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

Prepared for the New Mexico Public Regulation Commission

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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 in order 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] http://energycode.pnl.gov/EnergyCodeReqs/?state=New%20Mexico

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%

Building Type	Abbreviation	Prevalence
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%

3 Commercial Measures

3.1 Low-flow Faucet Aerator

This measure saves water heating energy by reducing 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]

$$Svgs = \frac{(FlowPre - FlowPost) \times (\mathrm{TempUsage} - \mathrm{TempCold}) \times Minutes \times Days \times HeatCapacity \times Density \times Const \times Fuel\% \times ISR}{EffDHW} \quad (1)$$

where:

Svgs	= Annual energy savings, in therms
FlowPre	= Baseline flow rate, depends on facility type, see table, 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 below
Minutes	= Minutes per day faucet is used, depends on facility type, see table
Days	= Days per year faucet is used, depends on facility type, see table
HeatCapacity	= Heat capacity of water, 1 Btu per pound per °F

[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.

Density	=	Density of water, 8.33 pounds per gallon
Const	=	Constant, 1 therm/100,000 Btus, or .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, 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 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
Elementary School	1.8	13.5	180

Table 8: Inlet water temperature[6]

City	Temperature Cold
Albuquerque	62.6

[4] US Energy Information Administration. https://www.eia.gov/consumption/commercial/data/2012/bc/cfm/b31.php The split considered for the Mountain West region in the table.

[5] Illinois Technical Reference Manual, measure 4.3.2

[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"

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 10CFR430.32.
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 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

(https://www.nrel.gov/docs/fy06osti/38238.pdf). Ambient temperatures were taken from TMY3 data for each city.

[7] Ibid

	(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 below

Table 10: Coincidence Factor[8]

City	Coincidence Factors
Prison	0.0220
Hospital, Nursing Home	0.0144
Dormitory	0.0220
Hospitality	0.0006
Commercial	0.0128
Middle or High School	0.0288
Elementary School	0.0096

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

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"

$$Svgs = \frac{((FlowPre \times UsagePre) - (FlowPost \times UsagePost)) \times DeltaT \times Days \times Const}{EffDHW} \quad (2)$$

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, minutes per day
FlowPost	= Measure flow rate, 1.25 gpm
UsagePost	= Measure usage duration, depends on facility type, see table, minutes per day
DeltaT	= Temperature difference between hot and cold water, see table, °F
Days	= Days per year faucet is used, depends on facility type, see table
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 following sources. [12]

[12] Ibid

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
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]

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

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]

[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.

$$Svgs = (kW_{PRE} - kW_{POST}) \times OperatingHours \times HVAC\_Energy\_Factor \quad (3)$$

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 below
HVAC_Energy_Factor	= Adjustment to lighting savings to account for the decreased cooling load, see below

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 (http://aa.usno.navy.mil/data/docs/Dur_OneYear.php). 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]	
Building Type	**Other**	**Screw-In Bulb**	**All**	**Saturation**
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	2,549
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
Health/Medical - Hospital	Whole Building		
Health/Medical - Hospital	Office (General)	4,901	4,013
Health/Medical - Hospital	Dining Area	5,892	4,248
Health/Medical - Hospital	Kitchen and Food Preparation	5,892	4,248
Health/Medical - Hospital	Medical and Clinical Care	5,223	4,109
Health/Medical - Hospital	Laboratory, Medical	4,281	3,283
Health/Medical - Hospital	Medical and Clinical Care	5,223	4,109
Health/Medical - Nursing Home	Whole Building		
Health/Medical - Nursing Home	Hotel/Motel Guest Room (incl. toilets)	5,398	4,148
Health/Medical - Nursing Home	Office (General)	4,602	4,077
Health/Medical - Nursing Home	Corridor	8,760	5,535
Health/Medical - Nursing Home	Dining Area	4,715	4,140
Health/Medical - Nursing Home	Kitchen and Food Preparation	4,715	4,140

Building Type	Space Use	Other	Screw-In Bulbs
Lodging - Hotel	Whole Building		
Lodging - Hotel	Hotel/Motel Guest Room (incl. toilets)	1,692	1,718
Lodging - Hotel	Corridor	8,760	8,760
Lodging - Hotel	Dining Area	7,382	6,684
Lodging - Hotel	Kitchen and Food Preparation	8,760	7,830
Lodging - Hotel	Bar, Cocktail Lounge	8,091	7,043
Lodging - Hotel	Lobby (Hotel)	8,760	8,760
Lodging - Hotel	Laundry	8,760	7,712
Lodging - Hotel	Office (General)	7,026	6,465
Lodging - Motel	Whole Building		
Lodging - Motel	Hotel/Motel Guest Room (incl. toilets)	884	828
Lodging - Motel	Office (General)	6,857	6,724
Lodging - Motel	Laundry	5,512	5,164
Lodging - Motel	Corridor	8,748	6,724
Manufacturing - Bio/Tech	Whole Building		
Manufacturing - Bio/Tech	Laboratory, Medical	1,244	1,023
Manufacturing - Bio/Tech	Office (General)	1,258	1,023
Manufacturing - Bio/Tech	Corridor	2,745	2,742
Manufacturing - Bio/Tech	Computer Room (Mainframe/Server)	1,202	1,023
Manufacturing - Bio/Tech	Dining Area	1,202	1,114
Manufacturing - Bio/Tech	Kitchen and Food Preparation	1,202	1,038
Manufacturing - Bio/Tech	Conference Room	1,451	1,047
Manufacturing - Light Industrial	Whole Building		
Manufacturing - Light Industrial	Comm/Ind Work (General, High Bay)	3,460	3,083
Manufacturing - Light Industrial	Storage (Unconditioned)	3,807	3,121
Office - Large	Whole Building		
Office - Large	Office (Open Plan)	3,208	2,538

Building Type	Space Use	Other	Screw-In Bulbs
Office - Large	Office (Executive/Private)	3,208	2,538
Office - Large	Corridor	3,208	3,161
Office - Large	Lobby (Office Reception/Waiting)	3,270	3,161
Office - Large	Conference Room	3,270	1,349
Office - Large	Copy Room (photocopying equipment)	3,270	3,161
Office - Large	Restrooms	3,270	3,161
Office - Large	Mechanical/Electrical Room	3,270	1,349
Office - Small	Whole Building		
Office - Small	Office (Executive/Private)	2,640	2,984
Office - Small	Corridor	2,640	3,271
Office - Small	Lobby (Office Reception/Waiting)	2,640	3,852
Office - Small	Conference Room	2,640	1,515
Office - Small	Copy Room (photocopying equipment)	2,640	3,852
Office - Small	Restrooms	2,640	3,852
Office - Small	Mechanical/Electrical Room	2,640	1,515
Restaurant - Sit-Down	Whole Building		
Restaurant - Sit-Down	Dining Area	2,601	2,993
Restaurant - Sit-Down	Lobby (Main Entry and Assembly)	2,601	2,993
Restaurant - Sit-Down	Kitchen and Food Preparation	2,584	2,973
Restaurant - Sit-Down	Restrooms	2,478	2,851
Restaurant - Fast-Food	Whole Building		
Restaurant - Fast-Food	Dining Area	4,845	4,845
Restaurant - Fast-Food	Lobby (Main Entry and Assembly)	4,845	4,845
Restaurant - Fast-Food	Kitchen and Food Preparation	4,807	4,807
Restaurant - Fast-Food	Restrooms	4,672	4,672
Retail - 3-Story Large	Whole Building		
Retail - 3-Story Large	Retail Sales and Wholesale Showroom	5,090	5,181
Retail - 3-Story Large	Storage (Conditioned)	3,878	3,324

Building Type	Space Use	Other	Screw-In Bulbs
Retail - 3-Story Large	Office (General)	3,726	3,324
Retail - Single-Story Large	Whole Building		
Retail - Single-Story Large	Retail Sales and Wholesale Showroom	4,389	4,390
Retail - Single-Story Large	Storage (Conditioned)	2,698	2,562
Retail - Single-Story Large	Office (General)	2,674	2,663
Retail - Single-Story Large	Auto Repair Workshop	3,379	3,913
Retail - Single-Story Large	Kitchen and Food Preparation	3,319	3,840
Retail - Small	Whole Building		
Retail - Small	Retail Sales and Wholesale Showroom	4,434	4,691
Retail - Small	Storage (Conditioned)	3,614	2,981
Storage - Conditioned	Whole Building		
Storage - Conditioned	Storage (Conditioned)	3,380	4,010
Storage - Conditioned	Office (General)	3,380	4,010
Storage - Unconditioned	Whole Building		
Storage - Unconditioned	Storage (Unconditioned)	3,420	2,760
Storage - Unconditioned	Office (General)	3,420	2,760
Grocery	Whole Building		
Grocery	Retail Sales, Grocery	3,475	2,807
Grocery	Office (General)	3,168	2,495
Grocery	Comm/Ind Work (Loading Dock)	3,475	2,807
Grocery	Refrigerated (Food Preparation)	3,066	2,495
Grocery	Refrigerated (Walk-in Freezer)	3,066	2,495
Grocery	Refrigerated (Walk-in Cooler)	3,066	2,495
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]

[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.

$$Svgs = (kW_{PRE} - kW_{POST}) \times HVAC\_Demand\_Factor \times Coincident\_Factor \quad (4)$$

where:

Svgs = Demand savings, in kW

kW_{PRE} = Wattage of the baseline lamp (divided by 1000)

kW_{POST} = Wattage of the installed lamp (divided by 1000)

Coincident_Factor = Adjusts the gross kW savings to account for overlap with the peak period, see below

HVAC_Demand_Factor = Adjustment to lighting savings to account for the decreased cooling load, see 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, August 20, 2012

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

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. The baseline is code requirements. This measure applies to reductions in lighting wattage; savings due to lighting controls are calculated separately after lighting wattage savings are determined.

3.4.1 Measure Overview

Sector	Commercial
End use	Lighting
Fuel	Electricity
Measure category	Lighting - new
Delivery mechanism	Rebate
Baseline description	Either federal standards or local building energy code
Efficient case description	Fixtures or lamps with lower wattage than the baseline

3.4.2 Savings

Allowable methods of deriving savings are described.

3.4.3 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 2009 or the Space-by-Space Method as defined in defined in ASHRAE 90.1 2007 can be used for calculating the Interior Lighting Power Density. Savings for each space are determined with the following equation.

$$Svgs = (LPD_{CODE} \times SquareFeet - kW_{POST}) \times OperatingHours \times HVAC\_Energy\_Factor \quad \mathbf{(5)}$$

where:

$Svgs$ = Annual energy savings, in kWh

LPD_{CODE} = Code Lighting Power Density, W/ft^2, see below

$SquareFeet$ = Square footage of the building area with the given LPD

OperatingHours	=	Annual hours the lamp is on, see below
HVAC_Energy_Factor	=	Adjustment to lighting savings to account for the decreased cooling load, see 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.[23]

Table 23: Baseline LPD by Building Type

Building Area Type	Lighting Power Density (w/ft^2)
Automotive Facility	0.9
Convention Center	1.2
Court House	1.2
Dining: Bar Lounge/Leisure	1.3
Dining: Cafeteria/Fast Food	1.4
Dining: Family	1.6
Dormitory	1
Exercise Center	1
Gymnasium	1.1
Healthcare – clinic	1
Hospital	1.2
Hotel	1
Library	1.3
Manufacturing Facility	1.3
Motel	1
Motion Picture Theater	1.2
Multifamily	0.7
Museum	1.1
Office	1
Parking Garage	0.3
Penitentiary	1

[23] IECC 2009

Building Area Type	Lighting Power Density (w/ft^2)
Performing Arts Theater	1.6
Police/Fire Station	1
Post Office	1.1
Religious Building	1.3
Retail	1.5
School/University	1.2
Sports Arena	1.1
Town Hall	1.1
Transportation	1
Warehouse	0.8
Workshop	1.4

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

Table 24: Baseline interior LPD by space type

Common Space Type	LPD (W/ft^2)	Building Specific Space Types	LPD (W/ft^2)
Office-Enclosed	1.1	Gymnasium/Exercise Center	
Office-Open Plan	1.1	Playing Area	1.4
Conference/Meeting/Multipurpose	1.3	Exercise Area	0.9
Classroom/Lecture/Training	1.4	Courthouse/Police Station/Penitentiary	
For Penitentiary	1.3	Courtroom	1.9
Lobby	1.3	Confinement Cells	0.9
For Hotel	1.1	Judges Chambers	1.3
For Performing Arts Theater	3.3	Fire Stations	
For Motion Picture Theater	1.1	Fire Station Engine Room	0.8
Audience/Seating Area	0.9	Sleeping Quarters	0.3
For Gymnasium	0.4	Post Office-Sorting Area	1.2

[24] ASHRAE 90.1 2007

Common Space Type	LPD (W/ft^2)	Building Specific Space Types	LPD (W/ft^2)
For Exercise Center	0.3	Convention Center-Exhibit Space	1.3
For Convention Center	0.7	Library	
For Penitentiary	0.7	Card File and Cataloging	1.1
For Religious Buildings	1.7	Stacks	1.7
For Sports Arena	0.4	Reading Area	1.2
For Performing Arts Theater	2.6	Hospital	
For Motion Picture Theater	1.2	Emergency	2.7
For Transportation	0.5	Recovery	0.8
Atrium—First Three Floors	0.6	Nurse Station	1
Atrium—Each Additional Floor	0.2	Exam/Treatment	1.5
Lounge/Recreation	1.2	Pharmacy	1.2
For Hospital	0.8	Patient Room	0.7
Dining Area	0.9	Operating Room	2.2
For Penitentiary	1.3	Nursery	0.6
For Hotel	1.3	Medical Supply	1.4
For Motel	1.2	Physical Therapy	0.9
For Bar Lounge/Leisure Dining	1.4	Radiology	0.4
For Family Dining	2.1	Laundry—Washing	0.6
Food Preparation	1.2	Automotive—Service/Repair	0.7
Laboratory	1.4	Manufacturing	
Restrooms	0.9	Low (<25 ft Floor to Ceiling Height)	1.2
Dressing/Locker/Fitting Room	0.6	High (>25 ft Floor to Ceiling Height)	1.7
Corridor/Transition	0.5	Detailed Manufacturing	2.1
For Hospital	1	Equipment Room	1.2
For Manufacturing Facility	0.5	Control Room	0.5
Stairs—Active	0.6	Hotel/Motel Guest Rooms	1.1
Active Storage	0.8	Dormitory—Living Quarters	1.1
For Hospital	0.9	Museum	
Inactive Storage	0.3	General Exhibition	1
For Museum	0.8	Restoration	1.7

Common Space Type	LPD (W/ft²)	Building Specific Space Types	LPD (W/ft²)
Electrical/Mechanical	1.5	Bank/Office—Banking Activity Area	1.5
Workshop	1.9	Religious Buildings	
Sales Area	1.7	Worship Pulpit, Choir	2.4
		Fellowship Hall	0.9
		Retail [For accent lighting, see 9.3.1.2.1(c)]	
		Sales Area	1.7
		Mall Concourse	1.7
		Sports Arena	
		Ring Sports Area	2.7
		Court Sports Area	2.3
		Indoor Playing Field Area	1.4
		Warehouse	
		Fine Material Storage	1.4
		Medium/Bulky Material Storage	0.9
		Parking Garage—Garage Area	0.2
		Transportation	
		Airport—Concourse	0.6
		Air/Train/Bus—Baggage Area	1
		Terminal—Ticket Counter	1.5

Exterior LPD are shown in Table 25.

