Report by **SBW CONSULTING, INC.**

NEW MEXICO TECHNICAL RESOURCE MANUAL FOR THE CALCULATION OF ENERGY EFFICIENCY SAVINGS

Submitted to

NEW MEXICO PUBLIC REGULATION COMMISSION
ENERGY EFFICIENCY EVALUATION COMMITTEE
1120 Paseo De Peralta
P.O. Box 1269
Santa Fe, NM 87504

Submitted by

SBW CONSULTING, INC.
2820 Northup Way, Suite 230
Bellevue, WA 98004

In association with **ADM ASSOCIATES**

January 5th, 2016

sbw

ENERGY + WATER + EFFICIENCY

TABLE OF CONTENTS

1. Introduction

The intent of this Technical Reference Manual (TRM) is to provide a transparent and consistent basis for calculating energy (kWh or therms), and demand (kW) savings generated by the State of New Mexico's energy efficiency programs. In addition, estimated measure lives and measure costs are provided in order to assist with calculations of measure cost-effectiveness. The TRM is relevant to the programs offered by 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' 2010-2011 programs conducted by ADM Associates
- California's Database for Energy Efficiency Resources (DEER)
- TRMs from other states
- the 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 14 measures included in the TRM:

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

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	4180	1322
Las Cruces	NEW MEXICO STATE UNIVERSITY	2816	1899
Roswell	ROSWELL INDUSTRIAL AIR PARK	3289	1790
Santa Fe	SANTA FE CO MUNICIPAL AIRPORT	5417	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 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.

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

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
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 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.

Table 3: DEER 2008 Building Types

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

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	Either federal standards or average existing conditions
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.

Table 4: Commercial low-flow faucet aerator savings (therms)

Facility Type	0.5 gpm Aerator Savings	1.0 gpm Aerator Savings
Prison	96.9	68.4
Hospital, Nursing Home	9.7	6.8
Dormitory	72.8	51.4
Multifamily	9.7	6.8
Hospitality	9.7	6.8
Commercial	69.3	48.9
Middle or High School	36.5	22.5
Elementary School	16.4	10.1

Electric savings are shown in Table 5.

Table 5: Commercial low-flow faucet aerator savings (kWh)

Facility Type	0.5 gpm Aerator Savings	1.0 gpm Aerator Savings
Prison	2319	1637
Hospital, Nursing Home	232	164
Dormitory	1741	1229
Multifamily	232	164
Hospitality	232	164
Commercial	1658	1170
Middle or High School	874	538
Elementary School	393	242

3.1.3. Energy Savings Estimation

Savings are derived with the following formula[2].

$$Svgs = \frac{(FlowPre - FlowPost) \times DeltaT \times Minutes \times Days \times HeatCapacity \times Density \times Const}{EffDHW} \quad (1)$$

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
DeltaT	=	Temperature difference between cold and usage, 50 °F
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
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

Values for facility-dependent parameters are shown in Table 6.

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

Table 6: 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
Multifamily	2.2	3	365
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

Parameter values are based on the following sources[3].

Table 7: 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 difference between cold and faucet	Vermont TRM No. 2008-53, pp. 273-274, 337, 367-368, 429-431. 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 groundwater T in New Mexico is 55 °F. Applying thermal balance equation yields assumption that 30% of water coming from the faucet is cold, 70% is hot. (Assumes a usage temp of ~105 °F and a cold water temp of 55 °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 multifamily, hotel guest rooms, hospital patient rooms, nursing homes; NY Standard Approach, October 15, 2010 uses 15 minutes per day for multifamily lavatories; 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

[3] Ibid

	faucet in a school. Field data acquired in fourteen elementary schools in Santa Fe and Albuquerque has shown that on average there is one faucet for every 9 students in an elementary school, partially due to additional faucets in classrooms. Minutes per faucet reflect that data (applying 9/20 ratio to 30 minutes). Limited data for middle and high schools (two middle schools and one high school) shows 22 students per aerator, consistent with the initial assumption of 30 minutes per faucet.
Thermal efficiency of water heater	Minimum federal standard (69 CFR 203, 10-21-2004) for a new commercial gas water heater (gas storage water heater 100 gallon or larger capacity)

3.1.4. Demand Savings Estimation

There are no demand savings associated with this measure.

3.1.5. Non-energy Benefits

Water savings are shown in Table 8. Local water and wastewater rates need to be applied to these values to monetize savings.

Table 8: 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
Multifamily	1,862	1,314
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[4].

3.1.7. Incremental Cost

The incremental cost for this measure is the total cost. The cost per direct-installed commercial aerator is $10[5].

[4] DEER 2008, MA TRM, Tacoma Water, Niagara Conservation

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 9.

Table 9: 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	4178
Fast Food	36	858
Prison	482	11,525
Hospital	482	11,525
Nursing Home	482	11,525
University Dining Hall	362	8651
School	119	2842

3.2.3. Energy Savings Estimation

Savings are derived with the following formula[6].

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

5 SBW Consulting, Direct-install program operator, 2013

6 ADM Associates, Evaluation of 2011 DSM Portfolio, New Mexico Gas Company, 2012, citing CLEAResult Workpaper, “Low Flow Pre-Rinse Spray Valve”

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 10.

Table 10: 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[7].

Table 11: 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)

[7] Ibid

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

Table 12: 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[8].

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[9].

8 *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, p. 30

9 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

Allowable methods of deriving savings are described.

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 are 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).

3.3.3.1. 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 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 publically reviewed and approved by state regulatory commissions.

- DEER 2008, with updates
- New York Device Codes and Rated Lighting System Wattage Table
- 2013 Massachusetts Device Codes and Rated Lighting System Wattage Table - Retrofit
- Pennsylvania 2013 TRM Appendix C Lighting Inventory Tool
- State of Illinois Energy Efficiency Technical Reference Manual Final Technical Version, August 20, 2012

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

3.3.3.2. Operating Hours

Prescriptive hours are derived from DEER 2008 by facility type. Table 13 shows the building weighted average DEER 2008 commercial lighting operating hours. Additional building types are allowed, with the constraint that the operating hours must be taken from a published recognized source.

Table 13: DEER 2008 Commercial Lighting Hours of Use

Lighting Hours of Use	Indoor	Indoor	Outdoor	
Building Type	**CFL**	**Other**	**All**	**Saturation**
Assembly	2287	2440	4100	6.1%
Education - Primary School	2399	2167	4100	2.6%
Education - Secondary School	2487	2323	4100	2.5%
Education - Community College	2282	2211	4100	2.3%
Education - University	2454	2450	4100	2.3%
Grocery	3876	4886	4100	4.2%
Health/Medical - Hospital	4087	4882	4100	2.2%
Health/Medical - Nursing Home	3573	4255	4100	2.2%
Lodging - Hotel	1660	1964	4100	2.2%
Lodging - Motel	1523	1666	4100	2.2%
Manufacturing - Bio/Tech	3501	3957	4100	5.9%
Manufacturing - Light Industrial	2619	3130	4100	5.9%
Office - Large	3151	2651	4100	17.0%
Office - Small	3082	2594	4100	5.1%
Restaurant - Sit-Down	4815	4815	4100	1.4%
Restaurant - Fast-Food	4835	4835	4100	1.4%
Retail - 3-Story Large	3703	3372	4100	5.5%
Retail - Single-Story Large	3813	3430	4100	5.3%
Retail - Small	3721	3253	4100	5.3%
Storage - Conditioned	2780	3441	4100	7.4%
Storage - Unconditioned	2780	3441	4100	7.4%
Storage - Refrigerated Warehouse	4781	4797	4100	0.8%
Education - Relocatable Classroom	2660	2445	4100	2.5%
Commercial - general	3090	3151	4100	100%

As an alternative to using the building weighted average operating hours, hours can be assigned on an area-type basis, as shown in Table 14. One method or the other should be used for all hours assigned to a given facility. 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.

Table 14: DEER equivalent full load hours for CFL and non-CFL fixtures

Building Type	Space Use	Other	CFL
Assembly	**Whole Building**		
Assembly	Auditorium	2,431	2,291
Assembly	Office (General)	3,173	2,338
Education - Primary School	Whole Building		
Education - Primary School	Classroom/Lecture	2,445	2,660
Education - Primary School	Exercising Centers and Gymnasium	2,051	2,434
Education - Primary School	Dining Area	1,347	1,530
Education - Primary School	Kitchen and Food Preparation	1,669	1,846
Education - Secondary School	Whole Building		
Education - Secondary School	Classroom/Lecture	2,445	2,608
Education - Secondary School	Office (General)	2,323	2,452
Education - Secondary School	Exercising Centers and Gymnasium	2,366	2,532
Education - Secondary School	Computer Room (Instructional/PC Lab)	2,137	2,522
Education - Secondary School	Dining Area	2,365	2,493
Education - Secondary School	Kitchen and Food Preparation	1,168	1,354
Education – Relocatable Classroom	Whole Building	2,445	2,608
Education - Community College	Whole Building		
Education - Community College	Classroom/Lecture	2,471	2,619
Education - Community College	Office (General)	2,629	2,568
Education - Community College	Computer Room (Instructional/PC Lab)	2,189	2,629
Education - Community College	Comm/Ind Work (General, Low Bay)	3,078	2,740
Education - Community College	Dining Area	2,580	2,620
Education - Community College	Kitchen and Food Preparation	2,957	2,602
Education - University	Whole Building		
Education - University	Classroom/Lecture	2,522	2,716
Education - University	Office (General)	2,870	2,640
Education - University	Computer Room (Instructional/PC Lab)	2,372	2,830
Education - University	Comm/Ind Work (General, Low Bay)	3,099	2,772
Education - University	Dining Area	2,963	2,713
Education - University	Kitchen and Food Preparation	3,072	2,823
Education - University	Hotel/Motel Guest Room (incl. toilets)	1,196	1,196
Education - University	Corridor	2,972	2,765
Health/Medical - Hospital	Whole Building		

Building Type	Space Use	Other	CFL
Health/Medical - Hospital	Office (General)	4,873	4,216
Health/Medical - Hospital	Office (General)	4,873	4,216
Health/Medical - Hospital	Dining Area	5,858	4,463
Health/Medical - Hospital	Kitchen and Food Preparation	5,858	4,463
Health/Medical - Hospital	Medical and Clinical Care	5,193	4,317
Health/Medical - Hospital	Laboratory, Medical	4,257	3,449
Health/Medical - Hospital	Medical and Clinical Care	5,193	4,317
Health/Medical - Hospital	Office (General)	4,873	4,216
Health/Medical - Nursing Home	Whole Building		
Health/Medical - Nursing Home	Hotel/Motel Guest Room (incl. toilets)	4,367	3,529
Health/Medical - Nursing Home	Office (General)	3,723	3,468
Health/Medical - Nursing Home	Office (General)	3,723	3,468
Health/Medical - Nursing Home	Corridor	7,884	4,709
Health/Medical - Nursing Home	Dining Area	3,814	3,522
Health/Medical - Nursing Home	Kitchen and Food Preparation	3,814	3,522
Lodging - Hotel	Whole Building		
Lodging - Hotel	Hotel/Motel Guest Room (incl. toilets)	799	799
Lodging - Hotel	Corridor	7,884	5,913
Lodging - Hotel	Dining Area	3,485	3,108
Lodging - Hotel	Kitchen and Food Preparation	4,524	3,641
Lodging - Hotel	Bar, Cocktail Lounge	3,820	3,275
Lodging - Hotel	Lobby (Hotel)	7,884	5,913
Lodging - Hotel	Laundry	4,154	3,586
Lodging - Hotel	Office (General)	3,317	3,006
Lodging - Motel	Whole Building		
Lodging - Motel	Hotel/Motel Guest Room (incl. toilets)	755	755
Lodging - Motel	Office (General)	5,858	6,132
Lodging - Motel	Laundry	4,709	4,709
Lodging - Motel	Corridor	7,474	6,132
Manufacturing - Bio/Tech	Whole Building		
Manufacturing - Bio/Tech	Laboratory, Medical	3,177	2,613
Manufacturing - Bio/Tech	Office (General)	3,212	2,613
Manufacturing - Bio/Tech	Corridor	7,008	7,008
Manufacturing - Bio/Tech	Computer Room (Mainframe/Server)	3,068	2,613
Manufacturing - Bio/Tech	Dining Area	3,068	2,847
Manufacturing - Bio/Tech	Kitchen and Food Preparation	3,068	2,653
Manufacturing - Bio/Tech	Conference Room	3,703	2,676
Manufacturing - Light Industrial	Whole Building		
Manufacturing - Light Industrial	Comm/Ind Work (General, High Bay)	3,068	2,613

Building Type	Space Use	Other	CFL
Manufacturing - Light Industrial	Storage (Unconditioned)	3,376	2,645
Office - Large	Whole Building		
Office - Large	Office (Open Plan)	2,641	3,100
Office - Large	Office (Executive/Private)	2,641	3,100
Office - Large	Corridor	2,641	3,860
Office - Large	Lobby (Office Reception/Waiting)	2,692	3,860
Office - Large	Conference Room	2,692	1,647
Office - Large	Copy Room (photocopying equipment)	2,692	3,860
Office - Large	Restrooms	2,692	3,860
Office - Large	Mechanical/Electrical Room	2,692	1,647
Office - Small	Whole Building		
Office - Small	Office (Executive/Private)	2,594	3,066
Office - Small	Corridor	2,594	3,360
Office - Small	Lobby (Office Reception/Waiting)	2,594	3,957
Office - Small	Conference Room	2,594	1,556
Office - Small	Copy Room (photocopying equipment)	2,594	3,957
Office - Small	Restrooms	2,594	3,957
Office - Small	Mechanical/Electrical Room	2,594	1,556
Restaurant - Sit-Down	Whole Building		
Restaurant - Sit-Down	Dining Area	4,836	4,836
Restaurant - Sit-Down	Lobby (Main Entry and Assembly)	4,836	4,836
Restaurant - Sit-Down	Kitchen and Food Preparation	4,804	4,804
Restaurant - Sit-Down	Restrooms	4,606	4,606
Restaurant - Fast-Food	Whole Building		
Restaurant - Fast-Food	Dining Area	4,850	4,850
Restaurant - Fast-Food	Lobby (Main Entry and Assembly)	4,850	4,850
Restaurant - Fast-Food	Kitchen and Food Preparation	4,812	4,812
Restaurant - Fast-Food	Restrooms	4,677	4,677
Retail - 3-Story Large	Whole Building		
Retail - 3-Story Large	Retail Sales and Wholesale Showroom	3,546	3,989
Retail - 3-Story Large	Storage (Conditioned)	2,702	2,559
Retail - 3-Story Large	Office (General)	2,596	2,559
Retail - Single-Story Large	Whole Building		
Retail - Single-Story Large	Retail Sales and Wholesale Showroom	4,454	4,512
Retail - Single-Story Large	Storage (Conditioned)	2,738	2,633
Retail - Single-Story Large	Office (General)	2,714	2,737
Retail - Single-Story Large	Auto Repair Workshop	3,429	4,022
Retail - Single-Story Large	Kitchen and Food Preparation	3,368	3,947
Retail - Single-Story Large	Retail Sales and Wholesale Showroom	4,454	4,512

Building Type	Space Use	Other	CFL
Retail - Small	Whole Building		
Retail - Small	Retail Sales and Wholesale Showroom	3,378	4,013
Retail - Small	Storage (Conditioned)	2,753	2,550
Storage - Conditioned	Whole Building		
Storage - Conditioned	Storage (Conditioned)	3,441	2,780
Storage - Conditioned	Office (General)	3,441	2,780
Storage - Unconditioned	Whole Building		
Storage - Unconditioned	Storage (Unconditioned)	3,441	2,780
Storage - Unconditioned	Office (General)	3,441	2,780
Grocery	Whole Building		
Grocery	Retail Sales, Grocery	4,964	3,942
Grocery	Office (General)	4,526	3,504
Grocery	Comm/Ind Work (Loading Dock)	4,964	3,942
Grocery	Refrigerated (Food Preparation)	4,380	3,504
Grocery	Refrigerated (Walk-in Freezer)	4,380	3,504
Grocery	Refrigerated (Walk-in Cooler)	4,380	3,504
Warehouse – Refrigerated	Whole Building		
Warehouse – Refrigerated	Refrigerated (Frozen Storage)	4,818	4,818
Warehouse – Refrigerated	Refrigerated (Cooled Storage)	4,818	4,818
Warehouse – Refrigerated	Comm/Ind Work (Loading Dock)	4,818	4,818
Warehouse – Refrigerated	Office (General)	3,522	2,719

Custom operating hours must be derived from a user-entered schedule rather than a single entry for annual hours. The schedule should include entries for weekdays, Saturdays, Sundays, and holidays, and allow for seasonal variation.

3.3.3.3. 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 15[10]. 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 15: 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

[10] Values were derived by KEMA for PNM using simulations with Albuquerque weather. (Public Service Company of New Mexico Commercial & Industrial Incentive Program Work Papers, 2011.

Building Type	Albuquerque	Santa Fe	Roswell	Las Cruces
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

3.3.3.4. 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 16 for lighting in refrigerated spaces[11].

Table 16: 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.

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

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

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 17[12], which also shows the *Coincident Factor*, which accounts for the overlap between the kW reduction and the peak period.

Table 17: 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
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

[12] Values were derived by KEMA for PNM using simulations with Albuquerque weather. (Public Service Company of New Mexico Commercial & Industrial Incentive Program Work Papers, 2011.

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 18[13].

