References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 30331—Established rules for energy efficiency programs, including factors for principal building activities (PBAs). Most PBA values were superseded by Docket 40885; however, some values from this docket remain valid.
- PUCT Docket 36779—Provides EUL for HVAC equipment.
- PUCT Docket 40083–Provides incorporation of early retirement savings for existing commercial HVAC SOP designs and updates for baseline equipment efficiency levels for ROB and new construction projects involving package and split systems.
- PUCT Docket 40885—Provides a petition to revise deemed savings values for commercial HVAC replacement measures. Items covered by this petition include the following:
- Updated baseline efficiencies use for estimating deemed savings for commercial PTAC/PTHP's, room air conditioners, and chilled water systems.
- Approved estimates of RUL of working chilled water systems.
- Updated demand and energy coefficients for all commercial HVAC systems.
- Updated EUL of centrifugal chilled water systems installed in ROB or new construction projects.
- Provide a method for utilizing the early retirement concept developed in the petition in Docket No. 40083 for packaged and split DX systems and applied to chilled water systems when the age of the system being replaced cannot be ascertained.
- PUCT Docket 41070—Provides energy and demand savings coefficients for an additional climate zone, El Paso, Texas. Previously these savings were taken from the Dallas-Fort Worth area, which has a colder winter, somewhat more moderate summer, more sunshine, and less precipitation than El Paso.
- PUCT Docket 43681—Updated the approach for calculating early replacement energy and demand savings using a Net Present Value (NPV) method. Documented in Appendix A.

Relevant Standards and Reference Sources

- ANSI/ASHRAE/IES Standard 90.1-1989. Energy Standard for Buildings Except Low-Rise Residential Buildings. Table 10-7.
- ANSI/ASHRAE/IES Standard 90.1-2004. Energy Standard for Buildings Except Low-Rise Residential Buildings. Table 6.8.1C.
- ANSI/ASHRAE/IES Standard 90.1-2007. Energy Standard for Buildings Except Low-Rise Residential Buildings, Addendum M. Table 6.8.1C.
- ANSI/ASHRAE/IES Standard 90.1-2010. Energy Standard for Buildings Except Low-Rise Residential Buildings. Table 6.8.1A through Table 6.8.1D.
- 2015 International Energy Conservation Code. Table C403.2.3(7).

Document Revision History

Table 59. Nonresidential HVAC Chillers Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. Modified savings calculations surrounding early retirement programs, and revised details surrounding RUL and Measure Life. Added references to Appendix A for EUL and RUL discussion, and Net Present Value (NPV) equations.
v2.1	01/30/2015	TRM v2.1 update. Minor text updates and clarification of early retirement requirements.
v3.0	04/10/2015	TRM v3.0 update. Update of savings method to allow for part-load efficiency calculations.
v3.1	11/05/2015	TRM v3.1 update. Updated table references to clarify building types and RUL references. Added "Other" building type for when building type is not explicitly listed. Added Religious Worship building type to Climate Zone 5 for consistency with other zones.
v4.0	10/10/2016	TRM v4.0 update. Used modeling approach to update DF and EFLH for applicable building types and climate zones.
v5.0	10/2017	TRM v5.0 update. Included Path A and Path B compliance options for chillers. Added 24-hour Retail load shape. Updated RUL table based on DOE survival curves.
v6.0	10/2018	TRM v6.0 update. Revised Path A and B savings methodology for mid-year guidance memo. Added Data Center as a new building type. Updated early retirement guidance for projects with a total capacity change.
v7.0	10/2019	TRM v7.0 update. Program tracking requirements updated.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits. Clarified use of post capacity for ROB baselines. Added unknown age defaults for early retirement.

2.2.4 Packaged Terminal Air Conditioners/Heat Pumps, and Room Air Conditioners Measure Overview

TRM Measure ID: NR-HV-PT

Market Sector: Commercial

Measure Category: HVAC

Applicable Building Types: See Table 63 through Table 67

Fuels Affected: Electricity

Decision/Action Type: Replace-on-burnout, early retirement, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Energy modeling, engineering algorithms, and estimates

Measure Description

This section presents the deemed savings methodology for the installation of packaged terminal air conditioners (PTAC), packaged terminal heat pumps (PTHP), and room AC (RAC) systems. This document covers assumptions made for baseline equipment efficiencies for early retirement (ER) of PTAC/PTHPs, replace-on-burnout (ROB), and new construction (NC) situations based current and previous on efficiency standards. For ER, the actual age of the baseline system should be determined from the equipment nameplate or other physical documentation whenever possible. Default values are provided for when the actual age of the unit is unknown.

Applicable efficient measure types include:

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

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

Eligibility Criteria

For a measure to be eligible for this deemed savings approach, the following conditions will be met:

- The existing and proposed cooling equipment is electric.

- The PTAC, PTHP, or RAC must be the primary cooling source for the space.
- For early retirement PTAC/PTHP projects: ER projects involve the replacement of a working system before natural burnout. Additionally, the ER approach cannot be used for projects involving a renovation where a major structural change or internal space remodel has occurred. A ROB approach should be used for these scenarios.

If one of these conditions is not met, the deemed savings approach cannot be used, and the Simplified M&V Methodology or the Full M&V Methodology must be used.

Manufacturer datasheets for installed equipment or documentation of AHRI or DOE CCMS certification must be provided.[143,144]

Baseline Condition

Early Retirement for PTAC/PTHP Systems

Early retirement systems involve the replacement of a working system prior to natural burnout. The early retirement baseline cannot be used for projects involving a renovation where a major structural change or internal space remodel has occurred. Two baseline condition efficiency values are required for an ER scenario, one for the ER (RUL) period and one for the ROB (EUL-RUL) period. For the ROB period, the baseline efficiency is the same as for a ROB/NC scenario. For the ER period, the baseline efficiency should be estimated according to the capacity, system type (PTAC or PTHP), and age (based on year manufactured) of the replaced system.[145] When the system age can be determined (from a nameplate, building prints, equipment inventory list, etc.), the baseline efficiency levels provided in Table 60, reflecting ASHRAE Standard 90.1-2001 through 90.1-2007, should be used. PTHPs replacing PTACs with built-in electric resistance heat should use a baseline heating efficiency of 1.0 COP.

When the system age is unknown, assume 15 years.[146] A default RUL may be used exclusively if applied consistently for all projects. Otherwise, the default should only be used when a project is reported and documented as having a nameplate that is illegible.

Existing systems manufactured as of February 2013 are not eligible for early retirement.

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143 Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Directory: https://www.ahridirectory.org/.

144 Department of Energy Compliance Certification Management System (DOE CCMS): https://www.regulations.doe.gov/certification-data/.

145 The actual age should be determined from the nameplate, building prints, equipment inventory list, etc. and whenever possible the actual source used should be identified in the project documentation.

146 As noted in Docket 40885, page 14-15: Failure probability weights are established by assuming that systems for which age information will be unavailable are likely to be older, setting a minimum age threshold, and using the survival functions for the relevant system type to estimate the likelihood that an operational system is of a given age beyond that threshold. Baseline efficiency for each year of system age is established relative to program year. Baseline efficiency levels can be estimated for the next ten program years, considering increments in efficiency standards that took place in the historical period.

Table 60. ER Baseline Efficiency Levels for Standard Size PTAC/PTHP Units[147]

Equipment	Cooling capacity (Btuh)	Baseline cooling efficiency (EER)	Baseline heating efficiency (COP) (No built-in resistance heat)	Baseline heating efficiency (COP) (with built-in resistance heat)
PTAC	<7,000	11.0	--	1.0
	7,000-15,000	$12.5 - (0.213 \times \text{Cap}/1000)$		
	>15,000	9.3		
PTHP	<7,000	10.8	3.0	--
	7,000-15,000	$12.3 - (0.213 \times \text{Cap}/1000)$	$3.2 - (0.026 \times \text{Cap}/1000)$	
	>15,000	9.1	2.8	

Replace-on-Burnout and New Construction

Table 61 provides minimum efficiency standards for PTAC/PTHP units and reflects the federal standards for packaged terminal air conditioners and heat pumps effective February 2013 and reflected in 10 CFR 431.

Table 61. Minimum Efficiency Levels for PTAC/PTHP ROB and NC Units[148,149]

Equipment	Category	Cooling capacity (Btuh)	Minimum cooling efficiency (EER)	Minimum heating efficiency (COP)
PTAC	Standard Size	<7,000	11.9	--
		7,000-15,000	$14.0 - (0.300 \times Cap/1000)$	--
		>15,000	9.5	--
	Non-Standard Size	<7,000	9.4	--
		7,000-15,000	$10.9 - (0.213 \times Cap/1000)$	--
		>15,000	7.7	--
PTHP	Standard Size	<7,000	11.9	3.3
		7,000-15,000	$14.0 - (0.300 \times Cap/1000)$	$3.7 - (0.052 \times Cap/1000)$
		>15,000	9.5	2.9
	Non-Standard Size	<7,000	9.3	2.7
		7,000-15,000	$10.8 - (0.213 \times Cap/1000)$	$2.9 - (0.026 \times Cap/1000)$
		>15,000	7.6	2.5

[147] ER only applies to Standard Size units because the minimum efficiency requirements for Non-Standard systems have never changed, making the ER baseline efficiency the same as for ROB.
[148] IECC 2015 Table C403.2.3(3).
[149] Cap refers to the rated cooling capacity in Btuh. If the capacity is less than 7,000 Btuh, use 7,000 Btuh in the calculation. If the capacity is greater than 15,000 Btuh, use 15,000 Btuh in the calculation.

Table 62 reflects the standards for room air conditioners, specified in 10 CFR 430.32(b).

Table 62. Minimum Efficiency Levels for Room Air Conditioners ROB and NC Units[150]

Category	Cooling capacity (Btuh)	Minimum cooling efficiency (EER)
Without reverse cycle, with louvered sides	< 8,000	11.0
	≥ 8,000 and < 14,000	10.9
	≥ 14,000 and < 20,000	10.7
	≥ 20,000 and < 25,000	9.4
	≥ 25,000	9.0
Without reverse cycle, without louvered sides	< 8,000	10.0
	≥ 8,000 and < 11,000	9.6
	≥ 11,000 and < 14,000	9.5
	≥ 14,000 and < 20,000	9.3
	≥ 20,000	9.4
With reverse cycle, with louvered sides	< 20,000	9.8
	≥ 20,000	9.3
With reverse cycle, without louvered sides	< 14,000	9.3
	≥ 14,000	8.7
Casement-only	All capacities	9.5
Casement-slider	All capacities	10.4

High-Efficiency Condition

The high-efficiency retrofits must exceed the minimum federal standards found in Table 61 and Table 62.

The high-efficiency retrofits must also meet the following criteria:[151]

- For early retirement projects only, the installed equipment cooling capacity must be within 80 percent to 120 percent of the replaced electric cooling capacity. For scenarios involving the replacement of a combination of systems by an alternate combination of systems of varying capacities, early retirement savings can still be claimed if the overall pre- and post-capacities for the total combination of systems are within ± 20%. In these cases, a custom calculation should be performed to establish the following weighted

[150] Direct final rule for new Room Air Conditioner Standards was published on April 21st, 2011 (76 FR 22454), effective August 19th, 2011, and are required starting June 1st, 2014. These are found in 10 CFR Part 430.

[151] Modified from PUCT Docket #41070 for TRMv3 to limit replacement of only smaller-sized units and extend Early Retirement to cover PTAC/PTHP.

savings factors to be applied over the early retirement portion of the savings calculation: manufacturer year, EUL, RUL, full and part-load baseline, demand factor, and EFLH. These factors should be weighted based on contribution to overall capacity.

- Non-standard size PTAC/PTHPs cannot be used for new construction
- No additional measures are being installed that directly affect the operation of the cooling equipment (e.g., control sequences)

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

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

Equation 30

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

Equation 31

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

Equation 32

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

Equation 33

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

Equation 34

Where:

$Cap_{C/H,pre}$	=	*For ER, rated equipment cooling/heating capacity of the existing equipment at AHRI standard conditions; for ROB & NC, rated equipment cooling/heating capacity of the new equipment at AHRI standard conditions [BTUH]; 1 ton = 12,000 Btuh*
$Cap_{C/H,post}$	=	*Rated equipment cooling/heating capacity of the newly installed equipment at AHRI standard conditions [Btuh]; 1 ton = 12,000 Btuh*
$\eta_{baseline,C}$	=	*Cooling efficiency of existing (ER) or standard (ROB/NC) equipment [EER, Btu/W-h] (Table 60 through Table 62)*
$\eta_{baseline,H}$	=	*Heating efficiency of existing (ER) or standard (ROB/NC)*

		equipment [COP] (Table 60 and Table 61) [152]
$\eta_{installed,C}$	=	*Rated cooling efficiency of the newly installed equipment [EER, Btu/W-h])—(Must exceed minimum federal standards found in Table 61 and Table 62)* [153]
$\eta_{installed,H}$	=	*Rated heating efficiency of the newly installed equipment [COP] (Must exceed minimum federal standards found in Table 61)*
$DF_{C,H}$	=	*Seasonal peak demand factor for appropriate climate zone, building type, and equipment type (Table 33 through Table 37)*
$EFLH_{C/H}$	=	*Cooling/heating equivalent full-load hours for newly installed equipment based on appropriate climate zone, building type, and equipment type [hours], see Table 63 through Table 67.*

The first-year savings algorithms in the above equations are used for all HVAC projects, across NC, ROB, and ER projects. However, ER projects require a weighted savings calculated over both the ER and ROB periods taking the EUL and RUL into account. The ER savings are applied over the remaining useful life (RUL) period, and the ROB savings are applied over the remaining period (EUL-RUL). The final reported savings for ER projects are not actually a "first-year" savings, but an "average annual savings over the lifetime (EUL) of the measure." These savings calculations are explained in Appendix A.

Claimed Peak Demand Savings

A summer peak period value is used for this measure. Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

Deemed Energy and Demand Savings Tables

Table 63 through Table 67 present the deemed peak demand factor (DF) and equivalent full-load hour (EFLH) values for PTAC/PTHPs and RACs. These values are calculated by climate zone, building type, and equipment type. A description of the calculation method can also be found in Docket No. 40885, Attachment B.

These tables also include an "Other" building type, which can be used for business types that are not explicitly listed. The DF and EFLH values used for Other are the most conservative values from the explicitly listed building types. When the Other building type is used, a description of the actual building type, the primary business activity, the business hours, and the HVAC schedule must be collected for the project site and stored in the utility tracking data system. For those combinations of technology, climate zone, and building type where no values are present, a project with that specific combination should use the "Other" building type.

[152] Rated efficiency is commonly reported at both 230V and 208V. Savings calculations should reference efficiency at 230V, as AHRI rating conditions specify that voltage.
[153] Ibid.

Table 63. PTAC/PTHP or RAC Equipment: DF and EFLH Values for Amarillo (CZ 1)

Building types	Principal building activity	Packaged terminal unit					
		Air conditioner		Heat pump			
		DF_C	$EFLH_C$	DF_C	$EFLH_C$	DF_H	$EFLH_H$
Education	Primary School	0.56	686	0.56	686	0.43	322
	Secondary School	0.61	496	0.61	496	0.43	338
Food Sales	Convenience	0.64	820	0.64	820	0.48	410
Food Service	Full-service Restaurant	0.73	946	0.73	946	0.43	516
	24-hour Full-service	0.71	1,014	0.71	1,014	0.43	619
	Quick-service Restaurant	0.64	710	0.64	710	0.48	473
	24-hour Quick-service	0.65	758	0.65	758	0.48	598
Lodging	Large Hotel	0.51	1,248	0.51	1,248	0.86	504
	Nursing Home	0.60	635	0.60	635	0.50	256
	Small Hotel	0.50	1,442	0.50	1,442	0.36	218
Mercantile	Strip Mall	0.66	637	0.66	637	0.39	346
Office	Small Office	0.63	660	0.63	660	0.29	156
Other	Other	0.50	496	0.50	496	0.29	156

Table 64. PTAC/PTHP or RAC Equipment: DF and EFLH Values for Dallas (CZ 2)

Building types	Principal building activity	Packaged terminal unit					
		Air conditioner		Heat pump			
		DF_C	$EFLH_C$	DF_C	$EFLH_C$	DF_H	$EFLH_H$
Education	Primary School	0.85	1,016	0.85	1,016	0.66	231
	Secondary School	0.99	912	0.99	912	0.59	285
Food Sales	Convenience	1.05	1,544	1.05	1,544	0.61	318
Food Service	Full-service Restaurant	1.06	1,534	1.06	1,534	0.50	401
	24-hour Full-service	1.06	1,734	1.06	1,734	0.49	509
	Quick-service Restaurant	1.05	1,336	1.05	1,336	0.61	368
	24-hour Quick-service	1.05	1,485	1.05	1,485	0.60	463
Lodging	Large Hotel	0.68	1,749	0.68	1,749	0.82	270
	Nursing Home	1.01	1,460	1.01	1,460	0.61	226
	Small Hotel	0.53	1,919	0.53	1,919	0.42	145
Mercantile	Strip Mall	0.88	925	0.88	925	0.55	219

Building types	Principal building activity	Packaged terminal unit					
		Air conditioner		Heat pump			
		DF_C	$EFLH_C$	DF_C	$EFLH_C$	DF_H	$EFLH_H$
Office	Small Office	0.89	1,012	0.89	1,012	0.40	89
Other	Other	0.53	912	0.53	312	0.40	89

Table 65. PTAC/PTHP or RAC Equipment: DF and EFLH Values for Houston (CZ 3)

Building types	Principal building activity	Packaged terminal unit					
		Air conditioner		Heat pump			
		DF_C	$EFLH_C$	DF_C	$EFLH_C$	DF_H	$EFLH_H$
Education	Primary School	0.71	1,186	0.71	1,186	0.50	52
	Secondary School	0.79	1,030	0.79	1,030	0.54	63
Food Sales	Convenience	0.83	1,760	0.83	1,760	0.51	70
Food Service	Full-service Restaurant	0.85	1,755	0.85	1,755	0.44	93
	24-hour Full-service	0.86	1,994	0.86	1,994	0.44	121
	Quick-service Restaurant	0.83	1,523	0.83	1,523	0.51	80
	24-hour Quick-service	0.85	1,692	0.85	1,692	0.50	104
Lodging	Large Hotel	0.57	2,080	0.57	2,080	0.33	54
	Nursing Home	0.81	1,695	0.81	1,695	0.24	44
	Small Hotel	0.53	1,903	0.53	1,903	0.19	32
Mercantile	Strip Mall	0.74	1,093	0.74	1,093	0.42	47
Office	Small Office	0.71	1,100	0.71	1,100	0.28	15
Other	Other	0.53	1,030	0.53	1,030	0.28	15

Table 66. PTAC/PTHP or RAC Equipment: DF and EFLH Values for Corpus Christi (CZ 4)