Table 25: Baseline exterior LPD[25]

		Zone 1	Zone 2	Zone 3	Zone 4
	Uncovered Parking Areas				
	Parking areas and drives	0.04 W/ft^2	0.06 W/ft^2	0.10 W/ft^2	0.13 W/ft^2
	Building Grounds				
	Walkways less than 10 feet wide	0.7 W/linear foot	0.7 W/linear foot	0.8 W/linear foot	1.0 W/linear foot
	Walkways 10 feet wide or greater, plaza areas special feature areas	0.14 W/ft^2	0.14 W/ft^2	0.16 W/ft^2	0.20 W/ft^2
	Stairways	0.75 W/ft^2	1.0 W/ft^2	1.0 W/ft^2	1.0 W/ft^2
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.)	Pedestrian Tunnels	0.15 W/ft^2	0.15 W/ft^2	0.2 W/ft^2	0.3 W/ft^2
	Building Entrances and Exits				
	Main entries	20 W/linear foot of door width	20 W/linear foot of door width	30 W/linear foot of door width	30 W/linear foot of door width
	Other doors	20 W/linear foot of door width	20 W/linear foot of door width	20 W/linear foot of door width	20 W/linear foot of door width
	Entry canopies	0.25 W/ft^2	0.25 W/ft^2	0.4 W/ft^2	0.4 W/ft^2
	Sales Canopies				
	Free standing and attached	0.6 W/ft^2	0.6 W/ft^2	0.8 W/ft^2	1.0 W/ft^2
	Outdoor Sales				
	Open areas (including vehicle sales lots)	0.25 W/ft^2	0.25 W/ft^2	0.5 W/ft^2	0.7 W/ft^2
	Street frontage for vehicle sales lots in addition to "open area" allowance	No allowance	10 W/linear foot	10 W/linear foot	30 W/linear foot

[25] IECC 2009

		Zone 1	Zone 2	Zone 3	Zone 4
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	0.1 W/ft^2 for each illuminated wall or surface or 2.5 W/linear foot for each illuminated wall or surface length	0.15 W/ft^2 for each illuminated wall or surface or 3.75 W/linear foot for each illuminated wall or surface length	0.2 W/ft^2 for each illuminated wall or surface or 5.0 W/linear foot for each illuminated wall or surface length
	Automated teller machines and night depositories	270 W per location plus 90 W per additional ATM per location	270 W per location plus 90 W per additional ATM per location	270 W per location plus 90 W per additional ATM per location	270 W per location plus 90 W per additional ATM per location
	Entrances and gatehouse inspection stations at guarded facilities	0.75 W/ft^2 of covered and uncovered area	0.75 W/ft^2 of covered and uncovered area	0.75 W/ft^2 of covered and uncovered area	0.75 W/ft^2 of covered and uncovered area
	Loading areas for law enforcement, fire, ambulance and other emergency service vehicles	0.5 W/ft^2 of covered and uncovered area	0.5 W/ft^2 of covered and uncovered area	0.5 W/ft^2 of covered and uncovered area	0.5 W/ft^2 of covered and uncovered area
	Drive-up windows/doors	400W per drive-through	400W per drive-through	400W per drive-through	400W per drive-through
	Parking near 24-hour retail entrances	800 W per main entry	800 W per main entry	800 W per main entry	800 W 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.

3.4.4 Demand Savings Estimation

Using the LPD method, savings are determined with the following equation.

$$Svgs = (LPD_{CODE} \times SquareFeet - kW_{POST}) \times HVAC\_Demand\_Factor \times Coincident\_Factor \tag{6}$$

where:

Svgs	=	Demand savings, in kW
LPD_{CODE}	=	Code Lighting Power Density, W/ft², see 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_Demand_Factor	=	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."

3.4.5 Non-energy Benefits

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

3.4.6 Measure Life

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

3.4.7 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 picked from the same table to line up 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,

$$Svgs = kW_{POST} \times OperatingHours \times Controls\ Factor \times HVAC\_Energy\_Factor \quad (7)$$

where:

$Svgs$ = Annual energy savings, in kWh

kW_{POST} = Power draw of the controlled lamps

$OperatingHours$ = 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.[26]

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,

$$Svgs = kW_{POST} \times \text{Controls Factor} \times HVAC\_Demand\_Factor \times CoincidentFactor \quad \textbf{(8)}$$

where:

Svgs = Demand savings, in kW

kW_{POST} = Power draw of the controlled lamps

[26] 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

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.[27]

3.5.7 Incremental Cost

Incremental cost for this measure is the full measure cost. Costs are shown in Table 27.[28]

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

[27] DEER 2014 EUL Table

[28] Utility work papers, DEER 2005

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 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 2009 efficiency
Efficient case description	Efficiency must exceed IECC 2009

3.6.2 Savings

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

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

3.6.3 Energy Savings Estimation

Savings for units under 5.4 tons are determined with the following equation,

$$Svgs = Cooling\ Savings + Heating\ Savings$$[29]

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

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

Savings for units 5.4 tons to under 20 tons are determined with the following equation,

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

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

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

Savings for units 20 tons and greater are determined with the following equation,

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

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

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

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 29

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

SEER = Seasonal Energy Efficiency Ratio, nominal rating of system, see Table 28 for baseline values, Btu/Wh

IEER = Integrated Energy Efficiency Ratio, nominal rating of system, see Table 28 for baseline values, Btu/Wh

IPLV = Integrated Part Load Value, nominal rating of system, see Table 28 for baseline values, Btu/Wh

Heating Capacity = System heating capacity, in kBtu/h

Heating EFLH = Effective full load heating hours, see Table 30

HSPF = Heating Seasonal Performance Factor, nominal rating of system, see Table 28 for baseline values, Btu/Wh

COP = Coefficient of Performance, nominal rating of packaged system, see Table 28 for baseline values, Btu/Btu

Conversion Constant = 0.293 kWh/kBtu

Baseline efficiencies are shown in Table 28.[32]

Table 28: 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	13.0 SEER
	≥65,000 Btu/h and <135,000 Btu/h	Split system and single package	11.2 EER 11.4 IEER
	≥135,000 Btu/h and <240,000 Btu/h	Split system and single package	11.0 EER 11.2 IEER
	≥240,000 Btu/h and <760,000 Btu/h	Split system and single package	10.0 EER 9.7 IPLV
	≥760,000 Btu/h	Split system and single package	9.7 EER 9.4 IPLV
Heat Pumps, Air cooled (Heating mode)	< 65,000 Btu/h (cooling capacity)	Split system	7.7 HSPF
		Single package	7.7 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

32 IECC 2009

[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 29.

Table 29: 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[33]	1,033	1,109	1,213	617

[33] 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.

Heating EFLH values are shown in Table 30. 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 30.

Table 30: 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[34]	339	179	178	450

[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

3.6.4 Demand Savings Estimation

Peak 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 31

Other parameters are as defined above for energy savings.

For units only rated in SEER, SEER will need to be converted to EER using the formula:[35]

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

Coincidence factors are shown in Table 31. 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 31: 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

[35] Code specified SEER values converted to EER using EER = -0.02 x SEER2 + 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
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[36]	0.34	0.38	0.29	0.34

3.6.5 Non-energy Benefits

Well-designed HVAC systems increase occupant comfort and productivity.

3.6.6 Measure Life

Measure Life for packaged AC is 15 years.[37]

3.6.7 Incremental Cost

The incremental cost for this measure is the incremental cost over a standard system. Costs are shown in Table 32.[38]

Table 32: 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

[36] 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

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

[38] 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 33, Table 34, and Table 35 do NOT include the Fuel% or ISR parameters.

Table 33: Gas Savings (in 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	3.42	8.02	103.14
Health patient shower	7.07	4.04	5.85	3.34	5.99	2.56	6.01	4.58
Employee shower	5.30	3.03	4.39	2.51	4.49	4.75	11.13	3.43
Hospitality	9.82	5.61	8.12	4.64	8.31	4.10	9.61	6.36
Other commercial shower	8.47	4.84	7.01	4.01	7.18	2.78	6.53	5.49

Table 34: Energy Savings (in 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 35: Demand Savings (in 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).[39] The basic equation for water heating energy used is:

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

where:

Svgs	=	Annual energy savings, therms or kWh
FlowPre	=	Baseline flow rate, gpm, see table
FlowPost	=	Measure flow rate, gpm, see table
$Temp_{Usage}$	=	Temperature of water coming out of showerhead, see table
$Temp_{Cold}$	=	Temperature of inlet water, see table
TimeOfUse	=	Annual time shower is used, minutes, see below
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
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.[40]
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 0.98[41]

[39] http://rtf.nwcouncil.org/measures/com/ComDHWShowerhead_v3_0.xlsm , 2015.

[40] US Energy Information Administration. https://www.eia.gov/consumption/commercial/data/2012/bc/cfm/b31.php The split considered for the Mountain West region in the table.

[41] Illinois Technical Reference Manual, measure 4.3.3

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

Table 36: Commercial showerhead parameters

Parameter	Value	
TimeOfUse (minutes per year)	Hospitality[42,43]	3,509
	Health Care[44]	2,528
	Commercial - Employee Shower[45]	1,894
	School[46]	2,057
	Any Commercial Except Fitness Center	3,029
	Fitness Center[47]	56,893
Water Heating Efficiency	Electric	98%
	Gas	80%
Temperature Usage (°F)	101°F[48]	
Temperature Cold (°F)	Table 8	
FlowPre (gpm)	2.2 [49]	

42 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 the appendix D: http://www.pacinst.org/reports/urban_usage/appendix_d.pdf

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

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

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

46 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.

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

48 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

49 Baseline: Median observed flow rate in 2007 SCL study. Median used instead of mean because study include 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)[50]	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 below.
CF	= Coincidence factor for electric load reduction, 0.0278[51]

3.7.5 Non-energy Benefits

Water savings are calculated as part of the energy savings equation and are shown in the table below.

Table 37: 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

[50] Ibid

[51] 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

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.[52]

3.7.7 Incremental Cost

The incremental cost for this measure is the total measure cost. Costs are shown below.

Table 38: Commercial Showerhead Water Savings

Retail[53]	$7.00
Direct Install[54]	$11.34
Mail-by-Request[55]	$8.11

52 RTF

53 State of Illinois Energy Efficiency Technical Reference Manual, 2012

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

55 $6 (2012$) 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 the following table.

Table 39: 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 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 from both the decrease in 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:

DP_{meas} = Measured dewpoint temperature inside the store.

$AllOFF_{SetPoint}$ = Low end of the humidity scale where heaters are not needed (0% duty cycle).

$AllON_{SetPoint}$ = 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 72F supermarket.

$AllOFF_{SetPoint}$ = 42.89F DP (35% RH)

$AllON_{SetPoint}$ = 52.87F DP (50% RH)

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

$$DP_{meas} = 0.005379 \times T_{dp\text{-}out}^2 + 0.171795 \times T_{dp\text{-}out} + 19.87006$$ [56]

Where:

$T_{dp\text{-}out}$ = outdoor dew point [57]

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

[57] 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:

$$kW_{ASH} = (0.37A/ft)(115V) = 0.04255kW/ft$$ [58]

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.

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

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

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

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, it 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.[59] The cooling load contribution from ASH is given by:

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

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%).

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

[59] 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.[60]

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

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	= -0.020187240339536
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
i	= -0.0214774331896676
j	= 0.000938305518020252

$Db_{adj,}$[61] SCT, and the resulting EER for each climate zone are shown in the table below.

[60] 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 compressor.

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

Table 40: 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 from 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.:

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

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

None.

3.8.6 Measure Life

Measure Life for this measure is 12 years.[62]

3.8.7 Incremental Cost

The incremental cost for this measure is the total measure cost. Wisconsin Focus on Energy lists new ASH controllers installed cost at $85 per door. Doors are typically 2.5 feet wide, giving a cost of approximately $34 per linear foot.[63]

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

[63] Anti-Sweat Heater Controls Technical Data Sheet. Wisconsin Focus on Energy. 2004. http://www.focusonenergy.com/data/common/pageBuilderFiles/AntiSweatTDS3429.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 the following table.

Table 41: 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 based on the following:

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

Where:

$kW_{baseline}$ = Connected load of a typical reach-in cooler or freezer door with a heater. The values shown in the table below are based on a range of wattages from two manufacturers and metered data. [64]

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 heat generated by door enters the refrigerated case.

The values shown in the table below are based on the average of standard compressor efficiencies with the listed Saturated Suction Temperatures and a condensing temperature of 90°F. [65]

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

Table 42: 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	-20F	2.0	1.30
Medium-Temp Cooler	0.075	20F	3.5	1.20
High-Temp Cooler	0.075	45F	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

None.

3.9.6 Measure Life

The lifetime of a zero-energy door is expected to be 10 years.[66]

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

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

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

3.9.7 Incremental Cost

The incremental cost for this measure is the total measure cost: $275 for coolers, $800 for freezers.[67]

[67] 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 the following table:

Table 43: 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.[68]

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.[69]

3.10.5 Non-energy Benefits

None.

3.10.6 Measure Life

The lifetime of Guest Room EM is expected to be 15 years.[70]

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.[71]

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[68] 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.

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

[70] Deer 2008 value for energy management systems.

[71] 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 44: 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 45: 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 46: 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 47: Energy Savings for commercial style, Et rated, water heaters, therms per kBtuh per year, part 2

Storage, greater than 75 kBtuh	Mtl	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	**Mtl**	**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)[72] 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).[73] 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).[74] 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),[75] 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.

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

72 Deeresources.com, accessed on Oct 6, 2015 with READi version 2.3.0.

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

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

75 Southern California Gas Company, Workpaper WPSCGNRWH120206B Revision 3 Tankless Water Heaters, 2012

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%.

3.11.4 Non-energy Benefits

None

3.11.5 Measure Life

The lifetime of storage water heaters is 15 years.[76] The lifetime for instantaneous water heaters is 20 years.[77]

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 48: 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 1 (Energy Star) EF=0.67[78]	$7.22
CEE Tier 2 EF=0.8[79]	$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 1 EF=0.82[80]	$0.94
CEE Tier 2 (Energy Star) EF=0.9[63]	$3.44
Commercial water heaters, thermal efficiency (Et) rated	
Storage, greater than 75 kBtuh	

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

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

[78] SCG Workpaper

[79] TecMarket Works, Indiana Technical Resource Manual Version 1.0, 2013

[80] SCG Workpaper

CEE Tier 1 Et=0.9[81]	$7.97
CEE Tier 2 (Energy Star) Et=0.94	$7.97
Instantaneous	
CEE Tier 1 Et=0.9	$3.01
CEE Tier 2 (Energy Star) Et=0.94[63]	$12.55

[81] Online: http://www.supplyhouse.com/AO-Smith-Commercial-Water-Heaters-1249000

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 1) Supply Fan 2) Return Fan 3) Chilled water pump (central plant) 4) Hot water pump (central plant) 5) Cooling tower fan (central plant) 6) Water source heat pump (WSHP) circulation pump

3.12.2 Savings

Annual energy savings are shown in the following table, per unit horsepower.