Table 18: 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	EUL varies by building type
Outdoor Lighting	HID Lighting - High Pressure Sodium	15
Outdoor Lighting	HID Lighting - Metal Halide	15
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 19.

Table 19: Lighting Measure Life (years) Depending on Building Type

Building Type	CFL	LED	Other
Assembly	4.37	10.9	15
Education - Primary School	4.17	10.4	15
Education - Secondary School	4.02	10.1	15
Education - Community College	4.38	11.0	15
Education - University	4.08	10.2	15

13 DEER 2008

Building Type	CFL	LED	Other
Grocery	2.58	6.5	14.33
Health/Medical - Hospital	2.45	6.1	14.34
Health/Medical - Nursing Home	2.8	7.0	15
Lodging - Hotel	6.02	15.1	15
Lodging - Motel	6.57	16.4	15
Manufacturing - Bio/Tech	2.86	7.1	15
Manufacturing - Light Industrial	3.82	9.5	15
Office - Large	3.17	7.9	15
Office - Small	3.25	8.1	15
Restaurant - Sit-Down	2.08	5.2	14.54
Restaurant - Fast-Food	2.07	5.2	14.48
Retail - 3-Story Large	2.7	6.8	15
Retail - Single-Story Large	2.62	6.6	15
Retail - Small	2.69	6.7	15
Storage - Conditioned	3.6	9.0	15
Storage - Unconditioned	3.6	9.0	15
Storage - Refrigerated Warehouse	2.09	5.2	14.59
Education - Relocatable Classroom	3.76	9.4	15
Commercial - general	3.24	8.1	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 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.

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

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 20[14].

Table 20: Baseline LPD by Building Type

Building Area Type [1]	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
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

[14] IECC 2009, as shown in Illinois State Technical Reference Manual Final Technical Draft, 2012.

Building Area Type [1]	Lighting Power Density (w/ft^2)
Town Hall	1.1
Transportation	1
Warehouse	0.8
Workshop	1.4

Allowable LPD by space-type are shown in Table 21[15].

Table 21: Baseline interior LPD by space type

Common Space Type[2]	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
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

15 ASHRAE 90.1 2007, taken from Pennsylvania State TRM, 2013.

Common Space Type[2]	LPD (W/ft^2)	Building Specific Space Types	LPD (W/ft^2)
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
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

Common Space Type[2]	LPD (W/ft^2)	Building Specific Space Types	LPD (W/ft^2)
		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 22.

Table 22: Baseline exterior LPD.

Building Exterior	Space Description	LPD
Uncovered Parking Area	Parking Lots and Drives	0.15 W/ft2
Building Grounds	Walkways less than 10 ft wide	1.0 W/linear foot
	Walkways 10 ft wide or greater	0.2 W/ft2
	Plaza areas	
	Special feature areas	
	Stairways	1.0 W/ft2
Building Entrances and Exits	Main entries	30 W/linear foot of door width
	Other doors	20 W/linear foot of door width
Canopies and Overhangs	Free standing and attached and overhangs	1.25 W/ft2
Outdoor sales	Open areas (including vehicle sales lots)	0.5 W/ft2
	Street frontage for vehicle sales lots in addition to “open area” allowance	20 W/linear foot
Building facades		0.2 W/ft2 for each illuminated wall or surface or 5.0 W/linear foot for each illuminated wall or surface length
Automated teller machines and night depositories		270 W per location plus 90 W per additional ATM per location
Entrances and gatehouse inspection stations at guarded facilities		1.25 W/ft2 of uncovered area

Building Exterior	Space Description	LPD
Loading areas for law enforcement, fire, ambulance, and other emergency service vehicles		0.5 W/ft2 of uncovered area
Drive-through windows at fast food restaurants		400 W per drive-through
Parking near 24-hour retail entrances		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 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.

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

where:

Svgs	=	Demand savings, in kW
LPD_{CODE}	=	Code Lighting Power Density, W/ft^2, 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 actually 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,

$$Svgs = kW_{POST} \times (OperatingHour_{BASE} - OperatingHours_{POST}) \times HVAC\_Energy\_Factor \quad (7)$$

where:

Svgs	=	Annual energy savings, in kWh
kW_{POST}	=	Power draw of the controlled lamps
$OperatingHours_{BASE}$	=	Annual hours the lamp is on in the baseline, determined as for a standard lighting measure
$OperatingHours_{POST}$	=	Annual hours the lamp is on following controls installation, see below
HVAC_Energy_Factor	=	Adjustment to lighting savings to account for the decreased cooling load, as for a standard lighting measure

For occupancy sensors and interior daylighting controls, post operating hours are derived with the following equation,

$$OperatingHours_{POST} = OperatingHours_{BASE} \times (1 - ControlsFactor)$$

where *ControlsFactor* is derived from Table 23.

Table 23: Lighting Controls Reduction in Operating Hours.

Control Type	Controls Factor
Occupancy Sensor	30%
Daylighting, continuous dimming	30%
Daylighting, multi-step dimming	20%
Daylighting, On/Off	10%

For exterior photocell controls, $OperatingHours_{POST}$ can be assumed to be 12 hours per day.

3.5.4. Demand Savings Estimation

Demand savings are derived with the following equation,

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

where:

Svgs = Demand savings, in kW

kW_{POST} = Power draw of the controlled lamps

HVAC_Demand_Factor = Adjustment to lighting savings to account for the decreased cooling load, as for a standard lighting measure

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

kW_{POST} and *HVAC Demand Factor* are determined as described in the “Lighting – Retrofit” section. *CoincidentFactor* is derived from Table 24.

Table 24: Lighting Controls Coincident Factors.

Control Type	Coincident Factor
Occupancy sensor	15%
Daylighting	90%
Photocell	Determined per site (100% for 24-hour baseline)

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[16].

3.5.7. Incremental Cost

Incremental cost for this measure is the full measure cost. Costs are shown in Table 25[17].

Table 25: Lighting Controls Measure Cost.

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

[16] DEER 2008

[17] Utility work papers, DEER 2005

3.6. High Efficiency Packaged Air Conditioning System

This measure promotes the installation of high-efficiency unitary air-cooled air conditioning 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
Delivery mechanism	Rebate
Baseline description	IECC 2009 SEER/EER
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.

3.6.3. Energy Savings Estimation

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

$$Svgs = Capacity \times EFLH \times Conversion\ Constant \times \left(\frac{1}{SEER_{Base}} - \frac{1}{SEER_{Post}}\right)$$

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

$$Svgs = Capacity \times EFLH \times Conversion\ Constant \times \left(\frac{1}{EER_{Base}} - \frac{1}{EER_{Post}}\right)$$

where:

Svgs	=	Annual energy savings, in kWh
Capacity	=	Nominal rating of packaged system, in tons
EFLH	=	Effective full load hours, see table below
SEER	=	Seasonal energy efficiency ratio, nominal rating of packaged system, Btu/Wh
EER	=	Energy efficiency ratio, nominal rating of packaged system, Btu/Wh

Conversion Constant = 12,000 Btuh/ton x 1/1000 kW/W

Baseline efficiencies are shown in Table 26[18].

Table 26: Packaged AC system baseline efficiency ratings.

Size	SEER	EER
< 5.4 tons	13.0	11.1
5.5 - 11.3 tons	12.9	11.0
11.4 - 19.9 tons	12.7	10.8
20 - 63.3 tons	11.5	9.8
Greater than 63.3 tons	11.2	9.5

EFLH values, derived from eQuest simulations of DEER building prototypes, are shown in Table 27.

Table 27: Packaged AC 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

[18] IECC 2009

Building Type	Albuquerque	Las Cruces	Roswell	Santa Fe
Warehouse - Refrigerated	1,477	1,498	1,596	745
Commercial	1033	1109	1213	617

3.6.4. Demand Savings Estimation

Peak savings are determined with the following equation,

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

Parameters are as defined above for energy savings.

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[19].

3.6.7. Incremental Cost

The incremental cost for this measure is the incremental cost over a standard system. Costs are shown in Table 28[20].

Table 28: 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

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

[20] 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	Pre-existing showerhead
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.

Table 29: Energy and Demand Savings for Commercial Low-flow Showerheads

		Gas water heat	Electric water heat	Unknown water heat		Electric water heat	Unknown water heat
Facility type	Nominal measure flow rate, gpm	Energy Savings, therms	Energy Savings, kWh	Energy Savings, kWh	Energy Savings, therms	Demand savings, kW	Demand savings, kW
K-12 School	2.0	5.0	113	25	3.9	0.063	0.014
K-12 School	1.5	8.8	197	44	6.8	0.110	0.025
University dorm	2.0	20.8	467	226	10.7	0.124	0.060
University dorm	1.5	36.4	817	396	18.8	0.216	0.105

Fitness center	2.0	139.0	3117	952	96.5	0.474	0.145
Fitness center	1.5	243.3	5455	1667	169.0	0.830	0.254
Health patient shower	2.0	6.2	139	31	4.8	0.032	0.007
Health patient shower	1.5	10.8	242	54	8.4	0.055	0.012
Employee shower	2.0	4.6	104	50	2.4	0.035	0.017
Employee shower	1.5	8.1	182	88	4.2	0.061	0.029
Hospitality	2.0	8.6	192	19	7.7	0.029	0.003
Hospitality	1.5	15.0	336	33	13.5	0.051	0.005
Other commercial shower	2.0	7.4	166	59	4.8	0.055	0.020
Other commercial shower	1.5	13.0	290	103	8.4	0.097	0.034

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).[21] The basic equation for water heating energy used is:

$$WtrHtgEnergy = VolFlowRate \times DensityWtr \times TimeOfUse \times (T_{hot} - T_{cold}) \times HeatCapacityWater / Efficiency$$

where:

WtrHtgEnergy	= Annual energy used to heat water, Btu
VolFlowRate	= Showerhead flow rate, gpm
DensityWtr	= Density of water, 8.33 pounds per gallon
TimeOfUse	= Annual time shower is used, minutes, see below
T_{hot}	= Temperature of hot water, ˚F, see below
T_{cold}	= Temperature of cold water, ˚F, see below
HeatCapacityWater	= Heat capacity of water, 1 Btu per pound per ˚F
Efficiency	= Assumed efficiency of water heater, see below

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

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

Table 30: Commercial showerhead parameters

Parameter	Value	
Usage (minutes per year)	Hospitality[22],[23]	3,509
	Health Care[24]	2,528
	Commercial - Employee Shower[25]	1,894
	School[26]	2,057
	Any Commercial Except Fitness Center[26]	3,029
	Fitness Center[27]	56,893
Water Heating Efficiency	Electric	98%
	Gas	75%
Water Heater Temperature Rise (˚F)	108 to 112 ˚F, depending on flow rate.[28]	
Percent Hot Water[29]	2.5 gpm: 73%	
	2.0 gpm: 76%	
	1.75 gpm: 77%	
	1.5 gpm: 78%	

[22] 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

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

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

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

[26] 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.

[27] Phone survey of five PNW Fitness Centers conducted by RTF staff

[28] Professional judgment based on "Energy Efficient Showerhead and Faucet Aerator Metering Study - Single Family Residences". SBW Consulting, Inc.; Puget Sound Power and Light. December 1994.

[29] 2.5 gpm and 2.0 gpm: observed in "Single Family 2007 Showerhead Kit Impact Evaluation". SBW Consulting; Seattle City Light. October 2008 [<www.seattle.gov/light/Conserve/Reports/Evaluation_14.pdf>] Hot water percentage values for 1.75 and 1.5 gpm showerheads are extrapolated from 2.5 and 2.0 values. Lower flow rates result in higher temperature drop from showerhead to user, necessitating higher showerhead temperatures to compensate for the higher loss. NOTE: for this manual, SBW used the median value for all flow rates.

Baseline flow rate	2.2 gpm[30]	
Efficient flow rate[31]	2.00 gpm rated: 1.8 gpm 1.75 gpm rated: 1.75 gpm 1.5 gpm rated: 1.5 gpm	

University dorm rooms were added to the above list for this manual.[32]

Gas/Electric water heating saturation

Savings are provided for gas and electric water heating, and also for the "average" water heater, where the type of water heating is unknown. The average measures provide both gas and electric savings according to the mix of water heating types by facility type. The gas/electric split was estimated based on the Commercial Building Energy Consumption Survey (CBECS)[33] for the Mountain West census division, and is shown in the table below.

Table 31: Commercial Gas and Electric Water Heating Saturations by Facility Type

	Electric DHW saturation	Gas DHW saturation
K-12 School	22%	78%
University dorm	48%	52%
Fitness center	31%	69%
Health patient shower	22%	78%
Employee shower	49%	51%
Hospitality	10%	90%
Other commercial shower	35%	65%

3.7.4. Demand Savings Estimation

We do not have solid data on how demand during summer peak periods compares with demand at other times. We assume that shower usage during peak hours of 3:00-6:00pm on

[30] 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>]

[31] Ibid

[32] Annual usage is estimated as RTF residential annual minutes of use * 75% occupancy * 3 residents per shower.

[33] http://www.eia.gov/consumption/commercial/data/2012/index.cfm?view=microdata Analysis of microdata by SBW

hot summer days is the same as average usage during typical shower hours, e.g. for a university dorm from 6:00am – 12:00am. Then demand savings are derived with the following equation.

$$DemandSvgs = EnergySvgs/TypicalHours$$

where:

DemandSvgs = Demand savings, kW

EnergySvgs = Annual energy savings, kWh

TypicalHours = Number of hours shower would typically be in use, see below[34]

Table 32: Commercial Shower Typical Hours of Use

Facility Type	Shower open hours, daily
K-12 School	9
K-12 School	9
University dorm	18
University dorm	18
Fitness center	18
Fitness center	18
Health patient shower	12
Health patient shower	12
Employee shower	12
Employee shower	12
Hospitality	18
Hospitality	18
Other commercial shower	12
Other commercial shower	12

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 33: Commercial Showerhead Water Savings

Facility Type	Nominal measure gpm	Water savings, gallons/year
K-12 School	2.0	823
K-12 School	1.5	1,440
University dorm	2.0	3,409

[34] Professional judgment

University dorm	1.5	5,966
Fitness center	2.0	22,757
Fitness center	1.5	39,825
Health patient shower	2.0	1,011
Health patient shower	1.5	1,770
Employee shower	2.0	758
Employee shower	1.5	1,326
Hospitality	2.0	1,404
Hospitality	1.5	2,456
Other commercial shower	2.0	1,212
Other commercial shower	1.5	2,120

3.7.6. Measure Life

Lifetime for this measure is 10 years[35].

3.7.7. Incremental Cost

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

Table 34: Commercial Showerhead Water Savings

Retail[36]	$7.00
Direct Install[37]	$11.34
Mail-by-Request[38]	$8.11

[35] RTF

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

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

[38] $6 (2012$) 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 35: 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:

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

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:

$$DP_{meas} = 0.005379 \times T_{dp\text{-}out}^2 + 0.171795 \times T_{dp\text{-}out} + 19.87006$$ [39]

Where:

$T_{dp\text{-}out}$ = outdoor dew point [40]

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

$kW_{ASH} = (0.37A/ft)(115V) = 0.04255kW/ft$ [41]

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.

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

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

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

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

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

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

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.

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

It is assumed that 35% of sensible heat generated by the ASH ends up as a cooling load (Q_{ASH}) inside the case[42]**Error! Reference source not found.**. The cooling load contribution from ASH is given by:

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

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%).

For medium and low temperature compressors, the following equation is used to determine the EER.[43]

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

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

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

[43] 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.

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}[44], SCT, and the resulting EER for each climate zone are shown in the table below.

Table 36: 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.

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

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

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

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.:

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

[44] 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.

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 x 1000) x 100%

$kW_{comp\text{-}efficient} = Q_{ASH}$ / (EER x 1000) x 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[45].

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. [46]

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

[46] 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 37: 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	2277.6
Medium-Temp Cooler	0.0900	788.4
High-Temp Cooler	0.0825	722.7

3.9.3. Energy Savings Estimation

Savings are based on the following:

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

Where:

$kW_{baseline}$ = Connected load of a typical reach-in cooler or freezer door with a heater. The values shown in the table below are based on a range of wattages from two manufacturers and metered data. [47]

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. [48]

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

Table 38: Connected Load and Bonus Factor for Typical Cooler and Freezer Doors

	$kW_{baseline}$	Saturated Suction Temperature	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.

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

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. [49]

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

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

[49] 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.[50]

[50] 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 39: 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[51].

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[52].

3.10.5. Non-energy Benefits

None

3.10.6. Measure Life

The lifetime of Guest Room EM is expected to be 15 years[53].

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.[54]

[51] 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.

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

[53] Deer 2008 value for energy management systems.

[54] 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 40: 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	1240	558

Table 41: 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 42: 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 43: 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)[55] 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).[56] 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).[57] 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),[58] DEER savings are adjusted according to efficiency level as follows. Energy savings are based on the following formula.

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

where:

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

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

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

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

3.11.4. Non-energy Benefits

None

[55] Deeresources.com, accessed on Oct 6, 2015 with READi version 2.3.0.