Building types	Principal building activity	Packaged terminal unit					
		Air conditioner		Heat pump			
		DF_c	$EFLH_C$	DF_c	$EFLH_C$	DF_H	$EFLH_H$
Education	Primary School	0.70	1,355	0.70	1,355	0.30	73
	Secondary School	0.76	1,212	0.76	1,212	0.35	92
Food Sales	Convenience	0.74	2,025	0.74	2,025	0.34	94

Building types	Principal building activity	Packaged terminal unit					
		Air conditioner		Heat pump			
		DF_c	$EFLH_C$	DF_c	$EFLH_C$	DF_H	$EFLH_H$
Food Service	Full-service Restaurant	0.77	2,041	0.77	2,041	0.35	136
	24-hour Full-service	0.77	2,337	0.77	2,337	0.36	176
	Quick-service Restaurant	0.74	1,752	0.74	1,752	0.34	108
	24-hour Quick-service	0.74	1,968	0.74	1,968	0.34	138
Lodging	Large Hotel	0.51	2,404	0.51	2,404	0.21	61
	Nursing Home	0.73	1,832	0.73	1,832	0.15	47
	Small Hotel	0.46	2,041	0.46	2,041	0.10	38
Mercantile	Strip Mall	0.65	1,218	0.65	1,218	0.21	66
Office	Small Office	0.63	1,213	0.63	1,213	0.14	18
Other	Other	0.46	1,212	0.46	1,212	0.14	18

Table 67. PTAC/PTHP or RAC Equipment: DF and EFLH Values for El Paso (CZ 5)

Building types	Principal building activity	Packaged terminal unit					
		Air conditioner		Heat pump			
		DF_c	$EFLH_C$	DF_c	$EFLH_C$	DF_H	$EFLH_H$
Education	Primary School	0.88	1,009	0.88	1,009	0.37	271
	Secondary School	0.84	751	0.84	751	0.43	286
Food Sales	Convenience	0.74	1,267	0.74	1,267	0.26	300
Food Service	Full-service Restaurant	0.74	1,292	0.74	1,292	0.28	407
	24-hour Full-service	0.72	1,431	0.72	1,431	0.27	538
	Quick-service Restaurant	0.74	1,096	0.74	1,096	0.26	347
	24-hour Quick-service	0.75	1,186	0.75	1,186	0.26	463
Lodging	Large Hotel	0.61	1,723	0.61	1,723	0.21	292
	Nursing Home	0.85	1,244	0.85	1,244	0.15	211
	Small Hotel	0.61	1,945	0.61	1,945	0.06	123
Mercantile	Strip Mall	0.80	943	0.80	943	0.27	298
Office	Small Office	0.81	1,050	0.81	1,050	0.15	97
Other	Other	0.61	751	0.61	751	0.15	97

Measure Life and Lifetime Savings

Effective Useful Life (EUL)

The EUL of PTAC/PTHP units is 15 years, as specified in DEER 2014.[154]

The EUL of RAC units is 10 years based on current DOE Final Rule standards for room air conditioners. This value is consistent with the EUL reported in the Department of Energy Technical Support Document for Room Air conditioners.[155]

Remaining Useful Life (RUL) for PTAC/PTHP Systems

The RUL of ER replaced systems is provided according to system age in Table 68.

For ER units of unknown age, assume a default value of 15 years, equal to the measure EUL. Default RUL may be used exclusively if applied consistently for all projects. Otherwise, the default should only be used when a project is reported and documented as having a nameplate that is illegible. Both the RUL and EUL are needed to estimate savings for early retirement projects for two distinct periods: The ER period (RUL) and the ROB period (EUL-RUL). The calculations for early retirement projects are extensive, and as such, are provided in Appendix A.

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154 http://www.deeresources.com/

155 Technical Support Document: Room Air Conditioners, June 2020, p. ES-14. https://beta.regulations.gov/document/EERE-2014-BT-STD-0059-0013.

Table 68. Remaining Useful Life of ER PTAC/PTHP Systems[156,157]

Age of replaced system (years)	PTAC/PTHP RUL (years)	Age of replaced system(years)	PTAC/PTHP RUL (years)
1	14.0	10	5.7
2	13.0	11	5.0
3	12.0	12	4.4
4	11.0	13	3.8
5	10.0	14	3.3
6	9.1	15	2.8
7	8.2	16	2.0
8	7.3	17	1.0
9	6.5	18[158]	0.0

Program Tracking Data and Evaluation Requirements

The below list of primary inputs and contextual data is recommended to be specified and tracked by the program database to inform the evaluation and apply the savings properly.

- Decision/action type: ROB, NC, ER, system type conversion
- Building type
- Climate zone
- Baseline number of units
- Baseline equipment type
- Baseline rated cooling and heating capacities
- **For ER only**: Baseline age and method of determination (e.g., nameplate, blueprints, Customer reported, not available)
- **For ER only**: Photograph of retired unit nameplate demonstrating model number, serial number, and manufacturer if blueprints are not provided; if photograph of nameplate is unavailable or not legible, provide a photo or description documenting the reason why the nameplate photo was unobtainable (alternate forms of documentation can be approved at the evaluator's discretion)

[156] PUCT Docket No. 40083, Attachment A describes the process in which the RUL of replaced systems has been calculated.

[157] Current federal standard effective date is 2/2013. Existing systems manufactured after this date are not eligible to use the early retirement baseline and should use the ROB baseline instead. These values are greyed out in the table and displayed for informational purposes only.

[158] RULs are capped at the 75th percentile of equipment age, 18 years, as determined based on DOE survival curves. Systems older than 18 years should use the ROB baseline. See the January 2015 memo, "Considerations for early replacement of residential equipment," for further detail.

- Installed number of units
- Installed equipment type (PTAC, PTHP, RAC)
- Equipment configuration category: Standard/non-standard or room AC
- Installed rated heating and cooling capacities
- Installed cooling and heating efficiency ratings
- Installed manufacturer and model
- Installed unit AHRI/DOE CCMS certificate or reference number
- **For retrofit only:** Proof of purchase: invoice showing model number; a photo of the model number on product packaging and installed unit(s); OR an evaluator pre-approved inspection approach
- **For new construction only:** Proof of purchase: invoice showing model number; a photo of the model number on product packaging and installed unit(s); as-built design drawings; HVAC specifications package that provides detailed make and model information on installed unit(s); OR an evaluator pre-approved inspection approach
- **For Other building type only**: A description of the actual building type, the primary business activity, the business hours, and the HVAC schedule.

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 36779—Provides EUL for HVAC equipment.
- PUCT Docket 40083—Provides incorporation of early retirement savings for existing commercial HVAC SOP designs and updates for baseline equipment efficiency levels for ROB and new construction projects involving package and split systems.
- PUCT Docket 40885—Provides a petition to revise deemed savings values for commercial HVAC replacement measures. This petition updated demand and energy coefficients for all commercial HVAC systems.

Relevant Standards and Reference Sources

- ANSI/ASHRAE/IES Standard 90.1-2001 through ASHRAE 90.1-2007. Energy Standard for Buildings Except Low-Rise Residential Buildings. Table 6.8.1D.
- ANSI/ASHRAE/IES Standard 90.1-2010. Energy Standard for Buildings Except Low-Rise Residential Buildings. Table 6.8.1D.
- Code of Federal Regulations. Title 10. Part 431—Energy Efficiency Program for Certain Commercial and Industrial Equipment. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=46

- Code of Federal Regulations. Title 10. Part 430—Energy Efficiency Program for Certain Commercial and Industrial Equipment. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=52
- 2015 International Energy Conservation Code. Table C403.2.3(3).

Document Revision History

Table 69. Nonresidential PTAC/PTHP and Room AC Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. Updated EUL value for DX units, based on PUCT Docket No. 36779. Updated the minimum baseline efficiencies for Standard PTAC and PTHP based on new federal standards, 10 CFR 431.97, and updated the minimum efficiencies for Room AC units and added specifications for new Casement-only and Casement-slider equipment. Expanded application to "Hotel—Large" business type for PTAC/PTHP equipment and changed the RAC energy and demand coefficients to reference those for DX systems, rather than those for PTAC/PTHP systems.
v2.1	01/30/2015	TRM v2.1 update. Corrections to energy and demand coefficients for heat pumps in Climate Zone 3 (Houston).
v3.0	04/10/2015	TRM v3.0 update. Added energy and demand coefficients for RAC units. Included text to allow for early retirement changes. For PTHPs: Added heating efficiencies and split EFLH into cooling and heating components.
v3.1	11/05/2015	TRM v3.1 update. Added updated building type definitions and descriptions, minor updates to text for clarification and consistency.
v4.0	10/10/2016	TRM v4.0 update. No revisions.
v5.0	10/2017	TRM v5.0 update. Used modeling approach to update DF and EFLH for applicable building types and climate zones. Updated baseline efficiency values for IECC 2015 and added 24-hour building load shapes. Updated RUL table based on DOE survival curves. Added several new building types.
v6.0	10/2018	TRM v6.0 update. Revised early retirement criteria for systems with an overall capacity change.
v7.0	10/2019	TRM v7.0 update. Revised early retirement criteria for systems with an overall capacity change. Added clarification for PTHPs replacing PTACs with electric resistance heating. Program tracking requirements updated.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits. Clarified use of post capacity for ROB baselines. Added unknown age defaults for early retirement.

2.2.5 Computer Room Air Conditioners Measure Overview

TRM Measure ID: NR-HV-CR

Market Sector: Commercial

Measure Category: HVAC

Applicable Building Types: See Table 71 and Table 72

Fuels Affected: Electricity

Decision/Action Type: Retrofit, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Calculator

Measure Description

This section summarizes the deemed savings methodology for the installation of computer room air conditioning (CRAC) systems. A CRAC unit is a device that monitors and maintains the temperature, air distribution, and humidity in a network room or data center. This measure covers assumptions made for baseline equipment efficiencies for early retirement (ER) based on the age of the replaced equipment and replace-on-burnout (ROB) and new construction (NC) situations based on efficiency standards. Savings calculations incorporate the use of only part-load efficiency values, as these types of units are only rated in units of seasonal COP (SCOP). For ER, the actual age of the baseline system should be determined from the equipment nameplate or other physical documentation whenever possible. If the actual age of the unit is unknown, default values are provided.

Eligibility Criteria

For a measure to be eligible to use this deemed savings approach, the following conditions must be met:

- The existing and proposed cooling equipment is electric
- The building type is a network room or data center
- For early retirement projects: ER projects involve the replacement of a working system. Additionally, the ER approach cannot be used for projects involving a renovation where a major structural change or internal space remodel has occurred. A ROB approach should be used for these scenarios.
- In the event that these conditions are not met, the deemed savings approach cannot be used, and the Simplified M&V Methodology or the Full M&V Methodology must be used.

Manufacturer datasheets for installed equipment or documentation of AHRI or DOE CCMS certification must be provided.[159,160]

Baseline Condition

The baseline conditions related to efficiency and system capacity for early retirement and replace-on-burnout/new construction are as follows:

Early Retirement

Early retirement projects should claim savings using the replace-on-burnout/new construction baseline, as no additional savings are specified for early retirement projects. This section will not apply until the current baseline is updated, allowing the measure to refer to the existing baseline for early retirement projects.

Replace-on-Burnout (ROB) and New Construction (NC)

Baseline efficiency levels for CRACs are provided in Table 70. These baseline efficiency levels reflect the minimum efficiency requirements from IECC 2015, which uses the Sensible Coefficient of Performance (SCOP) as the standard efficiency metric.

Table 70. Baseline Efficiency Levels for ROB and NC CRACs[161]

System type	Cooling capacity (Btu/hr)	Baseline efficiencies for downflow/upflow units (SCOP)	Source
Air conditioners, air cooled	< 65,000	2.20 / 2.09	IECC 2015
	≥ 65,000 and < 240,000	2.10 / 1.99	
	≥ 240,000	1.90 / 1.79	
Air conditioners, water cooled	< 65,000	2.60 / 2.49	
	≥ 65,000 and < 240,000	2.50 / 2.39	
	≥ 240,000	2.40 / 2.29	
Air conditioners, water cooled with fluid economizer	< 65,000	2.55 / 2.44	
	≥ 65,000 and < 240,000	2.45 / 2.34	
	≥ 240,000	2.35 / 2.24	
Air conditioners, glycol cooled (rated at 40% propylene glycol)	< 65,000	2.50 / 2.39	
	≥ 65,000 and < 240,000	2.15 / 2.04	
	≥ 240,000	2.10 / 1.99	

159 Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Directory: https://www.ahridirectory.org/.
160 Department of Energy Compliance Certification Management System (DOE CCMS): https://www.regulations.doe.gov/certification-data/.
161 IECC 2015 Table C403.2.3(1) and C403.2.3(2).

System type	Cooling capacity (Btu/hr)	Baseline efficiencies for downflow/upflow units (SCOP)	Source
Air conditioners, glycol cooled (rated at 40% propylene glycol) with fluid economizer	< 65,000	2.45 / 2.34	
	≥ 65,000 and < 240,000	2.10 / 1.99	
	≥ 240,000	2.05 / 1.94	

High-Efficiency Condition

Package and split-systems must exceed the minimum efficiencies specified in Table 30.

Additional conditions for replace-on-burnout, early retirement, and new construction are as follows:

New Construction and Replace on Burnout

This scenario includes equipment used for new construction and retrofit/replacements that are not covered by early retirement, such as units that are replaced after natural failure.

Early Retirement

Early retirement projects should claim savings using the replace-on-burnout/new construction baseline, as no additional savings are specified for early retirement projects. This section will not apply until the current baseline is updated, allowing the measure to refer to the existing baseline for early retirement projects.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

$$Peak\ Demand\ [kW_{Savings,C}] = \left(\frac{Cap_{C,pre}}{\eta_{baseline,C}} - \frac{Cap_{C,post}}{\eta_{installed,C}}\right) \times DF_C \times \frac{1\ kW}{3{,}412\ Btuh}$$

Equation 35

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

Equation 36

Where:

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

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

$\eta_{baseline,C}$ = *Cooling efficiency of existing equipment (ER) or standard equipment (ROB/NC) [SCOP]*

$\eta_{installed,C}$ = *Rated cooling efficiency of the newly installed equipment (SCOP)—(Must exceed ROB/NC baseline efficiency standards in Table 30) [SCOP]*

Note: Use SCOP for both kW and kWh savings calculations.

DF = *Seasonal peak demand factor for appropriate climate zone, and equipment type (Table 33 through Table 37)*

$EFLH_C$ = *Cooling equivalent full-load hours for appropriate climate zone, and equipment type [hours] (Table 33 through Table 37)*

Early Retirement Savings

Early retirement projects should claim savings using the replace-on-burnout/new construction baseline, as no additional savings are specified for early retirement projects. This section will not apply until the current baseline is updated, allowing the measure to refer to the existing baseline for early retirement projects.

Deemed Energy and Demand Savings Tables

Deemed peak demand factor (DF) and equivalent full-load hour (EFLH) values are presented by building type and climate zone. This measure is restricted to the data center building types, derived from the EIA CBECS study.[162]

The DF and EFLH values for CRAC units are presented in Table 72. A description of the calculation method used to derive these values can be found in Docket No. 40885, Attachment B.

Table 71. Commercial CRAC Building Type Descriptions and Examples

Building type	Principal building activity	Definition	Detailed business type examples[163]
Data Center	Data Center	Buildings used to house computer systems and associated components.	1) Data Center

[162] The Commercial Building Energy Consumption Survey (CBECS) implemented by the US Energy Information Administration includes a principal building activity categorization scheme that separates the commercial sector into 29 categories and 51 subcategories based on principal building activity (PBA). For its purposes, the CBECS defines commercial buildings as those *buildings greater than 1,000 square feet that devote more than half of their floor space to activity that is neither residential, manufacturing, industrial, nor agricultural. The high-level building types adopted for the TRM are adapted from this CBECS categorization, with some building types left out and one additional building type - Large Multifamily – included.*

[163] Principal Building Activities are based on sub-categories from 2003 CBECS questionnaire.

Table 72. DF and EFLH Values for All Climate Zones

Climate zone reference city	Building type and principal building activity	CRACs	
		DF_C	$EFLH_C$
Climate Zone 1: Amarillo	Data Center	0.89	2,048
Climate Zone 2: Dallas		1.08	3,401
Climate Zone 3: Houston		1.05	4,022
Climate Zone 4: Corpus Christi		0.97	4,499
Climate Zone 5: El Paso		0.88	2,547

Claimed Peak Demand Savings

A summer peak period value is used for this measure. Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

Measure Life and Lifetime Savings

The EUL and RULs for this HVAC equipment are provided below. The reader should refer to the definitions of effective useful life and remaining useful life in the glossary in Volume 1 for guidance on how to determine the decision type for system installations.

Effective Useful Life (EUL)

The EUL for CRACs is 15 years, consistent with the EUL specified for split and packaged air conditioners and heat pumps.[164]

Remaining Useful Life (RUL)

This section will not apply unless the current baseline is updated, allowing the measure to refer to the existing baseline for early retirement projects.

Program Tracking Data and Evaluation Requirements

The below list of primary inputs and contextual data is recommended to be specified and tracked by the program database to inform the evaluation and apply the savings properly.

- Decision/action type: ER, ROB, NC, system type conversion
- Climate zone
- Baseline number of units

[164] The EUL of 15 years has been cited in several places - PUCT Docket No. 36779, DOE 77 FR 28928, 10 CFR Part 431, and in the DEER 2014 update.

- Baseline equipment type
- Baseline equipment rated cooling capacity
- Installed number of units
- Installed equipment type
- Installed equipment rated cooling capacity
- Installed cooling efficiency ratings
- Installed manufacturer and model
- Installed unit AHRI/DOE CCMS certificate or reference number

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 36779—Provides EUL for HVAC equipment.
- PUCT Docket 40083– Provides incorporation of early retirement savings for existing commercial HVAC SOP designs and updates for baseline equipment efficiency levels for ROB and new construction projects involving package and split systems.
- PUCT Docket 40885—Provides a petition to revise deemed savings values for Commercial HVAC replacement measures. Items covered by this petition include the following:
- Updated baseline efficiencies use for estimating deemed savings for commercial PTAC/PTHP's, Room Air Conditioners, and chilled water systems.
- Approved estimates of RUL of working chilled water systems.
- Updated demand and energy coefficients for all commercial HVAC systems.
- Updated EUL of centrifugal chilled water systems installed in ROB or new construction projects.
- Provide a method for utilizing the early retirement concept developed in the petition in Docket No. 40083 for Packaged and Split DX systems and applied to chilled water systems when the age of the system being replaced cannot be ascertained.
- PUCT Docket 41070—Provides energy and demand savings coefficients for an additional climate zone, El Paso, TX. Prior to this filing, savings for the Dallas-Fort Worth area were used for El Paso, but Dallas-Fort Worth has a colder winter, somewhat more moderate summer, more sunshine, and less precipitation than El Paso.
- PUCT Docket 43681—Updated the approach for calculating early replacement energy and demand savings using a net present value (NPV) method. Documented in Appendix A.