Table 49: 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 the following table, per unit horsepower.

Table 50: 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	0.220	0.179	0.249	0.259
Hot Water Pumps	0.089	0.094	0.085	0.083
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.[82] 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

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

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 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:

$Svgs_{NM}$	=	Annual energy or demand savings, in kWh or kW
DD_{NM}	=	Degree-days (base 65) for the New Mexico climate zone, either heating or cooling
DD_{NE}	=	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%
$Svgs_{NE}$	=	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,[83] 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

Demand savings are estimated with the formula shown above. They are based on the NEEP demand savings values, and an adjustment is made for New Mexico climate zones using the same weighting factor and degree-day ratios. In addition, a demand savings value for the cooling tower fan application is taken straight from the Indiana TRM.

3.12.5 Non-energy Benefits

There are no non-energy benefits.

[83] 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.[84]

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.[85] For motors larger than 20 HP, costs should be on a per-site basis.

Table 51: 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

[84] DEER 2014

[85] Vermont Energy Investment Corp, State of Ohio Energy Efficiency Technical Reference Manual, 2010

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.

All gas savings for a boiler improvement are tabulated by climate, improvement type, building type, and climate zone. For multifamily boilers, refer to the residential boiler measures. Gas savings are in therms per thousand Btu per hour boiler capacity (kBtuh).

Table 52: Savings for Water Boiler 300 to 2500 kBtuh – Albuquerque (Therms/kBtuh)

	Commercial Typical[86]	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

[86] 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 53: Savings for Water Boiler 300 to 2500 kBtuh – Roswell (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	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

[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 – Santa Fe (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	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

[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 – Las Cruces (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	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

[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 Greater than 2500 kBtuh – Albuquerque (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, 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	3.66	1.81	1.50	2.18	9.10	3.24	0.49	4.79	1.30	0.92	1.28

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).

reset from 115 to 140 F											
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

Table 57: Savings for Water Boiler Greater than 2500 kBtuh – Roswell (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	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

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 – Santa Fe (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	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

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 – Las Cruces (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	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

[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 Less than 300 kBtuh – Albuquerque (Therms/kBtuh)

	Commercial Typical[94]	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

[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 – Roswell (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	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	1.31	0.89	0.89	1.07	5.37	2.57	0.24	2.10	0.86	0.53	0.64

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).

reset from 140 to 165 F

Table 62: Savings for Water Boiler Less than 300 kBtuh – Santa Fe (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	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	3.48	1.82	1.45	2.22	8.80	3.00	0.56	4.29	1.34	0.91	1.26

[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).

reset from 115 to 140 F											
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

Table 63: Savings for Water Boiler Less than 300 kBtuh – Las Cruces (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	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	1.54	1.02	1.03	1.23	7.15	3.13	0.33	2.53	1.03	0.61	0.72

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).

reset from 115 to 140 F											
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

Table 64: Savings for Steam Boiler – Albuquerque (Therms/kBtuh)

	Commercial Typical[98]	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

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 – Roswell (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	1.04	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

[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 – Santa Fe (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	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

[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 – Las Cruces (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	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

3.13.3 Energy Savings Estimation

Energy Savings are taken from DEER 2016 simulation data for commercial water and steam boilers with federally established baseline efficiencies.[102] The data from the CA

[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).

[102] 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.[103] TMY 3 data for New Mexico climate zones were used.

$$\Delta Therms/KBtuh_{Climate\ Adjusted\ Heating} = \Delta Therms/KBtuh_{Baseline\ Climate\ Heating}\frac{HDD_{Target\ Climate}}{HDD_{Baseline\ Climate}}$$

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.[104] DEER data was filtered to only include information from the most similar climate zone for heating.

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[105]

3.13.7 Incremental Cost

Table 68: Incremental Boiler Costs[106]

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

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

[104] 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". ftp://ftp2.cpuc.ca.gov/PG&E20150130ResponseToA1312012Ruling/2013/07/SB_GT&S_0882437.pdf

[105] DEER 2014 EUL Table

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

<=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 the following table.

Table 69: 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.[107] 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 70: 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 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.

Table 71: 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%

[107] http://rtf.nwcouncil.org/measures/com/ComGroceryWalkinECM_v2_1.xlsm

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 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 72: 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.[108] 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

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

an ECM and SP installation. In an early replacement, the cost is the full cost of an ECM installation.

Table 73: Incremental cost for walk-in ECM's

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

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 the following table.

Table 74: 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.[109] The RTF relied on data from the Energy Smart Grocer (ESG) program of Portland Energy Conservation, Inc. (PECI). ESG audit data 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 75: 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 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 below, Btu/Wh

[109] http://rtf.nwcouncil.org/measures/com/ComGroceryDisplayCaseECMs_v3.xlsm

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

3.15.4 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 77: 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 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:[110]

- 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

[110] 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

3.16.2 Savings

Baseline efficiency levels for chillers are provided in Table 78 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 reference the 2009 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 78: Baseline Efficiencies for ROB and NC Air-Cooled and Water-Cooled Chillers[111]

System Type [Efficiency Units]		Efficiency Type	Capacity [Tons]	Path A		Path B	
				Full-Load	IPLV	Full-Load	IPLV
Air-Cooled Chiller		EER	< 150	≥ 9.562	≥ 12.500	--	--
			≥ 150	≥ 9.562	≥ 12.750	--	--
Water-Cooled Chiller	Screw/ Scroll/ Recip.	kW/ton	< 75	≤ 0.780	≤ 0.630	≤ 0.800	≤ 0.600
			≥ 75 and < 150	≤ 0.775	≤ 0.615	≤ 0.790	≤ 0.586
			≥ 150 and < 300	≤ 0.680	≤ 0.580	≤ 0.718	≤ 0.540
			≥ 300	≤ 0.620	≤ 0.540	≤ 0.639	≤ 0.490
	Centrifugal		< 150	≤ 0.634	≤ 0.596	≤ 0.639	≤ 0.450
			≥ 150 and < 300	≤ 0.634	≤ 0.596	≤ 0.639	≤ 0.450
			≥ 300 and < 600	≤ 0.576	≤ 0.549	≤ 0.600	≤ 0.400
			≥ 600	≤ 0.570	≤ 0.539	≤ 0.590	≤ 0.400

Chillers must exceed the minimum efficiencies specified in Table 78 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

[111] IECC 2009 Table C503.2.3(7).

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.[112]

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.

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

3.16.3 Energy Savings Estimation

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

Equation 9

Where:

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

$Cap_{C,pre}$ = 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

$IPLV_{baseline,C}$ = 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 78)

$IPLV_{installed,C}$ = 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 78)

$EFLH_{C-pre}$ = 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 79* through *Table 82*)

$EFLH_{C-post}$ = Cooling equivalent full-load hours for newly installed equipment based on appropriate climate zone, building type, and equipment type; [hours] (See *Table 79* through *Table 82*)

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:

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

Equation 10

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

Equation 11

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:

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

Equation 12

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

Equation 13

Table 79: 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[113]	Other	0.40	280	0.49	412

Table 80: 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

[113] 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

Building Type	Principal Building Activity	Chiller			
		Air Cooled		Water Cooled	
		CF	EFLHc	CF	EFLHc
	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[114]	Other	0.59	428	0.55	562

Table 81: 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

[114] 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

Other[115]	Other	0.53	391	0.49	513

115 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 82: 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[116]	Other	0.26	166	0.32	245

3.16.4 Demand Savings Estimation

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

Equation 14

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)

CF_{post} = Seasonal peak demand factor for newly installed equipment for appropriate climate zone, building type, and equipment type; (See tables above)

116 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

$EER_{baseline,C}$ = 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 78)

$EER_{installed,C}$ = 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 Table 78)

3.16.5 Non-energy Benefits

None.

3.16.6 Measure Life

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

- Screw/Scroll/Reciprocating Chillers–20 years[117]
- Centrifugal Chillers–25 years[118]

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.

[117] 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.

[118] 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 (O3), 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:[119]

- 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

[119] 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.

HP	=	Brake horsepower of boiler feed water pump;
	=	Actual or use 5 HP if unknown[120]
$Conversion\ Factor$	=	Conversion from horsepower to kW; 0.746
$Hours$	=	Actual associated boiler feed water pump hours; 800 hours[121] 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%[122]

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

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

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

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

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

122 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)

$Density$	=	Density of water, 8.33 pounds per gallon
$Constant$	=	Constant, 1 therm/100,000 Btus, or .00029307107 kWh/Btu
$Efficiency$	=	Assumed boiler efficiency, 80%
UF_{Washer}	=	Washer Utilization Factor: Annual pounds of clothes washed per year;
	=	actual, if unknown use 916,150 lbs laundry[123] 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[124]

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

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

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

$\%Hot\ Water_{savings}$ = 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%[125]

Using defaults from above:

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

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

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

123 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.

124 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.

125 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).

3.17.4 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.

3.17.5 Non-energy Benefits

None.

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.[126]

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.[127]

[126] Based on data presented in Illinois TRM v7.0 (confirmed via vendor interviews)

[127] In the Illinois TRM v7.0, 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) 2009 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 (0.16 x 20) sq. ft. x (127.5 – 61.6) °F x 1/0.80 x 8760 hours x 1/(100,000 BTU/Therm)

= 6.8 Therms

3.18.3 Energy Savings Estimation

Hot water pipe insulation energy savings are calculated using the formula:

Energy Savings per Year:

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

Where:

U_{Pre}[128] = 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_{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.

Table 83: Pipe Surface Area and Pipe Diameter

Pipe Diameter (inches)	Pipe Surface Area (sq. ft.)
0.5	0.16 * Pipe Length Insulated (in feet)
0.75	0.23 * Pipe Length Insulated (in feet)
1.0	0.29 * Pipe Length Insulated (in feet)

T_{Pipe} = Average temperature of the heated water in the pipe, use 127.5 °F[129]

$T_{Ambient}$ = Average annual temperature, use table below

[128] 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.

[129] 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 84: Annual Ambient Temperature for Unconditioned and Conditioned Spaces

Climate Zone	$T_{ambient}$ (Unconditioned) [130]	$T_{ambient}$ (Conditioned)
Albuquerque	61.6°F	72.0 °F[131]
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

Tank insulation demand savings (kW, only for electric and heat pump water heater):

$$Demand\ Savings = \frac{Annual\ Energy\ Savings}{8760}$$

130 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.

131 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

3.18.5 Non-energy Benefits

None

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.[132]

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[133] including material and installation.

[132] 2014 California Database for Energy Efficiency Resources. http://www.deeresources.com/index.php/deer2013-update-for-2014-codes

[133] 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 sped 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.[134] 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.[135] 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:

[134] 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

[135] 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

Energy star pool pump (capacity = 2 HP) is installed in place of standard efficiency single speed pool pump.

$kWh_{conventional}$ = 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 85: Conventional Pool Pumps Assumptions[136]

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 86: ENERGYSTAR Pool Pumps Assumptions[137]

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

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

[137] 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)

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

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

$hours_{HS}$ = 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

Table 87: 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

None

3.19.6 Measure Life

According to DEER 2014, the Estimated Useful Life for this measure is 10 years.[138]

3.19.7 Incremental Cost

For Multi-Speed Pumps, incremental cost is assumed to be $235 and $549 for Variable Speed Pumps.[139]

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[138] Database for Energy Efficient Resources (2014). http://www.deeresources.com/

[139] 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, 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,[140] 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

[140] 10 CFR 430.32(b)

3.20.2 Savings

Table 88 provides 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 88: Minimum Efficiency Levels for PTAC/PTHP ROB and NC Units[141,142]

Equipment	Category	Cooling Capacity [Btuh]	Minimum Cooling Efficiency [EER]	Minimum Heating Efficiency [COP]
PTAC	Standard Size	<7,000	11.7	--
		7,000-15,000	$13.8 - \left(0.300 \times \frac{\text{Cap}}{1000}\right)$	--
		>15,000	9.3	--
	Non-Standard Size	<7,000	9.4	--
		7,000-15,000	$10.9 - (0.213 \times \text{Cap}/1000)$	--
		>15,000	7.7	--
PTHP	Standard Size	<7,000	11.9	3.3
		7,000-15,000	$14.0 - (0.300 \times \text{Cap}/1000)$	$3.7 - (0.052 \times \text{Cap}/1000)$
		>15,000	9.5	2.9
	Non-Standard Size	<7,000	9.3	2.7
		7,000-15,000	$10.8 - (0.213 \times \text{Cap}/1000)$	$2.9 - (0.026 \times \text{Cap}/1000)$
		>15,000	7.6	2.5

141 10 CFR 431.97(c)

142 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 89 reflects the federal standards for Room Air Conditioners specified in 10 CFR 430.32(b).

Table 89: Minimum Efficiency Levels for Room Air Conditioners ROB and NC Units[143]

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 88 and Table 89. 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).

143 10 CFR 430.32(b)

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 values are derived from the values listed for measure **Error! Reference source not found.** 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 for measure **Error! Reference source not found.** 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 school 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 [$kW_{Savings}$] = (20,000 Btuh/9.3 – 20,000 Btuh/10.4) x 0.54 x 1 kW/1000 W

= 0.133 kW

3.20.3 Energy Savings Estimation

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

Equation 15

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

Equation 16

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

Equation 17

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 88 and Table 89)

$\eta_{baseline,H}$ = Heating efficiency of standard baseline equipment [COP] (See Table 88 and Table 89)

$\eta_{installed,C}$ = Rated cooling efficiency of the newly installed equipment [EER or CEER, Btu/W-h]) (Must exceed minimum federal standards from Table 88 and Table 89)

$\eta_{installed,H}$ = Rated heating efficiency of the newly installed equipment [COP] (Must exceed minimum federal standards from Table 88 and Table 89)

$EFLH_{C/H}$ = 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 90: 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[144]	958	1,123	1,228	572

Table 91: 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

[144] 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.

Storage - Conditioned	0	0	0	0
Warehouse - Refrigerated	0	0	0	0
Other[145]	156	119	118	207

Table 92: 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[146]	0.30	0.37	0.28	0.30

[145] 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.

[146] 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.

3.20.4 Demand Savings Estimation

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

Equation 18

Where:

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

3.20.5 Non-energy Benefits

n/a

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).[147]

3.20.7 Incremental Cost

The incremental cost is estimated to be $84/ton.[148]

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[147] 2014 California Database for Energy Efficiency Resources. http://www.deeresources.com/index.php/deer2013-update-for-2014-codes.

[148] 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

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,[149] 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 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.

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.

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.

[149] 10 CFR 431.296

Table 93: 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

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 - Large	51	835	1,019	799	755	976	958
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 94: Deemed 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 95: 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

	Manufactured before 3/27/2017				Manufactured on or after 3/27/2017			
Building Type	**Under Counter**	**Single Door**	**Double Door**	**Triple Door**	**Under Counter**	**Single Door**	**Double Door**	**Triple Door**
Education - University	1,013	1,387	1,922	2,672	415	727	1,173	1,798
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 96: Deemed Vending Machine Demand Savings (kW/yr per Vending Machine)

	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
0.0007	0.0134	0.0165	0.0128	0.0121	0.0158	0.0155

Table 97: 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 and SCE17CS005.0 Beverage Merchandise Controller. 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. For example, in a small office the DEER2017 occupancy sensor-based lighting effective full load operating hours is 1,760 hours, therefore the time the vending machine control would turn the internal lights off would be

8,760 hours minus 1,760 hours, resulting in 7,000 hours of off time. See Equation 19 below for the general form.

