	20.1	5	2

For PAR, MR, and MRX Lamps Types:

For these highly focused directional lamp types, it is necessary to have Center Beam Candle Power (CBCP)and beam angle measurements to accurately estimate the equivalent baseline wattage. The formula below is based on the ENERGY STAR Center Beam Candle Power tool.[641] If CBCP and beam angle information are not available or if the equation below returns a negative value (or undefined), use the manufacturer's recommended baseline wattage equivalent.[642]

$Watts_{base} = 375.1 - 4.355(D) - \sqrt{(227{,}800 - 937.9(D) - 0.9903(D^2) - 1479(BA) - 12.02(D * BA) + 14.69(BA^2) - 16{,}720 * \ln(CBCP))}$ for other specialty lamps is detailed in Table 194.

where:

D	= Bulb diameter (e.g. for PAR20 D = 20)
BA	= Beam angle
$CBCP$	= Center beam candle power

The result of the equation above should be rounded DOWN to the nearest wattage established by ENERGY STAR:

Diameter	Permitted Wattages
16	20, 35, 40, 45, 50, 60, 75
20	50
30S	40, 45, 50, 60, 75
30L	50, 75
38	40, 45, 50, 55, 60, 65, 75, 85, 90 100, 120, 150, 250

Table 327: Baseline & Efficiency Wattage – Specialty Lamps

Bulb Type	Minimum Lumens	Maximum Lumens	LED Wattage	Baseline (Watts)	Baseline for New Construction	Delta Watts	Delta Watts for New Construction

[641] See 'ESLampCenterBeamTool.xls'.

[642] The ENERGY STAR Center Beam Candle Power tool does not accurately model baseline wattages for lamps with certain bulb characteristic combinations – specifically for lamps with very high CBCP.

			(Wat ts)		(Watts)		(Watts EE)	(WattsEE)	
					IECC 2015	IECC 2018		IECC 2015	IECC 2018
Omni-Directional	1100	1999	14.7	100	36	23.2	85.3	21.3	8.5
3-Way	2000	2700	22.6	150	54.5	35.3	127.4	31.9	12.7
Globe (medium and intermediate bases less than 750 lumens)	150	349	3	25	8.5	5.2	22	5.5	2.2
	350	499	4.7	40	13.5	8.2	35.3	8.8	3.5
	500	574	5.7	60	19.3	11.1	54.3	13.6	5.4
	575	649	6.5	75	23.6	13.4	68.5	17.1	6.9
	650	1000	8.2	100	31.2	17.4	91.8	23	9.2
Globe (candelabra bases less than 1050 lumens)	150	349	3.5	25	8.9	5.7	21.5	5.4	2.2
	350	499	4.4	40	13.3	8	35.6	8.9	3.6
	500	574	5.5	60	19.1	11	54.5	13.6	5.5
Decorative (Shapes B, BA, C, CA, DC, F, G, medium and intermediate bases less than 750 lumens)	160	299	2.6	25	8.2	4.8	22.4	5.6	2.2
	300	499	4.3	40	13.2	7.9	35.7	8.9	3.6
	500	800	5.8	60	19.4	11.2	54.2	13.6	5.4
Decorative (Shapes B, BA, C, CA, DC, F, G, candelabra bases less than 1050 lumens)	120	159	1.5	15	4.9	2.9	13.5	3.4	1.4
	160	299	2.7	25	8.3	4.9	22.3	5.6	2.2
	300	499	4.2	40	13.2	7.8	35.8	9	3.6
	500	650	5.5	60	19.1	11	54.5	13.6	5.5

Decorative (Shape ST)	250	499	6.5	40	14.9	9.9	33.5	8.4	3.4
	500	999	8.8	60	21.6	13.9	51.2	12.8	5.1
	1000	1500	10	100	32.5	19	90	22.5	9
Decorative (Shape S)	50	75	1	11	3.5	2	10	2.5	1
	100	120	1.2	15	4.7	2.6	13.8	3.5	1.4
	120	340	2.25	25	7.9	4.5	22.8	5.7	2.3