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

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

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

3.11.5. Measure Life

The lifetime of storage water heaters is 15 years[59]. The lifetime for instantaneous water heaters is 20 years.[60]

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 44: 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[61]	$7.22
CEE Tier 2 EF=0.8[62]	$28.00
Large (> 55 gallons) storage	
Energy Star EF=0.77[62]	$28.00
Instantaneous less than 200 kBtuh, less than 2 gal, EF rated	
CEE Tier 1 EF=0.82[63]	$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	
CEE Tier 1 Et=0.9[64]	$7.97
CEE Tier 2 (Energy Star) Et=0.94[64]	$7.97
Instantaneous	
CEE Tier 1 Et=0.9[63]	$3.01
CEE Tier 2 (Energy Star) Et=0.94[63]	$12.55

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

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

61 SCG Workpaper

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

63 SCG Workpaper

64 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 45: Energy savings (kWh per HP) for HVAC VFD

Equipment Type	Albuquerque	Santa Fe	Roswell	Las Cruces
Supply Fans	2033	2033	2033	2033
Return Fans	1788	1788	1788	1788
Cooling Water Pumps	1944	1576	2199	2286
Hot Water Pumps	1431	1510	1373	1344
WSHP Circulation Pumps	2562	2562	2562	2562
Cooling Tower Fan	784	784	784	784

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

Table 46: 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.[65] The NEEP team metered, post-installation, around 400 HVAC VFD installations in the mid-Atlantic and New England regions in 2012-2013. The study also included a previous, pre/post, VFD metering study in Massachusetts of 26 sites.

The NEEP study found many VFD's were run at a constant speed, and that energy savings were often not closely related to weather. The NEEP study presented single savings values for each HVAC application across the entire region in order to achieve higher statistical significance. For applications which apply to both heating and cooling, the NEEP savings values are unchanged for New Mexico. For the applications which are specific to heating or cooling, the values are adjusted for New Mexico climate zones. The adjustment is based on a degree-day ratio of the New Mexico climate zone to an approximate average New England degree day value. This degree-day ratio is given a weight, and 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 simply taken from the Indiana state TRM,[66] 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.

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

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

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.

3.12.6. Measure Life

The lifetime for this measure is 15 years[67].

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

Table 47: 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

[67] DEER 2014

[68] 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

All gas savings for a boiler improvement are tabulated by climate improvement type, building type, and climate zone. Gas savings are in therms per thousand Btu per hour (kBtuh).

Table 48 Savings for Water Boiler 300 to 2500 kBtuh – Albuquerque (Therms/kBtuh)

	Commercial Typical	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large
83.0 Et, OA Reset from 140 to 165 F	6	8	7	11	45	18	2	23	6	4	6
85.0 Et, OA Reset from	6	10	8	13	56	23	2	30	8	5	7

140 to 165 F											
90.0 Et, condensing, OA reset from 115 to 140 F	8	18	15	22	78	35	5	40	13	9	13
90.0 Et, condensing, load reset from 115 to 140 F	9	20	16	24	95	33	6	47	15	10	14
90.0 Et, condensing, OA reset from 140 to 165 F	7	16	13	19	55	29	4	33	11	8	12
94.0 Et, condensing, OA reset from 115 to 140 F	9	21	18	26	98	43	5	53	15	11	16
94.0 Et, condensing, load reset from 115 to 140 F	10	23	19	27	114	40	6	60	16	12	16
94.0 Et, condensing, OA reset from 140 to 165 F	8	19	16	23	76	37	5	47	13	10	14

Table 49 Savings for Water Boiler 300 to 2500 kBtuh – Roswell (Therms/kBtuh)

	Commercial Typical	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large
83.0 Et, OA Reset from 140 to 165 F	6	8	8	10	73	31	3	25	9	5	6
85.0 Et, OA Reset from 140 to 165 F	7	9	10	11	85	35	3	31	10	6	7
90.0 Et, condensing, OA reset from 115 to 140 F	10	16	16	19	111	48	5	41	16	10	11
90.0 Et, condensing, load reset from 115 to 140 F	11	17	18	20	129	47	7	48	18	11	12
90.0 Et, condensing, OA reset from 140 to 165 F	9	14	14	17	88	41	4	35	14	9	10
94.0 Et, condensing, OA reset from 115 to 140 F	11	17	18	21	132	54	5	50	17	11	13
94.0 Et, condensing, load reset from 115 to	12	19	20	22	149	53	7	57	19	12	14

140 F											
94.0 Et, condensing, OA reset from 140 to 165 F	10	16	17	19	110	48	4	45	15	10	12

Table 50 Savings for Water Boiler 300 to 2500 kBtuh – Santa Fe (Therms/kBtuh)

	Commercial Typical	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large
83.0 Et, OA Reset from 140 to 165 F	8	12	9	15	63	26	3	32	9	6	8
85.0 Et, OA Reset from 140 to 165 F	9	14	12	18	80	32	3	43	11	7	10
90.0 Et, condensing, OA reset from 115 to 140 F	12	25	21	32	110	50	7	56	19	13	19
90.0 Et, condensing, load reset from 115 to 140 F	13	28	22	34	134	46	8	67	21	14	19
90.0 Et, condensing, OA reset from 140 to 165 F	10	22	18	27	77	40	6	47	16	12	17
94.0 Et, condensing, OA reset from 115 to 140 F	13	29	25	36	138	61	8	74	21	15	22
94.0 Et, condensing, load reset from 115 to 140 F	14	32	27	39	161	57	9	85	23	16	23
94.0 Et, condensing, OA reset from 140 to 165 F	12	27	23	32	107	52	6	66	19	14	20

Table 51 Savings for Water Boiler 300 to 2500 kBtuh – Las Cruces (Therms/kBtuh)

	Commercial Typical	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large

83.0 Et, OA Reset from 140 to 165 F	6	7	8	9	69	29	2	24	9	5	5
85.0 Et, OA Reset from 140 to 165 F	7	8	9	10	80	33	3	29	10	6	6
90.0 Et, condensing, OA reset from 115 to 140 F	9	15	15	18	105	45	5	38	15	9	11
90.0 Et, condensing, load reset from 115 to 140 F	10	16	17	19	122	44	6	45	17	10	11
90.0 Et, condensing, OA reset from 140 to 165 F	8	13	13	16	83	38	4	33	13	8	10
94.0 Et, condensing, OA reset from 115 to 140 F	10	16	17	19	124	51	5	47	16	10	12
94.0 Et, condensing, OA reset from 140 to 165 F	11	18	19	21	140	50	7	54	18	11	13
94.0 Et, condensing, OA reset from 140 to 165 F	9	15	16	18	103	45	4	42	14	9	11

Table 52 Savings for Water Boiler Greater than 2500 kBtuh – Albuquerque (Therms/kBtuh)

	Commercial Typical	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large
83.0 Et, 85.0Ec, OA Reset from 140 to 165 F	6	8	7	11	45	18	2	23	6	4	6
85.0 Et, 87.0Ec, OA Reset from 140 to 165 F	6	10	8	13	56	23	2	30	8	5	7
90.0 Et, condensing, OA reset from 115 to 140 F	8	18	15	22	78	35	5	40	13	9	13
90.0 Et, condensing, load reset from 115 to 140 F	9	20	16	24	95	33	6	47	15	10	14
90.0 Et, condensing, OA reset from 140 to 165 F	7	16	13	19	55	29	4	33	11	8	12
94.0 Et, condensing, OA reset from 115 to 140 F	9	21	18	26	98	43	5	53	15	11	16
94.0 Et, condensing, load reset from 115 to	10	23	19	27	114	40	6	60	16	12	16

140 F											
94.0 Et, condensing, OA reset from 140 to 165 F	21	9	9	13	71	31	3	28	9	6	6

Table 53 Savings for Water Boiler Greater than 2500 kBtuh – Roswell (Therms/kBtuh)

	Commercial Typical	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large
83.0 Et, 85.0Ec, OA Reset from 140 to 165 F	6	8	8	10	73	31	3	25	9	5	6
85.0 Et, 87.0Ec, OA Reset from 140 to 165 F	7	9	10	11	85	35	3	31	10	6	7
90.0 Et, condensing, OA reset from 115 to 140 F	10	16	16	19	111	48	5	41	16	10	11
90.0 Et, condensing, load reset from 115 to 140 F	11	17	18	20	129	47	7	48	18	11	12
90.0 Et, condensing, OA reset from 140 to 165 F	9	14	14	17	88	41	4	35	14	9	10
94.0 Et, condensing, OA reset from 115 to 140 F	11	17	18	21	132	54	5	50	17	11	13
94.0 Et, condensing, load reset from 115 to 140 F	12	19	20	22	149	53	7	57	19	12	14
94.0 Et, condensing, OA reset from 140 to 165 F	10	16	17	19	110	48	4	45	15	10	12

Table 54 Savings for Water Boiler Greater than 2500 kBtuh – Santa Fe (Therms/kBtuh)

	Commercial Typical	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large
83.0 Et, 85.0Ec, OA Reset from 140 to 165 F	8	12	9	15	63	26	3	32	9	6	8
85.0 Et, 87.0Ec, OA Reset from 140 to 165 F	9	14	12	18	80	32	3	43	11	7	10
90.0 Et, condensing, OA	12	25	21	32	110	50	7	56	19	13	19

reset from 115 to 140 F											
90.0 Et, condensing, load reset from 115 to 140 F	13	28	22	34	134	46	8	67	21	14	19
90.0 Et, condensing, OA reset from 140 to 165 F	10	22	18	27	77	40	6	47	16	12	17
94.0 Et, condensing, OA reset from 115 to 140 F	13	29	25	36	138	61	8	74	21	15	22
94.0 Et, condensing, load reset from 115 to 140 F	14	32	27	39	161	57	9	85	23	16	23
94.0 Et, condensing, OA reset from 140 to 165 F	12	27	23	32	107	52	6	66	19	14	20

Table 55 Savings for Water Boiler Greater than 2500 kBtuh – Las Cruces (Therms/kBtuh)

	Commercial Typical	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large
83.0 Et, 85.0Ec, OA Reset from 140 to 165 F	6	7	8	9	69	29	2	24	9	5	5
85.0 Et, 87.0Ec, OA Reset from 140 to 165 F	7	8	9	10	80	33	3	29	10	6	6
90.0 Et, condensing, OA reset from 115 to 140 F	9	15	15	18	105	45	5	38	15	9	11
90.0 Et, condensing, load reset from 115 to 140 F	10	16	17	19	122	44	6	45	17	10	11
90.0 Et, condensing, OA reset from 140 to 165 F	8	13	13	16	83	38	4	33	13	8	10
94.0 Et, condensing, OA reset from 115 to 140 F	10	16	17	19	124	51	5	47	16	10	12
94.0 Et, condensing, load reset from 115 to 140 F	11	18	19	21	140	50	7	54	18	11	13
94.0 Et, condensing, OA reset from 140 to 165 F	9	15	16	18	103	45	4	42	14	9	11

Table 56 Savings for Water Boiler Less than 300 kBtuh – Albuquerque (Therms/kBtuh)

	Commercial Typical	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large
84.0 AFUE, OA Reset from 140 to 165 F	4	5	4	7	28	12	1	12	4	2	3
84.5 AFUE, OA Reset from 140 to 165 F	4	5	4	7	30	13	1	14	4	3	4
85.0 AFUE, OA Reset from 140 to 165 F	4	6	5	8	33	14	2	15	5	3	4
87.0 AFUE, OA Reset from 140 to 165 F	4	7	6	10	43	18	2	22	6	4	5
90.0 AFUE, condensing, OA reset from 115 to 140 F	6	13	10	17	51	25	4	23	10	7	10
90.0 AFUE, condensing, OA reset from 140 to 165 F	7	15	11	19	68	22	5	30	12	7	10
94.0 AFUE, condensing, OA reset from 115 to 140 F	5	11	9	14	28	18	3	16	8	6	8
94.0 AFUE, condensing, load reset from 115 to 140 F	7	16	13	20	69	32	5	34	12	8	12
94.0 AFUE, condensing, OA reset from 140 to 165 F	7	18	14	22	85	29	5	42	13	9	12

Table 57 Savings for Water Boiler Less than 300 kBtuh – Roswell (Therms/kBtuh)

	Commercial Typical	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large
84.0 AFUE, OA Reset from 140 to 165 F	4	5	5	7	49	22	2	14	6	3	3
84.5 AFUE, OA Reset from 140 to 165 F	5	5	6	7	51	23	2	16	7	3	4
85.0 AFUE, OA Reset	5	5	6	7	54	24	2	17	7	4	4

from 140 to 165 F											
87.0 AFUE, OA Reset from 140 to 165 F	5	7	7	8	64	27	2	22	8	4	5
90.0 AFUE, condensing, OA reset from 115 to 140 F	7	12	12	14	77	36	4	25	12	7	8
90.0 AFUE, condensing, OA reset from 140 to 165 F	8	14	13	16	94	35	6	32	15	8	9
94.0 AFUE, condensing, OA reset from 115 to 140 F	6	10	10	13	53	28	3	20	10	6	7
94.0 AFUE, condensing, load reset from 115 to 140 F	8	14	14	16	95	42	4	33	14	8	10
94.0 AFUE, condensing, OA reset from 140 to 165 F	9	15	15	17	112	41	6	40	16	9	10

Table 58 Savings for Water Boiler Less than 300 kBtuh – Santa Fe (Therms/kBtuh)

	Commercial Typical	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large
84.0 AFUE, OA Reset from 140 to 165 F	5	7	5	10	39	16	2	17	6	3	5
84.5 AFUE, OA Reset from 140 to 165 F	5	8	6	11	43	18	2	20	6	4	5
85.0 AFUE, OA Reset from 140 to 165 F	5	8	6	11	47	19	2	22	7	4	5
87.0 AFUE, OA Reset from 140 to 165 F	6	10	9	14	61	25	2	31	8	5	7
90.0 AFUE, condensing, OA reset from 115 to 140 F	8	19	15	24	73	35	6	32	14	9	14
90.0 AFUE, condensing, OA reset from 140 to 165 F	9	21	16	26	96	31	7	43	16	11	14
94.0 AFUE, condensing, OA reset from 115 to 140 F	7	16	12	19	40	26	5	23	12	8	12
94.0 AFUE, condensing, load reset from 115 to	9	22	19	28	98	45	6	48	16	11	17

140 F											
94.0 AFUE, condensing, OA reset from 140 to 165 F	11	25	20	30	121	41	8	59	18	12	17

Table 59 Savings for Water Boiler Less than 300 kBtuh – Las Cruces (Therms/kBtuh)

	Commercial Typical	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large
84.0 AFUE, OA Reset from 140 to 165 F	4	5	5	6	46	21	2	14	6	3	3
84.5 AFUE, OA Reset from 140 to 165 F	4	5	5	6	48	22	2	15	6	3	3
85.0 AFUE, OA Reset from 140 to 165 F	4	5	6	7	51	22	2	16	7	3	4
87.0 AFUE, OA Reset from 140 to 165 F	5	6	7	8	60	26	2	20	7	4	4
90.0 AFUE, condensing, OA reset from 115 to 140 F	7	11	11	14	72	34	4	24	12	7	8
90.0 AFUE, condensing, OA reset from 140 to 165 F	8	13	12	15	89	33	6	30	14	7	8
94.0 AFUE, condensing, OA reset from 115 to 140 F	6	10	9	12	50	27	3	19	10	6	7
94.0 AFUE, condensing, load reset from 115 to 140 F	8	13	13	15	89	39	4	32	13	8	9
94.0 AFUE, condensing, OA reset from 140 to 165 F	9	14	14	16	106	38	6	38	15	8	10

Table 60 Savings for Steam Boiler – Albuquerque (Therms/kBtuh)

	Commercial Typical	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large
Steam boiler 300 - 2500 kBtuh											
81.0 Et, OA Reset from 140 to 165 F	5	7	5	9	37	15	2	18	5	3	4
82.0 Et, OA Reset from 140 to 165 F	5	8	6	10	43	17	2	22	6	4	5
Steam Greater Than 2500 kBtuh											
80.0 Et, OA Reset from 140 to 165 F	4	6	4	8	30	12	2	14	5	3	3
81.0 Et, OA Reset from 140 to 165 F	5	7	5	9	37	15	2	18	5	3	4
82.0 Et, OA Reset from 140 to 165 F	5	8	6	10	43	17	2	22	6	4	5
Steam Boiler Less Than 300 kBtuh											
82.0 AFUE, OA Reset from 140 to 165 F	3	4	3	6	26	11	1	11	4	2	3
83.0 AFUE, OA Reset from 140 to 165 F	3	5	4	7	31	13	1	14	4	2	3

Table 61 Savings for Steam Boiler – Roswell (Therms/kBtuh)

	Commercial Typical	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large
Steam boiler 300 - 2500 kBtuh											
81.0 Et, OA Reset from 140 to 165 F	6	6	7	8	63	27	2	20	8	4	4
82.0 Et, OA Reset from 140 to 165 F	6	7	8	9	70	29	2	23	8	5	5
Steam Greater Than 2500 kBtuh											
80.0 Et, OA Reset from 140 to 165 F	5	6	6	7	57	25	2	17	7	4	4
81.0 Et, OA Reset from 140 to 165 F	6	6	7	8	63	27	2	20	8	4	4

82.0 Et, OA Reset from 140 to 165 F	6	7	8	9	70	29	2	23	8	5	5
Steam Boiler Less Than 300 kBtuh											
82.0 AFUE, OA Reset from 140 to 165 F	4	4	5	6	45	20	2	12	6	3	3
83.0 AFUE, OA Reset from 140 to 165 F	4	5	5	6	50	22	2	14	6	3	3

Table 62 Savings for Steam Boiler – Santa Fe (Therms/kBtuh)

	Commercial Typical	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large
Steam boiler 300 - 2500 kBtuh											
81.0 Et, OA Reset from 140 to 165 F	7	9	7	13	52	21	2	25	8	5	6
82.0 Et, OA Reset from 140 to 165 F	7	11	8	14	61	25	2	30	8	5	7
Steam Greater Than 2500 kBtuh											
80.0 Et, OA Reset from 140 to 165 F	6	8	6	11	43	18	2	19	7	4	5
81.0 Et, OA Reset from 140 to 165 F	7	9	7	13	52	21	2	25	8	5	6
82.0 Et, OA Reset from 140 to 165 F	7	11	8	14	61	25	2	30	8	5	7
Steam Boiler Less Than 300 kBtuh											
82.0 AFUE, OA Reset from 140 to 165 F	4	6	5	9	37	15	2	15	5	3	4
83.0 AFUE, OA Reset from 140 to 165 F	5	7	6	10	44	18	2	20	6	3	5

Table 63 Savings for Steam Boiler – Las Cruces (Therms/kBtuh)

	Commercial Typical	Community College	Secondary School	University	Hospital	Hotel	Biotech	Nursing Home	Large Office	Small Office	Multistory Large
Steam boiler 300 - 2500 kBtuh											
81.0 Et, OA Reset from	5	6	7	8	60	25	2	19	7	4	4

140 to 165 F											
82.0 Et, OA Reset from 140 to 165 F	6	6	7	8	66	27	2	22	8	4	5
Steam Greater Than 2500 kBtuh											
80.0 Et, OA Reset from 140 to 165 F	5	5	6	7	54	23	2	16	7	4	4
81.0 Et, OA Reset from 140 to 165 F	5	6	7	8	60	25	2	19	7	4	4
82.0 Et, OA Reset from 140 to 165 F	6	6	7	8	66	27	2	22	8	4	5
Steam Boiler Less Than 300 kBtuh											
82.0 AFUE, OA Reset from 140 to 165 F	4	4	4	5	42	19	2	11	6	3	3
83.0 AFUE, OA Reset from 140 to 165 F	4	5	5	6	47	21	2	14	6	3	3

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[69]. The data from the CA 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, degree hour fractions were used for each climate zone.[70] TMY 3 data for New Mexico climate zones were used.