Relevant Standards and Reference Sources

- ANSI/ASHRAE/IES Standard 90.1-2010. Energy Standard for Buildings Except Low-Rise Residential Buildings. Table 6.8.1A through Table 6.8.1D.
- ANSI/ASHRAE/IES Standard 90.1-2010. Energy Standard for Buildings Except Low-Rise Residential Buildings. Table 6.8.1-1 and Table 6.8.1-2.
- 2015 International Energy Conservation Code. Table C403.2.3(1) and Table C403.2.3(2).
- Code of Federal Regulations. Title 10. Part 431—Energy Efficiency Program for Certain Commercial and Industrial Equipment. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=31.

Document Revision History

Table 73. Nonresidential Computer Room Air Conditioners Revision History

TRM version	Date	Description of change
v7.0	10/2019	TRM v7.0 origin.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits. Removed text referring to building types other than data centers.

2.2.6 Computer Room Air Handler Motor Efficiency Measure Overview

TRM Measure ID: NS-HV-CM

Market Sector: Commercial

Measure Category: HVAC

Applicable Building Types: Data Centers

Fuels Affected: Electricity

Decision/Action Type: Retrofit

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed Savings Calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure involves improving the operational efficiency of a computer room air handler (CRAH) through the installation of a variable frequency drive (VFD) or electronically commutated motor (ECM). Savings for this measure include fan motor savings resulting from the ability to modulate the fan speed. Any associated cooling energy savings are not captured.

Eligibility Criteria

Eligible equipment includes fan motors and VFDs, 15 horsepower and smaller used to distribute conditioned air throughout a data center[165].

Baseline Condition

The CRAH baseline is a conventional AC motor driven, constant speed fan.

High-Efficiency Condition

The high-efficiency condition is the installation of a variable frequency drive (VFD) and/or electronically commutated motor (ECM).

[165] The existing associated computer room air conditioning (CRAC) unit condenser and evaporator are expected to remain in place for this measure. If those units are also replaced, reference the CRAC measure TRM entry.

Savings Algorithms and Input Variables

Energy and demand savings are estimated using input assumptions taken from site measured motor kW and operating hours for 243 CRAH units.[166]

Energy Savings Algorithms

$$Annual\ Energy\ Savings\ (kWh) = \left(kW_{pre} - kW/hp_{post} \times hp_{post}\right) \times hours$$

Equation 37

$$kW_{pre} = 0.746 \times hp_{pre} \times \frac{LF}{\eta}$$

Equation 38

Where:

hp_{pre} = Rated horsepower of the existing motor

LF = Load factor—ratio of the operating load to the nameplate rating of the motor—assumed to be 75% at the fan or pump design 100% per DEER

η = Motor efficiency of a standard efficiency Open Drip Proof (ODP) motor operating at 1800 RPM taken from ASHRAE Standard 90.1-2013

Table 74. Motor Efficiences for Open Drip Proof Motors at 1,800 RPM

Motor horsepower	Full load efficiency
1	0.855
2	0.865
3	0.895
5	0.895
7.5	0.91
10	0.917
15	0.93

[166] Site data are sourced from 3 data centers in Oncor territory that replaced 243 CRAH fan motors either with ECMs or retrofitted with VFDs.

0.746	=	HP to kW conversion factor
kW/hp_{post}	=	Efficient kW per motor hp, 0.27[167]
hp_{post}	=	Total efficient motor horsepower
$hours$	=	Annual operating hours, 8760

Demand Savings Algorithms

$$Demand\ Savings\ (kW) = \frac{Annual\ Energy\ Savings\ (kWh)}{hours} \times CF$$

Equation 39

Where:

CF	=	*peak coincidence factor, summer and winter: 0.11*[168]

Deemed Energy and Demand Savings Tables

There are no deemed savings tables for this measure.

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

Measure Life and Lifetime Savings

The median estimated useful life (EUL) premium efficiency motors is 15 years.[169]

The estimated useful life (EUL) for HVAC VFD measure is 15 years.

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[167] Oncor site data. Average kW/hp values are weighted by measure count.

[168] Peak coincidence factors are calculated according to the method in Section 4 of the Texas TRM Vol 1 using average hourly kW trends from Oncor site data. Summer and winter CF ranged from 0.10 to 0.12 across all climate zones, and the average value of 0.11 is used as the default input assumption for calculating demand savings.

[169] U.S. DOE, Technical Support Document, "Energy Efficiency Program for Commercial Equipment: Energy Conservation Standards for Electric Motors", Median of "Table 8.2.23 Average Application Lifetime". Download TSD at: https://www.mercatus.org/system/files/1904-AC28-TSD-Electric-Motors.pdf. Accessed July 2020.

Program Tracking Data and Evaluation Requirements

The below list of primary inputs and contextual data is recommended to be specified and tracked by the program database to inform the evaluation and apply the savings properly.

- Motor quantity, type, horsepower, and control; pre-installation
- Motor quantity, type, horsepower, and control; post-installation
- Climate zone

References and Efficiency Standards

Petitions and Rulings

None.

Relevant Standards and Reference Sources

Not applicable.

Document Revision History

Table 75. Nonresidential Computer Room Air Handler Motor Efficiency Revision History

TRM version	Date	Description of change
v8.0	10/2020	TRM v8.0 origin.

2.2.7 HVAC Variable Frequency Drives Measure Overview

TRM Measure ID: NR-HV-VF

Market Sector: Commercial

Measure Category: HVAC

Applicable Building Types: See Table 80 through Table 86

Fuels Affected: Electricity

Decision/Action Type: Retrofit

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure involves the installation of a variable frequency drive (VFD) in a commercial HVAC application. Eligible applications include:

- AHU supply fan on a split or packaged HVAC system. The fan is in a variable air volume (VAV) system with terminal VAV boxes or constant air volume (CAV) unit with no control device.
- Hot water distribution pumps
- Chilled water distribution pumps

This measure does not apply to controls installed on the HVAC compressor. This measure accounts for the interactive air conditioning demand savings during the utility defined summer peak period. The savings are on a per-control basis, and the lookup tables show the total savings for eligible scenarios.

Eligibility Criteria

Supply fans may not have variable pitch blades. Supply fans must be less than or equal to 100 hp. New construction systems are ineligible. Equipment used for process loads is ineligible.

Baseline Condition

The AHU supply fan baseline is a centrifugal supply fan with a single-speed motor on a direct expansion (DX) VAV or CAV air conditioning (AC) unit. The motor is a standard efficiency motor based on ASHRAE Standard 90.1-2013, which are provided by horsepower. The AC unit has standard cooling efficiency based on IECC 2015. The part-load fan control is an outlet damper, inlet damper, inlet guide vane, or no control (constant volume systems).

The HVAC pump baseline is a constant speed pump with a standard-efficiency motor. This measure is applicable to both primary and secondary hot or chilled water pumping systems.

High-Efficiency Condition

The high-efficiency condition is the installation of a VFD on an AHU supply fan, hot water pump, or chilled water pump.

For AHU supply fans, when applicable, the existing damper or inlet guide vane will be removed or set completely open permanently after installation. The VFD will maintain a constant static pressure by adjusting fan speed and delivering the same amount of air as the baseline condition.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Demand Savings are calculated for each hour over the course of the year:

Step 1: Determine the percent flow rate for each of the year (*i*)

For AHUs:

$$\%CFM_i = m \times t_{db,i} + b$$

Equation 40

Where:

$t_{db,i}$ = *The hourly dry bulb temperature (DBT) using TMY3[170] data*

m = *The slope of the relationship between DBT and CFM, see Table 76*

b = *The intercept of the relationship between DSBT and CFM, see Table 76*

The minimum flow rate is set to 60% cfm based on common design practice.[171] Determination of the minimum dry bulb temperature assumes that cooling will only operate above the cooling reference temperature of 65°F dry bulb. The maximum DBT is the ASHRAE dry bulb design temperature.[172]

[170] National Renewable Energy Laboratory's (NREL) National Solar Radiation Data Base: 1991- 2005 Update for Typical Meteorological Year 3 (TMY3). Available at https://sam.nrel.gov/weather-data.html.

[171] For AHU, a 60% minimum setpoint strategy is assumed, so any results below 60% are set to 60%. Similarly, any results greater than 100% are set to 100%.

[172] ASHRAE 2017 Fundamentals, Ch 14 Appendix: design conditions for selected locations, 0.4% Cooling DB.

Table 76. AHU Supply Fan VFD %CFM Inputs

Climate zone	Condition	Minimum	Maximum	Slope (m)	Intercept (b)
Zone 1	Flow Rate (%CFM)	60	100	1.19	-17.38
	Dry Bulb T (°F)	65	98.6		
Zone 2	Flow Rate (%CFM)	60	100	1.10	-11.43
	Dry Bulb T (°F)	65	101.4		
Zone 3	Flow Rate (%CFM)	60	100	1.23	-20.00
	Dry Bulb T (°F)	65	97.5		
Zone 4	Flow Rate (%CFM)	60	100	1.26	-21.76
	Dry Bulb T (°F)	65	96.8		
Zone 5	Flow Rate (%CFM)	60	100	1.11	-12.02
	Dry Bulb T (°F)	65	101.1		

For chilled water pumps:

$$\%GPM_i = m \times t_{db\_i} + b$$

Equation 41

Where:

$t_{db,i}$ = *The hourly dry bulb temperature (DBT) using TMY3 data*

m = *The slope of the relationship between DBT and GPM, see Table 77*

b = *The intercept of the relationship between DSBT and GPM, see Table 77*

The minimum flow rate is set to 10% GPM based on the ANSI/ASHRAE/IES Standard 90.1-2016 Performance Rating Method Reference Manual.[173] Determination of the minimum dry bulb temperature assumes that cooling will only operate above the cooling reference temperature of 65°F dry bulb. The maximum DBT is the ASHRAE dry bulb design temperature.[174]

[173] PNNL, ANSI/ASHRAE/IES Standard 90.1-2016 Performance Rating Method Reference Manual, page 3.249, pump minimum speed default.

[174] ASHRAE 2017 Fundamentals, Ch 14 Appendix: design conditions for selected locations, 0.4% Cooling DB.

Table 77. Chilled Water Pump VFD %CFM Inputs

Climate zone	Condition	Minimum	Maximum	Slope (*m*)	Intercept (*b*)
Zone 1	Flow Rate (%GPM)	10	100	2.68	-164.11
	Dry Bulb T (°F)	65	98.6		
Zone 2	Flow Rate (%GPM)	10	100	2.47	-150.71
	Dry Bulb T (°F)	65	101.4		
Zone 3	Flow Rate (%GPM)	10	100	2.77	-170.00
	Dry Bulb T (°F)	65	97.5		
Zone 4	Flow Rate (%GPM)	10	100	2.83	-173.96
	Dry Bulb T (°F)	65	96.8		
Zone 5	Flow Rate (%GPM)	10	100	2.49	-152.05
	Dry Bulb T (°F)	65	101.1		

For hot water pumps:

$$\%GPM_i = m \times t_{db\_i} + b$$

Equation 42

Where:

$t_{db,i}$ = *The hourly dry bulb temperature (DBT) using TMY3 data*[170]

m = *The slope of the relationship between DBT and GPM, see Table 78*

b = *The intercept of the relationship between DSBT and GPM, see Table 78*

The minimum flow rate is set to 10% GPM based on the ANSI/ASHRAE/IES Standard 90.1-2016 Performance Rating Method Reference Manual.[175] Determination of the minimum dry bulb temperature assumes that heating will only operate below the heating reference temperature of 65°F dry bulb. The maximum DBT is the ASHRAE dry bulb design temperature.[176]

[175] PNNL, ANSI/ASHRAE/IES Standard 90.1-2016 Performance Rating Method Reference Manual, page 3.249, pump minimum speed default.

[176] ASHRAE 2017 Fundamentals, Ch 14 Appendix: design conditions for selected locations, 99.6% Heating DB.

Table 78. Hot Water Pump VFD %CFM Inputs

Climate zone	Condition	Minimum	Maximum	Slope (*m*)	Intercept (*b*)
Zone 1	Flow Rate (%GPM)	10	100	-1.64	116.56
	Dry Bulb T (°F)	65	10.1		
Zone 2	Flow Rate (%GPM)	10	100	-2.16	150.29
	Dry Bulb T (°F)	65	23.3		
Zone 3	Flow Rate (%GPM)	10	100	-2.65	182.57
	Dry Bulb T (°F)	65	31.1		
Zone 4	Flow Rate (%GPM)	10	100	-3.15	214.55
	Dry Bulb T (°F)	65	36.4		
Zone 5	Flow Rate (%GPM)	10	100	-2.26	156.62
	Dry Bulb T (°F)	65	25.1		

Step 2 - Calculate the %power for the applicable baseline and the new VFD technology:

Baseline Technologies

For AHU supply fan: [177]

$$\%power_{i,OutletDamper} = 0.00745 \times \%CFM_i^{\,2} + 0.10983 \times \%CFM_i + 20.41905$$

Equation 43

$$\%power_{i,InletDamper} = 0.00013 \times \%CFM_i^{\,3} - 0.01452 \times \%CFM_i^{\,2} + 0.71648 \times \%CFM_i + 50.25833$$

Equation 44

$$\%power_{i,InletGuideVane} = 0.00009 \times \%CFM_i^{\,3} - 0.00128 \times \%CFM_i^{\,2} + 0.06808 \times \%CFM_i + 20$$

Equation 45

Note: %power for constant volume baseline technologies with no fan control is set equal to 1 for each hour where %power is less than 1 for the other baseline control types. When %power exceeds 1 for the other baseline control types, %power for no fan control is set equal to the maximum value from the other baseline control types.

For chilled and hot water pumps[178]:

$$\%power_{base} = 2.5294 \times \%GPM_i^{\,3} - 4.7443 \times \%GPM_i^{\,2} + 3.2485 \times \%GPM_i + 0$$

Equation 46

[177] https://focusonenergy.com/sites/default/files/Focus%20on%20Energy_TRM_January2015.pdf, page 225. Please note, the CFM^2 coefficients in Equation 38 and Equation 39 have the wrong sign in the reference document.

[178] PNNL, ANSI/ASHRAE/IES Standard 90.1-2016 Performance Rating Method Reference Manual, Table 87 Default Part-load CIRC-PUMP-FPLR Coefficients – Constant Speed, no VSD.

VFD Technology

For AHU supply fan[179]:

$$\%power_{VFD} = 0.00004 \times \%CFM_i^3 + 0.00766 \times \%CFM_i^2 - 0.19567 \times \%CFM_i + 5.9$$

Equation 47

For chilled and hot water pumps[180]:

$$\%power_{VFD} = 0.7347 \times \%GPM_i^3 - 0.301 \times \%GPM_i^2 + 0.5726 \times \%GPM_i + 0$$

Equation 48

Step 3 - Calculate kW_{full} using the hp from the motor nameplate, LF (75%), and the applicable motor efficiency from ASHRAE 2013, Table 10.8-1 Minimum Nominal Efficiency for General Purpose Electric Motors; Use that result and the %power results to determine power consumption at each hour:

$$kW_{full} = 0.746 \times HP \times \frac{LF}{\eta}$$

Equation 49

$$kW_i = kW_{full} \times \%power_i$$

Equation 50

Where:

$\%power_i$	=	*Percentage of full load power at the i^{th} hour calculated by an equation based on the control type (outlet damper, inlet box damper, inlet guide vane-IGV, or VFD)*[181]
kW_{full}	=	*Fan motor power demand operating at the fan design 100% CFM or pump design 100% GPM*
kW_i	=	*Fan or Pump real-time power at the i^{th} hour of a year*
HP	=	*Rated horsepower of the motor*

[179] https://focusonenergy.com/sites/default/files/Focus%20on%20Energy_TRM_January2015.pdf, page 225.

[180] PNNL, ANSI/ASHRAE/IES Standard 90.1-2016 Performance Rating Method Reference Manual, Table 87 Default Part-load CIRC-PUMP-FPLR Coefficients – Default (VSD, No Reset).

[181] Fan curves by control type are provided in the BPA ASD Calculator, http://www.bpa.gov/EE/Sectors/Industrial/Documents/ASDCalculators.xls.

LF = *Load factor—ratio of the operating load to the nameplate rating of the motor—assumed to be 75% at the fan or pump design 100% per DEER 2005*

η = *Motor efficiency of a standard efficiency Open Drip Proof (ODP) motor operating at 1800 RPM taken from ASHRAE Standard 90.1-2013*

Table 79. Motor Efficiencies for Open Drip Proof Motors at 1,800 RPM

Motor horsepower	Full load efficiency
1	0.855
2	0.865
3	0.895
5	0.895
7.5	0.91
10	0.917
15	0.93
20	0.93
25	0.936
30	0.941
40	0.941
50	0.945
60	0.95
75	0.95
100	0.954

0.746 = *HP to kW conversion factor*

Step 4 - Calculate the kW savings for each of the top 20 hours within the applicable peak probability analysis for the building's climate zone from Volume 1. Sum the kW savings for each hour multiplied by the peak demand probability factor from the 20 individual hourly calculations, then divide by the sum of the PDPF for the 20 hours to get the average peak demand impact, and then calculate the total peak demand saved by adding peak demand interactive effects:

Hourly Savings Calculations

$$(kW_i)_{Saved} = [(kW_i)_{Baseline} - (kW_i)_{VFD}] \times schedule_i$$

Equation 51

Where:

schedule = *1 when building is occupied, 0.2 when building is unoccupied, see Table 80*

Table 80. Yearly Motor Operation Hours by Building Type[182,183]

Building type	Weekday schedule	Weekend schedule	Annual building occupied hours	Annual motor operation hours[184]
Hospitals and Healthcare	24 hr	24 hr	8,760	8,760
Office—Large	8am–8pm	8am–10am	3,340	4,424
Office—Small	8am–6pm	8am–10am	2,818	4,006
Education—K-12	7am–5pm	8am–12pm	3,026	4,173
Education—College and University	8am–8pm	8am–12pm	3,548	4,590
Retail	9am–10pm	9am–10pm	4,745	5,548
Restaurants—Fast Food	6am–11pm	6am–11pm	6,205	6,716
Restaurants—Sit Down	11am–11pm	11am–11pm	4,380	5,256
Other[185]	8am–6pm	8am–10am	2,818	4,006

Average Peak Demand Saved Calculation, excluding interactive effects

$$kW_{PDPF,Saved} = \frac{\sum_{i=1}^{20}(kW_i)_{Saved} * PDPF_i)}{\sum_{i=1}^{20}(PDPF_i)}$$

Equation 52

Where:

PDPF = *Peak demand probability factor from the applicable climate zone table in Volume 1.*

Total Peak Demand Saved Calculation, including interactive effects. This applies only to AHU supply fans. Total peak demand savings for pumps are found using Equation 52 above:

$$kW_{TotalSaved} = kW_{PDPF,Saved} \times (1 + \frac{3.412}{Cooling_{EER}})$$

Equation 53

Where:

$Cooling_{EER}$ = *Air conditioner full-load cooling efficiency, assumed at 11.2, based on IECC 2015 minimum efficiency of a unitary AC system between 5 and 11.3 tons*

182 The building hours of operation were noted in PUCT Docket 40668 to have been referenced from Commercial Building Energy Consumption Survey (CBECS) 2003. The specific analysis/report could not be confirmed.