Equation 19

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

Sensor hours by building type are as follows:[150]

Table 98: 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
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

[150] Derived from SDG&E workpaper WPSDGEENRCS0001

Building Type	OccSnsrBldgHrs
Storage - Unconditioned	1,870
Warehouse - Refrigerated	4,470

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

The logic for the interior display lighting the backlit display will be calculated with the same strategy as the interior display light. The only deviation will be the wattage controlled. According to E Source tech Update TU-96-7,[151] the typical backlit display for a cooled beverage vending machine consists of two 5-foot linear fluorescent lamps. For 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.

(3) Energy savings for the reduction in refrigeration time for federally-defined 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.[152] The Federal Energy Management Program (FEMP) used a 21 ft^3 refrigerated volume when calculating efficient vending machine savings,.[153]and the savings for this measure are based on this volume.

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

[152] 10 CFR 431.296

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

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

Maximum Daily Energy Consumption (kWh)=3.715 kWh

Maximum Power (kW)=3.715 kWh / 24 hr

Maximum Power (kW)=0.155 kW

Class B

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

Maximum Daily Energy Consumption (kWh)=4.693 kWh

Maximum Power (kW)=0.196 kW

Vending machines manufactured on or after January 8, 2019:

Class A

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

Maximum Daily Energy Consumption (kWh)=3.522 kWh

Maximum Power (kW)=0.147 kW

Class B

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

Maximum Daily Energy Consumption (kWh)=3.292 kWh

Maximum Power (kW)=.0137 kW

Combination A

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

Maximum Daily Energy Consumption (kWh)=4.466 kWh

Maximum Power (kW)=0.186 kW

Combination B

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

Maximum Daily Energy Consumption (kWh)=4.371 kWh

Maximum Power (kW)=0.182 kW

For merchandise cooler, the base case energy usage is established using the federal standards for commercial refrigerators.[154] 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

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

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[154] 10 CFR 431.66

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).[155] Therefore, the amount of time the refrigeration system will be automatically turned on is calculated as follows:

Auto-On Hours = [(8,760 – OccSnsrBldgHrs) / (1.5 hours + 0.4 hours)] x 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:

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:

$$kW_{Savings} = \left(kW_{Lighting} + kW_{Refrigeration}\right) x\ DSF$$

Where

kWSavings	=	Peak demand savings, kW
kWLighting	=	Connected lighting load, kW
		0.009 kW for uncooled machines

[155] Based on the Vending Miser savings calculator created by Sanders and Associates: http://www.vendingenergymisers.com/documents/calculator.xlsx

		0.024 kW for refrigerated vending machines others
		0 kW for merchandise coolers
kWRefrigeration	=	Maximum refrigeration power, kW
		0 kW for uncooled
		Vending Machines before 1/8/2019:
		0.155 kW for Class A
		0.196 kW for Class B
		Vending Machines on or after 1/8/2019:
		0.147 kW for Class A
		0.137 kW for Class B
		0.186 kW for Combination A
		0.182 kW for Combination B
		Coolers before 3/27/2017:
		0.189 for Under Counter
		0.259 for Single Door
		0.359 for Double Door
		0.499 for Triple Door
		Coolers on or after 3/27/2017:
		0.078 for Under Counter
		0.136 for Single Door
		0.219 for Double Door
		0.336 for Triple Door
DSF	=	Demand Savings Factor, 0.075 [156]

3.21.5 Non-energy Benefits

None.

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).[157]

[156] Arkansas TRM v7.0

[157] 2014 California Database for Energy Efficiency Resources. http://www.deeresources.com/index.php/deer2013-update-for 2014-codes.

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:[158]

- Uncooled Vending Machine Controls: $239.72
- Refrigerated Vending Machine Controls: $267.57
- Merchandise Cooler Controls: $248.36

[158] SCE17CS005.0 Beverage Merchandise Controller & 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 101. 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.[159] The method estimates reduction in solar heat gain/insolation

[159] See, for example, section 5.4 of the Equipment Efficiency Standards Appendices to the AEP companies' 2013 Commercial & Industrial Standard Offer Program Manual. Online. Available: http://www.aepefficiency.com/cisop/downloads/2013_C&I_SOP_Appendices.pdf

attributable to a given window treatment using shading coefficients for 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

$$Energy\ Savings = \sum(Cooling\ Energy\ Savings_o + Heating\ Energy\ Savings_o)$$ [160]

Equation 20

$$Cooling\ Energy\ Savings_o = \frac{A_{film,o} \times Cooling\ SHG_o \times (SC_{pre,o} - SC_{post,o})}{Cooling\ Efficiency_{PL} \times 1{,}000}$$

Equation 21

$$Heating\ Energy\ Savings_o = -\left(\frac{A_{film,o} \times Heating\ SHG_o \times (SC_{pre,o} - SC_{post,o})}{Heating\ Efficiency \times Heating\ Conversion}\right)$$

Equation 22

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 [ft2]

$Cooling\ SHG_o$ = Cooling season solar heat gain for orientation of interest [Btu/ft2-year].

See *Table 99*

$SC_{pre,o}$ = Shading coefficient for existing glass/interior-shading device.

See *Table 101***Error! Reference source not found.**

$SC_{post,o}$ = 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[161]

[160] 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.

[161] Weighted average of HVAC cooling part load system efficiency of commercial buildings in the DEER 2008 database

1,000	=	Conversion factor [W/kW]
$Heating\ SHG_o$	=	Heating season solar heat gain for orientation of interest [Btu/ft2-year]. See Table 100
$Heating\ Efficiency$	=	Average heating efficiency of commercial and industrial spaces, Assumed to be 3.2 COP for electric heat and 80% for gas heat[162]
$Heating\ Conversion$	=	Conversion factor based on units of Heating Efficiency For gas heat, 100,000 Btu/therm For electric heat COP, 3,412 Btu/kWh

Table 99: Cooling Season Solar Heat Gain Factors[163]

	Cooling Solar Heat Gain [Btu/ft^2-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
West	133,326	139,363	137,442	127,718
North-West	93,741	100,581	99,132	91,707

[162] Weighted average of HVAC heating system efficiency of commercial buildings in the DEER 2008 database

[163] 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.

Table 100: Heating Season Solar Heat Gain Factors[164]

	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 101: Recommended Shading Coefficient (SC) for Different Pre-Existing Shade Types

Shading Type	Shading Coefficient[165]	Source[166]
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 Weave	0.56	Table 13G: Based on ID 1b, Medium Closed Weave
Double-Pane - None	0.80	Table 10: Based on ¼” clear double-pane glass (ID

164 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.

165 For shading devices, IAC is multiplied by unshaded SC to determine listed shading coefficient.

166 Table numbers and shading coefficients provided are from 2009 ASHRAE Fundamentals Handbook, Chapter 15.

		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

$$Peak\ Demand\ Savings\ [kW] = DemandSaving_{o,max}$$

Equation 23

$$Demand\ Savings_o\ [kW] = \frac{A_{film,o} \times Peak\ SHG_o \times (SC_{pre,o} - SC_{post,o})}{1000 \times Cooling\ Efficiency_{FL}}$$

Equation 24

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 SHGo = Peak solar heat gain factor for orientation of interest [Btu/hr-ft2-year]. See Table 102*: Peak Hourly Solar Heat Gain Factors*

Cooling $Efficiency_{FL}$ = Average cooling full load efficiency of commercial and industrial spaces; assumed to be 10.17 EER[167]

[167] Weighted average of HVAC cooling full load system efficiency of commercial buildings in the DEER 2008 database

Table 102: Peak Hourly Solar Heat Gain Factors[168]

	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
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

None.

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).[169]

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.

168 Values are derived using NREL's PV

169 2014 California Database for Energy Efficiency Resources. http://www.deeresources.com/index.php/deer2013-update-for-2014-codes.

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 105, Table 106, Table 107, and Table 108. 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 ENERGY STAR® specifications. 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[170]
- An initial solar reflectance of greater than or equal to 65%

[170] As defined in proposed ASTN Standard E 1918-97.

- A maintenance of solar reflectance of greater than or equal to 50% three years after installation under normal conditions
- 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 the ENERGY STAR® list of qualified products.[171]

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.[172]

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 103: 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.

[171] ENERGY STAR® Certified Roofs. http://www.energystar.gov/productfinder/product/certified-roof-products/. Accessed 08/10/2018.

[172] 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 ENERGY STAR® material 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 an ENERGY STAR® material 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 101 to estimate the R-value based on the year of construction.

Table 104: Estimated R-value based on Year of Construction

Year of Construction	Estimated R-value[173]
Before 2011	R ≤ 13
2011 and later	13 > R ≤ 20

[173] Estimates R-values are based on applicable code requirements in the year of construction.

Table 105: Albuquerque Savings Factors

Building Type[174]	Pre R-Value	Post R-Value	ESF (kWh/SF)	PSDF (10^{-5} kW/SF)
Retail	R ≤ 13	R ≤ 13	0.76	19.84
	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

[174] Building types are derived from the US Energy Information Administration (EIA) Commercial Building Energy Consumption Survey (CBECS).

Building Type[174]	Pre R-Value	Post R-Value	ESF (kWh/SF)	PSDF (10^{-5} kW/SF)
	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
	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 106: 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

Building Type	Pre R-Value	Post R-Value	ESF (kWh/SF)	PSDF (10^{-5} kW/SF)
	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
	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

Building Type	Pre R-Value	Post R-Value	ESF (kWh/SF)	PSDF (10^{-5} kW/SF)
	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
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 107: 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

Building Type	Pre R-Value	Post R-Value	ESF (kWh/SF)	PSDF (10^{-5} kW/SF)
	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
	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

Building Type	Pre R-Value	Post R-Value	ESF (kWh/SF)	PSDF (10^{-5} kW/SF)
	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 108: 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
	R ≤ 13	R ≤ 13	0.21	6.64

Building Type	Pre R-Value	Post R-Value	ESF (kWh/SF)	PSDF (10^{-5} kW/SF)
Office - Chiller	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
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 is 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:

$$Energy\ Savings = Roof\ Area \times ESF$$

Equation 25

Where:

Roof Area	=	Total area of Energy Star® 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:

$$Peak\ Summer\ Demand\ Savings = Roof\ Area \times PSDF \times 10^{-5}$$

Equation 26

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

None.

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).[175]

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.

[175] 2014 California Database for Energy Efficiency Resources. http://www.deeresources.com/index.php/deer2013-update-for-2014-codes.

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[176]: • Albuquerque: R-38 • Santa Fe: R-38 • Roswell: R-30 • Las Cruces: R-30
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. The better the R-value of the insulation being installed, higher the savings achieved.

Projects may claim heating energy savings even if cooling energy savings are not claimed e.g. in the case of homes with evaporative cooling.

[176] IECC 2009 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:

$$\Delta kWh_{Cooling} = \frac{\left(\frac{1}{R_{Old}} - \frac{1}{R_{New}}\right) * A_{Ceiling} * \left(1 - FF_{Ceiling}\right) * CDD * 24}{1000 * \eta_{Cooling}}$$

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%[177]

CDD = Cooling Degree Days, as listed in Table 107

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 109:

Table 109: 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

[177] 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:

$$\Delta kWh_{Heating} = \frac{\left(\frac{1}{R_{Old}} - \frac{1}{R_{New}}\right) * A_{Ceiling} * (1 - FF_{Ceiling}) * HDD * 24}{1000 * \eta_{Heating}}$$

HDD = Heating Degree Days, as listed in Table 107

Table 110: 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

Where:

$\eta_{Heating}$ = Efficiency of heating system (kBtu/kWh)

= Nameplate ratings wherever possible, if unavailable use the following efficiencies listed in Table 111

Table 111: 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:

$$\Delta therms_{Heating} = \frac{\left(\frac{1}{R_{Old}} - \frac{1}{R_{New}}\right) * A_{Ceiling} * (1 - FF_{Ceiling}) * HDD * 24}{10^5 * \eta_{Heating}}$$

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.[178]

$$Peak\ Demand\ Savings = \frac{\Delta kWh_{Cooling}}{EFLH_{Cool}} * CF$$

where:

$Peak\ Demand\ Savings$	=	Summer peak kW savings, kW
$\Delta kWh_{Cooling}$	=	Cooling energy savings, kWh
$EFLH_{Cool}$	=	Effective Full Load Cooling Hours, Table 112.

[178] Based on ADM ceiling insulation calculator spreadsheet

Table 112: 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[179]

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.[180]

4.1.7 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.[181]

[179] 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

[180] US Department of Energy, WPN 19-4: Revised Energy Audit Approval Procedures, Related Audit, and Material Approvals, Attachment 9, January 17, 2019.

[181] Public Service Company of New Mexico Commercial & Industrial Incentive Program Work Papers, 2011.

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 113 and Table 114 do NOT include the Fuel% or ISR parameters.

Table 113: 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 114: 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.[182]

$$Svgs = (Pre_F - Post_F) \times (TempUsage - TempCold) \times Mins \times HtrEnergy \text{ x } Fuel\% \text{ x } ISR \quad (27)$$

where:

Svgs = Annual energy savings, in therms

PreF = Baseline flow rate, nominal flow rate adjusted by an in situ flow percentage (90%), see below Table 115

PostF = Measure flow rate, nominal flow rate adjusted by an in situ flow percentage (90%), see below Table 115

$Temp_{Usage}$ = Temperature of water coming out of showerhead , 101F[183]

$Temp_{Cold}$ = Water heater inlet temperature, refer Table 8

Mins = Annual minutes showerhead is used; for single family: 2979.8, for multifamily: 3438.21 . Calculated from data shown in Table 116

HeaterEnergy = 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).

182 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), http://rtf.nwcouncil.org/.

183 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

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[184].

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[185]

Varying parameters are shown in Table 115.

Table 115: 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	
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 116.

184 US Energy Information Administration. https://www.eia.gov/consumption/residential/data/2015/hc/php/hc8.8.php. The fuel use split is considered for West Mountain South Region.

185 El Paso Electric New Mexico LivingWise® Program Summary Report Fall 2017

Table 116: Residential Low-Flow Showerhead Minutes Parameters[186]

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.[187]

Table 117: Residential Low-Flow Showerhead Parameter Sources

Baseline flow rate	10 CFR 430.32(p)
Hot Water %	Percentage hot water is calculated using the heat balance equation considering hot water temperature as 127.5⁰F, cold water from Table 8 and the usage temperature as 101⁰F.
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

[186]As reported in ibid., except persons per residence, which uses data specific for New Mexico households

[187] As reported in ibid. 182, except baseline flow rate.

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 118. Local water and wastewater rates need to be applied to these values to monetize savings.

Table 118: 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.[188]

4.2.7 Incremental Cost

The incremental cost for this measure is the total cost. The cost per direct-installed residential showerhead is $24.[189]

[188] Ibid. 182

[189] Ibid.

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 119 do NOT include the Fuel% or ISR parameters.