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

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 HDH to Albuquerque and Santa Fe. Climate Zone 14 (China Lake) was closest in HDH to Roswell and Las Cruces. DEER data was filtered to only include information from the most similar climate zone for heating.

[69] DEER 2016, This file created on 10/26/2015 4:41:05 PM while connected to deeresources.net as sptviewer by READI (v2.3.0).

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

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

25 years[71]

3.13.7. Incremental Cost

Table 64 Incremental Boiler Costs[72]

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

[71] MA TRM 2011

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

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 65: 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	1263	0.144
Low Temperature walk-in evaporator fan ECM	1317	0.158
Average walk-in evaporator fan ECM	1281	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.[73] The RTF relied on data from the Energy Smart Grocer (ESG) program of

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

Portland Energy Conservation, Inc. (PECI). ESG audit data showed the following distribution of walk-in evaporator fan motor sizes.

Table 66: 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 67: Walk-in evaporator motor size distribution

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

Refrigeration savings are based on the following formula.

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

where:

RefrigSvgs = Annual refrigeration savings due to reduced waste heat, kWh

ConvConst = 3.413 Btu/Wh

EER = Efficiency of walk-in refrigeration, see 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 68: 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.[74] 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 69: Incremental cost for walk-in ECM's

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

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

3.15. Refrigerated Reach-in Efficient Evaporator Fan Motor

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

3.15.1. Measure Overview

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

3.15.2. Savings

Energy and demand savings are shown in the following table.

Table 70: 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.[75] 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

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

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

Table 71: 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

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

3.15.4. 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 73: Incremental cost for reach-in ECM’s

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

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	Maximum of R-22
Efficient case description	Minimum of R-30

4.1.2. Savings

The savings are on a square foot basis customized for each representative location and baseline R-Value as show in the tables below.

Table 74: Ceiling Insulation Savings Values per square foot - Albuquerque

Existing R-Value	kWh Savings/ft^2					Therms/ft^2	Summer Peak kW Savings/ft^2
	Gas Heat with AC	Electric Resistance Heat with AC	Heat Pump	Gas Heat with Evap Cooling	Electric Resistance Heat with Evap Cooling	Gas Heat	Electric AC
R-0	0.177	5.13	2.69	0.035	4.99	0.217	0.0003093
R-1 to R-4	0.094	2.72	1.43	0.019	2.64	0.115	0.0001639
R-5 to R-8	0.057	1.66	0.87	0.011	1.61	0.070	0.0000999
R-9 to R-14	0.029	0.85	0.45	0.006	0.83	0.036	0.0000512
R-15 to R-22	0.011	0.30	0.16	0.002	0.30	0.013	0.0000184

Table 75: Ceiling Insulation Savings Values per square foot – Las Cruces

Existing R-Value	kWh Savings/ft^2					Therms/ft^2	Summer Peak kW Savings/ft^2
	Gas Heat with AC	Electric Resistance Heat with AC	Heat Pump	Gas Heat with Evap Cooling	Electric Resistance Heat with Evap Cooling	Gas Heat	Electric AC
R-0	0.342	3.82	2.06	0.068	3.55	0.152	0.0003369
R-1 to R-4	0.181	2.03	1.09	0.036	1.88	0.081	0.0001786
R-5 to R-8	0.110	1.23	0.67	0.022	1.15	0.049	0.0001088
R-9 to R-14	0.057	0.63	0.34	0.011	0.59	0.025	0.0000558
R-15 to R-22	0.020	0.23	0.12	0.004	0.21	0.009	0.0000200

Table 76: Ceiling Insulation Savings Values per square foot – Roswell

Existing R-Value	kWh Savings/ft^2					Therms/ft^2	Summer Peak kW Savings/ft^2
	Gas Heat with AC	Electric Resistance Heat with AC	Heat Pump	Gas Heat with Evap Cooling	Electric Resistance Heat with Evap Cooling	Gas Heat	Electric AC
R-0	0.279	4.66	2.44	0.055	4.43	0.191	0.0003093
R-1 to R-4	0.148	2.47	1.29	0.029	2.35	0.102	0.0001639
R-5 to R-8	0.090	1.50	0.79	0.018	1.43	0.062	0.0000999
R-9 to R-14	0.046	0.77	0.40	0.009	0.73	0.032	0.0000512
R-15 to R-22	0.017	0.28	0.14	0.003	0.26	0.011	0.0000184

Table 77: Ceiling Insulation Savings Values per square foot – Santa Fe

Existing R-Value	kWh Savings/ft^2					Therms/ft^2	Summer Peak kW Savings/ft^2
	Gas Heat with AC	Electric Resistance Heat with AC	Heat Pump	Gas Heat with Evap Cooling	Electric Resistance Heat with Evap Cooling	Gas Heat	Electric AC
R-0	0.098	6.39	3.67	0.019	6.32	0.275	0.0002540
R-1 to R-4	0.052	3.39	1.95	0.010	3.35	0.146	0.0001347
R-5 to R-8	0.032	2.07	1.19	0.006	2.04	0.089	0.0000821
R-9 to R-14	0.016	1.06	0.61	0.003	1.05	0.046	0.0000420
R-15 to R-22	0.006	0.38	0.22	0.001	0.37	0.016	0.0000151

4.1.3. Energy Savings Estimation

Savings are calculated with a spreadsheet based on the following formulas[76].

$$Svgs = (E_{Baseline} - E_{Measure})/Equipment\ Factor \times Conversion\ Constant \quad (9)$$

where:

Svgs	=	Annual energy savings, in therms or kWh
$E_{Baseline}$	=	Annual baseline heat transfer through the ceiling as calculated using the energy equation below
$E_{Measure}$	=	Annual post installation heat transfer through the ceiling as calculated using equation below
Equipment Factor	=	Heating or cooling equipment efficiency. Some values have conversion factors applied to transform them into a standard efficiency format. See Table 78 for values used
Conversion Constant	=	Constant(s) required to get to the desired end units

$$Energy = Area_{Insulation} \times \sum_i \{Hours_i \times \Delta Temperature_i\}/\left(R_{Insulation} + R_{Roof\ Construction}\right) \quad (10)$$

where:

Energy	=	Energy transfer through the ceiling, in Btus
$Area_{Insulation}$	=	Total surface area of the roof insulation, in ft^2
$Hours_i$	=	Annual operation hours in temperature bin i for the appropriate city
$\Delta Temperature_i$	=	Temperature difference between the outside temperature bin i (5°F increments) and the indoor temperature set point (72°F for cooling, 68°F for heating), in °F
$R_{insulation}$	=	R-value of the roof insulation, values used were 0,4,8,14,22, in $h \cdot ft^2 \cdot °F/Btu$
$R_{Roof\ Construction}$	=	R-value of the roof construction material. Assumed to be 6.3, in $h \cdot ft^2 \cdot °F/Btu$

Table 78: Equipment Efficiencies

Equipment Type	Value	Notes	Source
Air Conditioning	13.2	SEER	ADM
Evaporative Cooler	0.2	kW/ton	ADM
Gas Furnace	0.78	Efficiency	ADM
Electric Resistance Heat	1.00	Efficiency	
Heat Pump – Heating	7.7	HSPF base, then modified for each city	PNM WP

[76] Modified from ADM Associates, Evaluation of 2011 DSM Portfolio, New Mexico Gas Company, 2012

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. Since the savings are calculated using a bin method it is not feasible to determine the exact usage for those hours. Instead it is assumed that the time spent in the hottest bin is likely during the peak time. Which bin is the hottest depends on the climate zone. Due to the high run hours associated with evaporative cooling in high temperatures, no demand savings are assigned to homes with evaporative cooling. Based on these assumptions, the demand savings for homes with standard DX cooling are derived with the following equation[77].

$$Svgs = kWh/Hours \quad (11)$$

where:

Svgs = Summer peak kW savings

kWh = *Total kWh saved in the hottest bin*

Hours = *Total hours in the hottest bin*

4.1.5. Non-energy Benefits

There are no non-energy benefits.

4.1.6. Measure Life

The lifetime for this measure is 25 years[78].

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[79].

[77] Based on ADM ceiling insulation calculator spreadsheet

[78] GDS Associates, Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, 2007

[79] 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	2.5 gpm or greater
Efficient case description	2.0, 1.75, or 1.5 gpm

4.2.2. Savings

The measure applies to both single and multifamily residences.

Table 79: Residential Low-flow Showerhead Savings (therms or kWh per year)

Efficient Flow Rate (gpm)	Savings (Therms/ yr/ showerhead)	Savings (kWh/ yr/ showerhead)
2.0	13.5	303
1.75	17.6	395
1.5	21.9	491

4.2.3. Energy Savings Estimation

Savings are derived with the following formula[80].

$$Svgs = (Pre_F \times \text{PreHot\%} - Post_F \times PostHot\%) \times \Delta T \times Mins \times HtrEnergy \quad (12)$$

where:

Svgs = Annual energy savings, in therms

PreF = Baseline flow rate, 2.53 gpm

PreHot% = Baseline hot water percentage, 73.1%

[80] 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/.

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

PostHot% = Measure hot water percentage, see Table 80 for specifics

ΔT = Water heater outlet temperature minus inlet temperature, 75 °F

Mins = Annual minutes showerhead is used, 3,307.1. Calculated from data shown in Table 81

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). 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

Varying parameters are shown in Table 80.

Table 80: Residential Low-Flow Showerhead Flow Rate Dependent Parameters

Nominal Flow Rate	Flow Rate (gpm)	Hot Water %
2.0	1.8	75.5
1.75	1.575	76.9
1.5	1.35	78.2

The annual minutes value is calculated by taking the product of the four parameters listed in Table 81.

Table 81: Residential Low-Flow Showerhead Minutes Parameters[81]

Parameter	Value	Source
Daily showers per Person, weighted average between primary and secondary showerheads (showers per person per day)	0.46	"Survey Research for the Home Water Savers Program: Phase I Report". Prepared by Karen A. Brattesani, Research Innovations. Prepared for Seattle City Lights (April 1993)
Annualized Occupancy (days per year)	350	RTF estimate

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

Parameter	Value	Source
Persons per residence (people per housing unit)	2.62	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 Revised: Thursday, 23-May-2013 14:17:24 EDT
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[82].

Table 82: Residential Low-Flow Showerhead Parameter Sources

Baseline flow rate	"Single Family 2007 Showerhead Kit Impact Evaluation". SBW Consulting; Seattle City Light. October 2008
Hot Water %	"Seattle Home Water Conservation Study"; Seattle Public Utilities and the U.S. E.P.A. (December 2000) is used for baseline and 2.0 gpm efficient case hot water mix%. The 1.75 gpm and 1.5 gpm cases follow a linear relationship between the in-situ flow rates and the hot water mix %s from the referenced source.
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
Temperature difference between heater outlet and inlet	RTF decision based on "Energy Efficient Showerhead and Faucet Aerator Metering Study - Single Family Residences". SBW Consulting, Inc.; Puget Sound Power and Light. December 1994. (as cited in an RTF meeting presentation dated February 2, 2010)
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

[82] As reported in ibid. 80, 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 83. Local water and wastewater rates need to be applied to these values to monetize savings.

Table 83: Residendial Low-Flow Showerhead Water Savings

Nominal Flow Rate	Water Savings (gallons)
2.0	2414
1.75	3158
1.5	3902

4.2.6. Measure Life

The lifetime for this measure is 10 years[83].

4.2.7. Incremental Cost

The incremental cost for this measure is the total cost. The cost per direct-installed residential showerhead is $24[84].

[83] Ibid. 80
[84] 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	Either federal standards or average existing conditions
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.

Table 84: Residential low-flow faucet aerator savings (therms or kWh per year)

Facility Type	Location	Efficient Flow Rate (gpm)	Savings (Therms/ yr/ housing unit)	Savings (kWh/ yr/ housing unit)
Single Family	Kitchen	1.5	10.5	236
Single Family	Bathroom	1	8.0	180
Single Family	Bathroom	0.5	11.4	255
Multifamily	Kitchen	1.5	7.8	176
Multifamily	Bathroom	1	10.7	240
Multifamily	Bathroom	0.5	15.2	340

4.3.3. Energy Savings Estimation

Savings are derived with the following formula[85].

$$Svgs = (FlowPre - FlowPost) \times DeltaT \times Minutes \times Days \times HeatCapacity \times Density \times Const/EffDHW \quad (13)$$

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
DeltaT	=	Temperature difference between cold and usage, 50 °F
Minutes	=	Minutes per day faucet is used, depends on facility type and location, see Table 6
Days	=	Days per year faucet is used, 365
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

Varying parameters are shown in Table 85.

Table 85: Residential low-flow faucet aerator facility-dependent parameters

Facility Type	Location	Post Flow Rate	Minutes/day[86]
Single Family	Kitchen	1.5	7.42
Single Family	Bathroom	1	3.30
Single Family	Bathroom	0.5	3.30
Multifamily	Kitchen	1.5	5.53
Multifamily	Bathroom	1	4.40
Multifamily	Bathroom	0.5	4.40

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

[86] The single family values are from SBW Consulting study, "Energy Efficient Showerhead and Faucet Aerator Metering Study: Single Family Residences", 1994. The multifamily values are from an unpublished SBW Consulting study, 2013.

Parameter values are based on the following sources[87].

Table 86: 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.
Temperature difference between cold and faucet	Vermont TRM No. 2008-53, pp. 273-274, 337, 367-368, 429-431. 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 groundwater T in New Mexico is 55 °F. Applying thermal balance equation yields assumption that 30% of water coming from the faucet is cold, 70% is hot. (Assumes a usage temp of ~105 °F and a cold water temp of 55 °F)
Thermal efficiency of water heater	Heater efficiency is based on RTF decision informed by "Energy Efficient Showerhead and Faucet Aerator Metering Study" (PSE/BPA/SBW 1994) and "Single Family 2007 Showerhead Kit Impact Evaluation". Seattle City Light. October 2008

4.3.4. Demand Savings Estimation

There are no demand savings associated with this measure.

4.3.5. Non-energy Benefits

Water savings are shown in Table 87. Local water and wastewater rates need to be applied to these values to monetize savings.

Table 87: Residendial low-flow faucet aerator water savings (gallons)

Facility Type	Kitchen – 1.5 gpm	Bathroom – 1.0 gpm	Bathroom – 0.5 gpm
Single Family	1896	1444	2046
Multifamily	1412	1926	2729

4.3.6. Measure Life

The lifetime for this measure is 5 years[88].

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

[88] CLEAResult Workpaper

4.3.7. Incremental Cost

The incremental cost for this measure is the total cost. The cost per direct-installed residential aerator is $10[89].

[89] 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	CFL wattage

4.4.2. Savings

The savings depend on baseline wattage, as shown in Table 88. Tier 1 became effective January 1st, 2014. Tier 2 is effective January 1st, 2020.

Table 88: Residential Lighting Baseline – General Service

Lumen Range	EISA Status	EISA Baseline: 1st Tier	EISA Baseline: 2nd Tier EISA
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 89 details wattage equivalence EISA specifications for reflector lamps. Program administrators should use model-specific wattages within these categorizations.

Table 89: Baseline Wattage – Reflector Lamps

Lamp Type	Pre-EISA Incandescent Equivalent	Baseline Wattage – Post-EISA
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[90]. Wattage for other specialty lamps is detailed in Table 90.