183 Data centers are covered in 2.2.6 Computer Room Air Handler Motor Efficiency.

184 Motor operation hours are building occupied hours plus 20 percent of unoccupied hours.

185 The “other” building type may be used when none of the listed building types apply. The values used for other are the most conservative of the listed building types.

Energy Savings are calculated in the following manner:

Step 1 – For both the baseline and new technology, calculate the sum of individual kWh consumption in each hour of the year:

$$Annual\ kWh = \sum_{i=1}^{8760} (kW_i \times schedule_i)$$

Equation 54

Where:

8760 = *Total number of hours in a year*

Step 2 - Subtract the Annual kWh_{new} from the Annual $kWh_{baseline}$ to get the Annual Energy Savings:

$$Annual\ Energy\ Savings\ [kWh] = kWh_{baseline} - kWh_{new}$$

Equation 55

Deemed Energy and Demand Savings Tables[186]

Table 81. AHU Supply Fan Outlet Damper Baseline Savings per Motor HP

Building type	Climate zone				
	1	2	3	4	5
Energy savings (kWh per motor HP)					
Hospitals and Healthcare	1,160	1,101	1,071	1,046	1,121
Office—Large	569	536	515	499	545
Office—Small	514	484	464	449	493
Education—K-12	539	508	484	469	517
Education—College and University	590	555	533	517	565
Retail	710	668	645	629	680
Restaurants—Fast Food	872	823	796	776	838
Restaurants—Sit Down	674	635	617	603	646
Other	514	484	464	449	493
Summer kW savings (kW per motor HP)					
All Building Types	0.041	0.032	0.038	0.061	0.041

186 Data centers are covered in 2.2.6 Computer Room Air Handler Motor Efficiency.

Table 82. AHU Supply Fan Inlet Damper Baseline Savings per Motor HP

Building type	Climate zone				
	1	2	3	4	5
Energy savings (kWh per motor HP)					
Hospitals and Healthcare	1,824	1,672	1,597	1,533	1,722
Office—Large	881	801	754	716	822
Office—Small	797	724	678	643	743
Education—K-12	837	761	709	673	782
Education—College and University	914	830	780	741	852
Retail	1,098	998	944	904	1,024
Restaurants- Fast Food	1,358	1,238	1,172	1,122	1,272
Restaurants—Sit Down	1,044	949	906	870	974
Other	797	724	678	643	743
Summer kW Savings (kW per Motor HP)					
All Building Types	0.047	0.037	0.047	0.067	0.047

Table 83. AHU Supply Fan Inlet Guide Vane Baseline Savings per Motor HP

Building type	Climate zone				
	1	2	3	4	5
Energy savings (kWh per motor HP)					
Hospitals and Healthcare	388	345	324	307	359
Office—Large	185	163	151	141	169
Office—Small	167	148	135	126	153
Education—K-12	176	156	142	132	161
Education—College and University	192	169	156	145	175
Retail	230	203	189	178	210
Restaurants- Fast Food	286	253	236	222	262
Restaurants—Sit Down	219	194	182	172	200
Other	167	148	135	126	153
Summer kW savings (kW per motor HP)					
All Building Types	0.009	0.009	0.01	0.011	0.01

Table 84. AHU Supply Fan No Control Baseline Savings per Motor HP

Building type	Climate Zone 1	2	3	4	5
Energy savings (kWh per motor HP)					
Hospitals and Healthcare	3,300	3,035	2,904	2,792	3,124
Office—Large	1,595	1,453	1,368	1,299	1,490
Office—Small	1,442	1,313	1,228	1,165	1,348
Education—K-12	1,514	1,380	1,285	1,219	1,418
Education—College and University	1,654	1,505	1,414	1,344	1,545
Retail	1,988	1,809	1,712	1,640	1,857
Restaurants—Fast Food	2,458	2,245	2,128	2,040	2,307
Restaurants—Sit Down	1,889	1,720	1,644	1,579	1,765
Other	1,442	1,313	1,228	1,165	1,348
Summer kW savings (kW per motor HP)					
All Building Types	0.049	0.037	0.061	0.086	0.051

Table 85. Chilled Water Pump Savings per Motor HP

Building type	Climate Zone 1	2	3	4	5
Energy savings (kWh per motor HP)					
Hospitals and Healthcare	777	1,154	1,337	1,479	1,049
Office—Large	455	621	699	758	590
Office—Small	411	560	633	683	533
Education—K-12	422	577	655	710	549
Education—College and University	475	644	727	788	613
Retail	576	780	888	958	738
Restaurants—Fast Food	662	924	1,057	1,152	868
Restaurants—Sit Down	540	736	837	908	690
Other	411	560	633	683	533
Summer kW savings (kW per motor HP)					
All Building Types	0.046	0.029	0.035	0.087	0.049

Table 86. Hot Water Pump Savings per Motor HP

Building type	Climate Zone 1	2	3	4	5
Energy savings (kWh per motor HP)					
Hospitals and Healthcare	1,304	912	723	597	1,044
Office—Large	600	417	323	257	468
Office—Small	541	378	286	228	421
Education—K-12	572	399	301	239	448
Education—College and University	620	431	332	264	487
Retail	746	510	397	321	593
Restaurants—Fast Food	940	649	510	413	745
Restaurants—Sit Down	710	487	386	314	566
Other	541	378	286	228	421
Winter kW savings (kW per motor HP)					
All Building Types	0.123	0.045	0.047	0.108	0.229

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

Measure Life and Lifetime Savings

The estimated useful life (EUL) for this VFD measure is 15 years per both the PUCT-approved Texas EUL filing (Docket No. 36779) and DEER 2014 (EUL ID—HVAC-VSD-fan).

Program Tracking Data and Evaluation Requirements

The below list of primary inputs and contextual data is recommended to be specified and tracked by the program database to inform the evaluation and apply the savings properly.

- Building type
- Application type (AHU supply fan, hot water pump, chilled water pump)
- Climate zone
- Motor horsepower
- **For AHU supply fans only**: Baseline part-load control type (e.g., outlet damper, inlet damper, inlet guide vane, constant volume/no control).

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 36779—Provides EUL for VFD equipment
- PUCT Docket 40668—Provides details on deemed savings calculations for VFDs.

Relevant Standards and Reference Sources

- ASHRAE Fundamentals 1997: Chapter 26, Table 1B—Cooling and Dehumidification Design Conditions—United States.
- ASHRAE Standard 90.1-2013: Table 10.8-1 Minimum Nominal Full-load Efficiency for General Purpose Electric Motors (Subtype I), Except Fire-Pump Electric Motors and Table 10.8-2 Minimum Nominal Full-load Efficiency for General Purpose Electric Motors (Subtype II), Except Fire-Pump Electric Motors.
- National Renewable Energy Laboratory's (NREL) National Solar Radiation Data Base: 1991- 2005 Update for Typical Meteorological Year 3 (TMY3). Available at https://sam.nrel.gov/weather-data.html.
- California Public Utility Commission. Database for Energy Efficiency Resources, 2005.
- Bonneville Power Authority Adjustable Speed Drive Calculator—Fan curves utilized from that calculator were derived from "Flow Control," a Westinghouse publication, Bulletin B-851, F/86/Rev-CMS 8121. http://www.bpa.gov/EE/Sectors/Industrial/Documents/ASDCalculators.xls. Accessed 07/09/2020.

Document Revision History

Table 87. Nonresidential HVAC VFD Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. No revisions.
v3.0	04/10/2015	TRM v3.0 update. Corrected ASHRAE 0.4 percent Dry Bulb Design Temperature references for three climate zone reference cities: DFW, El Paso, and Houston. Updated Valley climate zone reference city to Corpus Christi to be consistent with TRM guidance. Corrected Motor Load Factor to 75 percent.
v4.0	10/10/2016	TRM v4.0 update. Added reference for percent power and corrected signs for variables in Equation 47.
v5.0	10/2017	TRM v5.0 update. Updated deemed energy/demand tables for revised peak demand definition.
v6.0	10/2018	TRM v6.0 update. Added no control device option for constant volume systems. Corrected error in previous kW and kWh deemed savings calculations for Outlet Damper baseline control.

TRM version	Date	Description of change
v7.0	10/2019	TRM v7.0 update. Renamed measure to HVAC Variable Frequency Drives. Added methodology for chilled and hot water pumps.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits. Added motor efficiency default assumptions.

2.2.8 Condenser Air Evaporative Pre-Cooling Measure Overview

TRM Measure ID: NR-HV-EP

Market Sector: Commercial

Measure Category: HVAC

Applicable Building Types: See Table 89 through Table 93

Fuels Affected: Electricity

Decision/Action Type: Retrofit, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

This section summarizes the deemed savings methodology for the installation of an evaporative pre-cooling system onto HVAC equipment. This process reduces the temperature of the outside air before it is used to cool the condenser coil for direct expansion (DX) units or air-cooled chillers. The temperature reduction is achieved by having the incoming air pass through a saturated media or mist wall, which will increase the humidity ratio under adiabatic conditions. This allows the dry bulb temperature to decrease while the wet bulb temperature remains constant, effectively increasing the heat rejection capacity from the condenser coils into the air. This measure is not applicable to the replacement of an air-cooled condenser with an evaporative condenser.

Applicable evaporative pre-cooling product types include:

- Evaporative media panels that incoming air must pass through
- Misting based system that sprays fine droplets into the air in front of the air intake area.

Eligibility Criteria

For a measure to be eligible to use this deemed savings approach, the following conditions must be met:

- Must have chemical or mechanical water treatment
    - Must have periodic purge control for sump-based systems
- Must have a control system for operation
    - Minimum temperature controls for sump-based systems
    - Minimum enthalpy controls for mist-based systems
- All air to condenser coils must pass through the evaporative pre-cooling system
- Systems must be installed by a qualified contractor and must be commissioned

- Evaporative effectiveness performance of greater than or equal to 0.75 (i.e., 75 percent) for average dry bulb temperature and humidity during peak hours
- Operation manuals must be provided
- If these conditions are not met, the deemed savings approach cannot be used, and the Simplified M&V Methodology or the Full M&V Methodology must be used.

Baseline Condition

The baseline conditions are the operation of a direct expansion (DX) unit or air-cooled chiller without evaporative pre-cooling.

High-Efficiency Condition

Evaporative pre-cooling systems must exceed the evaporative effectiveness performance of 75 percent for average dry bulb temperature humidity during peak hours. Table 88 contains values that can be used as a reference for evaluating evaporative effectiveness.

Table 88. Average Weather During Peak Conditions[187]

Climate zone	Temperature (°F)	Humidity (%)
1—Amarillo	95.8	25
2—Dallas	101.2	34
3—Houston	99.1	37
4—Corpus Christi	92.5	49
5—El Paso	97.4	15

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

$$Energy\ Savings\ [kWh_{savings}] = (Cap_C \times \eta_C) \times EFLH_{reduction}$$

Equation 56

$$Peak\ Demand\ [kW_{savings}] = (Cap_C \times \eta_C) \times DRF$$

Equation 57

[187] Extracted from weather data from building models that were used to create summer peak period value used for this measure.

Where:

Cap_C	=	*Rated equipment cooling capacity of the existing equipment at AHRI standard conditions [Btuh or ton]*
η_C	=	*Cooling efficiency of existing equipment [Btu/W-h, or kW/ton]*
$EFLH_{reduction}$	=	*Annual cooling energy reduction divided by the rated full loaded demand. Annual cooling energy reduction is determined according to the same method as other HVAC coefficients contained in the TRM. Rated full loaded demand is the Cap_C divided by its rated full load efficiency. See Table 89 through Table 93.*
DRF	=	*Demand reduction factor. The average peak hour energy reduction divided by the rated full loaded demand. See Table 89 through Table 93.*

Note: For DX systems, use EER for kW savings calculations and SEER/IEER for kWh savings calculations. For air-cooled chillers, use full-load efficiency (kW/ton) for kW savings calculations and part-load efficiency (IPLV) for kWh savings calculations. In the cases where the full-load efficiency is provided in terms of EER rather than kW/ton, a conversion to kW/ton needs to be performed using the following conversion:

$$\frac{kW}{Ton} = \frac{12}{EER}$$

Equation 58

Deemed Energy and Demand Savings Tables

Deemed peak demand reduction factor (DRF) and equivalent full-load hour reduction ($EFLH_{reduction}$) values are presented by building type and climate zone. A description of the building types that are used for HVAC systems is presented in Table 31. These building types are derived from the EIA CBECS study.[188]

The DRF and $EFLH_{reduction}$ values for packaged and split AC are presented in Table 89 through Table 93. These tables also include an "Other" building type, which can be used for business types that are not explicitly listed. The DRF and $EFLH_{reduction}$ values used for Other are the most conservative

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[188] The Commercial Building Energy Consumption Survey (CBECS) implemented by the US Energy Information Administration includes a principal building activity categorization scheme that separates the Commercial sector into 29 categories and 51 subcategories based on principal building activity (PBA). For its purposes, the CBECS defines Commercial buildings as those *buildings greater than 1,000 square feet that devote more than half of their floor space to activity that is neither residential, manufacturing, industrial, nor agricultural. The high-level building types adopted for the TRM are adapted from this CBECS categorization, with some building types left out and one additional building type—Large Multifamily—included.*

values from the explicitly listed building types. When the Other building type is used, a description of the actual building type, the primary business activity, the business hours, and the HVAC schedule must be collected for the project site and stored in the utility tracking data system.

Deemed savings are estimated using building simulation models, which estimate the hourly impacts of installing an evaporative pre-cooling system (i.e., modeling the difference between base and change case). The base models are the same models used to derive values for the other commercial HVAC sections of the TRM. Adjustments are made for the evaporative pre-cooling measure by updating all existing HVAC equipment to operate with evaporative pre-cooling when the outside temperature is above 70°F.

Table 89. DRF and EFLH Reduction Values for Amarillo (Climate Zone 1)

Building type	Principal building activity	Direct expansion		Air cooled chiller	
		DRF	$EFLH_{reduction}$	DRF	$EFLH_{reduction}$
Education	College	0.19	130	0.17	150
	Primary School	0.20	83	0.13	69
	Secondary School	0.19	89	0.17	102
Food Sales	Convenience	0.18	125	-	-
	Supermarket	0.08	37	-	-
Food Service	Full-service Restaurant	0.21	134	-	-
	Quick-service Restaurant	0.18	109	-	-
Healthcare	Hospital	0.21	160	0.18	151
	Outpatient Healthcare	0.17	145	-	-
Large Multifamily	Midrise Apartment	0.18	113	0.10	59
Lodging	Large Hotel	0.13	111	0.15	165
	Nursing Home	0.18	115	0.10	60
	Small Hotel/Motel	0.13	104	-	-
Mercantile	Stand-alone Retail	0.19	108	0.14	74
	Strip Mall	0.21	121	-	-
Office	Large Office	0.25	206	0.18	119
	Medium Office	0.19	75	-	-
	Small Office	0.20	111	-	-
Public Assembly	Public Assembly	0.20	112	0.13	93
Religious Worship	Religious Worship	0.19	65	0.14	45

Building type	Principal building activity	Direct expansion		Air cooled chiller	
		DRF	$EFLH_{reduction}$	DRF	$EFLH_{reduction}$
Service	Service	0.21	104	-	-
Warehouse	Warehouse	0.12	34	-	-
Other	Other	0.08	34	0.10	45

Table 90. DRF and EFLH Reduction Values for Fort Worth (Climate Zone 2)

Building type	Principal building activity	Direct expansion		Air cooled chiller	
		DRF	$EFLH_{reduction}$	DRF	$EFLH_{reduction}$
Education	College	0.21	192	0.19	195
	Primary School	0.24	120	0.12	80
	Secondary School	0.21	131	0.19	132
Food Sales	Convenience	0.24	214	-	-
	Supermarket	0.15	78	-	-
Food Service	Full-service Restaurant	0.23	194	-	-
	Quick-service Restaurant	0.24	185	-	-
Healthcare	Hospital	0.24	230	0.22	216
	Outpatient Healthcare	0.19	174	-	-
Large Multifamily	Midrise Apartment	0.16	230	0.15	120
Lodging	Large Hotel	0.15	137	0.18	212
	Nursing Home	0.16	234	0.15	122
	Small Hotel/Motel	0.15	133	-	-
Mercantile	Stand-alone Retail	0.24	158	0.19	120
	Strip Mall	0.23	156	-	-
Office	Large Office	0.26	220	0.23	231
	Medium Office	0.20	102	-	-
	Small Office	0.22	156	-	-
Public Assembly	Public Assembly	0.24	161	0.12	108
Religious Worship	Religious Worship	0.24	95	0.19	72
Service	Service	0.23	150	-	-
Warehouse	Warehouse	0.20	93	-	-
Other	Other	0.15	78	0.12	72

Table 91. DRF and EFLH Reduction Values for Houston (Climate Zone 3)

Building type	Principal building activity	Direct expansion		Air cooled chiller	
		DRF	$EFLH_{reduction}$	DRF	$EFLH_{reduction}$
Education	College	0.20	173	0.17	175
	Primary School	0.21	118	0.10	74
	Secondary School	0.20	118	0.17	119
Food Sales	Convenience	0.22	193	-	-
	Supermarket	0.14	76	-	-
Food Service	Full-service Restaurant	0.21	171	-	-
	Quick-service Restaurant	0.22	167	-	-
Healthcare	Hospital	0.21	202	0.19	187
	Outpatient Healthcare	0.18	157	-	-
Large Multifamily	Midrise Apartment	0.17	257	0.14	105
Lodging	Large Hotel	0.14	120	0.14	193
	Nursing Home	0.17	261	0.14	107
	Small Hotel/Motel	0.13	113	-	-
Mercantile	Stand-alone Retail	0.22	152	0.19	128
	Strip Mall	0.21	152	-	-
Office	Large Office	0.24	203	0.23	150
	Medium Office	0.19	94	-	-
	Small Office	0.20	138	-	-
Public Assembly	Public Assembly	0.21	159	0.10	99
Religious Worship	Religious Worship	0.22	92	0.19	77
Service	Service	0.21	132	-	-
Warehouse	Warehouse	0.18	81	-	-
Other	Other	0.13	76	0.10	74

Table 92. DRF and EFLH Reduction Values for Corpus Christi (Climate Zone 4)

Building type	Principal building activity	Direct expansion		Air cooled chiller	
		DRF	$EFLH_{reduction}$	DRF	$EFLH_{reduction}$
Education	College	0.13	161	0.11	160
	Primary School	0.14	113	0.07	68
	Secondary School	0.13	110	0.11	109
Food Sales	Convenience	0.14	188	-	-
	Supermarket	0.08	74	-	-
Food Service	Full-service Restaurant	0.13	157	-	-
	Quick-service Restaurant	0.14	162	-	-
Healthcare	Hospital	0.15	199	0.09	169
	Outpatient Healthcare	0.12	150	-	-
Large Multifamily	Midrise Apartment	0.14	181	0.09	104
Lodging	Large Hotel	0.08	116	0.10	179
	Nursing Home	0.14	183	0.09	106
	Small Hotel/Motel	0.08	109	-	-
Mercantile	Stand-alone Retail	0.14	148	0.12	120
	Strip Mall	0.13	146	-	-
Office	Large Office	0.16	192	0.13	137
	Medium Office	0.11	90	-	-
	Small Office	0.13	131	-	-
Public Assembly	Public Assembly	0.14	152	0.07	92
Religious Worship	Religious Worship	0.14	89	0.12	72
Service	Service	0.13	122	-	-
Warehouse	Warehouse	0.12	74	-	-
Other	Other	0.08	74	0.07	68

Table 93. DRF and EFLH Reduction Values for El Paso (Climate Zone 5)

Building type	Principal building activity	Direct expansion		Air cooled chiller	
		DRF	$EFLH_{reduction}$	DRF	$EFLH_{reduction}$
Education	College	0.27	240	0.22	254
	Primary School	0.30	161	0.17	120
	Secondary School	0.27	163	0.22	172
Food Sales	Convenience	0.25	232	-	-
	Supermarket	0.12	76	-	-
Food Service	Full-service Restaurant	0.25	223	-	-
	Quick-service Restaurant	0.25	201	-	-
Healthcare	Hospital	0.26	273	0.20	247
	Outpatient Healthcare	0.23	259	-	-
Large Multifamily	Midrise Apartment	0.28	264	0.15	140
Lodging	Large Hotel	0.19	201	0.19	300
	Nursing Home	0.28	268	0.15	142
	Small Hotel/Motel	0.17	193	-	-
Mercantile	Stand-alone Retail	0.25	198	0.18	131
	Strip Mall	0.26	207	-	-
Office	Large Office	0.32	314	0.22	199
	Medium Office	0.25	137	-	-
	Small Office	0.26	215	-	-
Public Assembly	Public Assembly	0.30	217	0.17	162
Religious Worship	Religious Worship	0.25	119	0.18	79
Service	Service	0.25	173	-	-
Warehouse	Warehouse	0.25	82	-	-
Other	Other	0.12	76	0.15	79

Claimed Peak Demand Savings

A summer peak period value is used for this measure. Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

Measure Life and Lifetime Savings

Pre-cooling components may consist of pumps, sprayers, electronic controllers, and evaporative media, with the evaporative media requiring periodic replacement.