Table 119: Residential low-flow faucet aerator savings

Location	Flow	Albuquerque	Las Cruces	Roswell	Santa Fe
In therms					
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.[190]

$$Svgs = \frac{(FlowPre - FlowPost) \times (TempUsage - TempCold) \times Minutes \times Days \times HeatCapacity \times Density \times Const\ X\ Fuel\%\ X\ ISR}{EffDHW} \quad (28)$$

where:

Svgs	= Annual energy savings, in therms
FlowPre	= Baseline flow rate, 2.2 gpm
FlowPost	= Measure flow rate, 0.5, 1.0, or 1.5 gpm
TempUsage	= Temperature of water coming out of aerator, see Table 120
TempCold	= Water heater inlet temperature, refer Table 8
MinutesOf Use	= Minutes per faucet per day faucet is used, 1.59 mins/faucet/day[191]
Days	= Days per year faucet is used, 365

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

[191] 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.

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, 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[192].

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[193]

Table 120: Residential low-flow faucet aerator usage temperatures

Location	Usage Temperature[194]
Kitchen	93.0
Bathroom	86.0

Parameter values are based on the following sources.

Table 121: 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

[192] US Energy Information Administration. https://www.eia.gov/consumption/residential/data/2015/hc/php/hc8.8.php. The fuel use split is considered for West Mountain South Region.

[193] El Paso Electric New Mexico LivingWise® Program Summary Report Fall 2017

[194] 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 93°F and 86°F, 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

	"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 122. Local water and wastewater rates need to be applied to these values to monetize savings.

Table 122: 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.[195]

4.3.7 Incremental Cost

The incremental cost for this measure is the total cost. The cost per direct-installed residential aerator is $10.[196]

195 DEER 2014 EUL Table

196 SBW Consulting, Direct-install program operator, 2013

4.4 Residential Lighting

This measure replaces incandescent 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

4.4.2 Savings

The savings depend on baseline wattage, as shown in Table 123. Tier 1 became effective January 1st, 2014. Tier 2 is effective January 1st, 2020.

Table 123: Residential Lighting Baseline – General Service

Lumen Range	EISA Status	EISA Baseline: 1st Tier (W)	EISA Baseline: 2nd Tier EISA (W)
250-309	Exempt	25	25
310-749	Non-exempt	29	12
750-1,049	Non-exempt	43	20
1,050-1,489	Non-exempt	53	28
1,490-2,600	Non-exempt	72	45
2,601-2,999	Exempt	150	150
3,000-5,279	Exempt	200	200
5,280-6,209	Exempt	300	300

Table 124 details wattage equivalence EISA specifications for reflector lamps. Program administrators should use model-specific wattages within these categorizations.

Table 124: Baseline Wattage – Reflector Lamps

Lamp Type	Pre-EISA Incandescent Equivalent (W)	Baseline Wattage – Post-EISA (W)
PAR20	50	35
PAR30	50	35
R20	50	45
PAR38	60	45
BR30	65	Exempt
BR40	65	Exempt
ER40	65	Exempt
BR40	75	65
BR30	75	65
PAR30	75	55
PAR38	75	55
R30	75	65
R40	75	65
PAR38	90	70
PAR38	120	70
R20	≤ 45	Exempt
BR30	≤ 50	Exempt
BR40	≤ 50	Exempt
ER30	≤ 50	Exempt
ER40	≤ 50	Exempt

There are 22 incandescent lamps exempt from EISA 2007.[197] Wattage for other specialty lamps is detailed in Table 125.

[197] These are listed in listed in the United States Department of *Energy Impact of EISA 2007 on General Service Incandescent Lamps: FACT SHEET*. http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/general_service_incandescent_factsheet.pdf.

Table 125: Baseline Wattage – Other Speciality Lamps

Bulb Type	Lumen Range	Baseline Watts
3-Way	250-449	25
	450-799	40
	800-1,099	60
	1,100-1,599	75
	1,600-1,999	100
	2,000-2,549	125
	2,550-2,999	150
Globe (medium & intermediate base, ≤ 750 lumens)	90-179	10
	1810-249	15
	250-349	25
	350-749	40
Decorative (shapes B, BA, C, CA, DC, F, G, medium base, ≤ 750 lumens)	70-89	10
	90-149	15
	150-299	25
	300-499	40
	500-1,049	60
Globe (Candelabra base, ≤ 1,049 lumens)	90-179	10
	180-249	15
	250-349	25
	350-499	40
	500-1,049	60
Decorative (shapes B, BA, C, CA, DC, F, G, candelabra base, ≤ 1,050 lumens)	70-89	10
	90-149	15
	150-299	25
	300-499	40
	500-1,049	60

The tables above reflect baseline wattages based on the current status of EISA regulations. Originally, the definition of general service lamp was slated to change on January 1, 2020 to expand the covered lumen range (see Table 123) and revise the exempt lamps (see Table 124 and Table 125). However, in Fall 2018, DOE proposed to withdraw the revised definition of general service lamp.[198] The baseline wattages in the above tables assume this proposal will be finalized, and do not expand the covered lumen range or change the list of exempt lamps in 2020. If this proposal is not finalized and the revised definition goes into effect, the TRM will be updated to reflect the revised definition, and the evaluator will work with the utilities to properly account for lifetime savings.

[198] https://www.reginfo.gov/public/do/eAgendaViewRule?pubId=201810&RIN=1904-AE26

4.4.3 Energy Savings Estimation

Savings are calculated per lamp with the following formula.

$$Svgs = (Watts_{Baseline} - Watts_{Efficient})/1000 \times HoursOfUse \times HVAC\_Energy\ Factor \quad (29)$$

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 by the Energy Independence and Security Act of 2007 (EISA), as shown in Table 123, Table 124, and Table 125.

Table 126: HVAC Energy Factor[199]

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		0.88
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	0.701.02	0.89	1.04

199 Values derived from TX TRM values, adjusted based on a comparison of CDD between Texas Cities and New Mexico cities.

Hours of use were derived from the 2011 evaluations of New Mexico programs by ADM Associates.[200] Hours are shown in Table 127. The weighted average hours are based on actual installations in 2011 in New Mexico.

Table 127: 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.[201]

$$Svgs = (Watts_{Baseline} - Watts_{Efficient})/1000 \times CoincidentFactor \times HVAC\_Demand\ Factor \qquad (30)$$

where:

$Svgs$ = Summer peak kW savings

[200] 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.

[201] Coincidence factors were derived from the ADM 2011 evaluations of the New Mexico utilities. ADM cited the KEMA 2009 study and DEER 2008.

$Watts_{Baseline}$ = Baseline Wattage of lamp, as determined from table above

$Watts_{Efficient}$ = 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 128: HVAC Demand Factor[202]

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.

[202] Values derived from TX TRM values, adjusted based on a comparison of CDD between Texas Cities and New Mexico cities.

4.4.6 Measure Life

Table 129: Residential Lighting Measure LIves

Measure	Rated Life	Expected Useful Life
CFL	8,000	5.1
	10,000	6.4[203]
	12,000	7.7
LED		20

Lifetime savings calculations need to account for the changing baseline during the lifetime of the installed lamp. For example, a 14W general service spiral CFL installed in 2016 at Las Cruces with a gas heating in AC would have lifetime savings calculated as follows:

- Total EUL: 6.4 years
- Years under EISA Tier 1: (2020 – 2016) = 4 years
- Years under EISA Tier 2: 6.4 – 4 = 2.4 years

As a result, a 14W CFL rebated in 2016 would have lifetime savings calculated as follows:

- 2.24 hours/day x 365 days/yr. x (43W – 14W) / 1000 W/kW x 4 years x 2.69 = 255.12 kWh
- 2.24 hours/day x 365 days/yr. x (20W – 14W) / 1000 W/kW x 2.4 years x 2.69 = 31.66 kWh
- Total Lifetime Savings: 286.78 kWh

When calculating lifetime savings, utilities may claim the first year savings over a reduced weighted-average measure life, may claim a reduced weighted-average savings over the full measure life, or may explicitly calculate the lifetime savings by considering each baseline as shown above.

203 DEER 2014, using New Mexico average daily hours of use, 10,000 hours rated life, and degradation factor of 0.523.

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 $1.62 per lamp.[204] The CFL/LED cost is determined by the program.

[204] Home Depot Ecovantage average of 29, 43, 72 W, June, 2013.

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.

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.[205]

$$Svgs = (DL_{Baseline} - DL_{Post}) \times 0.77 \times EFLH \times (h_{Out} \times \rho_{Out} - h_{In} \times \rho_{In}) \times 60/(1000 \times SEER) \quad \textbf{(31)}$$

where:

Svgs	=	Annual cooling savings, kWh
$DL_{baseline}$	=	Duct leakage, baseline, measured at 25 Pascals, CFM
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 109:

Table 130: 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

[205] Frontier Associates, Deemed Savings based on El Paso Specific Climate Data, Filing with TX Regulatory Commission, 2012.

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 131. Full-load hours for Albuquerque and Roswell were derived from the Energy Star Calculator for residential air conditioning.[206] 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 131: Residential Full Load Cooling Hours for New Mexico Climate Zones

Location	EFLC
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.[207]

$$Svgs = (DL_{Baseline} - DL_{Post}) \times 0.77 \times HDD \times 24 \times 60 \times 0.018 / (ConvFactor \times Efficiency) \quad (32)$$

where:

$Svgs$ = *Annual heating savings, kWh or therms*

$DL_{baseline}$ = *Duct leakage, baseline, measured at 25 Pascals, CFM*

DL_{post} = *Duct leakage, after installation, measured at 25 Pascals, CFM*

[206] http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=CA

[207] Frontier Associates, Deemed Savings based on El Paso Specific Climate Data, Filing with TX Regulatory Commission, 2012.

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/ft3°F)*

60 = *Conversion factor from minutes to hours*

ConvFactor = *Conversion factor which yields either kWh or therms, see below*

Efficiency = *Heating system efficiency, see below*

Table 132: 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 133.[208]

Table 133: Heating-degree-days for New Mexico Climate Zones

Location	HDD
Albuquerque	4,180
Las Cruces	2,816
Roswell	3,289
Santa Fe	5,417

Equipment and conversion factor depend on the type of heating system, as shown in Table 134.

Table 134: Heating system type conversion factors and efficiencies

Heating System Type	Description	Value
Heat Pump	Adjusted HSPF; Btu to kWh	1,000 x adjusted HSPF

[208] http://www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-datasets/climate-normals

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.[209]

$$adjHSPF = HSPF \times (1 - (0.1392 + (-0.00846 * DTemp) + (-0.0001074 * (DTemp)^{\wedge}2) + (0.0228 * HSPF))) \quad (33)$$

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 135.

Table 135: Residential heating design temperatures for New Mexico locations

Location	Design Temperature (°F)
Albuquerque	18
Las Cruces	20
Roswell	20
Santa Fe	10

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.

$$Svgs = (DL_{Baseline} - DL_{Post}) \times 0.77 \times (h_{Out} \times \rho_{Out} - h_{In} \times \rho_{In}) \times 60/(1000 \times SEER) \times CF \quad (34)$$

where:

Svgs	= Peak cooling savings, kW
CF	= Coincident Factor, 0.87

[209] http://www.fsec.ucf.edu/en/publications/html/fsec-pf-413-04/

The Coincident Factor is derived as follows.[210] 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 Measure Life

The lifetime for this measure is 18 years.[211]

4.5.6 Incremental Cost

The incremental cost for this measure is the full measure cost, $0.24 per square foot.[212]

[210] Frontier Associates, Deemed Savings based on El Paso Specific Climate Data, Filing with TX Regulatory Commission, 2012.

[211] DEER 2008, RTF

[212] RTF; DEEMED SAVINGS TECHNICAL ASSUMPTIONS, Southwestern Public Service Company, Program: Home Energy Services, 2011

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):[213]

Table 136: 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

213 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

Table 137: Baseline Efficiencies for Residential Packaged Terminal Air-Conditioner and Heat Pump

System Type	Manufactured Before January 2006		Manufactured Between January 2015 and 2006	
	SEER	**HSPF**	**SEER**	**HSPF**
Packaged Terminal Air Conditioner (PTAC)	9.7	-	10.6	-

System Type	Manufactured After January 2015	
	SEER[214]	**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)

= 222 kWh

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

$EER_{eff} = -0.02 \times (16)^2 + 1.12 \times 16 = 12.8$

$kW_{Savings}$ = 24000 Btu/hr x 1/1000 x (1/11.76 – 1/12.8) x 0.87

[214] 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 2009).

= 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 138)

$SEER_{base}$ = Seasonal Energy Efficiency Rating of the baseline cooling equipment, use "Manufactured after January 2015" column of (Table 136 & Table 137)

$SEER_{eff}$ = Seasonal Energy Efficiency Rating of the efficient cooling equipment (AHRI Certificate)

Table 138: 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:

1. The estimated remaining life of the equipment that is being removed, designated the Remaining Useful Life (RUL; see Table 139), and

2. The remaining time in the EUL period, i.e. (EUL-RUL)

For Remaining Useful Life (RUL):

$$kWh_{Savings,RUL} = Capacity_{Cool} * \frac{1}{1000} * EFLH_C * \left(\frac{1}{SEER_{existing}} - \frac{1}{SEER_{eff}}\right)$$

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 136)

$SEER_{eff}$ = Seasonal Energy Efficiency Rating of the efficient cooling equipment

(AHRI Certificate)

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

$$kWh_{Savings,EUL-RUL} = Capacity_{Cool} * \frac{1}{1000} * EFLH_C * \left(\frac{1}{SEER_{base}} - \frac{1}{SEER_{eff}}\right) +$$

Hence,

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

Where:

RUL = Remaining Useful Life (Table 139)

EUL = Estimate Useful Life

= 18 Years

Table 139: Remaining Useful Life (Years) of Replaced Air Conditioner Unit[215]

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:[216]

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

Peak demand savings:

$$kW_{Savings} = Capacity_{Cool} * \frac{1}{1000} * \left(\frac{1}{EER_{base}} - \frac{1}{EER_{eff}}\right) * CF$$

[215] 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.

[216] Code specified SEER values converted to EER using EER = -0.02 x SEER2 + 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

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[217]
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)

4.6.5 Non-energy Benefits

Well-designed HVAC systems increase occupant comfort and productivity.

[217] 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

4.6.6 Measure Life

The lifetime for this measure is 18 years.[218]

4.6.7 Incremental Cost

The assumption here is 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 140.[219]

Table 140: High Efficiency Air Conditioner incremental cost per ton cooling capacity

Model	Incremental cost per ton
15 SEER	$119
16 SEER	$238
17 SEER	$357
18 SEER	$477
19 SEER	$596
20 SEER	$715
21 SEER	$789

[218] Texas TRM v6.0 Volume 2: Residential Measure

[219] DEER 2008; online pricing

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 141 for the four New Mexico climate zones.