[90] 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 90: 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
	500-1049	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

4.4.3. Energy Savings Estimation

Savings are calculated per lamp with the following formula.

$$Svgs = (Watts_{Baseline} - Watts_{CFL})/1000 \times HoursOfUse \quad (14)$$

where:

Svgs	=	Annual energy savings, in kWh
$Watts_{Baseline}$	=	Wattage of baseline incandescent lamp
$Watts_{CFL}$	=	Wattage of corresponding CFL
HoursOfUse	=	Annual average hours of use

Baseline and efficient lamp watts are determined by the Energy Independence and Security Act of 2007 (EISA), as shown in Table 88, Table 89, and Table 90.

Hours of use were derived from the 2011 evaluations of New Mexico programs by ADM Associates[91]. Hours are shown in Table 91. The weighted average hours are based on actual installations in 2011 in New Mexico.

Table 91: Residential CFL 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**

[91] 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.

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[92].

$$Svgs = (Watts_{Baseline} - Watts_{CFL})/1000 \times CoincidentFactor \quad (15)$$

where:

Svgs = Summer peak kW savings

Watts = Wattage of lamp, as determined from table above

CoincidentFactor = *0.1017 for residences, 0.18 for dormitories*

4.4.5. Non-energy Benefits

There is added benefit from deferred replacement cost, as a CFL or LED lamp has a significantly longer rated life than an incandescent or halogen equivalent. Program staff may endeavor to quantify this.

4.4.6. Measure Life

Table 92: Residential Lighting Measure LIves

Measure	Rated Life	Expected Useful Life
CFL	8,000	5.1
	10,000	6.4[93]
	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 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:

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

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

- 2.24 hours/day x 365 days/yr. x (43W – 14W) / 1000 W/kW x 4 years = 94.84 kWh
- 2.24 hours/day x 365 days/yr. x (20W – 14W) / 1000 W/kW x 2.4 years = 11.77 kWh
- Total Lifetime Savings: 110.61 kWh

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[94]. The CFL/LED cost is determined by the program.

[94] 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.

4.5.3. Energy Savings Estimation

Total savings are the sum of cooling and heating savings. Cooling savings are derived with the following equation[95].

$$Svgs = (DL_{Baseline} - DL_{Post}) \times 0.77 \times EFLH \times (h_{Out} \times \rho_{Out} - h_{In} \times \rho_{In}) \times 60/(1000 \times SEER) \quad \textbf{(16)}$$

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 Peso)*

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

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 Peso)*
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	= *Efficiency of cooling system, Btu/Wh*

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 93. Full-load hours for Albuquerque and Roswell were derived from the Energy Star Calculator for residential air conditioning[96]. 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 93: Residential Full Load Cooling Hours for New Mexico Climate Zones

Location	EFLC
Albuquerque	1038
Las Cruces	1290
Roswell	1355
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[97].

$$Svgs = (DL_{Baseline} - DL_{Post}) \times 0.77 \times HDD \times 24 \times 60 \times 0.018/(ConvFactor \times Efficiency) \quad (17)$$

where:

Svgs	= *Annual heating savings, kWh or therms*
$DL_{baseline}$	= *Duct leakage, baseline, measured at 25 Pascals, CFM*

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

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

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 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*

HDD are shown in Table 84[98].

Table 94: Heating-degree-days for New Mexico Climate Zones

Location	HDD
Albuquerque	4180
Las Cruces	2816
Roswell	3289
Santa Fe	5417

Equipment and conversion factor depend on the type of heating system, as shown in Table 95.

Table 95: Heating system type conversion factors and efficiencies

Heating System Type	Description	Value
Heat Pump	Adjusted HSPF; Btu to kWh	1000 x adjusted HSPF
Electric Resistance	100% efficiency; Btu to kWh	3412
Gas furnace	78% efficiency; Btu to Therms	0.78 x 100,000

The adjusted HSPF is derived with the following formula[99].

$$adjHSPF = (HSPF - (HSPF \times ((0.1392 + (-0.00846 \times DTemp) + (-0.0001074 \times DTemp^2) + (0.0228 \times HSPF))))) \quad \textbf{(18)}$$

where:

adjHSPF	= *HSPF adjusted for location*

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

[99] http://www.eia.doe.gov/neic/experts/heatcalc.xls

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 96.

Table 96: 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.

$$Svgs = (DL_{Baseline} - DL_{Post}) \times 0.77 \times (h_{Out} \times \rho_{Out} - h_{In} \times \rho_{In}) \times 60/(1000 \times SEER) \times CF \qquad (19)$$

where:

Svgs = *Peak cooling savings, kW*

CF = *Coincident Factor, 0.87*

The Coincident Factor is derived as follows[100]. 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[101].

4.5.6. Incremental Cost

The incremental cost for this measure is the full measure cost, $0.24 per square foot[102].

---

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

101 DEER 2008, RTF

4.6. High Efficiency Air Conditioner

This measure involves a residential HVAC high efficiency central air conditioning system (split system consisting of an indoor unit with a matching remote condensing unit).

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	Federal minimum: 13 SEER
Efficient case description	14 SEER or above 5-ton, or under, cooling capacity

4.6.2. Savings

The annual energy savings are shown in the following tables for each of the four New Mexico climate zones.

Table 97: High Efficiency Air Conditioner savings (Albuquerque) (kWh)

	SEER Range				
Size (tons)	14.5	15	16	17	18+
1.5	89	182	279	304	452
2.0	119	243	372	405	603
2.5	149	304	465	506	754
3.0	178	365	558	607	905
3.5	208	426	651	709	1056
4.0	238	487	745	810	1206
5.0	297	608	931	1012	1508

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

Table 98: High Efficiency Air Conditioner savings (Roswell) (kWh)

	SEER Range				
Size (tons)	14.5	15	16	17	18+
1.5	107	217	339	372	559
2.0	142	290	451	496	745
2.5	178	362	564	620	931
3.0	214	435	677	744	1117
3.5	249	507	790	868	1303
4.0	285	579	903	992	1490
5.0	356	724	1129	1240	1862

Table 99: High Efficiency Air Conditioner savings (Santa Fe) (kWh)

	SEER Range				
Size (tons)	14.5	15	16	17	18+
1.5	74	152	228	247	366
2.0	99	202	304	330	488
2.5	123	253	380	412	610
3.0	148	304	456	494	732
3.5	173	354	532	577	855
4.0	197	405	607	659	977
5.0	247	506	759	824	1221

Table 100: High Efficiency Air Conditioner savings (Las Cruces) (kWh)

Size (tons)	14.5	15	16	17	18+
1.5	122	247	388	424	639
2.0	162	330	518	566	852
2.5	203	412	647	707	1065
3.0	243	495	776	848	1278
3.5	284	577	906	990	1491
4.0	324	660	1035	1131	1704
5.0	405	825	1294	1414	2130

The demand savings are shown in the following tables for each of the four New Mexico climate zones.

Table 101: High Efficiency Air Conditioner demand savings (Albuquerque) (kW)

	SEER Range				
Size (tons)	14.5	15	16	17	18+
1.5	0.053	0.107	0.180	0.209	0.305
2.0	0.070	0.142	0.239	0.279	0.406
2.5	0.088	0.178	0.299	0.348	0.508
3.0	0.105	0.214	0.359	0.418	0.609
3.5	0.123	0.249	0.419	0.488	0.711
4.0	0.140	0.285	0.479	0.557	0.812
5.0	0.175	0.356	0.598	0.696	1.015

Table 102: High Efficiency Air Conditioner demand savings (Roswell) (kW)

	SEER Range				
Size (tons)	14.5	15	16	17	18+
1.5	0.046	0.097	0.173	0.188	0.282
2.0	0.062	0.130	0.231	0.251	0.376
2.5	0.077	0.163	0.289	0.313	0.470
3.0	0.093	0.195	0.347	0.376	0.565
3.5	0.108	0.228	0.404	0.439	0.659
4.0	0.124	0.260	0.462	0.501	0.753
5.0	0.155	0.325	0.578	0.627	0.941

Table 103: High Efficiency Air Conditioner demand savings (Santa Fe) (kW)

	SEER Range				
Size (tons)	14.5	15	16	17	18+
1.5	0.059	0.121	0.198	0.237	0.349
2.0	0.078	0.161	0.264	0.316	0.466
2.5	0.098	0.201	0.330	0.395	0.582
3.0	0.118	0.241	0.396	0.474	0.698
3.5	0.137	0.282	0.462	0.553	0.815
4.0	0.157	0.322	0.528	0.631	0.931
5.0	0.196	0.402	0.660	0.789	1.164

Table 104: High Efficiency Air Conditioner demand savings (Las Cruces) (kW)

	SEER Range				
Size (tons)	**14.5**	**15**	**16**	**17**	**18+**
1.5	0.046	0.093	0.167	0.181	0.275
2.0	0.062	0.124	0.223	0.241	0.366
2.5	0.077	0.155	0.279	0.302	0.458
3.0	0.093	0.186	0.334	0.362	0.55
3.5	0.108	0.217	0.39	0.423	0.641
4.0	0.124	0.248	0.446	0.483	0.733
5.0	0.140	0.279	0.502	0.543	0.825

4.6.3. Energy Savings Estimation

Savings are derived based on the capacity and efficiencies of the AC units[103]. Baseline SEER is the federal minimum 14. AC usage is calculated per temperature bin with the following formula.

$$Usage = Load \times Hours/LoadCapacity \times Actual\_Capacity/(1000 \times EER) \quad (20)$$

where:

Usage = *Cooling usage, kWh*

Load = *Cooling load for the given temperature bin, assuming a 15% oversize in capacity, and even increases in load from 65 °F to the design temperature, Btu/hr*

Hours = *Number of hours within the temperature bin, according to TMY3*

LoadCapacity = *The greater of the cooling load and the actual capacity for the temperature bin, Btu/hr*

ActualCapacity = *The actual capacity of the cooling unit at the given temperature, based on the nominal capacity with an empirical degradation factor for temperature and on/off cycling, Btu/hr*

EER = *Energy Efficiency Ratio, based on the nominal capacity with an empirical degradation factor for temperature and on/off cycling, Btu/Wh*

Savings are the difference in usage at the respective EER's, and are derived according to unit capacity and EER for each weather zone.

[103] "AC Replacement Deemed Savings Values For Submittal 12 20 2012" (for Central A/C Replacement), EPE, 2012. TMY3 weather data and design temperatures for New Mexico cities were substituted for the existing values.

4.6.4. 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. Savings are derived as the difference in usage between models at the 1% design temperature[104]. Usage is derived with the following formula.

$$Usage = Actual\_Capacity/(1000 \times EER) \quad (21)$$

where:

Usage	=	*Cooling usage, kW*
ActualCapacity	=	*The actual capacity of the cooling unit at the design temperature, based on the nominal capacity with an empirical degradation factor for temperature and on/off cycling, Btu/hr*
EER	=	*Energy Efficiency Ratio at the design temperature, based on the nominal capacity with an empirical degradation factor for temperature and on/off cycling, Btu/Wh*

4.6.5. Measure Life

The lifetime for this measure is 15 years[105].

4.6.6. 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 105[106].

Table 105: 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

[104] ASHRAE Fundamentals, Chapter 14, 2009.

[105] DEER 2008

[106] 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 106 for the four New Mexico climate zones.

Table 106: 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

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[107].

[107] DEER 2008

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[108].

[108] 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.

4.8.3. Energy Savings Estimation

Savings are derived using the methodology in the State of Ohio Energy Efficiency Technical Reference Manual, August 6, 2012.

Annual cooling energy savings are derived with the following formula.

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

where:

ΔkWh	= Annual energy savings, kWh
CFM50exist	= Existing Cubic Feet per Minute at 50 Pascal pressure differential as measured by the blower door before airsealing.

CFM50new	= New Cubic Feet per Minute at 50 Pascal pressure differential as measured by the blower door after airsealing.
Nfactor	= Conversion factor to convert 50-pascal air flows to natural airflow = 21.5[109]
60	= Constant to convert cubic feet per minute to cubic feet per hour
CDH	= Cooling Degree Hours, see Table 107
DUA	= Discretionary Use Adjustment to account for the fact that people do not always operate their air conditioning system when the outside temperature is greater than 75°F = 0.75[110]
0.018	= Volumetric heat capacity of air (Btu/ft3°F)
$\eta Cool$	= Efficiency of Air Conditioning equipment (i.e. SEER rating)

Table 107: Cooling Degree Hours for New Mexico Climate Zones

	Cooling Degree Hours[111] (65°F Reference Temp)
Albuquerque	31,728
Las Cruces	45,600
Roswell	42,936
Santa Fe	15,504

Annual space heating savings are derived with the following formulas.

$$Svgs\ Gas\ Heating = \frac{\left(\frac{CFM50exist - CFM50new}{Nfactor}\right) \times 60 \times 24 \times HDD \ \times \ 0.018}{(100{,}000 \ \times \ \eta Heat)}$$

$$Svgs\ Electric\ Heating = \frac{\left(\frac{CFM50exist - CFM50new}{Nfactor}\right) \times 60 \times 24 \times HDD \ \times \ 0.018 \ \times \ 29.31}{(100{,}000 \ \times \ \eta Heat)}$$

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

110 Based on Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p31

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

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[112]
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 108
0.018	= Volumetric heat capacity of air (Btu/ft3°F)
$\eta Heat$	= Average Net Heating System Efficiency (Equipment Efficiency * Distribution Efficiency) [113]
29.31	= Constant to convert therms to kWh

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

[113] 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).

Table 108: Heating Degree Days for New Mexico Climate Zones

	Heating Degree Days[114] (65°F Reference Temp)
Albuquerque	4180
Las Cruces	2816
Roswell	3289
Santa Fe	5417

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.

$$kW = \Delta kWh \,/\, EFLH \times CF$$

where:

ΔkWh	= Summer coincident peak savings, kW
EFLH	= Effective Full Load Hours for residential cooling
CF	= Summer peak Coincidence Factor for measure = 0.87

Full load cooling hours (EFLH) are shown in Table 109. EFLH for Albuquerque and Roswell were derived from the Energy Star Calculator for residential air conditioning[115]. 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 109: Full Load Cooling Hours for New Mexico Climate Zones

	Full Load Cooling Hours (EFLH)
Albuquerque	1038
Las Cruces	1290
Roswell	1355
Santa Fe	629

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

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

The Coincidence Factor, CF, is derived as follows[116]. 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[117].

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.

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

[117] 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 tankless water heaters, effective 2004 and April, 2015
Efficient case description	Efficiencies greater than standards, see below

4.9.2. Energy Savings Estimation

New codes took effect for residential water heaters as of April 16, 2015. These are detailed in Table 110.

Table 110: Code Update: Residential Water Heating

Product Class	Energy Factor as of Jan. 20, 2004	Energy Factor as of April 17, 2015
Gas: ≥ 20 gal, ≤ 100 gal	.67 – (.0019 x V)	≤ 55 gallons: .675 – (.0015 x V) > 55 gallons: .8012 – (.00078 x V)
Electric: ≥ 20 gal, ≤ 120 gal	.97 – (.000132 x V)	≤ 55 gallons: .96 – (.0003 x V) > 55 gallons: 2.057 – (.00113 x V)

V = Rated Storage Volume

Savings depend on the technology, fuel, and the date of implementation, as shown below. After April 16, 2015, the baseline energy factor (EF) for large water heaters (> 55 gallons) results in no savings for large electric water heaters and makes savings difficult to attain for gas water heaters other than condensing and tankless water heaters.

Table 111: Electric water heater savings (kWh)

Size (gallons)	Storage Water Heater	HPWH in unconditioned space
30	33	1642
40	33	1652
50	33	1662

Table 112: Gas water heater savings (therms)

Size (gallons)	Storage	Tankless	Condensing
30	10	37	34
40	14	41	38
50	18	45	42
60		11	8
70		12	9
80		14	11
90		15	12
100		17	13
110		18	15

4.9.3. Energy Savings Estimation

Savings are determined with the following equations,

$$Savings = EnergyInWater * \left(\frac{1}{EF_{Base}} - \frac{1}{EF_{Measure}}\right)$$

where:

Savings = Annual energy savings, kWh or therms

EnergyInWater = Derived with the equation below

EF_{Base} = Baseline energy factor, the overall annual water heater efficiency as measured in the DOE Test Procedure, see below

$EF_{Measure}$ = Efficient energy factor, see below

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

where:

EnergyInWater = Annual energy increase in water, kWh or therms

GallonsPerDay	= Average hot water daily usage, 50 gallons[118]
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, 130 °F
$Temp_{Cold}$	= Temperature of inlet water, 63 °F[119]
ConversionConstant	= Converts Btus into kWh or therms: 0.0002932972 kWh/Btu, 0.00001 therms/Btu

New federal minimum EF standards take effect April 16, 2015. Baseline EF's are shown in the table below.

Table 113: Baseline EF

Size (gallons)	Electric	Gas
30	0.951	0.630
40	0.948	0.615
50	0.945	0.600
60	1.989	0.754
70	1.978	0.747
80	1.967	0.739
90	1.955	0.731
100	1.944	0.723
110	1.933	0.715

Efficient case EF's are shown in the table below.

[118] IL TRM: Federal Register, Test Procedures for Water Heaters, Comments on "Test Conditions," http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/wtrhtr.pdf

[119] US DOE Building America Program. Building America Analysis Spreadsheet. For Albuquerque http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html

Table 114: Measure EF

	Electric	Gas storage	Gas tankless	Gas condensing	Heat pump WH
30	0.96	0.67	0.82	0.8	2
40	0.96	0.67	0.82	0.8	2
50	0.96	0.67	0.82	0.8	2
60			0.82	0.8	
70			0.82	0.8	
80			0.82	0.8	
90			0.82	0.8	
100			0.82	0.8	
110			0.82	0.8	

Note: There are no savings for blank entries in table

Note that this analysis does not include an HVAC interaction factor. For standard water heaters, this impact is minor and TRM-approved tables typically ignore the HVAC factor, but for HPWH's in conditioned spaces it is significant. The HPWH removes heat from the space and adds it to the water, reducing the cooling load and adding to the heating load. The impact depends on heating and cooling system types.