The EUL for Evaporative Pre-cooling System is 10 years, consistent with the typical manufacturer warranty for evaporative pre-cooling equipment.[189]

Program Tracking Data and Evaluation Requirements

The below list of primary inputs and contextual data is recommended to be specified and tracked by the program database to inform the evaluation and apply the savings properly.

- Decision/action type: Retrofit or new construction
- Building type
- Climate zone
- Baseline equipment type
- Baseline equipment rated cooling capacity
- Baseline equipment cooling efficiency ratings
- Baseline number of units
- Baseline manufacturer and model
- Installed number of units
- Installed evaporative pre-cooling system manufacturer and model
- Installed evaporative pre-cooling system evaporative effectiveness
- Copy of operation manuals
- **For Other building types only**: A description of the actual building type, the primary business activity, the business hours, and the HVAC schedule.

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 47612—Provides deemed savings for Condenser Evaporative Pre-cooling

Relevant Standards and Reference Sources

Not applicable.

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[189] ET13SCE1020: Evaporative Condenser Air Pre-Coolers, Southern California Edison. December 2015. https://wcec.ucdavis.edu/wp-content/uploads/2016/06/et13sce1020_evaporative_pre-cooler_final.pdf.

Document Revision History

Table 94. Nonresidential Condenser Air Evaporative Pre-Cooling Revision History

TRM version	Date	Description of change
v5.0	10/2017	TRM v5.0 origin.
v6.0	10/2018	TRM v6.0 update. No revisions.
v7.0	10/2019	TRM v7.0 update. No revisions.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits.

2.2.9 High-Volume Low-Speed Fans Measure Overview

TRM Measure ID: NR-HV-HF

Market Sector: Commercial

Measure Category: HVAC

Applicable Business Types: Agriculture

Fuels Affected: Electricity

Decision/Action Type: Retrofit, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

Circulation fans are used in agricultural applications such as dairy, swine, or poultry barns to destratify air, reduce animal heat stress, control insects, dry surfaces, and cool people and animals. This measure applies to the installation of high-volume low-speed (HVLS) fans in a horizontal orientation in such agricultural applications. HVLS fans may be installed in lieu of conventional (small diameter) circulation fans in new construction applications or in replacement of existing (still functioning) conventional circulation fans in retrofit projects.

Deemed savings are provided for displaced fan load only: applications in which HVLS fans are installed to reduce air conditioning requirements may be considered in the future: for now, such applications would require additional M&V to demonstrate (and claim) complete savings.

Eligibility Criteria

While many applications exist for HVLS fans, the guidance in this measure is specific to agricultural operations. Savings estimates may be developed for other applications in future iterations of the TRM.

HVLS fans may be used to replace existing conventional circulating fans or installed in new barns. To claim savings for a retrofit, the conventional fans being replaced should be in proper working condition.

Default values are provided for dairy applications while other facility types are eligible and should use the dairy values until other livestock specific factors are developed.

Baseline Condition

The baseline condition is an installation of conventional fans.

Retrofit (Early Retirement)

When replacing existing (working) fans, the baseline is set by the number of fans to be replaced, with power requirements calculated according to their operating airflow rates (CFM), and rated efficiency (e.g., CFM/watt).

Replace on Burnout/New Construction

When existing fans are reaching the end of their useful life, or for new construction, the baseline assumes installation of conventional fans that would produce a comparable total airflow (CFM) as the HVLS fan to be installed.

High-Efficiency Condition

HVLS fans with diameters of eight to 24 feet typically use 1 hp to 2 hp motors per fan and move between 50,000 CFM and 150,000 or more CFM.[190] To be eligible for this measure, HVLS fans shall be a minimum of 8 feet in diameter and move more cubic feet of air per watt than conventional circulating fans. The fan should be installed in a horizontal orientation and have the ability to operate at different speeds.

Energy and Demand Savings Methodology

Savings are estimated assuming operation of the baseline (conventional) and high efficiency (HVLS) fans at their rated speed and power input during all hours of expected use.

Savings Algorithms and Input Variables

$$Energy\ Savings\ (kWh) = \left(\frac{W_{base} - W_{HVLS}}{1000}\right) \times Hours$$

Equation 59

$$Summer\ Demand\ Savings\ (kW) = \left(\frac{W_{base} - W_{HVLS}}{1000}\right) \times CF$$

Equation 60

190 Motor hp from manufacturer product specification sheets available from https://macroairfans.com/architects-engineers/ and https://www.bigassfans.com/aedownloads/. Airflow range from Kammel et al, "Design of High Volume Low Speed Fan Supplemental Cooling System in Dairy Free Stall Barns," available at https://www.researchgate.net/publication/271433461_Design_of_high_volume_low_speed_fan_supplemental_cooling_system_in_dairy_freestall_barns, and from MacroAir Fans "Horse Barn Ventilation Systems" white paper, available at https://macroairfans.com/wp-content/uploads/2012/03/Horse-Barn-Ventilation-White-Paper.pdf.

Where:

W_{base}	=	*power input required to move replaced fans at rated speed*
W_{HVLS}	=	*power input required to move installed HVLS fans at rated speed*
Hours	=	*hours of operation in the project application, as described below*
CF	=	*coincidence factor (1.0, as fans are always operating in summer peak conditions)*

Retrofit (Early Retirement)

For early retirement projects, the base wattage (W_{base}) is estimated according to the number of fans replaced and their rated efficiency:

$$W_{base,ER} = \frac{CFM_{base} * N_{base}}{\eta_{base}}$$

Equation 61

Where:

CFM_{base}	=	*airflow rate produced by replaced fans*
η_{base}	=	*efficacy of replaced fans (CFM/watt)*

Note: For retrofit projects where the baseline equipment ratings cannot be determined, the use of the replace-on-burnout/new construction calculation procedure is permitted.

Replace-on-Burnout/New Construction

For replace-on-burnout or new construction projects, base case power requirements are estimated for conventional fans producing an equivalent/comparable airflow (CFM) as that of the HVLS fan(s) being installed. The efficiency of the baseline conventional fans shall be 22 CFM/watt.[191]

$$W_{base,ROB/NC} = \frac{CFM_{HVLS}}{22\ CFM/W}$$

Equation 62

[191] Database of circulating fans tested by the Bioenvironmental and Structural Systems Laboratory of the Agricultural and Biological Engineering Dept., University of Illinois at Urbana-Champagne including 231 fan models by 17 manufacturers. Average efficacy ratio (CFM/watt) of single-phase, 230V circulating fans 48" diameter and larger. Available at http://www.bess.illinois.edu/currentc.asp.

Hours of Operation

Table 95 provides the hours to be used in calculating energy savings for HVLS fan installation by climate zone.

Table 95. Hours of Circulating Fan Operation by Barn Type[192]

Climate zone	Hours
Climate Zone 1: Amarillo	2,215
Climate Zone 2: Dallas	3,969
Climate Zone 3: Houston	4,750
Climate Zone 4: Corpus Christi	5,375
Climate Zone 5: El Paso	3,034

Claimed Peak Demand Savings

A summer peak period value is used for this measure. Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.Deemed Energy and Demand Savings Tables

This section is not applicable as these calculations are entirely dependent on site-specific parameters.

Measure Life and Lifetime Savings

The EUL of an HVLS fan is closely related to that of its motor. The US DOE Advanced Manufacturing Office's Motor Systems Tip Sheet #3[193] suggests motors should last approximately 35,000 hours. The average annual hours of operation in dairy farms for the Texas TRM zones is about 3,870 hours. Accordingly, the EUL for HVLS fans in Texas is estimated to be 9 years.

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192 Docket No. 40885 provides demand and energy savings by building type and cooling equipment for the four different climate zones. This original petition was dated 10/29/2012. An amended petition, dated 11/13/2012 was approved, which provides the original energy and demand coefficients (Table 2 18: CF and EFLH Values for Amarillo (Climate Zone 1) through Table 2-16, but also amended Tables (B3a through B3d and B4a through B4d).

193 DOE Motor Systems Tip Sheet #3 available at https://www.energy.gov/sites/prod/files/2014/04/f15/extend_motor_operlife_motor_systemts3.pdf. Accessed August 2020.

Program Tracking Data and Evaluation Requirements

The below list of primary inputs and contextual data is recommended to be specified and tracked by the program database to inform the evaluation and apply the savings properly.

All Projects:

- Barn type (animal)
- Climate zone
- Decision/action type: ROB, NC, or ER
- HVLS fan(s): diameter, rated HP, rated CFM, count
- **For early retirement only:** replaced fans: count, diameter, rated HP, rated CFM, rated CFM/watt

References and Efficiency Standards

Petitions and Rulings

None.

Relevant Standards and Reference Sources

- Kammel, David and Raabe, and Kappelman, J.. (2003). Design of high-volume low-speed fan supplemental cooling system in dairy freestall barns. Proceedings of the Fifth International Dairy Housing Conference. 10.13031/2013.11628. Online. Available: https://www.researchgate.net/publication/271433461_Design_of_high_volume_low_speed_fan_supplemental_cooling_system_in_dairy_freestall_barns.
- https://macroairfans.com/wp-content/uploads/2012/03/Horse-Barn-Ventilation-White-Paper.pdf
- BESS Laboratory Database of Agricultural Fans. Bioenvironmental and Structural Systems Laboratory of the Agricultural and Biological Engineering Dept., University of Illinois at Urbana-Champagne. Online. Data for Circulating Fans available: http://www.bess.illinois.edu/currentc.asp.

Document Revision History

Table 96. Nonresidential High-Volume Low-Speed Fans Revision History

TRM version	Date	Description of change
v7.0	10/2019	TRM v7.0 origin.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits.

2.3 NONRESIDENTIAL: BUILDING ENVELOPE

2.3.1 Cool Roofs Measure Overview

TRM Measure ID: NR-BE-CR

Market Sector: Commercial

Measure Category: Building envelope

Applicable Building Types: All commercial

Fuels Affected: Electricity

Decision/Action Type: Retrofit

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Energy modeling, engineering algorithms, and estimates

Measure Description

Reflective roofing materials reduce the overall heat load on a building by reducing the total heat energy absorbed into the building system from incident solar radiation. This reduction in total load provides space cooling energy savings during the cooling season but reduces free heat during the heating season, so the measure saves energy in the summer but uses more energy in winter. Cool roofs are most beneficial in warmer climates and may not be recommended for buildings where the primary heat source is electric resistance. The measure is for retrofit of existing buildings.

Eligibility Criteria

Measures installed through utility programs must be a roof that is compliant with the current ENERGY STAR® specification, effective July 2017.[194] For nonresidential facilities, these criteria for a high-efficiency roof include:

- An existing roof undergoing retrofit conditions as further defined under high-efficiency condition below; a roof installed in a new construction application is not eligible for applying these methodologies.
- A roof with a low-slope of 2:12 inches or less[195]
- An initial solar reflectance of greater than or equal to 65 percent

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[194] ENERGY STAR® Roof Products Specification. https://www.energystar.gov/products/building_products/roof_products/key_product_criteria.

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

- Maintenance of solar reflectance of greater than or equal to 50 percent three years after installation under normal conditions

- 75 percent of the roof surface over conditioned space must be replaced

- No significant obstruction of direct sunlight to roof

- The facility must be conditioned with cooling, heating, or both

- Be listed on the ENERGY STAR® list of qualified products[196] or have a performance rating that is validated by the Cool Roof Rating Council (CRRC). ENERGY STAR® test criteria[197] allows for products already participating in the CRRC Product Rating Program[198] to submit solar reflectance and thermal emittance product information derived from CRRC certification.

- The ENERGY STAR® specification for roof products will sunset effective June 1, 2022.[199] No new roof products will be certified as of June 1, 2021. At this point, ENERGY STAR® legacy or CRRC product certification will be required to demonstrate compliance with the previous ENERGY STAR® specification.

If one of these conditions is not met, the deemed savings approach cannot be used, and the Simplified M&V Methodology or the Full M&V Methodology must be used.

Baseline Condition

The baseline is the thermal resistance (i.e., R-value) of the existing roof make-up and the solar reflectance and emissivity of the surface layer. The R-value is estimated based on code envelope requirements applicable in the year of construction. Solar reflectance and emissivity of the surface layer are assumed to be 0.2 and 0.9, respectively, based on roof properties listed in the LBLN Roofing Materials Database.[200]

The cooling and heating efficiencies are assumed based on the space conditioning of the top floor of the building and are based on typical code requirements applicable in the year of construction.

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196 ENERGY STAR® Certified Roofs. http://www.energystar.gov/productfinder/product/certified-roof-products/. Accessed 08/15/2016.
197 ENERGY STAR® Program Requirements for Roof Products v2.1. https://www.energystar.gov/ia/partners/product_specs/program_reqs/roofs_prog_req.pdf.
198 CRRC Rated Products Directory: https://coolroofs.org/directory.
199 ENERGY STAR® Roof Products Sunset Decision Memo. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Roof%20Products%20Sunset%20Decision%20Memo.pdf.
200 Lawrence Berkeley National Lab Cool Roofing Material Database. https://heatisland.lbl.gov/resources/cool-roofing-materials-database. Accessed 08/2018.

Table 97. Cool Roofs—Assumed Cooling and Heating Efficiencies (COP)

Year of construction; applicable code	RTU	PTHP cooling	PTHP heating	Air cooled chiller	Water cooled chiller
Before 2011; 2000 IECC	2.9	2.9	2.9	2.5	4.2
Between 2011-2016; 2009 IECC	3.8	3.1	2.9	2.8	5.5
After 2016; 2015 IECC	3.8	3.1	2.9	2.8	5.5

High-Efficiency Condition

The high-efficiency condition depends on the project scope. The project scope is defined as one of:

- Adding surface layer only
- Adding insulation and surface layer
- Rebuilding entire roof assembly

If the project scope is only to add a new ENERGY STAR® material as the new surface layer, then the R-value used for the baseline condition is used for the high-efficiency condition. If the project scope is to add insulation and an ENERGY STAR® material as the new surface layer, then the R-value of the additional insulation is added to the R-value used for the baseline condition. If the entire roof assembly is rebuilt, then the R-value for each layer of the new roof construction is summed to get a total new R-value.

The measure requires installation of roof products that have been rated by the CRRC and demonstrate compliance with ENERGY STAR® certified roof product performance specifications for the relevant roof application. Initial and 3-year reflectance ratings must meet or exceed the minimum thresholds specified in Table 98.

Table 98. Cool Roofs—ENERGY STAR® Specification[201]

Roof slope	Characteristic	Performance specification
Low Slope $\leq$ 2/12	Initial Solar Reflectance	$\geq$ 0.65
	3-Year Solar Reflectance	$\geq$ 0.50

201 ENERGY STAR® Roof Products Specification. https://www.energystar.gov/products/building_products/roof_products/key_product_criteria.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy savings are estimated using EnergyPlus v8.3.0 whole-building simulation. The prototype building characteristics match those used for developing commercial HVAC demand factors and EFLH and can be found from Table 100 through Table 104. The savings represent the difference of the modeled energy use of the baseline condition and the high-efficiency condition divided by the square foot of the roof area. The demand savings are calculated following the method described in TRM Volume 1.

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

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

Equation 63

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

Equation 64

$$Peak\ Winter\ Demand\ Savings = Roof\ Area \times PWDF \times 10^{-6}$$

Equation 65

Where:

Roof Area	=	*Total area of ENERGY STAR® roof in square feet*
ESF	=	*Energy Savings Factor from Table 100 through Table 104 by building type, pre/post insulation levels, and heating/cooling system.*
PSDF	=	*Peak Summer Demand Factor from Table 100 through Table 104 by building type, pre/post insulation levels, and heating/cooling system.*
PWDF	=	*Peak Winter Demand Savings Factor from Table 100 through Table 104 by building type, pre/post insulation levels, and heating/cooling system.*

If the insulation levels are unknown, use the mapping in Table 99 to estimate the R-value based on the year of construction.