Table 141: 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 142: 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 Measure Life

The lifetime for this measure is 15 years.[220]

4.7.6 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.[221]

[220] DEER 2008

[221] 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.

$$\Delta \text{kWh}_{Cooling} = \frac{\left(\frac{CFM50exist - CFM50new}{Nfactor}\right) \times 60 \times CDH \times 0.018}{(1000 \times \eta Cool)}$$

where:

$\Delta \text{kWh}_{\text{Cooling}}$	= 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[222]
60	= Constant to convert cubic feet per minute to cubic feet per hour
CDH	= Cooling Degree Hours, see Table 143
0.018	= Volumetric heat capacity of air (Btu/ft3°F)
$\eta Cool$	= Efficiency of Air Conditioning equipment (i.e. SEER rating)

Table 143: Cooling Degree Hours for New Mexico Climate Zones

	Cooling Degree Hours[223] (65°F Reference Temp)
Albuquerque	31,728
Las Cruces	45,600
Roswell	42,936
Santa Fe	15,504

222 Nfactor from methodology developed by the Lawrence Berkeley Laboratory (LBL) for Zone 3 (as defined by LBL), single story, normal exposure.

223 www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-datasets/climate-normals

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.
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[224]
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 144
0.018	= Volumetric heat capacity of air (Btu/ft3°F)
$\eta Heat$	= Heating Equipment Efficiency
	(AFUE or COP; convert HSPF to COP using COP = HSPF/3.412)
$\eta Dist$	= Distribution Efficiency [225] (default = 80%)

[224] Nfactor from methodology developed by the Lawrence Berkeley Laboratory (LBL) for Zone 3 (as defined by LBL), single story, normal exposure.

[225] 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).

29.31 = Constant to convert therms to kWh

Table 144: Heating Degree Days for New Mexico Climate Zones

	Heating Degree Days[226] (65°F Reference Temp)
Albuquerque	4,180
Las Cruces	2,816
Roswell	3,289
Santa Fe	5,417

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.

$$kW = \Delta kWh_{Cooling} / EFLH_{Cooling} \times CF$$

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 145. EFLH for Albuquerque and Roswell were derived from the Energy Star Calculator for residential air conditioning.[227] 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.

[226] www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-datasets/climate-normals

[227] Full Load Hour assumptions taken from the ENERGY STAR calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls)

Table 145: 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.[228] 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.

4.8.5 Measure Life

The estimated useful Life is 11 years for this measure.[229]

4.8.6 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.

[228] Frontier Associates, Deemed Savings based on El Paso Specific Climate Data, Filing with TX Regulatory Commission, 2012.

[229] 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.[230]

[230] The savings below are derived using the average Uniform Energy Factors across the draw patterns.

Table 146: 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

Table 147: 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 148: Gas-fired water heater savings (therms)

Number of Bedrooms	1	2		3		4		5	6
Storage capacity	20	30	40	30	40	40	50	50	50
Gas-fired storage water heater									
Albuquerque	35.2	44.7	69.6	53.7	83.5	75.8	109.2	112.3	126.4
Las Cruces	31.6	46.9	62.5	48.2	75.0	68.0	98.1	100.9	113.5
Roswell	32.0	47.4	63.3	48.8	75.9	68.9	99.3	102.1	114.9
Santa Fe	38.0	56.3	75.1	57.9	90.1	81.8	117.9	121.2	136.4

Instantaneous gas-fired water heater[231]									
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[232]									
Albuquerque	75.2	87.5	126.6	105.0	152.0	137.9	186.9	192.2	216.2
Las Cruces	67.5	78.6	113.7	94.3	136.5	123.8	167.8	172.6	194.2
Roswell	68.4	79.6	115.2	95.5	138.2	125.4	169.9	174.8	196.6
Santa Fe	81.1	94.5	136.7	113.3	164.0	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
UEF_{Base}	=	Baseline uniform energy factor, see below
$UEF_{Measure}$	=	Efficient uniform energy factor, see below

$$EnergyInWater = GallonsPerDay * 365 * Density * C_p * (Temp_{Hot} - Temp_{Cold}) * ConversionConstant$$

where:

EnergyUse	=	Annual energy use due to change in water temperature, kWh or therms

231 These savings are for replacing a baseline instantaneous gas-fried water heater with a high-efficiency instantaneous gas-fired water heater.

232 These savings are for replacing a baseline storage gas-fired water heater with a high-efficiency instantaneous gas-fired water heater.

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[233]
ConversionConstant	=	Converts Btus into kWh or therms: 0.0002932972 kWh/Btu, 0.00001 therms/Btu

Table 149: Daily hot water usage[234]

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.

[233] 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.

[234] 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 150: Baseline UEF for electric and gas-fired water heater[235]

Product Class	Rated Storage Volume	Draw pattern[236]	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

[235] 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

[236] 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 151: Measure UEF for electric and gas fired water heater[237]

Product Class	Rated Storage Volume	Uniform Energy Factor
Electric	≤ 55 gallons	2.00
	> 55 gallons	2.20
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

$Ratio_{Annual\ kWh}^{Peak\ kW}$ = Peak kW to annual energy kWh ratio, 0.0000877[238]

4.9.5 Non-energy Benefits

Higher efficiency water heaters generally have a longer lifespan.

[237] 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

[238] 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 152.[239]

Table 152: 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 153: Residential water heater incremental measure cost[240]

Measure	Incremental cost
Gas storage	$117
Condensing gas storage	$627
Tankless	$547
Electric (HPWH)	$995

[239] 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

[240] 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 residential sized ENERGY STAR-qualified 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 > or = 0.90

4.10.2 Savings

Savings is a function of the as-installed furnace annual fuel utilization efficiency (AFUE). Savings are presented in Table 154 for each of the four New Mexico regions.

Table 154: Gas furnace savings (Therms)

AFUE	Albuquerque	Roswell	Santa Fe	Las Cruces
0.900	53.7	38.7	75.1	33.1
0.905	56.1	40.4	78.4	34.5
0.910	58.5	42.1	81.7	36.0
0.915	60.8	43.8	84.9	37.4
0.920	63.1	45.5	88.1	38.8
0.925	65.4	47.1	91.3	40.2
0.930	67.6	48.7	94.5	41.6
0.935	69.8	50.3	97.6	43.0
0.940	72.0	51.9	100.6	44.3
0.945	74.2	53.5	103.7	45.7
0.950	76.4	55.0	106.7	47.0
0.955	78.5	56.6	109.7	48.3
0.960	80.6	58.1	112.6	49.6
0.965	82.7	59.6	115.5	50.9
0.970	84.8	61.1	118.4	52.2
0.975	86.8	62.6	121.3	53.4
0.980	88.8	64.0	124.1	54.7
0.985	90.8	65.5	126.9	55.9
0.990	92.8	66.9	129.7	57.1

4.10.3 Energy Savings Estimation

Savings are determined with the following equations,

$$Savings = 0.78 * To * \left(\frac{1}{0.80} - \frac{1}{EF_A}\right)$$

where:

Savings = Annual energy savings, therms

T_o = Pre-existing furnace therm consumption, see below

EF_A = As-installed furnace AFUE

$$To = M * HDD + B$$

where:

M, B = Slope and y-intercept, see Table 155

HDD = Heating Degree Days

The slope and y-intercept, M and B respectively, were derived from empirical data as part of an evaluation done for the New Mexico Gas Company in 2011.[241] Table 155 shows the M and B constants for each of the four New Mexico regions. Las Cruces was not included in the NMGCO evaluation; it is assumed here that Roswell is the best representation of Las Cruces.

The 0.78 and 0.80 factors in the above savings equation are necessary in order to adjust the empirically derived pre-existing furnace consumption, for which it is assumed the AFUE was the Federal minimum at the time (0.78) to the new Federal minimum AFUE (0.80).

Table 155: Slope and y-intercept for therm consumption

Equation Component	Albuquerque	Roswell	Santa Fe	Las Cruces
M	0.12	0.11	0.13	0.11
B	-5.6	-4.35	-11.12	-4.35

The Heating Degree Day (HDD) data is provided in Table 156. The HDD data differ from those which can be derived from the evaluation done for New Mexico Gas Company,[242] but they are consistent with the HDD data used elsewhere in this TRM.

Table 156: Heating Degree Days (HDD)

Albuquerque	Roswell	Santa Fe	Las Cruces
4,180	3,289	5,417	2,816

[241] Evaluation of 2011 DSM Portfolio, Submitted to New Mexico Gas Company, June 2012 Final. Prepared by ADM Associates, Inc. Section 4.1, M&V Methodologies, High Efficiency Gas Furnaces.

[242] Excel workbook provided by ADM Associates, Inc. as part of their Evaluation of 2001 DSM Portfolio for New Mexico Gas Company. "NM Furnace Participant Data 2011 - Savings Calcs.xlsx"

4.10.4 Demand Savings Estimation

No demand savings are associated with 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.[243]

4.10.7 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.

Table 157: High efficiency gas furnace incremental measure cost[244]

AFUE (%)	Incremental cost
90	$310
92	$477
94	$657
96	$851

[243] US Department of Energy, WPN 19-4: Revised Energy Audit Approval Procedures, Related Audit, and Material Approvals, Attachment 9, January 17, 2019.

[244] State of Ohio Energy Efficiency Technical Reference Manual, 2010; State of Illinois Energy Efficiency Technical Reference Manual, 2012

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[245]
C_E	= De-rating factor for efficient boiler, 0.941[246]
$EFLH_{CR}$	= 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,

$$EFLH_{CR} = (24 * (\frac{1}{Sizing\ Factor}) * HDD_{CR})/(55 - T_{CR})$$

where:

Sizing Factor	= Sizing factor to account for the difference between net and gross output, given piping losses and initial pickup, 1.15[247]

245 High Efficiency Heating Equipment Impact Evaluation (Cadmus, 2015)

246 Ibid.

247 2016 ASHRAE Handbook – HVAC Systems and Equipment, Chapter 32 Section 5.

HDD_{CR} = Heating Degree Days at base 55°F for the climate zone[248]

T_{CR} = 99% Heating Design Outdoor Air Temperature for the climate zone[249]

Table 155
shows the HDD_{CR}, T_{CR}, and $EFLH_{CR}$ for each of the four New Mexico climate regions.

Table 158: 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

None.

4.11.6 Measure Life

The measure life for this equipment is 20 years.[250]

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.

Table 159: High efficiency gas boiler incremental measure cost[251]

AFUE (%)	Incremental cost
90	$1,272

[248] An Analysis of Representative Heating Load Lines for Residential HSPF Ratings (ORNL, July 2015)

[249] Energy-Star Certified Homes Design Temperatures by County

[250] US Department of Energy, WPN 19-4: Revised Energy Audit Approval Procedures, Related Audit, and Material Approvals, Attachment 9, January 17, 2019.

[251] 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

92	$1,443
94	$1,614
96	$1,785

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

Energy and demand savings are shown in Table 160.

Table 160: 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,[252]

$$kWh_{Savings} = IdlePower_{App} \times DailyIdleHours_{App} \times 365 \times ISR$$

Parameters are described in Table 161. 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.[253]

Table 161: Energy Savings Estimation Variable & Sources

Variable	Definition	Value
$IdlePower_{TV}$	Idle power draw of home entertainment peripheral devices, kW	0.0085[254,255]
$DailyIdleHours_{TV}$	Number of hours per day the home entertainment system is not in use	20[254]
$IdlePower_{Comp}$	Idle power draw of home office peripheral devices, kW	0.0049[254,255,256]
$DailyIdleHours_{Comp}$	Number of hours per day the home office system is not in use	20[254]
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 162.[257] These weightings are used to derive the "Unspecified" measure application.

[252] 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

[253] PNM/Ecova Savings Brief, citing ADM evaluation

[254] 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.

[255] PNM/Ecova Savings Brief, citing "Advanced Power Strip Research Report", NYSERDA, August 2011

[256] PNM/Ecova Savings Brief, citing "Smart Plug Strips", ECOS, July 2009.

[257] Northwest Power & Conservation Council, Regional Technical Forum, http://rtf.nwcouncil.org/measures/res/ResAdvancedPowerStrips_v2_1.xlsm (The PA TRM just uses a 50/50 installation split with no source cited.)

Table 162: 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 163.

Table 163: 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[258]

4.12.5 Non-energy Benefits

None.

[258] 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."

4.12.6 Measure Life

The measure life for this equipment is 4 years.[259]

4.12.7 Incremental Cost

The cost for an APS is $16.46,[260] based on the TrickleStar 7-outlet APS 1080 Joules.

[259] PNM/Ecova Savings Brief, citing "Smart Strip Electrical Savings and Usability", David Rogers, Power Smart Engineering, October 2008."

[260] PNM/Ecova Savings Brief, citing "EFI Quote November 2014." An online search on Sept 22, 2015 found the same power strip for a retail price starting at $22.51.

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 CFR 430.32(c)(3):[261]

Table 164: Baseline Efficiencies for Residential Heat Pump

	Manufactured Before January 2006		Manufactured Between January 2015 and 2006		Manufactured After January 2015	
System Type	**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

[261] 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

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 165: Baseline Efficiencies for Residential Packaged Terminal Heat Pump

	Manufactured Before January 2006		Manufactured Between January 2015 and 2006	
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[262]**	**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.

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:

[262] 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 2009).

$kWh_{Savings}$ = 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 166)

$SEER_{base}$ = Seasonal Energy Efficiency Rating of the baseline cooling equipment, use "Manufactured after January 2015" column of 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 CFR 430.32(c)(3):

Table 164 & Table 165

$SEER_{eff}$ = 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 166)

$HSPF_{base}$ = Heating System Performance Factor of the baseline cooling equipment, use "Manufactured after January 2015" column of 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 CFR 430.32(c)(3):

Table 164 & Table 165

$HSPF_{eff}$ = Heating System Performance Factor of the efficient cooling equipment (AHRI Certificate)

Table 166: Residential Full Load Cooling and Heating Hours for New Mexico Climate Zones[263]

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 167), and
2. The remaining time in the EUL period, i.e. (EUL-RUL)

For Remaining Useful Life (RUL):

$$kWh_{Savings,RUL} = Capacity_{Cool} * \frac{1}{1000} * EFLH_C * \left(\frac{1}{SEER_{existing}} - \frac{1}{SEER_{eff}}\right) +$$

$$Capacity_{Heat} * \frac{1}{1000} * EFLH_H * \left(\frac{1}{HSPF_{existing}} - \frac{1}{HSPF_{eff}}\right)$$

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

[263] 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.

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 CFR 430.32(c)(3):

Table 164 & Table 165)

$SEER_{eff}$ = 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 (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 CFR 430.32(c)(3):

Table 164 & Table 165)

$HSPF_{eff}$ = Heating System Performance Factor of the efficient cooling equipment

(AHRI Certificate; Heat Pump only)

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

$$kWh_{Savings,EUL-RUL} = Capacity_{Cool} * \frac{1}{1000} * EFLH_C * \left(\frac{1}{SEER_{base}} - \frac{1}{SEER_{eff}}\right) +$$

$$Capacity_{Heat} * \frac{1}{1000} * EFLH_H * \left(\frac{1}{HSPF_{base}} - \frac{1}{HSPF_{eff}}\right)$$

Hence,

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

Where:

RUL = Remaining Useful Life (Table 167)

EUL = Estimate Useful Life

= 15 Years

Table 167: Remaining Useful Life (Years) of Replaced Central Heat Pump Unit[264]

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		
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:[265]

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

Peak demand savings:

[264] 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.

[265] Code specified SEER values converted to EER using EER = -0.02 x SEER2 + 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

$$kW_{Savings} = Capacity_{Cool} * \frac{1}{1000} * \left(\frac{1}{EER_{base}} - \frac{1}{EER_{eff}}\right) * CF$$

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[266]

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)

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.[267]

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.[268] 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.