4.9.4. Demand Savings Estimation

Demand savings are calculated using a ratio estimation of peak-to-annual of .0000877[120] .

Table 115: Electric water heater savings (kW)

Size (gallons)	Storage Water Heater	HPWH in unconditioned space
30	.0029	.144
40	.0029	.145
50	.0029	.146

4.9.5. Non-energy Benefits

Higher efficiency water heaters generally have a longer lifespan.

[120] 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 116[121].

Table 116: Residential water heater measure life (years)

Measure	Measure Life
Gas storage	11
Gas Tankless	20
HPWH	10
Electric storage	13

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 117: Residential water heater incremental measure cost[122]

Measure	Incremental cost prior to code change	Incremental cost after code change
Gas storage	$175	$117
Condensing gas storage	$685	$627
Tankless	$605	$547
HPWH	$1,100	$995
Electric storage	$73	Not eligible

[121] 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

[122] 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 118 for each of the four New Mexico regions.

Table 118: 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 119

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[123]. Table 119 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 119: 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

[123] 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.

The Heating Degree Day (HDD) data is provided in Table 120. The HDD data differ from those which can be derived from the evaluation done for New Mexico Gas Company,[124] but they are consistent with the HDD data used elsewhere in this TRM.

Table 120: Heating Degree Days (HDD)

Albuquerque	Roswell	Santa Fe	Las Cruces
4180	3289	5417	2816

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 18 years[125].

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 121: High efficiency gas furnace incremental measure cost[126]

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

[124] 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”

[125] CA DEER Database Res-HVAC

[126] 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.

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	Federal standard minimum efficiency for gas boiler, effective May 1, 2013. AFUE = 0.82
Efficient case description	ENERGY STAR qualified, AFUE > or = 0.90

4.11.2. Savings

Savings is a function of the as-installed boiler annual fuel utilization efficiency (AFUE), output capacity (CAP), and effective full load hours (EFLH) of operation. The AFUE 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[127].

4.11.3. Energy Savings Estimation

Savings are determined with the following equation,

$$Savings = CAP * \left(\frac{1}{C_B * 0.82} - \frac{1}{C_E * EF_{AE}}\right) * \ EFLH_{CR}$$

where:

Savings	= Annual energy savings, therms
CAP	= Efficient boiler rated output capacity, MBH
EF_E	= Efficient boiler rated AFUE
C_B	= De-rating factor for baseline boiler

[127] High Efficiency Heating Equipment Impact Evaluation (Cadmus, 2015)

C_E = De-rating factor for efficient boiler

$EFLH_{CR}$ = Effective full load hours of boiler operation for the climate region

CAP and EF_E are variable according to the application. C_B *and* C_E are assigned values of 0.967 and 0.941. $EFLH_{CR}$ is determined with the following equation,

$$EFLH_{CR} = (24 * RLF * HDD_{CR})/(55 - T_{CR})$$

where:

RLF = Rated Load Factor

HDD_{CR} = Heating Degree Days at base 55°F for the climate zone[128]

T_{CR} = 99% Heating Design Outdoor Air Temperature for the climate zone[129]

The RLF accounts for typical equipment oversizing and is assumed to be 80% [130]. Table 119 shows the HDD_{CR}, T_{CR}, and $EFLH_{CR}$ for each of the four New Mexico climate regions.

Table 122: Climate Region Parameters

Parameter	Albuquerque	Las Cruces	Roswell	Santa Fe
HDD_{CR}	2213	1508	1588	3121
T_{CR}	21	20	19	10
$EFLH_{CR}$	1250	827	847	1332

4.11.4. Demand Savings Estimation

No demand savings are associated with this measure.

4.11.5. Non-energy Benefits

4.11.6. Measure Life

The measure life for this equipment is 18 years[131].

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

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

[130] Engineering Methods for Estimating the Impacts of DSM Programs (EPRI, 1993)

131 Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.

http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

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 123: High efficiency gas boiler incremental measure cost[132]

AFUE (%)	Incremental cost
90	$1,272
92	$1,443
94	$1,614
96	$1,785

[132] Costs derived from Page E-13 of Appendix E of Residential Furnaces and Boilers Final Rule Technical Support Document: http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/fb_fr_tsd/appendix_e.pdf

4.12. Advanced Power Strips

Advanced power strips (APS) reduce "vampire" load in home entertainment or home office environments by sensing when the controlling device, assumed to be either a TV or a computer, is turned off or switches into low power mode, and shutting off power at that point to peripheral devices plugged into the APS.

4.12.1. Measure Overview

Sector	Residential
End use	Plug Load
Fuel	Electricity
Measure category	Advanced Power Strips
Delivery mechanism	Rebate/Direct Install/Leave-behind/Mail-by-request
Baseline description	Standard power strip, or no power strip
Efficient case description	Load sensing Advanced Power Strip (APS) - power to peripheral devices is shut off when the controlling device is turned off or enters low power mode - in one of the following applications 1. Home Entertainment 2. Home Office 3. Unspecified application

4.12.2. Savings

Energy and demand savings are shown in Table 124.

Table 124: 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[133],

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

Parameters are described in Table 125. 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[134].

Table 125: Energy Savings Estimation Variable & Sources

Variable	Definition	Value
$IdlePower_{TV}$	Idle power draw of home entertainment peripheral devices, kW	0.0085[135],[136]
$DailyIdleHours_{TV}$	Number of hours per day the home entertainment system is not in use	20[135]
$IdlePower_{Comp}$	Idle power draw of home office peripheral devices, kW	0.0049[135,136,137]
$DailyIdleHours_{Comp}$	Number of hours per day the home office system is not in use	20[135]
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 126[138]. These weightings are used to derive the “Unspecified” measure application.

Table 126: Advanced Power Strip Installation Weightings

Application	Weighting
Home Entertainment	61%
Home Office	39%

[133] 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

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

[135] 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.

[136] PNM/Ecova Savings Brief, citing “Advanced Power Strip Research Report”, NYSERDA, August 2011

[137] PNM/Ecova Savings Brief, citing “Smart Plug Strips”, ECOS, July 2009.

[138] 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.)

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 127.

Table 127: 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[139]

4.12.5. Non-energy Benefits

None.

4.12.6. Measure Life

The measure life for this equipment is 4 years[140].

4.12.7. Incremental Cost

The cost for an APS is $16.46[141], based on the TrickleStar 7-outlet APS 1080 Joules.

[139] 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."

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

[141] 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. Clothes Washers

Efficient clothes washers save energy by using less motor energy, using less hot water, and reducing dryer energy by spinning more moisture from the clothes. Efficient washers also save water. Savings can be both natural gas and electric, depending on the fuel used to heat water and dry clothes.

4.13.1. Measure Overview

Sector	Residential
End use	Appliance
Fuel	Electricity/Gas
Measure category	Efficient Clothes Washers
Delivery mechanism	Rebate
Baseline description	Federal minimum efficiency clothes washer
Efficient case description	Efficient washers are either top- or front-loading that match one of the following tiers 1. Energy Star 2. Energy Star Most Efficient/CEE Tier2 3. CEE Tier 3 (front-loading only) Gas and electric savings are defined for each combination of gas or electric hot water and dryer (four cases), as well as statewide “average” cases.

4.13.2. Savings

Energy savings are shown in Table 128 for three statewide average measures – where the source of hot water heating (DHW) is known, and where the DHW fuel is unknown.

Table 128: Clothes Washer Energy Savings

	Electric DHW		Gas DHW		Unknown DHW	
Application	**kWh**	**Therms**	**kWh**	**Therms**	**kWh**	**Therms**
Top-loading Energy Star	194	0.2	89	4.4	109	3.6
Top-loading CEE Tier 2	374	0.2	89	12.4	143	10.1
Front-loading Energy Star	260	0.1	51	9.2	91	7.5
Front-loading CEE Tier 2	293	0.1	61	10.2	105	8.3
Front-loading CEE Tier 3	311	0.2	71	10.5	117	8.5

Demand savings are shown in Table 129.

Table 129: Clothes Washer Demand Savings

Application	Electric DHW kW	kW	Unknown DHW kW
Top-loading Energy Star	0.282	0.130	0.159
Top-loading CEE Tier 2	0.596	0.142	0.228
Front-loading Energy Star	0.360	0.071	0.126
Front-loading CEE Tier 2	0.420	0.088	0.151
Front-loading CEE Tier 3	0.453	0.104	0.170

4.13.3. Energy Savings Estimation

Savings are derived following the method outlined in the workpaper by Pacific Gas & Electric (PG&E)[142]. This workpaper relies on the Department of Energy (DOE) Residential Technical Support Document (2012 TSD)[143] and Energy Star methodologies[144].

Annual energy usage for a washing machine is based on the formula:

$$Usage_{kWh} = {CyclesPerYear \times WasherCapacity}/_{IMEF}$$

where:

CyclesPerYear = Average number of loads per household per year; varies according to washer capacity

WasherCapacity = Size of washer, in cubic feet; varies according to washer efficiency

IMEF = Integrated Modified Energy Factor, measure of washer efficiency, as specified by DOE

Relevant values for IMEF are shown in the following table (along with the Integrated Water Factor (IWF)).

---

142 www.caltf.org/s/PGECOAPP127-R1-Clothes-Washers_Final-zj3s.docx

143 U.S. Department of Energy. *Technical Support Document: Energy Efficiency Program For Consumer Products And Commercial And Industrial Equipment: Residential Clothes Washers.* April 2012. Energy Values from Ch. 7, Table 7.2.1 and Table 7.2.2. Market share values from Ch. 9, Figure 9.3.5. Dryer Usage factor from Ch. 7, page 7-4. Cycles per year from Ch. 7, page 7-6.

http://www1.eere.energy.gov/buildings/appliance_standards/residential/rcw_direct_final_rule_tsd.html

144 http://www.energystar.gov/ia/partners/downloads/most_efficient/2015/Final_ENERGY_STAR_Most_Efficient_2015_Recognition_Criteria_Clothes_Washers.pdf?ad45-754d

Table 130: Clothes Washer Efficiency Levels[145,146]

Case	IMEF	IWF
Federal minimum Residential top-loading	1.29	8.4
Federal minimum Residential front-loading	1.84	4.7
Energy Star Top-loading	2.06	4.3
Energy Star Front-loading/CEE Tier 1	2.38	3.7
Energy Star Most Efficient/CEE Tier 2	2.74	3.2
CEE Tier 3	2.92	3.2

Energy usage derived with the equation above is broken out into three categories, as shown in the following tables[147]. Dryer energy assumes a dryer usage factor of 91%, meaning 9% of loads are not dried in a dryer.

Table 131: Top-loading Clothes Washer Energy Usage Breakdown

			Energy Use (kWh/cycle)		
	IMEF	**Volume (cubic feet)**	**Machine**	**Dryer**	**Water Heat**
	0.84	3.09	0.279	2.16	1.24
	0.98	3.38	0.281	2.43	0.74
Federal Minimum	1.29	3.38	0.228	1.69	0.69
	1.37	3.76	0.082	1.41	1.26
	1.83	3.96	0.077	1.41	0.67
Energy Star	2.04	4.34	0.082	1.39	0.66

Table 132: Front-loading Clothes Washer Energy Usage Breakdown

			Energy Use (kWh/cycle)		
	IMEF	**Volume (cubic feet)**	**Machine**	**Dryer**	**Water Heat**
	1.41	3.00	0.113	1.31	0.69
Federal Minimum	1.84	3.41	0.154	1.34	0.36
	2.02	3.60	0.164	1.41	0.20
Energy Star	2.38	3.9	0.16	1.38	0.09
Energy Star Most Efficient	2.74	4.2	0.15	1.36	0.04
CEE Tier 3	2.92	4.4	0.13	1.34	0.04

Number of loads washed

[145] https://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/39

[146] http://library.cee1.org/content/cee-residential-clothes-washer-specification-march-7-2015/

[147] PG&E Workpaper, based on DOE TSD Tables 7.2.1 and 7.2.2

The 2012 TSD assumes an average of 295 loads per year. However, machine capacity increases as one method to increase the energy factor. Presumably people do fewer loads in a larger machine. However, we don't know how many fewer loads. The average size of a washer that corresponds to the 295 loads was approximately 3.1 cubic feet. If all loads were full, 914.5 cubic feet of laundry would be done per year. With larger size washers, we assume the number of loads is halfway between 295 and the number of loads required to wash 914.5 cubic feet with full loads.

Top-loading energy consumption

Putting together the number of annual loads with the per cycle energy consumption yields the following table for top-loading washers. Note that as of September, 2015, CEE only listed three top-loading machines that met CEE Tier 2 requirements.[148] Only one of these was found on the manufacturer's website. It was described as having "mega capacity," at 5.7 cubic feet. The top-loading Tier 2 measure is included here in case machines of this type gain significant market share at some point in the future.

Table 133: Top-loading Clothes Washer Annual Energy Usage

Case	IMEF	Volume (cubic feet)	Loads per year	Annual Energy Use (kWh)		
				Machine	Dryer	Water Heat
Federal Minimum	1.29	3.38	283	64	478	195
Energy Star	2.04	4.34	253	21	351	167
Energy Star Most Efficient	2.74	5.5	231	35	314	9

Baseline Definition

For the top-loading measures, the baseline unit is a top-loading unit. For the front-loading measures, the baseline unit is a mix of front-loading and top-loading units according to market saturations. The assumption is that the natural replacement unit would be top-loading for many people who actually buy an Energy Star front-loading unit. Survey data indicate that in 2009, 87% of washers in New Mexico were top-loading.[149] The 2012 TSD shows a rapid switch to front-loading washers, and predicts that nationwide over 50% of washers sold will be front-loading by 2016. On the assumption that many people would still prefer a top-loading washer except for the energy saving features of a front-loading machine, for the analysis of *gross savings* the baseline for front-loading washers is assumed to be 80% top-loading.

Front-loading energy consumption

The corresponding table for front-loading washers is shown below, including the baseline case described above.

[148] CEE Qualifying Products, http://library.cee1.org/content/qualifying-product-lists-residential-clothes-washers

[149] Residential Building Energy Consumption Survey (RBECS), 2009. Values for New Mexico and Nevada. http://www.eia.gov/consumption/residential/data/2009/#appliances

Table 134: Front-loading Clothes Washer Annual Energy Usage

Case	IMEF	Volume (cubic feet)	Loads per year	Annual Energy Use (kWh)		
				Machine	Dryer	Water Heat
Federal Minimum	1.84	3.41	282	43	377	101
Top/Front weighted baseline		3.39	283	60	458	176
Energy Star	2.38	3.9	265	42	365	24
Energy Star Most Efficient	2.74	4.2	256	38	349	10
CEE Tier 3	2.92	4.4	251	33	337	10

Energy Savings (all electric)

Annual energy savings assuming electric domestic hot water (DHW) and an electric dryer are shown below, using the tables above.

Table 135: Clothes Washer Energy Savings, Electric DHW, Electric Dryer

	Measure	Machine (kWh)	Dryer (kWh)	Water Heat (kWh)	Total electric savings (kWh)	Total gas savings (therms)
Top loading	Energy Star	44	126	28	198	0
	Energy Star Most Efficient	30	164	186	380	0
Front-loading	Energy Star	18	92	153	263	0
	Energy Star Most Efficient	22	109	166	297	0
	CEE Tier 3	28	121	166	315	0

Gas and electric distribution of savings

There are four possible combinations to consider, as well as statewide “average” cases, where the DHW or dryer fuel is unknown. To convert from electric savings to gas savings, in addition to converting kWh to therms, the correction factors used in the 2012 TSD are applied. These factors account for the differing efficiencies of gas and electric dryers and tank water heaters. The factors are shown below.

Table 136: Conversion factors from electric to gas

Dryer correction factor	1.12
DHW correction factor	1.33

Applying these conversion factors yields the additional three savings tables shown below.

Table 137: Clothes Washer Energy Savings, Electric DHW, Gas Dryer

	Measure	Machine (kWh)	Dryer (therms)	Water Heat (kWh)	Total electric savings (kWh)	Total gas savings (therms)
Top loading	Energy Star	44	4.8	28	72	4.8
	Energy Star Most Efficient	30	6.3	186	216	6.3
Front-loading	Energy Star	18	3.5	153	170	3.5
	Energy Star Most Efficient	22	4.2	166	188	4.2
	CEE Tier 3	28	4.6	166	194	4.6

Table 138: Clothes Washer Energy Savings, Gas DHW, Electric Dryer

	Measure	Machine (kWh)	Dryer (kWh)	Water Heat (therms)	Total electric savings (kWh)	Total gas savings (therms)
Top loading	Energy Star	44	126	1.3	170	1.3
	Energy Star Most Efficient	30	164	8.4	194	8.4
Front-loading	Energy Star	18	92	6.9	110	6.9
	Energy Star Most Efficient	22	109	7.5	131	7.5
	CEE Tier 3	28	121	7.5	148	7.5

Table 139: Clothes Washer Energy Savings, Gas DHW, Gas Dryer

	Measure	Machine (kWh)	Dryer (kWh)	Water Heat (therms)	Total electric savings (kWh)	Total gas savings (therms)
Top loading	Energy Star	44	4.8	1.3	43.7	6.1
	Energy Star Most Efficient	30	6.3	8.4	29.9	14.7
Front-loading	Energy Star	18	3.5	6.9	17.9	10.5
	Energy Star Most Efficient	22	4.2	7.5	21.8	11.7
	CEE Tier 3	28	4.6	7.5	27.6	12.2

Average Savings

Three additional measure savings are derived. The first of these assumes no knowledge of either the DHW fuel or the dryer fuel. The other two measures assume the DHW fuel is known. Savings are distributed between gas and electric according to the best available information of saturations of gas and electric DHW fuel in New Mexico, and the distribution of gas and electric dryers.