Table 99. Cool Roofs—Estimated R-Value based on Year of Construction

Year of construction	Estimated R-value[202]
Before 2011	R ≤ 13
Between 2011 - 2016	13 < R ≤ 20
After 2016	20 < R

Table 100. Cool Roofs—Savings Factors for Amarillo (Climate Zone 1)

Building type	Pre R-value	Post R-value	ESF	PSDF	PWDF
Retail	R ≤ 13	R ≤ 13	0.72	19.28	31.74
	R ≤ 13	13 < R ≤ 20	1.26	36.23	36.71
	R ≤ 13	20 < R	1.25	38.58	35.31
	13 < R ≤ 20	13 < R ≤ 20	0.13	4.81	1.88
	13 < R ≤ 20	20 < R	0.12	6.47	0.48
	20 < R	20 < R	0.09	3.32	1.30
Education - Chiller	R ≤ 13	R ≤ 13	0.65	11.80	8.31
	R ≤ 13	13 < R ≤ 20	1.10	21.76	31.52
	R ≤ 13	20 < R	1.25	25.53	37.31
	13 < R ≤ 20	13 < R ≤ 20	0.26	4.85	4.59
	13 < R ≤ 20	20 < R	0.38	7.80	9.20
	20 < R	20 < R	0.17	3.40	1.17
Education - RTU	R ≤ 13	R ≤ 13	0.26	8.26	2.62
	R ≤ 13	13 < R ≤ 20	0.43	15.47	12.49
	R ≤ 13	20 < R	0.49	18.20	14.02
	13 < R ≤ 20	13 < R ≤ 20	0.12	4.11	2.05
	13 < R ≤ 20	20 < R	0.18	6.67	3.58
	20 < R	20 < R	0.08	2.91	0.28
Office - Chiller	R ≤ 13	R ≤ 13	0.21	6.80	1.43
	R ≤ 13	13 < R ≤ 20	0.31	3.44	3.50
	R ≤ 13	20 < R	0.33	19.30	3.87
	13 < R ≤ 20	13 < R ≤ 20	0.09	16.58	0.11
	13 < R ≤ 20	20 < R	0.11	5.94	0.47
	20 < R	20 < R	0.06	2.36	0.08

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

Building type	Pre R-value	Post R-value	ESF	PSDF	PWDF
Office - RTU	R ≤ 13	R ≤ 13	0.28	7.46	11.88
	R ≤ 13	13 < R ≤ 20	0.87	15.48	168.51
	R ≤ 13	20 < R	1.10	18.61	236.76
	13 < R ≤ 20	13 < R ≤ 20	0.15	4.12	-1.23
	13 < R ≤ 20	20 < R	0.38	6.73	67.02
	20 < R	20 < R	0.11	2.92	-2.61
Hotel	R ≤ 13	R ≤ 13	0.07	1.33	-2.60
	R ≤ 13	13 < R ≤ 20	0.07	1.83	6.98
	R ≤ 13	20 < R	0.07	2.03	11.77
	13 < R ≤ 20	13 < R ≤ 20	0.04	0.81	-1.45
	13 < R ≤ 20	20 < R	0.04	1.00	3.39
	20 < R	20 < R	0.03	0.60	-1.12
Warehouse	R ≤ 13	R ≤ 13	0.04	3.83	-0.20
	R ≤ 13	13 < R ≤ 20	0.11	6.99	3.89
	R ≤ 13	20 < R	0.14	8.07	5.35
	13 < R ≤ 20	13 < R ≤ 20	0.01	1.35	-0.10
	13 < R ≤ 20	20 < R	0.04	2.24	1.36
	20 < R	20 < R	0.01	0.90	-0.07
Other	R ≤ 13	R ≤ 13	0.04	1.33	-2.60
	R ≤ 13	13 < R ≤ 20	0.07	1.83	3.50
	R ≤ 13	20 < R	0.07	2.03	3.87
	13 < R ≤ 20	13 < R ≤ 20	0.01	0.81	-1.45
	13 < R ≤ 20	20 < R	0.04	1.00	0.47
	20 < R	20 < R	0.01	0.60	-2.61

Table 101. Cool Roofs—Savings Factors for Dallas (Climate Zone 2)

Building type	Pre R-value	Post R-value	ESF	PSDF	PWDF
Retail	R ≤ 13	R ≤ 13	0.61	22.03	13.53
	R ≤ 13	13 < R ≤ 20	0.97	37.67	17.30
	R ≤ 13	20 < R	0.98	40.54	17.32
	13 < R ≤ 20	13 < R ≤ 20	0.16	7.57	1.28
	13 < R ≤ 20	20 < R	0.17	9.67	1.29
	20 < R	20 < R	0.13	6.22	1.04

Building type	Pre R-value	Post R-value	ESF	PSDF	PWDF
Education - Chiller	R ≤ 13	R ≤ 13	0.56	10.49	5.11
	R ≤ 13	13 < R ≤ 20	0.82	16.50	8.60
	R ≤ 13	20 < R	0.92	18.86	11.17
	13 < R ≤ 20	13 < R ≤ 20	0.29	5.41	2.36
	13 < R ≤ 20	20 < R	0.36	7.28	4.55
	20 < R	20 < R	0.24	4.37	1.88
Education - RTU	R ≤ 13	R ≤ 13	0.27	10.65	1.53
	R ≤ 13	13 < R ≤ 20	0.39	18.31	3.68
	R ≤ 13	20 < R	0.43	21.33	4.89
	13 < R ≤ 20	13 < R ≤ 20	0.17	7.21	0.77
	13 < R ≤ 20	20 < R	0.21	10.08	1.97
	20 < R	20 < R	0.13	5.88	0.60
Office - Chiller	R ≤ 13	R ≤ 13	0.23	11.99	0.81
	R ≤ 13	13 < R ≤ 20	0.33	27.48	1.78
	R ≤ 13	20 < R	0.34	30.55	1.93
	13 < R ≤ 20	13 < R ≤ 20	0.13	6.68	0.10
	13 < R ≤ 20	20 < R	0.15	9.76	0.26
	20 < R	20 < R	0.10	6.01	0.08
Office - RTU	R ≤ 13	R ≤ 13	0.27	12.14	14.86
	R ≤ 13	13 < R ≤ 20	0.52	24.53	84.63
	R ≤ 13	20 < R	0.62	29.45	112.16
	13 < R ≤ 20	13 < R ≤ 20	0.18	7.25	11.53
	13 < R ≤ 20	20 < R	0.28	11.09	39.06
	20 < R	20 < R	0.15	6.03	8.66
Hotel	R ≤ 13	R ≤ 13	0.07	1.71	-0.64
	R ≤ 13	13 < R ≤ 20	0.07	2.30	0.78
	R ≤ 13	20 < R	0.07	2.56	1.39
	13 < R ≤ 20	13 < R ≤ 20	0.05	1.17	-0.46
	13 < R ≤ 20	20 < R	0.05	1.42	0.17
	20 < R	20 < R	0.05	1.01	-0.36
Warehouse	R ≤ 13	R ≤ 13	0.05	4.01	-0.07
	R ≤ 13	13 < R ≤ 20	0.09	6.54	1.47
	R ≤ 13	20 < R	0.16	11.16	2.38
	13 < R ≤ 20	13 < R ≤ 20	0.02	1.18	-0.05
	13 < R ≤ 20	20 < R	0.08	4.94	0.86
	20 < R	20 < R	0.01	1.02	-0.03

Building type	Pre R-value	Post R-value	ESF	PSDF	PWDF
Other	R ≤ 13	R ≤ 13	0.05	1.71	-0.64
	R ≤ 13	13 < R ≤ 20	0.07	2.30	0.78
	R ≤ 13	20 < R	0.07	2.56	1.39
	13 < R ≤ 20	13 < R ≤ 20	0.02	1.17	-0.46
	13 < R ≤ 20	20 < R	0.05	1.42	0.17
	20 < R	20 < R	0.01	1.01	-0.36

Table 102. Cool Roofs—Savings Factors for Houston (Climate Zone 3)

Building type	Pre R-value	Post R-value	ESF	PSDF	PWDF
Retail	R ≤ 13	R ≤ 13	0.62	17.21	9.86
	R ≤ 13	13 < R ≤ 20	1.00	29.60	17.11
	R ≤ 13	20 < R	1.01	31.61	16.52
	13 < R ≤ 20	13 < R ≤ 20	0.41	10.43	7.67
	13 < R ≤ 20	20 < R	0.41	11.89	7.07
	20 < R	20 < R	0.14	4.66	1.07
Education - Chiller	R ≤ 13	R ≤ 13	0.62	9.56	-0.28
	R ≤ 13	13 < R ≤ 20	0.87	15.28	3.52
	R ≤ 13	20 < R	0.95	17.53	4.52
	13 < R ≤ 20	13 < R ≤ 20	0.33	5.04	-0.28
	13 < R ≤ 20	20 < R	0.39	6.81	0.50
	20 < R	20 < R	0.26	4.05	-0.29
Education - RTU	R ≤ 13	R ≤ 13	0.29	9.39	-0.03
	R ≤ 13	13 < R ≤ 20	0.40	15.76	0.90
	R ≤ 13	20 < R	0.44	18.26	1.08
	13 < R ≤ 20	13 < R ≤ 20	0.18	6.21	-0.01
	13 < R ≤ 20	20 < R	0.22	8.58	0.16
	20 < R	20 < R	0.14	5.08	-0.07
Office - Chiller	R ≤ 13	R ≤ 13	0.25	9.45	0.70
	R ≤ 13	13 < R ≤ 20	0.33	21.39	1.26
	R ≤ 13	20 < R	0.34	23.54	1.23
	13 < R ≤ 20	13 < R ≤ 20	0.17	10.75	0.65
	13 < R ≤ 20	20 < R	0.18	12.84	0.61
	20 < R	20 < R	0.12	4.54	0.12

Building type	Pre R-value	Post R-value	ESF	PSDF	PWDF
Office - RTU	R ≤ 13	R ≤ 13	0.28	8.30	6.91
	R ≤ 13	13 < R ≤ 20	0.46	18.66	37.60
	R ≤ 13	20 < R	0.54	22.36	50.18
	13 < R ≤ 20	13 < R ≤ 20	0.19	5.42	4.29
	13 < R ≤ 20	20 < R	0.26	8.39	16.87
	20 < R	20 < R	0.15	4.35	3.35
Hotel	R ≤ 13	R ≤ 13	0.08	1.69	0.54
	R ≤ 13	13 < R ≤ 20	0.07	2.26	0.17
	R ≤ 13	20 < R	0.07	2.50	-0.02
	13 < R ≤ 20	13 < R ≤ 20	0.06	1.21	0.37
	13 < R ≤ 20	20 < R	0.05	1.43	0.21
	20 < R	20 < R	0.05	1.03	0.32
Warehouse	R ≤ 13	R ≤ 13	0.05	2.96	-0.09
	R ≤ 13	13 < R ≤ 20	0.09	5.13	0.76
	R ≤ 13	20 < R	0.16	9.21	1.26
	13 < R ≤ 20	13 < R ≤ 20	0.02	1.32	-0.07
	13 < R ≤ 20	20 < R	0.08	4.66	0.43
	20 < R	20 < R	0.01	0.79	0.08
Other	R ≤ 13	R ≤ 13	0.05	1.69	-0.28
	R ≤ 13	13 < R ≤ 20	0.07	2.26	0.17
	R ≤ 13	20 < R	0.07	2.50	-0.02
	13 < R ≤ 20	13 < R ≤ 20	0.02	1.21	-0.28
	13 < R ≤ 20	20 < R	0.05	1.43	0.16
	20 < R	20 < R	0.01	0.79	-0.29

Table 103. Cool Roofs—Savings Factors for Corpus Christi (Climate Zone 4)

Building type	Pre R-value	Post R-value	ESF	PSDF	PWDF
Retail	R ≤ 13	R ≤ 13	0.62	13.05	54.33
	R ≤ 13	13 < R ≤ 20	0.99	21.99	35.94
	R ≤ 13	20 < R	1.00	23.21	34.63
	13 < R ≤ 20	13 < R ≤ 20	0.41	8.08	16.20
	13 < R ≤ 20	20 < R	0.41	8.95	14.89
	20 < R	20 < R	0.13	3.42	2.05

Building type	Pre R-value	Post R-value	ESF	PSDF	PWDF
Education - Chiller	R ≤ 13	R ≤ 13	0.60	8.46	0.28
	R ≤ 13	13 < R ≤ 20	0.83	13.55	17.33
	R ≤ 13	20 < R	0.90	15.49	30.14
	13 < R ≤ 20	13 < R ≤ 20	0.31	4.48	-3.69
	13 < R ≤ 20	20 < R	0.36	6.00	6.37
	20 < R	20 < R	0.24	3.64	-0.06
Education - RTU	R ≤ 13	R ≤ 13	0.28	7.34	-0.41
	R ≤ 13	13 < R ≤ 20	0.38	11.78	5.15
	R ≤ 13	20 < R	0.41	13.53	8.09
	13 < R ≤ 20	13 < R ≤ 20	0.17	4.64	-1.46
	13 < R ≤ 20	20 < R	0.20	6.29	1.47
	20 < R	20 < R	0.14	3.77	-0.14
Office - Chiller	R ≤ 13	R ≤ 13	0.22	6.44	2.33
	R ≤ 13	13 < R ≤ 20	0.31	13.55	2.86
	R ≤ 13	20 < R	0.32	15.30	2.47
	13 < R ≤ 20	13 < R ≤ 20	0.17	6.34	1.78
	13 < R ≤ 20	20 < R	0.18	7.96	1.40
	20 < R	20 < R	0.10	3.27	0.45
Office - RTU	R ≤ 13	R ≤ 13	0.26	5.02	23.11
	R ≤ 13	13 < R ≤ 20	0.40	8.66	78.05
	R ≤ 13	20 < R	0.45	10.09	100.16
	13 < R ≤ 20	13 < R ≤ 20	0.18	3.61	15.10
	13 < R ≤ 20	20 < R	0.24	4.83	37.21
	20 < R	20 < R	0.15	2.95	10.35
Hotel	R ≤ 13	R ≤ 13	0.07	1.13	1.99
	R ≤ 13	13 < R ≤ 20	0.07	1.44	-1.23
	R ≤ 13	20 < R	0.07	1.57	-2.70
	13 < R ≤ 20	13 < R ≤ 20	0.05	0.78	1.36
	13 < R ≤ 20	20 < R	0.05	0.90	0.00
	20 < R	20 < R	0.04	0.67	1.19
Warehouse	R ≤ 13	R ≤ 13	0.05	2.10	0.22
	R ≤ 13	13 < R ≤ 20	0.09	3.51	1.39
	R ≤ 13	20 < R	0.16	6.54	1.35
	13 < R ≤ 20	13 < R ≤ 20	0.02	1.21	0.28
	13 < R ≤ 20	20 < R	0.08	3.71	0.24
	20 < R	20 < R	0.01	0.70	-0.07

Building type	Pre R-value	Post R-value	ESF	PSDF	PWDF
Other	R ≤ 13	R ≤ 13	0.05	1.13	-0.41
	R ≤ 13	13 < R ≤ 20	0.07	1.44	-1.23
	R ≤ 13	20 < R	0.07	1.57	-2.70
	13 < R ≤ 20	13 < R ≤ 20	0.02	0.78	-3.69
	13 < R ≤ 20	20 < R	0.05	0.90	0.00
	20 < R	20 < R	0.01	0.67	-0.14

Table 104. Cool Roofs—Savings Factors for El Paso (Climate Zone 5)

Building type	Pre R-value	Post R-value	ESF	PSDF	PWDF
Retail	R ≤ 13	R ≤ 13	0.67	16.55	42.72
	R ≤ 13	13 < R ≤ 20	1.01	26.85	67.80
	R ≤ 13	20 < R	1.02	28.78	65.27
	13 < R ≤ 20	13 < R ≤ 20	0.19	5.83	6.64
	13 < R ≤ 20	20 < R	0.19	7.24	4.12
	20 < R	20 < R	0.15	4.74	5.40
Education - Chiller	R ≤ 13	R ≤ 13	0.69	9.09	3.85
	R ≤ 13	13 < R ≤ 20	0.97	14.42	4.87
	R ≤ 13	20 < R	1.07	16.52	5.43
	13 < R ≤ 20	13 < R ≤ 20	0.36	4.80	1.87
	13 < R ≤ 20	20 < R	0.44	6.47	2.34
	20 < R	20 < R	0.28	3.91	1.19
Education - RTU	R ≤ 13	R ≤ 13	0.30	8.21	3.09
	R ≤ 13	13 < R ≤ 20	0.42	13.43	4.02
	R ≤ 13	20 < R	0.46	15.49	4.27
	13 < R ≤ 20	13 < R ≤ 20	0.18	5.16	1.47
	13 < R ≤ 20	20 < R	0.22	7.09	1.72
	20 < R	20 < R	0.14	4.14	0.86
Office - Chiller	R ≤ 13	R ≤ 13	0.29	9.72	7.27
	R ≤ 13	13 < R ≤ 20	0.39	17.57	12.46
	R ≤ 13	20 < R	0.42	20.35	13.25
	13 < R ≤ 20	13 < R ≤ 20	0.17	6.68	0.12
	13 < R ≤ 20	20 < R	0.20	9.22	0.79
	20 < R	20 < R	0.14	5.39	2.02

Building type	Pre R-value	Post R-value	ESF	PSDF	PWDF
Office - RTU	R ≤ 13	R ≤ 13	0.31	9.93	24.02
	R ≤ 13	13 < R ≤ 20	0.55	16.57	105.15
	R ≤ 13	20 < R	0.64	19.26	135.96
	13 < R ≤ 20	13 < R ≤ 20	0.20	5.75	16.21
	13 < R ≤ 20	20 < R	0.29	7.78	47.02
	20 < R	20 < R	0.16	4.70	12.77
Hotel	R ≤ 13	R ≤ 13	0.10	1.33	7.04
	R ≤ 13	13 < R ≤ 20	0.08	1.58	1.80
	R ≤ 13	20 < R	0.08	1.68	-0.78
	13 < R ≤ 20	13 < R ≤ 20	0.07	0.95	4.98
	13 < R ≤ 20	20 < R	0.06	1.04	2.57
	20 < R	20 < R	0.06	0.81	4.27
Warehouse	R ≤ 13	R ≤ 13	0.04	2.76	-0.61
	R ≤ 13	13 < R ≤ 20	0.09	4.91	1.33
	R ≤ 13	20 < R	0.15	8.27	2.06
	13 < R ≤ 20	13 < R ≤ 20	0.02	1.31	-0.42
	13 < R ≤ 20	20 < R	0.07	3.98	0.30
	20 < R	20 < R	0.01	0.76	-0.19
Other	R ≤ 13	R ≤ 13	0.04	1.33	-0.61
	R ≤ 13	13 < R ≤ 20	0.08	1.58	1.33
	R ≤ 13	20 < R	0.08	1.68	-0.78
	13 < R ≤ 20	13 < R ≤ 20	0.02	0.95	-0.42
	13 < R ≤ 20	20 < R	0.06	1.04	0.30
	20 < R	20 < R	0.01	0.76	-0.19

Deemed Energy and Demand Savings Tables

There are no deemed energy or demand savings tables for this measure. Please use algorithms and inputs, as described above.

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

Measure Life and Lifetime Savings

Estimated Useful Life is 15 years for cool roofs, as discussed in PUCT Docket Nos. 36779 and 41070. The DEER 2014 update also provides a 15-year life for cool roofs (EUL ID—BldgEnv-CoolRoof).[203]

[203] Database for Energy Efficiency Resources (DEER), http://www.deeresources.com/.