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[266] 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

[267] Texas TRM v6.0 Volume 2: Residential Measures

[268] http://rtf.nwcouncil.org/measures/res/ResSFExistingHVAC_v3_2.xlsm

Table 168: High Efficiency Heat Pump incremental cost per ton cooling capacity

SEER[269]	Heat Pump (Per Ton Cooling)
15	$170
16	$340
17	$529
18+	$710

[269] Costs based upon average cost per ton for Equipment and Labor from Itron Measure Cost Study Results Matrix Volume 1 (part of "2010-2012 WA017 Ex Ante Measure Cost Study Draft Report", Itron, February 28, 2014). Note SEER 17 and 18 are extrapolated from other data points.

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 169:

Table 169: Federal Standards for Clothes Dryers (manufactured after Jan 1st 2015)[270]

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 170:

Table 170: ENERGY STAR® Clothes Dryer Efficiency Standards[271]

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

[270] Code of Federal Regulations 10 CFR 430.23(g)
https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=68&action=viewlive#current_standards

[271] ENERGY STAR® Clothes Dryer Key Product Criteria
https://www.energystar.gov/products/appliances/clothes_dryers/key_product_criteria

Table 171: ENERGY STAR® Clothes Dryer Cycle Time Standards[272]

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 172: Average load of clothes per drying cycle

Dryer Size	Load (lbs)[273]
Standard	8.45
Compact	3

[272] ENERGY STAR® Clothes Dryer Key Product Criteria https://www.energystar.gov/products/appliances/clothes_dryers/key_product_criteria

[273] 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[274]

$\%Electric$ = Percent of overall savings coming from electricity

(100% for Electric, 16% for Gas)[275]

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)

[274] 10 CFR Chapter II, Subchapter D, Part 430, Subpart B, Appendix D1– Uniform Test Method for Measuring the Energy Consumption of Dryers.

[275] %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.

4.14.4 Demand Savings Estimation

Demand savings are calculated using the following equation:

$$kW_{savings} = \frac{kWh_{savings}}{AOH} * CF$$

Where:

AOH = Annual Operating Hours

= $N_{Cycles} * \frac{d}{60\ min/hr}$

(where d is the Average Duration of a Drying cycle, 80 minutes)

CF = Conincidence Factor = 0.07[276]

4.14.5 Non-energy Benefits

None.

4.14.6 Measure Life

The average lifetime of this measure is 14 years according to the US DOE.[277]

4.14.7 Incremental Cost

The incremental cost for this measure is estimated to be $152.[278]

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[276] 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.

[277] 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

[278] 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.[279]

Table 173: 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

[279] 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

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 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.[280]

Table 174: 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.[281] 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 173 and Table 174. 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:

[280] 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

[281] 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

$$kWh_{savings} = \left(E_{conv,machine} + E_{conv,WH} + E_{conv,dryer}\right) - \left(E_{ES,machine} + E_{ES,WH} + E_{ES,dryer}\right)$$

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)
$E_{ES,machine}$	=	ENERGY STAR® Machine Energy (kWh)
$E_{ES,WH}$	=	ENERGY STAR® Water Heater Energy (kWh)
$E_{ES,dryer}$ (kWh)	=	Dryer Energy needed in combination with an ENERGY STAR® washer

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:

$$therms_{savings,dryer} =$$

$$\left[\left[\left(\frac{CAP * LPY}{IMEF_{FS}} - \frac{RUEC_{conv} \ * LPY}{RLPY}\right)\right] - \left[\left(\frac{CAP * LPY}{IMEF_{ES}} - \frac{RUEC_{ES} \ * LPY}{RLPY}\right)\right]\right]$$

$$* \frac{0.03412\ therms}{kWh} * \frac{DU_{DW}}{DUF}$$

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[282].

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 = Conincidence Factor = 0.07[283]

[282] 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

[283] 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.

4.15.5 Non-energy Benefits

None.

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.[284]

4.15.7 Incremental Cost

The incremental cost for this measure is estimated to be $400.[285]

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[284] 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

[285] 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.[286]

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 175 - Table 178) 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.

[286] Texas Technical Reference Manual, Version 5.0, Volume 2: Residential Measures, Program Year 2018 (Pg. 2-355 to 2-358)

Table 175: Albuquerque - Residential Floor Insulation Deemed Annual Energy Saving (kWh/sq.ft.)

	Cooling Savings		Heating Savings		
Home Type	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 176: Roswell - Residential Floor Insulation Deemed Annual Energy Saving (kWh/sq.ft.)

	Cooling Savings		Heating Savings		
Home Type	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 177: Las Cruces - Residential Floor Insulation Deemed Annual Energy Saving (kWh/sq.ft.)

	Cooling Savings		Heating Savings		
Home Type	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 178: Santa Fe - Residential Floor Insulation Deemed Annual Energy Saving (kWh/sq.ft.)

	Cooling Savings		Heating Savings		
Home Type	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 179: 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 180: 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 181: 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 182: 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

None.

4.16.6 Measure Life

The EUL for this measure is 30 years.[287]

4.16.7 Incremental Cost

The incremental cost for this measure is $175/sq.ft.[288]

[287] US Department of Energy, WPN 19-4: Revised Energy Audit Approval Procedures, Related Audit, and Material Approvals, Attachment 9, January 17, 2019.

[288] Incremental Cost Estimation Process (2008) https://aceee.org/files/proceedings/2008/data/papers/2_346.pdf

4.17 Water Heater Pipe Insulation

This measure requires the installation of pipe insulation on un-insulated of 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 (0.16 x 20) sq. ft. x (127.5 – 61.6) °F x 1/0.80 x 8760 hours x 1/(100,000 BTU/Therm)

= 6.8 Therms

4.17.3 Energy Savings Estimation

Hot water pipe insulation energy savings are calculated using the formula:

Energy Savings per Year:

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

Where:

U_{Pre}[289] = 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 below

Table 183: Pipe diameter and pipe surface area

Pipe Diameter (inches)	Pipe Surface Area (sq. ft.)
0.5	0.16 * Pipe Length Insulated (in feet)
0.75	0.23 * Pipe Length Insulated (in feet)
1.0	0.29 * Pipe Length Insulated (in feet)

T_{Pipe} = Average temperature of the pipe, use 127.5 °F[290]

[289] 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.

[290] 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.

$T_{Ambient}$ = Average annual temperature, use table below

Table 184: Temperature unconditioned and conditioned area

Climate Zone	$T_{Ambient}$ (Unconditioned)[291]	$T_{Ambient}$ (Conditioned)
Albuquerque	61.6°F	72.7 °F[292]
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[293] or 0.80 for natural gas storage water heaters and 0.82 for natural gas tankless water heaters[294]

$Hours_{Total}$ = 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):

$$Demand\ Savings = \frac{Annual\ Energy\ Savings}{8760}$$

291 Average ambient temperatures were taken from TMY3 data (adjusted for interior unconditioned spaces)

292 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

293 Default values based on median recovery efficiency of residential water heaters by fuel type in the AHRI database, at http://www.ahrinet.org

294 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

None

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.[295]

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[296] including material and installation.

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[295] 2014 California Database for Energy Efficiency Resources. http://www.deeresources.com/index.php/deer2013-update-for-2014-codes

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

4.18 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 sped for tasks which need water flow less than the maximum design flow.

4.18.1 Measure Overview

Sector	Residential
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

4.18.2 Savings

Savings are calculated using the algorithms and assumptions found in the ENERGY STAR® Pool Pump Calculator.[297] 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.[298] 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 2.0” and Pump Performance Curve A.

[297] 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

[298] 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

Example:

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

$kWh_{conventional}$ = 65.44 gal/min x 60 x 9.1062 hours x 365 days / (1.95 gal/W ·hr x 1000)

= 6,693 kWh

$kWh_{Energy\ Star}$ = [66.4 gal/min x 60 x 4.3 hours x 365 days / (1.951 gal/W ·hr x 1000)] + [33.3 gal/min x 60 x 9.7 hours x 365 days / (5.221 gal/W ·hr x 1000)]

= 4,560 kWh

$kWh_{Savings}$ = 6693 kWh – 4560 kWh = 2133 kWh

$kW_{Savings}$ = [6693 kWh/9.1062 hours – 4560 kWh/(4.3 hours + 9.7 hours)] x 0.4 / 365 days

= 0.448 kW

4.18.3 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

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

$$kWh_{ENERGYSTAR} = kWh_{HighSpeed} + kWh_{LowSpeed}$$

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

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

Where:

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

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

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

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

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

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

$PFR_{conventional}$ = Conventional single-speed pump flow rate, gal/min

$PFR_{HighSpeed}$ = ENERGY STAR® variable speed pump high speed flow rate, gal/min

$PFR_{LowSpeed}$ = ENERGY STAR® variable speed pump low speed flow rate, gal/min

$EF_{conventional}$ = Conventional single-speed pump energy factor, gal/W·hr

$EF_{HighSpeed}$ = ENERGY STAR® variable speed pump high speed energy factor, gal/W·hr

$EF_{LowSpeed}$ = 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 185: Conventional Pool Pumps Assumptions[299]

Rated Horsepower (HP)	$Hours_{Conventional}$[300]	$PFR_{conventional}$	$EF_{conventional}$
≤ 1.25	9.1062	60.06	2.40
1.25 < HP ≤ 1.75		64.38	2.09
1.75 < HP ≤ 2.25		65.44	1.95
2.25 < HP ≤ 2.75		68.40	1.88
2.75 < HP ≤ 3.00		73.11	1.65

Table 186: ENERGYSTAR Pool Pumps Assumptions[301]

Rated Horsepower	$Hours_{HighSpeed}$	$Hours_{LowSpeed}$	$PFR_{HighSpeed}$	$EF_{HighSpeed}$	$PFR_{LowSpeed}$	$EF_{LowSpeed}$
HP ≤ 1.25	4.3	9.7	56.0	2.398	31.0	5.407
1.25 < HP ≤ 1.75			61.0	2.267	31.9	5.433
1.75 < HP ≤ 2.25			66.4	1.951	33.3	5.221
2.25 < HP ≤ 2.75			66.0	2.024	34.0	4.796
2.75 < HP ≤ 3.00			74.0	1.617	37.0	4.764

4.18.4 Demand Savings Estimation

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

Where:

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

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

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

300 The daily average operating hours for conventional single-speed pumps, based on 2014 residential pool pump program survey results from CenterPoint Energy. (Texas Technical Resource Manual V5.0, Volume 2: Residential Measures)

301 The daily average operating hours for low and high VSP settings, based on 2016 residential pool pump program data from CenterPoint Energy

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

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

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

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

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

DF = Demand Factor, 0.4[302]

4.18.5 Non-energy Benefits

None

4.18.6 Measure Life

According to DEER 2014, the Estimated Useful Life for this measure is 10 years.[303]

4.18.7 Incremental Cost

For Multi-Speed Pumps, incremental cost is assumed to be $235 and $549 for Variable Speed Pumps.[304]

[302] Energy Efficient Pools and Spas Program; NV Energy - Southern Nevada (NPC); Program Year 2011- source for VFD replacement size and turnovers per day

[303] Database for Energy Efficient Resources (2014). http://www.deeresources.com/

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

4.19 Programmable Thermostat

This measure characterizes the household energy savings from the installation of a new or reprogramming of an existing programmable thermostat for reduced heating and cooling energy consumption through temperature setback during unoccupied or reduced demand times.

4.19.1 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

4.19.2 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 or 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:[305]

[305] A Guide to Energy-Efficient Heating and Cooling https://www.energystar.gov/ia/partners/publications/pubdocs/HeatingCoolingGuide%20FINAL_9-4-09.pdf

Table 187: Setpoint temperature for different time setting

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

4.19.3 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)[306]

$Capacity_{Heat}$ = Heating equipment's rated heating capacity, Btu/h

(34,560 Btu/h, if unknown)[307]

$EFLH_{Cool}$ = Estimate of annual residential cooling hours for air conditioning equipment, see Table 188

$EFLH_{Heat}$ = Estimate of annual residential cooling hours for air conditioning equipment, see Table 188

306 Conservative estimate based on program data from Texas IOUs showing average cooling capacity

307 Based on Frontier assumptions that heating capacity is 96% of cooling capacity, based on an analysis of AHRI-rated systems

Table 188: Residential Full Load Cooling and Heating Hours for New Mexico Climate Zones[308]

City	$EFLH_{Cool}$	$EFLH_{Hot}$
Albuquerque	1,038	2,162
Las Cruces	1,290	1,909
Roswell	1,355	1,596
Santa Fe	629	2,490

$1{,}000$ = 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%[309]

$Reduction_{Heat}$ = Assumed percentage reduction in total household heating energy consumption due to installation of a programmable thermostat, 6.2%[310]

$HSPF$ = 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[311]

$\Delta kWh_{heat.gasfurn}$ = Fan energy savings in a gas heat furnace, kWh

HP_{motor} = Gas furnace blower motor horsepower, HP (default = 0.5 HP)

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[308] 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.

[309] 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%

[310] Value published in Illinois Technical Resource Manual v7.0, Volume 3: Residential Measures, a conservative estimate based on studies done in various regions

[311] 2014 Energy Trust of Oregon Nest Thermostat Heat Pump Control Pilot Evaluation, http://energytrust.org/library/reports/Nest_Pilot_Study_Evaluation_wSR.pdf

η_{motor} = Efficiency of furnace blower motor horsepower (default = 50%)

%HeatPump = % of homes using heat pump heat. For upstream programs, default = 20%[312]. If heating type is known to be heat pump, use 100%.

%ElecFurn = % of homes using electric resistance heat. For upstream programs, default = 23%[313]. If heating type is known to be electric resistance, use 100%.

%GasFurn = % of homes using gas heat. For upstream programs, default = 57%[314]. 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:

$$\Delta kWh_{cooling} = \frac{36{,}000\ Btu/h}{1000\frac{W}{kW}} \times \frac{1}{13.0 \times 0.8} \times 1{,}290 \times 5.6\% = 250\ \text{kWh}$$

$$\Delta kWh_{heat} = \frac{34{,}560\frac{\text{Btu}}{\text{h}}(\text{default})}{1000\frac{W}{kW}} \times \frac{1}{3.412(\text{default}) \times 0.8} \times 1{,}909 \times 6.2\% = 1{,}498\ \text{kWh}$$

$$\Delta kWh = 250 + 1{,}498 = 1{,}748\ \text{kWh}$$

4.19.4 Demand Savings Estimation

Demand savings can be defined as:

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312 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.

313 Ibid.

314 Ibid.

$$Demand\ Savings = \frac{Annual\ Energy\ Savings}{Hours_{Thermostat}} * CF$$

Where, $Hours_{Thermostat}$ are the annual hours the HVAC is controlled by the thermostat (listed below):

Table 189: Operational Hours

City	$Hours_{Thermostat}$
Roswell	5,424
Las Cruces	5,035
Santa Fe	6,474
Albuquerque	5,876

CF = Coincidence Factor, 100%

4.19.5 Non-energy Benefits

None.

4.19.6 Measure Life

The expected measure life of a programmable thermostat is assumed to be 10 years[315] based upon equipment life only.[316]

4.19.7 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.[317] The

[315] Table 1, HVAC Controls, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

[316] 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.