According to ADM Associates, the distribution of DHW fuel is as shown below.

Table 140: New Mexico Statewide Saturations of Gas and Electric DHW Fuel

Gas DHW	81%
Electric DHW	19%

Survey data from California show the mix of dryer according to DHW fuel type,[150] shown below.

Table 141: Distribution of Dryer Fuel According to DHW Fuel, California RASS 2009

	Dryer Fuel	
DHW Fuel	Gas	Electric
Gas	64%	36%
Electric	4%	96%

Combining these two tables yields the mix of New Mexico fuel distributions shown below.

Table 142: New Mexico Mix of Gas and Electric DHW and Dryer Combinations

	Dryer Fuel	
DHW Fuel	Gas	Electric
Gas	52%	29%
Electric	1%	18%

Combining the fuel distributions with the savings tables above leads to the overall average New Mexico savings table.

Table 143: Energy Savings for Unknown Fuel Types

	Measure	Total electric savings (kWh)	Total gas savings (therms)
Top loading	Energy Star	109	3.6
	Energy Star Most Efficient	143	10.1
Front-loading	Energy Star	91	7.5
	Energy Star Most Efficient	105	8.3
	CEE Tier 3	117	8.5

[150] California Statewide Residential Appliance Saturation Study (RASS), 2009. https://websafe.kemainc.com/RASS2009/Default.aspx

Where the DHW fuel type is known, the assumption here is that the distribution of dryer types follows the California pattern. The following two tables assume the DHW fuel type is known.

Table 144: Energy Savings for Gas DHW

	Measure	Total electric savings (kWh)	Total gas savings (therms)
Top loading	Energy Star	89	4.4
	Energy Star Most Efficient	89	12.4
Front-loading	Energy Star	51	9.2
	Energy Star Most Efficient	61	10.2
	CEE Tier 3	71	10.5

Table 145: Energy Savings for Electric DHW

	Measure	Total electric savings (kWh)	Total gas savings (therms)
Top loading	Energy Star	194	0.2
	Energy Star Most Efficient	374	0.2
Front-loading	Energy Star	260	0.1
	Energy Star Most Efficient	293	0.1
	CEE Tier 3	311	0.2

4.13.4. Demand Savings Estimation

Demand savings are derived with the following equation.

$$DemandSavings = AnnualkWhSvgs / \frac{nCyclesPerYear}{HoursPerCycle} \times CF$$

where:

DemandSavings = Demand savings, in kW

AnnualkWhSvgs = As derived above

nCyclesPerYear = As derived above

HoursPerCycle = Taken to be 1.0 hours

CF = Coincidence Factor, taken to be 36.7%[151]

[151] PG&E workpaper, according to study in SCE territory

This formula leads to the following demand savings table.

Table 146: Demand Savings for Average Washer/Dryer Combinations

	Application	Electric DHW kW	Gas DHW kW	Unknown DHW kW
Top loading	Energy Star	0.282	0.130	0.159
	Energy Star Most Efficient	0.596	0.142	0.228
Front-loading	Energy Star	0.360	0.071	0.126
	Energy Star Most Efficient	0.420	0.088	0.151
	CEE Tier 3	0.453	0.104	0.170

4.13.5. Additional Benefits

Water savings of efficient washers are derived according to the Integrated Water Factor (IWF), which is the per cycle usage (in gallons) per cubic foot. Annual water usage depends on the number of annual loads, the machine size, and the IWF, as shown in the following table.

Table 147: Water Usage and Savings

	Application	IWF (gal per cubic foot per cycle)	Annual number of Loads	Washer Capacity (cubic feet)	Annual Usage (gallons)	Annual Savings (gallons)
Top loading	Federal Minimum	8.4	283	3.38	8029	
	Energy Star	4.3	253	4.34	4719	3310
	Energy Star Most Efficient	3.2	231	5.5	4059	3970
Front-loading	Federal Minimum	7.66	283	3.39	7328	
	Energy Star	3.7	265	3.90	3820	3508
	Energy Star Most Efficient	3.2	256	4.20	3446	3883
	CEE Tier 3	3.2	251	4.40	3540	3788

4.13.6. Measure Life

The life of this measure is 11 years.[152]

[152] PG&E Workpaper, www.caltf.org/s/PGECOAPP127-R1-Clothes-Washers_Final-zj3s.docx

4.13.7. Incremental Cost

Measure costs are taken from the PG&E workpaper,[153] with the baseline assumptions changed to match those assumed here – that the baseline washer for the front-loading measures is composed of 80% top-loading, and 20% front-loading. This is considered a "normal replacement," or "replace-on-burnout" measure, so the measure cost is the difference between the costs of the efficient and baseline washers, as shown in the table below.

Table 148: Measure Costs

	Application	Base Case Total Cost	Measure Total Cost	Incremental Measure Cost
Top-loading	Energy Star	$585	$615	$30
	Energy Star Most Efficient	$585	$1,500[154]	$915
Front-loading	Energy Star	$604	$683	$78
	Energy Star Most Efficient	$604	$711	$107
	CEE Tier 3	$604	$717	$113

[153] PG&E Workpaper, www.caltf.org/s/PGECOAPP127-R1-Clothes-Washers_Final-zj3s.docx, embedded workbook

[154] http://www.lg.com/us/washers/lg-WT7700HVA-top-load-washer

4.14. Heat Pumps

This measure category applies to residential heat pumps used for heating and cooling. This measure saves energy by increasing the efficiencies of heating and cooling processes.

4.14.1. Measure Overview

Sector	Residential
End use	Heating and Cooling
Fuel	Electricity
Measure category	Residential heat pumps – Electric only
Delivery mechanism	Rebate
Baseline description	1. Heat Pump Conversion From AC (SEER14) with Baseboard Heat 2. Heat Pump Conversion From AC (SEER14) with Forced Air Electric Furnace (AFUE 80) 3. Heat Pump Replacement (SEER 14, HSPF 8)
Efficient case description	SEER above 14 [155] HSPF above 8 1.5 to 5 Tons Cooling

4.14.2. Heating Energy Savings

Table 149: High Efficiency Heat Pump Replacing AC with Baseboard Heat - Heating Savings (Albuquerque) (kWh)

	HSPF Range							
Size (tons)	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6
1.5	3276	3292	3309	3325	3340	3355	3370	3384
2.0	4850	4860	4869	4879	4888	4896	4904	4912
2.5	5967	5982	5997	6010	6023	6036	6048	6059
3.0	7064	7084	7103	7121	7138	7154	7170	7185
3.5	8400	8420	8438	8456	8472	8488	8503	8517
4.0	10147	10165	10181	10196	10209	10223	10235	10247
5.0	12030	12043	12055	12067	12079	12090	12101	12111

[155] **There are no sources in the current document.**

Table 150: High Efficiency Heat Pump Replacing AC with Baseboard Heat - Heating Savings (Roswell) (kWh)

	HSPF Range							
Size (tons)	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6
1.5	2329	2341	2352	2364	2375	2386	2396	2406
2.0	3448	3455	3462	3469	3475	3481	3487	3493
2.5	4243	4253	4263	4273	4283	4291	4300	4308
3.0	5022	5036	5050	5063	5075	5087	5097	5108
3.5	5972	5986	5999	6012	6024	6034	6045	6055
4.0	7214	7227	7238	7249	7258	7268	7277	7286
5.0	8553	8562	8571	8579	8587	8596	8603	8610

Table 151: High Efficiency Heat Pump Replacing AC with Baseboard Heat - Heating Savings (Santa Fe) (kWh)

	HSPF Range							
Size (tons)	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6
1.5	4255	4277	4298	4319	4339	4359	4378	4396
2.0	6300	6313	6326	6338	6350	6361	6372	6382
2.5	7752	7772	7790	7808	7825	7842	7857	7872
3.0	9177	9203	9228	9251	9273	9294	9314	9334
3.5	10913	10938	10963	10985	11007	11027	11046	11064
4.0	13182	13205	13226	13246	13263	13280	13297	13313
5.0	15628	15646	15661	15676	15692	15706	15720	15733

Table 152: High Efficiency Heat Pump Replacing AC with Baseboard Heat - Heating Savings (Las Cruces) (kWh)

	HSPF Range							
Size (tons)	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6
1.5	2246	2257	2268	2279	2290	2300	2310	2320
2.0	3325	3332	3338	3345	3351	3357	3363	3368
2.5	4091	4101	4111	4121	4130	4138	4146	4154
3.0	4843	4857	4870	4882	4894	4905	4916	4926
3.5	5759	5773	5785	5797	5809	5819	5829	5839
4.0	6957	6969	6980	6990	7000	7009	7017	7026
5.0	8248	8257	8265	8273	8281	8289	8296	8303

Table 153: High Efficiency Heat Pump Replacing AC with Forced Air Furnace - Heating Savings (Albuquerque) (kWh)

	HSPF Range							
Size (tons)	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6
1.5	3583	3600	3616	3632	3648	3663	3678	3692
2.0	5027	5038	5047	5057	5065	5074	5082	5090
2.5	6199	6214	6228	6242	6255	6268	6280	6291
3.0	7339	7359	7378	7396	7414	7430	7445	7460
3.5	8716	8736	8754	8772	8788	8803	8818	8832
4.0	10515	10533	10549	10564	10577	10591	10603	10615
5.0	12471	12484	12496	12508	12519	12531	12542	12552

Table 154: High Efficiency Heat Pump Replacing AC with Forced Air Furnace - Heating Savings (Roswell) (kWh)

	HSPF Range							
Size (tons)	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6
1.5	5670	5696	5722	5748	5772	5796	5819	5842
2.0	7955	7971	7986	8001	8015	8029	8042	8054
2.5	9809	9832	9855	9877	9897	9917	9936	9954
3.0	11613	11644	11675	11703	11731	11756	11780	11804
3.5	13791	13822	13852	13879	13905	13930	13953	13975
4.0	16637	16666	16692	16715	16736	16757	16777	16797
5.0	19732	19753	19772	19791	19809	19827	19844	19860

Table 155: High Efficiency Heat Pump Replacing AC with Forced Air Furnace - Heating Savings (Santa Fe) (kWh)

	HSPF Range							
Size (tons)	**8.2**	**8.4**	**8.6**	**8.8**	**9.0**	**9.2**	**9.4**	**9.6**
1.5	2277	2287	2298	2308	2318	2327	2337	2346
2.0	3194	3201	3207	3213	3218	3224	3229	3234
2.5	3939	3948	3957	3966	3974	3982	3990	3997
3.0	4663	4676	4688	4699	4710	4721	4730	4740
3.5	5538	5550	5562	5573	5584	5593	5603	5612
4.0	6680	6692	6702	6712	6720	6729	6737	6745
5.0	7923	7932	7939	7947	7954	7962	7968	7975

Table 156: High Efficiency Heat Pump Replacing AC with Forced Air Furnace - Heating Savings (Las Cruces) (kWh)

	HSPF Range							
Size (tons)	**8.2**	**8.4**	**8.6**	**8.8**	**9.0**	**9.2**	**9.4**	**9.6**
1.5	6050	6078	6106	6133	6159	6185	6210	6233
2.0	8235	8259	8283	8306	8327	8348	8369	8388
2.5	10466	10491	10515	10539	10561	10582	10602	10621
3.0	12392	12425	12457	12488	12517	12544	12570	12596
3.5	14716	14749	14780	14810	14838	14864	14889	14912
4.0	17753	17783	17811	17836	17858	17881	17902	17923
5.0	21055	21078	21098	21117	21137	21157	21175	21192

Table 157: High Efficiency Heat Pump Upgrade - Heating Savings (Albuquerque) (kWh)

	HSPF Range							
Size (tons)	**8.2**	**8.4**	**8.6**	**8.8**	**9.0**	**9.2**	**9.4**	**9.6**
1.5	17	34	50	66	82	97	111	126
2.0	25	50	74	97	120	142	162	183
2.5	31	62	91	119	148	175	200	226
3.0	37	73	108	141	175	207	237	268
3.5	44	87	128	167	208	246	281	318
4.0	53	105	154	201	251	296	338	383
5.0	63	124	182	238	297	350	400	453

Table 158: High Efficiency Heat Pump Upgrade - Heating Savings (Rosewell) (kWh)

				HSPF Range				
Size (tons)	**8.2**	**8.4**	**8.6**	**8.8**	**9.0**	**9.2**	**9.4**	**9.6**
1.5	27	53	79	105	129	153	176	199
2.0	40	78	116	154	189	223	256	289
2.5	49	96	143	190	233	275	316	356
3.0	58	114	169	225	276	326	375	422
3.5	69	136	201	267	328	387	445	500
4.0	83	164	243	322	395	466	536	602
5.0	98	194	288	381	467	551	634	711

Table 159: High Efficiency Heat Pump Upgrade - Heating Savings (Santa Fe) (kWh)

				HSPF Range				
Size (tons)	**8.2**	**8.4**	**8.6**	**8.8**	**9.0**	**9.2**	**9.4**	**9.6**
1.5	11	21	32	42	52	62	71	80
2.0	16	31	47	62	76	90	103	116
2.5	20	38	58	76	94	111	127	143
3.0	24	45	69	90	111	132	151	170
3.5	29	53	82	107	132	157	179	202
4.0	35	64	99	129	159	189	215	243
5.0	41	76	117	153	188	224	254	287

Table 160: High Efficiency Heat Pump Upgrade - Heating Savings (Las Cruces) (kWh)

				HSPF Range				
Size (tons)	**8.2**	**8.4**	**8.6**	**8.8**	**9.0**	**9.2**	**9.4**	**9.6**
1.5	29	57	84	112	138	163	188	212
2.0	43	84	124	164	202	238	274	308
2.5	53	103	153	202	249	293	338	380
3.0	63	122	181	239	295	347	401	451
3.5	75	145	215	284	350	412	475	535
4.0	91	175	259	342	422	496	572	644
5.0	108	207	307	405	499	587	676	761

4.14.3. Cooling Energy Savings

Heat pumps can have different paired ratings of SEER and HSPF. Therefore, each improvement needs to be considered separately against comparable baseline measure and then summed for a total energy savings. The tables listing the approximate savings by ton, efficiency rating, baseline condition, and climate are listed below.

Table 161: High Efficiency Heat Pump Replacing AC with Baseboard Heat - Cooling Savings (Albuquerque) (kWh)

	SEER Range				
Size (tons)	14.5	15	16	17	18+
1.5	285	240	157	84	19
2.0	488	418	289	176	76
2.5	758	660	482	325	185
3.0	1037	912	685	485	308
3.5	1337	1184	907	663	446
4.0	1732	1543	1200	897	628
5.0	2191	1960	1540	1170	841

Table 162: High Efficiency Heat Pump Replacing AC with Baseboard Heat - Cooling Savings (Roswell) (kWh)

	SEER Range				
Size (tons)	14.5	15	16	17	18+
1.5	452	379	248	133	30
2.0	773	661	458	279	120
2.5	1200	1044	763	514	293
3.0	1640	1443	1084	768	487
3.5	2116	1874	1436	1049	705
4.0	2740	2441	1898	1419	994
5.0	3467	3101	2437	1852	1331

Table 163: High Efficiency Heat Pump Replacing AC with Baseboard Heat - Cooling Savings (Santa Fe) (kWh)

	SEER Range				
Size (tons)	14.5	15	16	17	18+
1.5	181	152	100	53	12
2.0	310	265	184	112	48
2.5	482	419	306	206	118
3.0	659	579	435	308	195
3.5	850	753	577	421	283
4.0	1100	980	762	570	399
5.0	1392	1245	979	744	535

Table 164: High Efficiency Heat Pump Replacing AC with Baseboard Heat - Cooling Savings (Las Cruces) (kWh)

	SEER Range				
Size (tons)	14.5	15	16	17	18+
1.5	482	405	265	141	32
2.0	825	705	489	298	128
2.5	1280	1114	814	549	313
3.0	1750	1539	1157	819	519
3.5	2258	2000	1532	1119	753
4.0	2924	2605	2025	1514	1060
5.0	3699	3309	2601	1976	1421

Table 165: High Efficiency Heat Pump Replacing AC with Forced Air Furnace - Cooling Savings (Albuquerque) (kWh)

	SEER Range				
Size (tons)	14.5	15	16	17	18+
1.5	245	199	116	43	22
2.0	516	445	317	204	104
2.5	794	695	517	360	221
3.0	1079	954	727	528	350
3.5	1386	1234	957	712	495
4.0	1789	1600	1257	954	685
5.0	2262	2031	1611	1241	912

Table 166: High Efficiency Heat Pump Replacing AC with Forced Air Furnace - Cooling Savings (Roswell) (kWh)

	SEER Range				
Size (tons)	14.5	15	16	17	18+
1.5	388	315	184	69	34
2.0	817	705	502	323	164
2.5	1256	1100	819	570	349
3.0	1707	1509	1151	835	554
3.5	2194	1952	1514	1127	783
4.0	2831	2532	1989	1510	1085
5.0	3579	3213	2549	1964	1443