Program Tracking Data and Evaluation Requirements

The following primary inputs and contextual data should be specified and tracked within the program database to inform the evaluation and apply the savings properly.

- Climate zone or county location
- Total and treated roofing square footage (over conditioned space)
- Roof slope
- Existing roof insulation R-value, or year of building construction
- New roof insulation R-Value, if adding insulation
- New roofing initial solar reflectance
- New roofing 3-year solar reflectance
- New roofing rated life
- Copy of ENERGY STAR® certification or alternative
- Copy of proof of purchase including date of purchase, manufacturer, and model

Building Type References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 36779—Provides EUL for Commercial Cool Roof.

Relevant Standards and Reference Sources

- ENERGY STAR® Certified Cool Roof Products. http://www.energystar.gov/productfinder/product/certified-roof-products/.
- IECC 2000 Table 802.2(17), 2009 Table 502.2(1), and 2015 Table C402.1.4
- DEER 2014 EUL update.

Document Revision History

Table 105. Nonresidential ENERGY STAR® Roofs Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. Clarified that reflectance is three years basis. Rounded off values, too many insignificant digits.
v3.0	04/10/2015	TRM v3.0 update. No revisions.
v4.0	10/10/2016	TRM v4.0 update. Clarified eligibility criteria, baseline condition, and high-efficiency condition. Added R-values for more materials. Added new high-performance roof calculator for use in determining

TRM version	Date	Description of change
		ENERGY STAR® roof savings.
v5.0	10/2017	TRM v5.0 update. No revisions.
v6.0	10/2018	TRM v6.0 update. Changed savings methodology from algorithms to simulation models. Deemed savings are presented per square foot by building type and climate zone.
v7.0	10/2019	TRM v7.0 update. Minor error updates to Savings Factor Table for greater than and less than symbols. Program tracking requirements updated.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits. Removed EStar qualification requirement and defers to meeting criteria.

2.3.2 Window Treatments Measure Overview

TRM Measure ID: NR-BE-WT

Market Sector: Commercial

Measure Category: Building Envelope

Applicable Building Types: All commercial building types

Fuels Affected: Electricity

Decision/Action Type: Retrofit

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

This section presents the deemed savings methodology for the installation of window films and solar screens. The installation of window treatments decreases the window-shading coefficient and reduces the solar heat transmitted to the building space. During months when perimeter cooling is required in the building, this measure decreases cooling energy useand summer demand.

Eligibility Criteria

This measure is applicable for treatment of single or double-paned clear glass windows without reflective or low-E coatings in south or west facing orientations (as specified in Table 106). Existing windows must have no solar films/screens, interior shades, or exterior awnings or overhangs, and must be installed in buildings that are mechanically cooled (DX or chilled water).

This methodology may be adapted for windows with existing shading devices on an individual project basis with prior evaluator approval of baseline solar heat gain coefficient (SHGC).

Baseline Condition

The baseline condition is single-pane clear glass, without existing window treatments.

High-Efficiency Condition

The high-efficiency condition is an eligible window treatment applied to eligible windows.

Energy and Demand Savings Methodology

The demand and energy savings equations in this section originated in calculations by the EUMMOT utilities, as presented in the EUMMOT program manual *Commercial Standard Offer Program: Measurement and Verification Guidelines for Retrofit and New Construction Projects.* The method estimates the reduction in solar heat gain/insolation attributable to a given window treatment using shading coefficients for the treated and untreated window and solar heat gain estimates by window orientation, according to ASHRAE Fundamentals. The reduction in building energy use attributable to the reduction in cooling system energy use is estimated based on the reduced heat removal requirement for a standard efficiency cooling system.

Savings Algorithms and Input Variables

$$Demand\ Savings_o\ [kW] = \frac{A_{film,o} \times SHGF_o \times (SHGC_{pre,o} - SHGC_{post,o})}{3{,}412 \times COP}$$

Equation 66

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

Equation 67

$$Energy\ Savings_o\ [kWh] = \frac{A_{film,o} \times SHG_o \times (SHGC_{pre,o} - SHGC_{post,o})}{3{,}412 \times COP}$$

Equation 68

$$Energy\ Savings\ [kWh] = \sum Energy\ Savings_o$$

Equation 69

Where:

Demand Savings	=	*Peak demand savings per window orientation*
Energy Savings	=	*Energy savings per window orientation*
$A_{film,o}$	=	*Area of window film applied to orientation [ft²]*
$SHGF_o$	=	*Peak solar heat gain factor for orientation of interest [Btu/hr-ft²-year]. See Table 106.*
SHG_o	=	*Solar heat gain for orientation of interest [Btu/ft2-year]. See Table 106.*
$SHGC_{pre}$	=	*Solar heat gain coefficient for existing glass with no interior-shading device. See Table 107.*
$SHGC_{post}$	=	*Solar heat gain coefficient for new film/interior-shading device, from manufacturer specs*

Note: Shading coefficients (SC) have been retired, but if a product specification lists SC instead of SHGC, you can convert to SHGC by multiplying SC by 0.87.[204]

COP	=	*Cooling equipment COP based on Table 108 or actual COP equipment, whichever is greater ; if building construction year is unknown, assume IECC 2009 as applicable code*
3,412	=	*Conversion factor [Btu/kWh]*

Table 106. Windows Treatments—Solar Heat Gain Factors[205]

Orientation	Solar heat gain (SHG) (Btu/ft^2-year)	Peak hour solar heat gain (SHGF) ($Btu/hr-ft^2$-year)				
		Zone 1[206]	Zone 2	Zone 3	Zone 4	Zone 5
South-East	158,844	28	30	26	27	35
South-South-East	134,794	28	31	28	28	37
South	120,839	37	44	47	45	56
South-South-West	134,794	88	94	113	113	101
South-West	158,844	152	151	170	173	141
West-South-West	169,696	191	184	201	206	160
West	163,006	202	189	201	207	155
West-North-West	139,615	183	167	171	178	128
North-West	107,161	136	120	115	121	85

Table 107. Windows Treatment— Recommended Clear Glass $SHGC_{pre}$ by Window Thickness[207]

Existing window thickness (inches)	$SHGC_{pre}$
Single-pane 1/8-inch clear glass	0.87
Single-pane 1/4-inch clear glass	0.83
Single-pane 1/2-inch clear glass	0.77
Double-pane clear glass[208]	0.70

204 2001 ASHRAE Handbook: Fundamentals, p. 30.39.

205 Values are taken from the 1997 ASHRAE Fundamentals, Chapter 29 Table 17, based on the amount of solar radiation transmitted through single-pane clear glass for a cloudless day at 32°N Latitude for the 21st day of each month by hour of day and solar orientation. The SHG values listed above have been aggregated into daily totals for weekdays during the months of April through October.

206 Coincidence factors specific to Climate Zone 1 could not be calculated since utility load data are not currently available for this region. In their absence, Climate Zone 2 values may be used.

207 1997 ASHRAE Fundamentals, Table 29. Converted to SHGC by multiplying SC by 1.15.

208 Not defined in 1997 ASHRAE Fundamentals. SHGC established as conservative end of range determined by general product review.

Table 108. Recommended COP by HVAC System Type[209]

Year of construction; applicable code	AC/HP	PTAC/PTHP	Air-cooled chiller	Water-cooled chiller
Before 2011; 2000 IECC	2.9	2.9	2.5	4.2
Between 2011-2016; 2009 IECC	3.8	3.1	2.8	5.5
After 2016; 2015 IECC	3.8	3.1	2.8	5.5

Deemed Energy and Demand Savings Tables

There are no deemed energy or demand savings tables for this measure. Please use algorithms and inputs, as described above.

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

Measure Life and Lifetime Savings

Estimated Useful Life is 10 years for solar screens, as discussed in PUCT Docket Nos. 36779 and 41070. The DEER 2014 update also provides an EUL of 10 years for this measure (EUL ID—GlazDaylt-WinFilm).[210]

Program Tracking Data and Evaluation Requirements

The following primary inputs and contextual data should be specified and tracked within the program database to inform the evaluation and apply the savings properly.

- Existing window type, thickness, and SHGC
- Description of existing window presence of exterior shading from other buildings or obstacles
- Window film or solar screen SHGC
- Eligible window treatment application area by orientation (e.g., S, SSW, SW)
- Year of construction, if available
- Cooling equipment type
- Cooling equipment rated efficiency

[209] Based on review applicable codes, including IECC 2000, 2009, and 2015.
[210] Database for Energy Efficiency Resources (DEER), http://www.deeresources.com/.

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 36779—Provides EUL for reflective window films and sunscreens.

Relevant Standards and Reference Sources

- 1997 ASHRAE Fundamentals, Chapter 29, Table 17.
- International Energy Conservation Code (IECC) 2000, 2009, and 2015DEER 2014 EUL update

Document Revision History

Table 109. Nonresidential Window Treatment Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. Eliminated east-facing windows from consideration for energy savings.
v3.0	04/10/2015	TRM v3.0 update. References to EPE-specific deemed savings removed (EPE to adopt methods used by the other utilities). Demand savings: Frontier Energy updated to incorporate new peak demand definition. Provided deemed values for shading coefficients and HVAC efficiencies. SHGF: Used CZ2 savings for CZ1 until better values can be developed.
v4.0	10/10/2016	TRM v4.0 update. No revisions.
v5.0	10/2017	TRM v5.0 update. No revisions.
v6.0	10/2018	TRM v6.0 update. No revisions.
v7.0	10/2019	TRM v7.0 update. No revisions.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits. Updated peak demand values for climate zones and PDPF values.

2.3.3 Entrance and Exit Door Air Infiltration Measure Overview

TRM Measure ID: NR-BE-DI

Market Sector: Commercial

Measure Category: Building Envelope

Applicable Building Types: All commercial building types

Fuels Affected: Electricity

Decision/Action Type: Retrofit

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure applies to the installation of weather stripping or door sweeps on entrance and exit doors for a contained, pressurized space. Entrance and exit doors often leave clearance gaps to allow for proper operation. The gaps around the doors allow for the infiltration of unconditioned air into the building, adding to the cooling and heating load of the HVAC system. Weatherstripping and door sweeps are designed to be installed along the bottom and jambs of exterior doors to prevent air infiltration to conditioned space.

Eligibility Criteria

Weatherstripping or doors sweeps must be installed on doors of a conditioned and/or heated space. Treated doors must have visible gaps of at least 1/8–3/4 inches along the outside edge of the door. Spaces with interior vestibule doors are not eligible.

Baseline Condition

The baseline standard for this measure is a commercial building with exterior doors that are not sealed from unconditioned space.

High-Efficiency Condition

The high-efficiency condition for this measure is a commercial building with exterior doors that have been sealed from unconditioned space using weather stripping and/or brush style door sweeps.

Energy and Demand Savings Methodology

This savings methodology was derived by analyzing TMY3 weather data for each Texas weather zone representative city.

Derivation of Pre-Retrofit Air Infiltration Rate

The pre-retrofit air infiltration rate for each crack width is calculated by applying the methodologies presented in Chapter 5 of the ASHRAE Cooling and Heating Load Calculation Manual (CHLCM).[211] Building type characteristics for a typical commercial building were found in the DOE study PNNL-20026,[212] and an average building height of 20 feet is assumed for the deemed savings approach.

Because air infiltration is a function of differential pressure due to stack effect, wind speed, velocity head, and the design conditions of the building, TMY3 for each Texas weather zone reference city was applied to account for the varying weather conditions that are characteristic throughout an average year.

Figure 5.13 from the ASHRAE CHLCM provides the infiltration rate based on various crack width and the corresponding pressure difference across a door. Figures 5.1 and 5.2 (CHLCM) provide the differential pressure due to stack and wind pressure necessary to determine the total pressure difference across the door.

Applying a regression analysis to Figure 5.1 returns an equation that allows solving for the pressure difference due to stack effect, Δp_s. The aggregate curve fit for Figure 5.1 is shown below where x is based on the dry bulb temperature from the TMY3 data and the design temperature based on the appropriate seasonal condition.

$$\Delta p_s / C_d = 0.0000334003x - 0.00014468$$

Equation 70

Where C_d is an assumed constant, 0.63, and the neutral pressure distance is 10 feet.

From Figure 5.2, $\Delta p_w/C_p$ is determined by applying a polynomial regression, which returns an equation for solving for the pressure difference due to wind, Δp_w. The curve fit for Figure 5.2 is shown below where x is the wind velocity based on TMY3 data.

$$\Delta p_w / C_p = 0.00047749x^2 - 0.00013041x$$

Equation 71

Where C_p is an assumed constant, 0.13 (average wind pressure coefficient from Table 5.5 from CHLCM).

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211 ASHRAE Cooling and Heating Load Calculation Manual, p. 5.8. 1980. http://portal.hud.gov/hudportal/documents/huddoc?id=doc_10603.pdf.

212 Cho, H., K. Gowri, and B. Liu, "Energy Saving Impact of ASHRAE 90.1 Vestibule Requirements: Modeling of Air Infiltration through Door Openings." November 2010. http://www.pnl.gov/main/publications/external/technical_reports/PNNL-20026.pdf.

This yields the total pressure difference across the door, Δp_{Total}:

$$\Delta p_{Total} = \Delta p_s + \Delta p_w$$

Equation 72

Solving for Δp_{Total} allows for the air infiltration rate per linear foot to be determined in Figure 5.13 (CHLCM). Applying a power regression analysis for each crack width (described in inches) represented in Figure 5.13 returns the equations listed below. In these equations, *Q* is the infiltration rate in cubic feet per minute through cracks around the door, and *P* is the perimeter of the door in feet.

$$Q/P_{1/8''} = 41.572x^{0.5120}$$

Equation 73

$$Q/P_{1/4''} = 81.913x^{0.5063}$$

Equation 74

$$Q/P_{1/2''} = 164.26x^{0.5086}$$

Equation 75

$$Q/P_{3/4''} = 246.58x^{0.5086}$$

Equation 76

These infiltration rates were further disaggregated based on TMY3 average monthly day and night conditions.

Derivation of Design and Average Outside Ambient Temperatures

Taking average daytime and nighttime outdoor temperature values, standard set points, and setbacks for daytime and nighttime design cooling and heating will yield the temperature difference needed for the sensible heat equation:

$$\Delta T = T_{design} - T_{avg\ outside\ ambient}$$

Equation 77

Where:

T_{design} = *Daytime and nighttime design temperature (°F, see Table 111)*

$T_{avg\ outside\ ambient}$ = *Average outside ambient temperature, specified by month (°F, see Table 110)*

Table 110. Average Monthly Ambient Temperatures (°F)[213]

	Climate zone 1 Amarillo		Climate zone 2 Dallas		Climate zone 3 Houston		Climate zone 4 Corpus Christi		Climate zone 5 El Paso	
Month	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
Jan	41.5	31.5	48.1	40.3	54.8	47.0	58.1	50.9	50.9	42.4
Feb	44.9	34.5	52.8	44.8	59.4	50.5	61.7	54.4	55.8	45.2
Mar	52.9	40.7	63.6	54.4	65.5	56.8	69.1	61.3	61.0	48.2
April	65.4	52.7	71.4	62.7	73.1	64.7	75.9	67.7	72.7	60.5
May	69.2	57.2	77.6	68.7	79.4	71.1	80.5	72.0	80.9	69.0
June	79.9	69.7	85.3	75.0	85.1	76.2	86.4	77.9	88.2	76.1
July	84.5	72.1	90.4	80.6	87.8	78.0	88.6	78.0	86.7	76.5
Aug	81.4	69.7	89.1	79.2	88.0	77.5	88.0	78.4	84.2	74.4
Sept	75.3	64.3	84.5	73.8	85.5	73.6	85.0	75.2	80.9	67.3
Oct	63.6	50.4	70.2	59.9	75.4	61.8	77.5	67.9	70.2	59.7
Nov	48.5	38.5	59.3	52.3	67.6	57.9	72.3	63.8	57.3	47.0
Dec	41.8	32.4	49.5	41.8	59.2	50.0	60.4	53.7	49.1	39.4

Table 111. Daytime and Nighttime Design Temperatures

Temperature description	T_{design} (°F)
Daytime Cooling Design Temperature	74
Daytime Heating Design Temperature	72
Nighttime Cooling Design Temperature[214]	78
Nighttime Heating Design Temperature[215]	68

Savings Algorithms and Input Variables

To calculate HVAC load associated with air infiltration, the following sensible heat equation is used:

Electric Cooling Energy Savings

$$Cooling\ Energy\ Savings\ [kWh]_{Day} = \frac{CFM_{pre,day} \times CFM_{reduction} \times 1.08 \times \Delta T \times 1.0\frac{kW}{ton} \times Hours_{day}}{12{,}000\ Btuh/ton}$$

Equation 78

[213] TMY3 climate data.
[214] Assuming 4-degree setback.
[215] Ibid.

$$Cooling\ Energy\ Savings\ [kWh]_{Night} = \frac{CFM_{pre,night} \times CFM_{reduction} \times 1.08 \times \Delta T \times 1.0 \frac{kW}{ton} \times Hours_{night}}{12{,}000\ Btuh/ton}$$

Equation 79

$$Cooling\ Energy\ Savings\ [kWh] = Cooling\ Energy\ Savings\ [kWh]_{Day} + Cooling\ Energy\ Savings\ [kWh]_{Night}$$

Equation 80

Electric Heating Energy Savings

$$Heating\ Energy\ Savings\ [kWh]_{Day} = \frac{CFM_{pre,day} \times CFM_{reduction} \times 1.08 \times \Delta T \times 1.0 \frac{kW}{ton} \times Hours_{day}}{COP \times 3{,}412\ Btuh/kW}$$

Equation 81

$$Heating\ Energy\ Savings\ [kWh]_{Night} = \frac{CFM_{pre,night} \times CFM_{reduction} \times 1.08 \times \Delta T \times 1.0 \frac{kW}{ton} \times Hours_{night}}{COP \times 3{,}412\ Btuh/kW}$$

Equation 82

$$Heating\ Energy\ Savings\ [kWh] = Cooling\ Energy\ Savings\ [kWh]_{Day} + Cooling\ Energy\ Savings\ [kWh]_{Night}$$

Equation 83

Electric Cooling Demand Savings (weighted by climate zone peak hour probability)

$$Summer\ Demand\ Savings\ [kW]_{Day} = \frac{CFM_{pre,day} \times CFM_{reduction} \times 1.08 \times \Delta T \times 1.0 \frac{kW}{ton}}{12{,}000\ Btuh/ton}$$

Equation 84

Electric Heating Demand Savings (weighted by climate zone peak hour probability)

$$Winter\ Demand\ Savings\ [kW]_{Day/Night} = \frac{CFM_{pre,day/night} \times CFM_{reduction} \times 1.08 \times \Delta T \times 1.0 \frac{kW}{ton}}{COP \times 3{,}412\ Btuh/kW}$$

Equation 85

Where:

CFM_{pre}	=	*Calculated pre-retrofit air infiltration (cubic feet per minute)*
$CFM_{reduction}$	=	*59%[216] x TDF*
TDF	=	*Technical degradation factor = 85%[217]*
1.08	=	*Sensible heat equation conversion[218]*
ΔT	=	*Change in temperature across gap barrier (°F)*
$Hours_{day}$	=	*12 hour cycles per day, per month = 4,380 hours*
$Hours_{night}$	=	*12 hour cycles per night, per month = 4,380 hours*
COP	=	*Heating coefficient of performance; 1.0 for electric resistance and 3.3 for heat pumps*

Deemed Energy and Demand Savings Tables

Deemed energy and demand savings per linear foot of installed weather stripping or door sweep are specified below based on climate zone and existing door gap width. The length measurement should be initially measured to the nearest ¼ inch and converted to linear feet rounded to hundredths (0.02) including any segments that are not sealed due to corners, hinges, handles, or other obstructions. The width of the door gap should be rounded to nearest gap width in inches in Table 112 through Table 117. Heating savings are specified for both electric resistance (ER) and heat pump (HP) heating. Cooling savings are available for buildings with electric cooling and gas heat, but no heating savings should be claimed for buildings with gas heat.