[317] 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.

cost for reprogramming is assumed to be $10 to account for the auditors time to reprogram and educate the homeowner.

4.20 Smart Thermostats

This measure estimates the annual energy savings from the installation of a new smart thermostat(s) for reduced heating and cooling consumption through a configurable schedule of temperature setpoints and automatic variations to that schedule 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.

4.20.1 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

4.20.2 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.[318]

The results summarized in the referenced study were found to be the most conservative and hence most reliable.

[318] 'Residential Smart Thermostats: Impact Analysis – Gas Preliminary Findings', December 2015

4.20.3 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)[319]

$Capacity_{Heat}$ = Heating equipment's rated heating capacity, Btu/h (34,560 Btu/h, if unknown)[320]

$EFLH_{Cool}$ = Estimate of annual residential cooling hours for air conditioning equipment, see Table 190

[319] Conservative estimate based on program data from Texas IOUs showing average cooling capacity

[320] Based on Frontier assumptions that heating capacity is 96% of cooling capacity, based on an analysis of AHRI-rated systems

$EFLH_{Heat}$ = Estimate of annual residential cooling hours for air conditioning equipment, see Table 190

Table 190: Residential Full Load Cooling and Heating Hours for New Mexico Climate Zones[321]

City	$EFLH_{Cool}$	$EFLH_{Heat}$
Albuquerque	1,038	2,162
Las Cruces	1,290	1,909
Roswell	1,355	1,596
Santa Fe	629	2,490

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% [322]

$Reduction_{Heat}$ = 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%[323]

$HSPF$ = Heating equipment's Heating Seasonal Performance Factor, Btu/Wh (Nameplate Data; default Heat Pump = 7.7, Electric Furnace = 3.412)

[321] 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.

[322] Value published in Illinois Technical Resource Manual v7.0, Volume 3: Residential Measures, a conservative estimate based on studies done in various regions

[323] Value published in Illinois Technical Resource Manual v7.0, Volume 3: Residential Measures, a conservative estimate based on studies done in various regions

Eff_{duct} = Duct System Efficiency, 0.8[324]

HP_{motor} = Gas furnace blower motor horsepower, 0.5 HP

η_{motor} = Efficiency of furnace blower motor horsepower, 50%

%HeatPump = % of homes using heat pump heat. For upstream programs, default = 20%[325]. If heating type is known to be heat pump, use 100%.

%ElecFurn = % of homes using electric resistance heat. For upstream programs, default = 23%[326]. If heating type is known to be electric resistance, use 100%.

%GasFurn = % of homes using gas heat. For upstream programs, default = 57%[327]. If heating type is known to be gas, use 100%.

Natural Gas Energy Savings:

$$\Delta Therms = \frac{Capacity_{Heat} \times EFLH_{Heat}}{AFUE \times Eff_{duct} \times 100{,}000\ BTU/Therm} \times Reduction_{Heat} \times \%GasFurn$$

Where:

$AFUE$ = Heating equipment's Annual Fuel Utilization Efficiency,

(Nameplate Data; default = 80%)

100,000 = Conversion between BTU and Therms

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324 2014 Energy Trust of Oregon Nest Thermostat Heat Pump Control Pilot Evaluation, http://energytrust.org/library/reports/Nest_Pilot_Study_Evaluation_wSR.pdf

325 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.

326 Ibid.

327 Ibid.

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:

$$\Delta kWh_{cooling} = \frac{36{,}000\ Btu/h}{1000\frac{W}{kW}} \times \frac{1}{13.0 \times 0.8} \times 629 \times 8\% = 174\ \text{kWh}$$

$$\Delta kWh_{heat.gasfurn} = \frac{0.5\ HP \times \left(746\frac{W}{HP}\right) \times 2{,}490}{50\% \times 1000\frac{W}{kW}} \times 5.6\% = 105\ \text{kWh}$$

$$Therms = \frac{34{,}560\ Btu/h \times 2{,}490}{80\% \times 0.8} \times 10^{-5} \times 5.6\% = 75\ \text{therms}$$

4.20.4 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 not strong evidence that smart thermostats save coincident demand any differently than programmable thermostats.

4.20.5 Non-energy Benefits

None.

4.20.6 Measure Life

The expected measure life for advanced thermostats is assumed to be like that of a programmable thermostat, i.e. 10 years.[328]

4.20.7 Incremental Cost

$175[329]

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[328] Table 1, HVAC Controls, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

[329] IL TRM v7.0, Advanced Thermostats

4.21 Water Heater Tank Insulation

This measure saves electric consumption by insulating an uninsulated water heater tank located in a conditioned or unconditioned space.

4.21.1 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

4.21.2 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

4.21.3 Energy Savings Estimation

Hot water tank insulation energy savings are calculated using the formula:

Energy Savings per Year:

$$\begin{aligned} &\mathit{Annual\ Energy\ Savings} \\ &\quad = (U_{Pre} - U_{Post}) * A * (T_{Tank} - T_{Ambient}) * \left(\frac{1}{Eff}\right) * Hours_{Total} \\ &\quad * \frac{1}{Conversion\ Factor} \end{aligned}$$

Where:

U_{Pre} = $1/(5^{330})$ Btu/hr sq. ft. °F

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")[331]

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 below

Table 191: Hot water gallons and tank surface area

Volume (gallons)	A (sq. ft.)[332]
30	17.45
40	21.81
50	22.63
60	26.94
80	30.36

330 Baseline R value as per Texas Technical Resource Manual v5.0

331 True R-Values of Round Residential Ductwork, https://aceee.org/files/proceedings/2006/data/papers/SS06_Panel1_Paper18.pdf

332 Tank area was obtained from a survey of electric water heater manufacturer data. Dimensions for each tank size were collected and averaged to determine a typical square footage of each size water heater. Accessed April 2013: http://www.hotwater.com/water-heaters/residential/conventional/electric/promax/standard/

Accessed April 2013: http://www.whirlpoolwaterheaters.com/products/electric-water-heaters/es40r92-45d/

120	38.73

T_{Tank} = Average temperature of the tank, use 127.5 °F[333]

$T_{Ambient}$ = Average annual temperature, use table below

Table 192: Hot water gallons and tank surface area

Climate Zone	$T_{ambient}$ (Unconditioned)[334]	$T_{ambient}$ (Conditioned)
Albuquerque	61.6°F	72.7 °F[335]
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[336] 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

333 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.

334 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.

335 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

336 Default values based on median recovery efficiency of residential water heaters by fuel type in the AHRI database, at http://www.ahrinet.org

4.21.4 Demand Savings Estimation

Tank insulation demand savings (kW, only for electric and heat pump water heater):

$$Demand\ Savings = \frac{Annual\ Energy\ Savings}{8760}$$

4.21.5 Non-energy Benefits

None

4.21.6 Measure Life

As per 2014 California Database for Energy Efficiency Resources (DEER), the EUL for this measure is listed as 7 years.[337]

4.21.7 Incremental Cost

As per 2008 California Database for Energy Efficiency Resources (DEER) Measure Cost Summary, the incremental cost for this measure is $79.[338]

[337] 2014 California Database for Energy Efficiency Resources. http://www.deeresources.com/index.php/deer2013-update-for-2014-codes

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

4.22 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.

4.22.1 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

4.22.2 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 194 should be assumed:[339]

Table 193: 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

[339] Baseline value for U-Factor and SHGC as per Texas Technical Resource Manual v5.0, Volume 2: Residential Measures

For the efficient condition, windows must satisfy ENERGY STAR® criteria.[340]

Table 194: ENERGY STAR® Windows Specification[341]

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

4.22.3 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.[342]

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.

Based on the cooling and heating equipment utilized in a particular residence, total deemed savings per square foot can be calculated using the formula:

$$Total\ Deemed\ Savings\ (kWh/sq.ft.) = Deemed\ Heating\ Svgs. + Deemed\ Cooling\ Svgs.$$

Deemed heating and cooling savings for ENERGY STAR® single pane windows are listed in Table 195:

340 ENERGY STAR® criteria for U.S. South-Central Region effective January 2015

341 Windows, Doors, and Skylights Climate Zone Finder: https://www.energystar.gov/index.cfm?fuseaction=windows_doors.search_climate

342 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.

Table 195: ENERGY STAR® Windows Replacing Single 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	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 196:

Table 196: ENERGY STAR® Windows Replacing 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	4.26	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

Therefore,

$$Annual\ Energy\ Svgs\ (kWh) = Total\ Deemed\ Svgs\ (kWh/sq.ft.) \times Area\ of\ Windows\ (sq.ft.)$$

4.22.4 Demand Savings Estimation

Deemed peak demand savings for installing ENERGY STAR® single pane windows are listed in Table 197:

Table 197: 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 198.

Table 198: ENERGY STAR® Windows Replacing Double Pane Windows, Deemed Peak Demand Savings (kW/sq.ft.)

	Cooling Savings (kW/sq.ft.)	
Climate Zone	**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

Therefore,

$$Peak\ Demand\ Savings\ (kW) = Deemed\ Cooling\ Savings\ (kW/sq.ft.) \times Area\ of\ Vertical\ Windows\ (sq.ft.)$$

4.22.5 Non-energy Benefits

None.

4.22.6 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.

4.22.7 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.

4.23 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.

4.23.1 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%

4.23.2 Savings

Cooling savings in this measure apply to customers with central or mini-split electric refrigerated air conditioning or evaporative cooling in their homes. 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.[343]

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.[344]

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

343 BEopt default values for single-paned windows with metal frames.

344 Performance data from Matrix, Inc., Mesa, Arizona testing facility for Phifer Wire Products' SunTex screen, blocks 80 percent of solar heat gain.

has a 22 percent improvement with the addition of a solar screen, whereas a double pane, 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[345] 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.

4.23.3 Energy Savings Estimation

Table 199 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 199: 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

4.23.4 Demand Savings Estimation

Table 199 presents the deemed summer peak demand savings value per square foot of solar screen installed.

Table 200: 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

345 Residential Windows – A Guide to New Technologies and Energy Performance, 2000.

Roswell	0.00327	0.00112
Santa Fe	0.00264	0.00123

4.23.5 Non-energy Benefits

None.

4.23.6 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).[346]

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.

[346] 2014 California Database for Energy Efficiency Resources. http://www.deeresources.com/index.php/deer2013-update-for-2014-codes.

4.24 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.

4.24.1 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

4.24.2 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 100.

Table 201: 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 202.

Table 202: 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: $0.15 \leq R < 0.3$ $0.3 \leq R < 0.5$ $0.5 \leq R < 0.7$ $0.7 \leq R$
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 203: 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 204: 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 205: 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 206: 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 207: 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 208: 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 209: 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 210: 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 211: 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 212: 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 213: 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 214: 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 215: 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 216: 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 217: 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 218: 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

4.24.3 Energy Savings Estimation

The deemed energy and demand savings values are used in the following formulas to calculate savings:

$$Cooling\ Energy\ Savings = Roof\ \ Area \times Deemed\ Cooling\ Savings$$

$$Heating\ Energy\ Savings = Roof\ \ Area \times Deemed\ Heating\ Savings$$

Equation 35

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*

4.24.4 Demand Savings Estimation

The deemed demand savings factors are used in the following formulas to calculate savings:

$$Peak\ Summer\ Demand\ Savings = Roof\ Area \times Deemed\ Demand\ Savings$$

Equation 36

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*

4.24.5 Non-energy Benefits

None.

4.24.6 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).[347]

4.24.7 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.

[347] 2014 California Database for Energy Efficiency Resources. http://www.deeresources.com/index.php/deer2013-update-for-2014-codes.

4.25 Wall Insulation

This measure saves space heating and cooling energy by reducing heat transfer through the walls.

4.25.1 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[348]: IECC 2009
Efficient case description	Insulation level higher than baseline level

4.25.2 Savings

Savings are derived as better wall insulation will lead to reduced consumption of heating and cooling during winter and summer months. The better the R-value of the insulation being installed, higher the savings achieved.

Baseline R-value for new construction projects are listed in Table 106:

Table 106: IECC 2009 Wall Insulation Baseline

Cities	Wood Frame Wall	Mass Wall	Basement Wall	Crawl Space Wall
Albuquerque	13	5/10*	10/13*	10/13*
Santa Fe	20 or 13+5**	13/17*	10/13*	10/13*
Roswell	13	5/8*	5/13*	5/13*
Las Cruces	13	5/8*	5/13*	5/13*

[348] IECC 2009 Code 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*

4.25.3 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:

$$\Delta kWh_{Cooling} = \frac{\left(\frac{1}{R_{Old}} - \frac{1}{R_{New}}\right) * A_{wall} * (1 - FF_{Wall}) * CDD * 24}{1000 * \eta_{Cooling}}$$

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%[349]

CDD = Cooling Degree Days, as listed in Table 107

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 109:

Table 219: Cooling Efficiency (Federal Standards)

Age of Equipment	SEER Ratings
Before 2006	10.0
2006 - 2014	13.0

[349] ASHRAE, 2001, "Characterization of Framing Factors for New Low-Rise Residential Building Envelopes (904-RP)," Table 7.1

Central AC after 1/1/2015	13.0
Heat Pump after 1/1/2015	14.0

Heating energy savings for electric resistance and heat pump systems can be calculated using:

$$\Delta kWh_{Heating} = \frac{\left(\frac{1}{R_{Old}} - \frac{1}{R_{New}}\right) * A_{wall} * (1 - FF_{wall}) * HDD * 24}{3412 * \eta_{Heating}}$$

HDD = Heating Degree Days, as listed in Table 107

Table 220: 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

Where:

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 111

Table 221: 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

= 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

$$\Delta therms_{Heating} = \frac{\left(\frac{1}{10} - \frac{1}{32}\right) * 2500 * (1 - 0.07) * 2{,}816 * 24}{10^5 * 0.8} = 109\ therms$$

4.25.4 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. 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.[350]

$$Peak\ Demand\ Savings = \frac{\Delta kWh_{Cooling}}{EFLH_{Cool}} * CF$$

[350] Based on ADM ceiling insulation calculator spreadsheet

where:

$Peak\ Demand\ Savings$ = Summer peak kW savings, kW

$\Delta kWh_{Cooling}$ = Cooling energy savings, kWh

$EFLH_{Cool}$ = Effective Full Load Cooling Hours, Table 112.

Table 222: 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[351]

4.25.5 Non-energy Benefits

There are no non-energy benefits.

4.25.6 Measure Life

The lifetime for this measure is 30 years.[352]

4.25.7 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.[353]

[351] 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

[352] US Department of Energy, WPN 19-4: Revised Energy Audit Approval Procedures, Related Audit, and Material Approvals, Attachment 9, January 17, 2019.

[353] Public Service Company of New Mexico Commercial & Industrial Incentive Program Work Papers, 2011.

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,

$$kWh_{Savings} = \left(\frac{HP * LF * .746}{Eff_{Motor} * Eff_{SurfMech}}\right) * (TC - \left(\frac{Run_{Const} + Run_{Coeff} * Eff_{VolPump} * TC * 100}{100}\right)) * 8760$$

The parameters in this equation are a combination of user defined, prescriptive, and empirically derived.

Table 223: 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 224: 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 225: 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.[354]

5.1.7 Incremental Cost

The cost for a pump off motor controller is $5,959 per controller.[355]

354 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.

355 NMx Pump Off Controller Custom Projects