Table 167: High Efficiency Heat Pump Replacing AC with Forced Air Furnace - Cooling Savings (Santa Fe) (kWh)

	SEER Range				
Size (tons)	14.5	15	16	17	18+
1.5	156	127	74	28	14
2.0	328	283	202	130	66
2.5	504	442	329	229	140
3.0	686	606	462	335	222
3.5	881	784	608	452	314
4.0	1137	1017	799	606	435
5.0	1437	1290	1024	789	580

Table 168: High Efficiency Heat Pump Replacing AC with Forced Air Furnace - Cooling Savings (Las Cruces) (kWh)

	SEER Range				
Size (tons)	14.5	15	16	17	18+
1.5	414	336	197	73	37
2.0	871	752	536	345	175
2.5	1340	1174	874	608	373
3.0	1822	1611	1228	891	591
3.5	2341	2083	1615	1202	836
4.0	3021	2702	2122	1611	1157
5.0	3819	3428	2720	2095	1540

Table 169: High Efficiency Heat Pump Upgrade - Cooling Savings (Albuquerque) (kWh)

	SEER Range				
Size (tons)	14.5	15	16	17	18+
1.5	49	95	178	251	316
2.0	76	147	275	388	488
2.5	105	203	381	539	678
3.0	134	259	485	685	863
3.5	164	317	594	838	1055
4.0	203	392	735	1038	1307
5.0	248	479	899	1269	1598

Table 170: High Efficiency Heat Pump Upgrade - Cooling Savings (Roswell) (kWh)

	SEER Range				
Size (tons)	14.5	15	16	17	18+
1.5	78	150	281	397	500
2.0	120	232	435	614	773
2.5	166	322	604	852	1073
3.0	212	410	768	1084	1366
3.5	259	501	939	1326	1670
4.0	321	620	1163	1642	2068
5.0	392	758	1422	2007	2528

Table 171: High Efficiency Heat Pump Upgrade - Cooling Savings (Santa Fe) (kWh)

	SEER Range				
Size (tons)	14.5	15	16	17	18+
1.5	31	60	113	159	201
2.0	48	93	175	246	310
2.5	67	129	242	342	431
3.0	85	164	308	435	548
3.5	104	201	377	532	670
4.0	129	249	467	659	830
5.0	158	305	571	806	1015

Table 172: High Efficiency Heat Pump Upgrade - Cooling Savings (Las Cruces) (kWh)

	SEER Range				
Size (tons)	14.5	15	16	17	18+
1.5	83	160	300	423	533
2.0	128	247	464	655	825
2.5	178	343	644	909	1145
3.0	226	437	820	1157	1457
3.5	276	534	1002	1415	1782
4.0	342	662	1241	1752	2206
5.0	419	809	1517	2142	2697

4.14.4. Energy Savings Estimation

Savings were estimated with eQuest 3.65 models for a range of heat pump efficiencies greater than the federal standard. Baseline models included: existing heat pump at federal standard efficiency, existing split system AC with electric forced air furnace for heating, existing AC with baseboard space heating. Residential buildings were simulated with e-Quest defaults for multifamily single floor residences with 2 exterior doors in Albuquerque New Mexico[156]. Floor spaces ranged from 800 sq. feet to 5600 sq. ft. Cooling demand was used to separate the houses into bins so that approximate system sizes could be grouped together.

$$\Delta kWh_{Cooling} = Modeled\ Cooling\ kWh_{Baseline} - Modeled\ Cooling\ kWh_{Efficient}$$
$$\Delta kWh_{Heating} = Modeled\ Heating\ kWh_{Baseline} - Modeled\ Heating\ kWh_{Efficient}$$

$$\Delta kWh_{Total\ Savings} = \Delta kWh_{Heating} + \Delta kWh_{Cooling}$$

To adjust simulations to different weather design conditions, degree hour fractions were used for each climate zone.[157]

$$\Delta kWh_{Climate\ Adjusted\ Cooling} = \Delta kWh_{Baseline\ Climate\ Cooling} \frac{CDH_{Target\ Climate}}{CDH_{Baseline\ Climate}}$$

$$\Delta kWh_{Climate\ Adjusted\ Heating} = \Delta kWh_{Baseline\ Climate\ Heating} \frac{HDH_{Target\ Climate}}{HDH_{Baseline\ Climate}}$$

It should be noted that studies by NREL[158] and Southern California Edison[159] found that only SEERs for similar system types are comparable. The cooling performance of a cooling-only AC will typically be more efficient than Heat pump with similar cooling capacity and SEER ratings.

[156] Hirsch, J. (2014, March 6). eQuest 3.65. Retrieved 2015, from http://www.doe2.com/equest/. The eQuest residential prototype is multifamily; it is adjusted to emulate a single-family residence.

[157]

There are no sources in the current document.

[158] NREL Improved Modeling of Residential Air Conditioners and Heat Pumps for Energy Calculations

[159] SCE EER & SEER AS PREDICTORS OF SEASONAL COOLING PERFORMANCE

As such, when simulations are run with different equipment types there will commonly be negative cooling savings found when switching out AC with electric heat for a Heat Pump.

Also note that heat pumps were sized by cooling requirement. As such the heating energy savings for an efficient heat pump will not have smooth trends.

4.14.5. Heating Demand Power Savings

Table 173: Replace a Baseboard Heater/electric forced Air Furnace with Heat Pump - Heating Demand Savings (Albuquerque) (kW)

	HSPF Range							
Size (tons)	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6
1.5	2.24	2.26	2.29	2.31	2.34	2.36	2.38	2.40
2.0	2.66	2.69	2.72	2.75	2.78	2.80	2.83	2.85
2.5	3.02	3.05	3.09	3.12	3.15	3.18	3.21	3.24
3.0	3.32	3.36	3.40	3.43	3.47	3.50	3.53	3.56
3.5	3.64	3.69	3.73	3.77	3.81	3.84	3.88	3.91
4.0	4.09	4.14	4.19	4.23	4.27	4.32	4.35	4.39
5.0	4.60	4.65	4.70	4.75	4.80	4.84	4.89	4.93

Table 174: Replace a Baseboard Heater/ electric forced Air Furnace with Heat Pump - Heating Demand Savings (Roswell) (kW)

	HSPF Range							
Size (tons)	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6
1.5	2.15	2.17	2.20	2.22	2.24	2.26	2.28	2.30
2.0	2.55	2.58	2.61	2.64	2.67	2.69	2.71	2.74
2.5	2.90	2.93	2.97	3.00	3.03	3.06	3.08	3.11
3.0	3.19	3.22	3.26	3.29	3.33	3.36	3.39	3.42
3.5	3.50	3.54	3.58	3.62	3.65	3.69	3.72	3.75
4.0	3.93	3.98	4.02	4.06	4.11	4.14	4.18	4.22
5.0	4.41	4.47	4.52	4.56	4.61	4.65	4.69	4.73

Table 175: Replace a Baseboard Heater/ electric forced Air Furnace with Heat Pump - Heating Demand Savings (Santa Fe) (kW)

	HSPF Range							
Size (tons)	**8.2**	**8.4**	**8.6**	**8.8**	**9.0**	**9.2**	**9.4**	**9.6**
1.5	2.77	2.80	2.83	2.86	2.89	2.92	2.95	2.97
2.0	3.29	3.33	3.37	3.40	3.44	3.47	3.50	3.53
2.5	3.74	3.78	3.82	3.86	3.90	3.94	3.97	4.01
3.0	4.11	4.16	4.20	4.25	4.29	4.33	4.37	4.41
3.5	4.51	4.56	4.62	4.66	4.71	4.76	4.80	4.84
4.0	5.07	5.13	5.18	5.24	5.29	5.34	5.39	5.44
5.0	5.69	5.76	5.82	5.88	5.94	6.00	6.05	6.10

Table 176: Replace a Baseboard Heater/ electric forced Air Furnace with Heat Pump - Heating Demand Savings (Las Cruces) (kW)

	HSPF Range							
Size (tons)	**8.2**	**8.4**	**8.6**	**8.8**	**9.0**	**9.2**	**9.4**	**9.6**
1.5	2.69	2.72	2.75	2.78	2.81	2.83	2.86	2.88
2.0	3.19	3.23	3.27	3.30	3.34	3.37	3.40	3.43
2.5	3.63	3.67	3.71	3.75	3.79	3.82	3.86	3.89
3.0	3.99	4.04	4.08	4.12	4.16	4.20	4.24	4.28
3.5	4.38	4.43	4.48	4.53	4.57	4.62	4.66	4.70
4.0	4.92	4.98	5.03	5.09	5.14	5.19	5.23	5.28
5.0	5.52	5.59	5.65	5.71	5.77	5.82	5.88	5.93

Table 177: Upgrade Heat Pump - Heating Demand Savings (Albuquerque) (kW)

	HSPF Range							
Size (tons)	**8.2**	**8.4**	**8.6**	**8.8**	**9.0**	**9.2**	**9.4**	**9.6**
1.5	0.03	0.05	0.08	0.10	0.13	0.15	0.17	0.19
2.0	0.03	0.06	0.09	0.12	0.15	0.18	0.20	0.23
2.5	0.04	0.07	0.11	0.14	0.17	0.20	0.23	0.26
3.0	0.04	0.08	0.12	0.15	0.19	0.22	0.25	0.28
3.5	0.05	0.09	0.13	0.17	0.21	0.24	0.28	0.31
4.0	0.05	0.10	0.15	0.19	0.23	0.27	0.31	0.35
5.0	0.06	0.11	0.16	0.21	0.26	0.31	0.35	0.39

Table 178: Upgrade Heat Pump - Heating Demand Savings (Roswell) (kW)

	HSPF Range							
Size (tons)	**8.2**	**8.4**	**8.6**	**8.8**	**9.0**	**9.2**	**9.4**	**9.6**
1.5	0.03	0.05	0.08	0.10	0.12	0.14	0.16	0.18
2.0	0.03	0.06	0.09	0.12	0.15	0.17	0.19	0.22
2.5	0.04	0.07	0.10	0.13	0.16	0.19	0.22	0.25
3.0	0.04	0.08	0.11	0.15	0.18	0.21	0.24	0.27
3.5	0.04	0.09	0.12	0.16	0.20	0.23	0.27	0.30
4.0	0.05	0.10	0.14	0.18	0.22	0.26	0.30	0.34
5.0	0.06	0.11	0.16	0.21	0.25	0.29	0.34	0.38

Table 179: Upgrade Heat Pump - Heating Demand Savings (Santa Fe) (kW)

	HSPF Range							
Size (tons)	**8.2**	**8.4**	**8.6**	**8.8**	**9.0**	**9.2**	**9.4**	**9.6**
1.5	0.03	0.07	0.10	0.13	0.16	0.18	0.21	0.24
2.0	0.04	0.08	0.12	0.15	0.19	0.22	0.25	0.28
2.5	0.05	0.09	0.13	0.17	0.21	0.25	0.28	0.32
3.0	0.05	0.10	0.15	0.19	0.23	0.27	0.31	0.35
3.5	0.06	0.11	0.16	0.21	0.26	0.30	0.34	0.38
4.0	0.06	0.12	0.18	0.24	0.29	0.34	0.39	0.43
5.0	0.07	0.14	0.20	0.26	0.32	0.38	0.43	0.48

Table 180: Upgrade Heat Pump - Heating Demand Savings (Las Cruces) (kW)

	HSPF Range							
Size (tons)	**8.2**	**8.4**	**8.6**	**8.8**	**9.0**	**9.2**	**9.4**	**9.6**
1.5	0.03	0.07	0.10	0.12	0.15	0.18	0.20	0.23
2.0	0.04	0.08	0.11	0.15	0.18	0.21	0.24	0.27
2.5	0.05	0.09	0.13	0.17	0.21	0.24	0.28	0.31
3.0	0.05	0.10	0.14	0.19	0.23	0.27	0.30	0.34
3.5	0.05	0.11	0.16	0.20	0.25	0.29	0.33	0.37
4.0	0.06	0.12	0.18	0.23	0.28	0.33	0.37	0.42
5.0	0.07	0.13	0.20	0.26	0.31	0.37	0.42	0.47

4.14.6. Cooling Demand Power Savings

Table 181: Replace an Air conditioner with Heat Pump or Upgrade Heat Pump - Cooling Demand Savings (Albuquerque) (kW)

	SEER Range				
Size (tons)	14.5	15	16	17	18+
1.5	0.03	0.07	0.12	0.17	0.21
2.0	0.05	0.09	0.17	0.23	0.29
2.5	0.06	0.11	0.21	0.29	0.36
3.0	0.07	0.14	0.25	0.35	0.44
3.5	0.08	0.16	0.29	0.41	0.50
4.0	0.10	0.19	0.34	0.48	0.60
5.0	0.11	0.22	0.40	0.56	0.70

Table 182: Replace an Air conditioner with Heat Pump or Upgrade Heat Pump - Cooling Demand Savings (Roswell) (kW)

	SEER Range				
Size (tons)	14.5	15	16	17	18+
1.5	0.04	0.07	0.13	0.18	0.23
2.0	0.05	0.10	0.18	0.25	0.31
2.5	0.06	0.12	0.23	0.32	0.39
3.0	0.08	0.15	0.27	0.38	0.47
3.5	0.09	0.17	0.32	0.44	0.55
4.0	0.10	0.20	0.37	0.52	0.64
5.0	0.12	0.24	0.44	0.61	0.75

Table 183: Replace an Air conditioner with Heat Pump or Upgrade Heat Pump - Cooling Demand Savings (Santa Fe) (kW)

	SEER Range				
Size (tons)	14.5	15	16	17	18+
1.5	0.03	0.06	0.10	0.15	0.18
2.0	0.04	0.08	0.14	0.20	0.25
2.5	0.05	0.10	0.18	0.25	0.31
3.0	0.06	0.12	0.22	0.30	0.37
3.5	0.07	0.14	0.25	0.35	0.43
4.0	0.08	0.16	0.30	0.41	0.51
5.0	0.10	0.19	0.35	0.48	0.60

Table 184: Replace an Air conditioner with Heat Pump or Upgrade Heat Pump - Cooling Demand Savings (Las Cruces) (kW)

	SEER Range				
Size (tons)	14.5	15	16	17	18+
1.5	0.04	0.07	0.13	0.19	0.23
2.0	0.05	0.10	0.18	0.26	0.32
2.5	0.07	0.13	0.23	0.32	0.40
3.0	0.08	0.15	0.28	0.39	0.48
3.5	0.09	0.17	0.32	0.45	0.56
4.0	0.11	0.21	0.38	0.53	0.66
5.0	0.13	0.24	0.44	0.62	0.77

4.14.7. Demand Savings Estimation

$$\Delta kW_{Peak} = max(\Delta kW_{Peak\ Cooling}, \Delta kW_{Peak\ Heating})$$ [160]

$$\Delta kW_{Peak\ Cooling} = kW\ Peak\ Cooling\ Demand\ \times \left(\frac{1}{EER_{Baseline}} - \frac{1}{EER_{Efficient}}\right)$$

$$\Delta kW_{Peak\ Heating} = kW\ Peak\ Heating\ Demand\ \times \left(\frac{1}{HSPF_{Baseline}} - \frac{1}{HSPF_{Efficient}}\right)$$

[160] Massachusetts TRM

$$EER = -0.02 \times SEER^2 + 1.12 \times SEER$$ [161]

$$\Delta kW_{Climate\ Adjusted\ Cooling} = \Delta kW_{Baseline\ Climate\ \ Cooling} \times \frac{Peak\ CDH_{Target\ Climate}}{Peak\ CDH_{Baseline\ Climate}}$$

$$\Delta kW_{Climate\ Adjusted\ Heating} = \Delta kW_{Baseline\ Climate\ \ Heating} \times \frac{Peak\ HDH_{Target\ Climate}}{Peak\ HDH_{Baseline\ Climate}}$$

4.14.8. Non-energy Benefits

Well-designed HVAC systems increase occupant comfort and productivity.

4.14.9. Measure Life

This measure life is 18 Years[162]

4.14.10. 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[163]. 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.

Table 185: Cost per Cooling Ton for Efficient Heat Pumps

SEER[164]	Heat Pump (Per Ton Cooling)
15	$170
16	$340
17	$529
18+	$710

[161] NREL Building America House Simulation Protocols

[162] Massachusetts TRM

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

[164] 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.

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,

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

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

Table 186: 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%
8760	Annual Hours	Total hours in a year
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

The motor efficiency in the POC calculator is pulled from the lookup table below based on motor horsepower and RPM.

Table 187: Deemed Plan B Table.

Motor HP	Plan B Existing Motor Efficiency
10	86.3%
15	87.2%
20	88.1%
25	88.9%
30	89.4%
40	89.7%
50	89.9%
60	90.4%
75	90.9%
100	90.9%

Plan B Existing Compressor Motor Efficiency values are from Pre-EPACT motors.

5.1.4. Demand Savings Estimation

Savings are derived with the following equation,

$$Demand\ kW_{Savings} = \left(\frac{HP * LF * 0.746}{Eff_{Motor} * Eff_{SurfMech}}\right) * (TC - \left(\frac{Run_{Const} + Run_{Coeff} * Eff_{VolPump} * TC * 100}{100}\right))$$

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

Table 188: 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%
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[165].

5.1.7. Incremental Cost

The cost for a pump off motor controller is $5,959 per controller[166].

[165] 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.

[166] NMx Pump Off Controller Custom Projects