Table 112. Deemed Cooling Energy Savings per Linear Foot of Weather Stripping/Door Sweep

Climate zone	Gap width (inches)			
	1/8	1/4	1/2	3/4
Zone 1: Amarillo	1.90	3.83	7.60	11.42
Zone 2: Dallas	3.90	7.88	15.65	23.49
Zone 3: Houston	3.01	6.09	12.09	18.14
Zone 4: Corpus Christi	5.00	10.08	20.03	30.06
Zone 5: El Paso	2.81	5.69	11.28	16.93

216 CLEAResult, "Commercial Door Air Infiltration Memo". March 18, 2015. Average reduction in Arkansas based on test results from the CLEAResult Brush Weather Stripping Testing Method and Results (59% infiltration reduction).

217 This factor is applied to account for the difference between the laboratory test from the "Commercial Door Air Infiltration Memo" and the real-world ability to seal the openings around a door. In the absence of research regarding the actual difference, this factor was set to 0.85.

218 2013 ASHRAE Handbook of Fundamentals; Equation 33, p. 16.11.

Table 113. Deemed ER Heating Energy Savings per Linear Foot of Weather Stripping/Door Sweep

Climate zone	Gap width (inches)			
	1/8	1/4	1/2	3/4
Zone 1: Amarillo	101.26	204.24	405.72	609.05
Zone 2: Dallas	48.90	98.82	196.15	294.44
Zone 3: Houston	27.18	55.06	109.19	163.91
Zone 4: Corpus Christi	22.78	46.02	91.35	137.13
Zone 5: El Paso	45.59	92.23	182.99	274.69

Table 114. Deemed HP Heating Energy Savings per Linear Foot of Weather Stripping/Door Sweep

Climate zone	Gap width (inches)			
	1/8	1/4	1/2	3/4
Zone 1: Amarillo	30.69	61.89	122.94	184.56
Zone 2: Dallas	14.82	29.95	59.44	89.22
Zone 3: Houston	8.24	16.69	33.09	49.67
Zone 4: Corpus Christi	6.90	13.94	27.68	41.56
Zone 5: El Paso	13.81	27.95	55.45	83.24

Table 115. Deemed Summer Demand Savings per Linear Foot of Weather Stripping/Door Sweep

Climate zone	Gap width (inches)			
	1/8	1/4	1/2	3/4
Zone 1: Amarillo	0.0053	0.0105	0.0210	0.0315
Zone 2: Dallas	0.0044	0.0090	0.0179	0.0269
Zone 3: Houston	0.0043	0.0087	0.0173	0.0259
Zone 4: Corpus Christi	0.0041	0.0082	0.0164	0.0246
Zone 5: El Paso	0.0041	0.0083	0.0165	0.0247

Table 116. Deemed ER Winter Demand Savings per Linear Foot of Weather Stripping/Door Sweep

Climate zone	Gap width (inches)			
	1/8	1/4	1/2	3/4
Zone 1: Amarillo	0.0268	0.0541	0.1074	0.1612
Zone 2: Dallas	0.0412	0.0828	0.1648	0.2474
Zone 3: Houston	0.0211	0.0425	0.0844	0.1267
Zone 4: Corpus Christi	0.0190	0.0383	0.0762	0.1144
Zone 5: El Paso	0.0099	0.0202	0.0400	0.0602

Table 117. Deemed HP Winter Demand Savings per Linear Foot of Weather Stripping/Door Sweep

Climate zone	Gap width (inches)			
	1/8	1/4	1/2	3/4
Zone 1: Amarillo	0.0138	0.0277	0.0550	0.0825
Zone 2: Dallas	0.0178	0.0357	0.0710	0.1066
Zone 3: Houston	0.0102	0.0207	0.0410	0.0615
Zone 4: Corpus Christi	0.0087	0.0175	0.0348	0.0523
Zone 5: El Paso	0.0049	0.0099	0.0197	0.0296

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

Measure Life and Lifetime Savings

The EUL for this measure is 11 years, according to the California Database of Energy Efficiency Resources (DEER 2014).[219] This measure life is consistent with the residential air infiltration measure in the Texas TRM.

Program Tracking Data and Evaluation Requirements

The following primary inputs and contextual data should be specified and tracked within the program database to inform the evaluation and apply the savings properly.

- Climate zone
- Existing gap width (1/8", 1/4", 1/2", or 3/4")
- Installed measure (weather stripping or door sweep)
- Linear feet (to nearest 0.02 feet = 1/4") of installed weather stripping or door sweep

References and Efficiency Standards

Petitions and Rulings

- Docket No. 48265. Petition of AEP Texas Inc., CenterPoint Energy Houston Electric, LLC, El Paso Electric Company, Entergy Texas, Inc., Oncor Electric Delivery Company LLC, Southwestern Electric Power Company, Southwestern Public Service Company, and Texas-New Mexico Power Company. *Petition to Approve Deemed Savings for New Nonresidential Door Air Infiltration, Nonresidential Door Gaskets, and Residential ENERGY STAR® Connected Thermostats.* Public Utility Commission of Texas.

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219 Database for Energy Efficient Resources, http://www.deeresources.com/.

Relevant Standards and Reference Sources

- Not applicable.

Document Revision History

Table 118. Nonresidential Entrance and Exit Door Air Infiltration Revision History

TRM version	Date	Description of change
v6.0	10/2018	TRM v6.0 origin.
v7.0	10/2019	TRM v7.0 update. Minor text revisions.
v8.0	10/20220	TRM v8.0 update. General reference checks and text edits. Degradation factor added to deemed savings values..Guidance clarified for measuring gap sizes.

2.4 NONRESIDENTIAL: FOOD SERVICE EQUIPMENT

2.4.1 ENERGY STAR® Combination Ovens Measure Overview

TRM Measure ID: NR-FS-CO

Market Sector: Commercial

Measure Category: Food Service Equipment

Applicable Business Types: See Eligibility Criteria

Fuels Affected: Electricity

Decision/Action Type: Retrofit, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This section presents the deemed savings methodology for the installation of high efficiency combination ovens. Combination ovens are convection ovens that include the added capability to inject steam into the oven cavity and typically offer at least three distinct cooking modes: combination mode to roast or bake with moist heat, convection mode to operate purely as a convection oven providing dry heat, and straight pressure-less steamer. The energy and demand savings are determined on a per-oven basis.

Eligibility Criteria

Eligible units must meet ENERGY STAR® qualifications, with half-size and full-size ovens as defined by ENERGY STAR® and a pan capacity ≥ 5 and ≤ 20.[220]

- Half-size combination oven: capable of accommodating a single 12 x 20 x 2½-inch steam table pan per rack position, loaded from front-to-back or lengthwise.
- Full-size combination oven: capable of accommodating two 12 x 20 x 2½-inch steam table pans per rack position, loaded from front-to-back or lengthwise.

[220] ENERGY STAR® Program Requirements for Commercial Ovens. https://www.energystar.gov/sites/default/files/Commercial%20Ovens%20Final%20Version%202.2%20Specification.pdf. Accessed 07/2020.

Eligible building types include independent restaurants, chain restaurants, elementary and secondary schools, colleges and universities, corporate and industrial foodservice operations, healthcare, hospitality, and supermarkets.[221]

The following products are excluded from the ENERGY STAR® eligibility criteria:

- 2/3-sized combination ovens
- Dual-fuel heat source combination ovens
- Gas combination ovens
- Electric combination ovens with a pan capacity < 5 or > 20
- Hybrid ovens not defined as eligible above (e.g. those incorporating microwave settings)
- Electric rack ovens
- Conventional or standard ovens, conveyor, slow cook-and-hold, deck, range, rapid cook, and rotisserie

Baseline Condition

The baseline condition for retrofit situations is a half-size or full-size combination oven with a pan capacity ≥ 5 and ≤ 20.

High-Efficiency Condition

Eliglble equipment must be compliant with the current ENERGY STAR® v2.2 specification, effective October 7, 2015. Qualified products must meet the minimum energy efficiency and idle energy rate requirementsfrom Table 119.

Table 119. Cooking Energy Efficiency and Idle Energy Rate Requirements[222]

Operation	Idle rate (kW)[223]	Cooking energy efficiency (%)
Steam Mode	≤ 0.133P + 0.6400	≥ 55
Convection Mode	≤ 0.080P + 0.4989	≥ 76

Furthermore, Pan Capacity[224] must be ≥ 5 and ≤ 20 (for both half- and full-size combination ovens).

[221] CEE Commercial Kitchens Initiative's overview of the Food Service Industry. http://library.cee1.org/sites/. default/files/library/4203/CEE_CommKit_InitiativeDescription_June2014.pdf. Accessed 07/2020.

[222] ENERGY STAR®. Savings Calculator for ENERGY STAR® Qualified Commercial Kitchen Equipment. Calculator: http://www.energystar.gov/buildings/sites/default/uploads/files/Commercial_kitchen_equipment_calculator.xlsx. Accessed 07/2020.

[223] P = Pan Capacity.

[224] Pan Capacity is defined as the number of steam table pans the combination oven is able to accommodate as per the ASTM F-1495-05 standard specification.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

The deemed values are calculated by using the following algorithms:

$$Energy\ Savings\ [kWh] = kWh_{base} - kWh_{post}$$

Equation 86

$$Peak\ Demand\ [kW] = \frac{\Delta kWh}{t_{hrs} \times t_{days}} \times CF$$

Equation 87

$$kWh_{base} = kWh_{conv} + kWh_{st}$$

Equation 88

$$kWh_{post} = kWh_{conv} + kWh_{st}$$

Equation 89

kWh_{conv} and kWh_{st} are each calculated the same for both the base (baseline) and post (ENERGY STAR®) cases, as shown in Equation 88 and Equation 89, except they require their respective *η (Cooking Efficiencies), E_{Idle} (Idle Energy Rates) and C_{cap} (Production Capacity)* relative to Convection and Steam Modes as seen in Table 120.

$$kWh = \left(\left(W_{food} \times \frac{E_{food} \times 50\%}{\eta_{cooking}} \right) + E_{idle} \times \left(\left(t_{hours} - \frac{W_{food}}{C_{cap}} \right) \times 50\% \right) \right) \times \frac{t_{days}}{1000}$$

Equation 90

Where:

kWh_{base}	=	*Baseline annual energy consumption [kWh]*
kWh_{post}	=	*Post annual energy consumption [kWh]*
t_{days}	=	*Facility operating days per year*
t_{hours}	=	*Equipment operating hours per day*
CF	=	*Peak coincidence factor*
W_{food}	=	*Pounds of food cooked per day [lb/day]*
E_{food}	=	*ASTM energy to food [Wh/lb]. (Differs for Convection-Mode and Steam-Mode®. See Table 120)*
E_{Idle}	=	*Idle energy rate [W]. (Differs for Convection-Mode and Steam-Mode, for Baseline and ENERGY STAR®. See Table 120*
$\eta_{cooking}$	=	*Cooking energy efficiency [%]. (Differs for Convection-Mode and Steam-Mode, for Baseline and ENERGY STAR®. See Table 120)*

C_{Cap}	=	*Production capacity per pan [lb/hr]. (Differs for Convection-Mode and Steam-Mode, for Baseline and ENERGY STAR®. See Table 120)*
1000	=	*Wh to kWh conversion*

Table 120. Deemed Variables for Energy and Demand Savings Calculations

Parameter		Convection-mode Baseline	Convection-mode ENERGY STAR®	Steam-mode Baseline	Steam-mode ENERGY STAR®
kWh_{base}		See Table 119			
kWh_{post}					
W_{food}	P < 15	200			
	P ≥ 15	250			
T_{hours}		12			
T_{days}		365			
CF[225]		0.92			
E_{food}		73.2		30.8	
$\eta_{cooking}$		72%	76%	49%	55%
E_{idleB}	P < 15	1,320	(0.133P + 0.6400) * 1000	5,260	(0.080P + 0.4989) * 1000
	P ≥ 15	2,280		8,710	
C_{cap}	P < 15	79	119	126	177
	P ≥ 15	166	201	295	349

Deemed Energy and Demand Savings Tables

The energy and demand savings of High-efficiency Combination Ovens in Table 121 are calculated in the Savings Calculator for ENERGY STAR® Qualified Commercial Kitchen Equipment using the default parameters shown above in Table 120.

Table 121. Deemed Energy and Demand Savings Values[226]

Pan capacity	kWh_{base}	kWh_{post}	Annual energy savings (kWh)	Peak Demand Savings (kW)
5	18,282	9,841	8,440	1.773
6	18,282	10,256	8,026	1.686
7	18,282	10,670	7,611	1.599

[225] California End Use Survey (CEUS), Building workbooks with load shapes by end use. Accessed 07/12.2012, http://capabilities.itron.com/CeusWeb/Chart.aspx.

[226] ENERGY STAR®. Savings Calculator for ENERGY STAR® Qualified Commercial Kitchen Equipment Calculator: http://www.energystar.gov/buildings/sites/default/uploads/files/Commercial_kitchen_equipment_calculator.xlsx. Accessed 01/27/2015.

Pan capacity	kWh_{base}	kWh_{post}	Annual energy savings (kWh)	Peak Demand Savings (kW)
8	18,282	11,085	7,197	1.512
9	18,282	11,499	6,782	1.425
10	18,282	11,914	6,368	1.338
11	18,282	12,328	5,953	1.250
12	18,282	12,743	5,539	1.163
13	18,282	13,157	5,124	1.076
14	18,282	13,572	4,710	0.989
15	29,601	15,711	13,890	2.918
16	29,601	16,141	13,459	2.827
17	29,601	16,572	13,028	2.737
18	29,601	17,003	12,597	2.646
19	29,601	17,434	12,167	2.556
20	29,601	17,865	11,736	2.465

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

Measure Life and Lifetime Savings

The EUL has been defined for this measure as 12 years, consistent with the ENERGY STAR® calculator and with the DEER 2014 EUL update (EUL ID—Cook-ElecCombOven).

Program Tracking Data and Evaluation Requirements

The following primary inputs and contextual data should be specified and tracked within the program database to inform the evaluation and apply the savings properly.

- High efficiency manufacturer make and model
- High efficiency heavy load cooking efficiency
- High efficiency equipment idle rate
- Oven size
- Pan capacity
- Copy of ENERGY STAR® certification
- Copy of proof of purchase including date of purchase, manufacturer, and model number

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

- ENERGY STAR® Equipment Standards for Commercial Ovens. http://www.energystar.gov/products/certified-products/detail/Commercial-ovens
- DEER 2014 EUL update.

Document Revision History

Table 122. Nonresidential ENERGY STAR® Combination Ovens Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. No revisions.
v3.0	04/10/2015	TRM v3.0 update. Updated previous method based upon the Food Service Technology Center (FSTC) assumptions to an approach using the newly developed ENERGY STAR® Commercial Ovens Program Requirements Version 2.1, which added combination ovens under this version. Simplified calculation methodology to a single representative building type consistent with the ENERGY STAR® Commercial Kitchen Equipment Savings Calculator.
v3.1	11/05/2015	TRM v3.1 update. Updated title to reflect ENERGY STAR® measure.
v4.0	10/10/2016	TRM v4.0 update. No revisions.
v5.0	10/2017	TRM v5.0 update. No revisions.
v6.0	10/2018	TRM v6.0 update. No revisions.
v7.0	10/2019	TRM v7.0 update. Program tracking requirements updated.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits. Removed EStar qualification requirement and defers to meeting criteria.

2.4.2 ENERGY STAR® Electric Convection Ovens Measure Overview

TRM Measure ID: NR-FS-CV

Market Sector: Commercial

Measure Category: Food Service Equipment

Applicable Building Types: See Eligibility Criteria

Fuels Affected: Electricity

Decision/Action Type: Retrofit, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This section covers the savings from retrofit (early retirement), replacement, or new installation of a full-size or half-size high efficiency electric convection oven. Convection ovens cook their food by forcing hot dry air over the surface of the food product. The rapidly moving hot air strips away the layer of cooler air next to the food and enables the food to absorb the heat energy. The energy and demand savings are deemed and based on oven energy rates, cooking efficiencies, operating hours, production capacities, and building type. Average energy and demand consumption, used to calculate the savings, are determined using these assumed default input values on a per-oven basis.

Eligibility Criteria

Eligible units must meet ENERGY STAR® qualifications, with half-size and full-size electric ovens as defined by ENERGY STAR®[227]

- Full-size convection oven: capable of accommodating standard full-size sheet pans measuring 18 x 26 x 1-inch.
- Half-size convection oven: capable of accommodating half-size sheet pans measuring 18 x 13 x 1-inch.

Eligible building types include independent restaurants, chain restaurants, elementary and secondary schools, colleges and universities, corporate foodservice operations, healthcare, hospitality, and supermarkets.[228]

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[227] ENERGY STAR® Program Requirements for Commercial Ovens. https://www.energystar.gov/sites/default/files/Commercial%20Ovens%20Final%20Version%202.2%20Specification.pdf. Accessed 07/2020.

[228] CEE Commercial Kitchens Initiative's overview of the Food Service Industry: http://library.cee1.org/sites/default/files/library/4203/CEE_CommKit_InitiativeDescription_June2014.pdf. Accessed 07/2020.

Convection ovens eligible for rebate do not include ovens that have the ability to heat the cooking cavity with saturated or superheated steam. However, eligible convection ovens may have moisture injection capabilities (e.g., baking ovens and moisture-assist ovens). Ovens that include a "hold feature" are eligible under this specification as long as convection is the only method used to fully cook the food.

The following products are excluded from the ENERGY STAR® eligibility criteria:

- Hybrid ovens not defined as eligible above (e.g., those incorporating microwave settings)
- Electric rack ovens
- Conventional or standard ovens, conveyor, slow cook-and-hold, deck, range, rapid cook, and rotisserie

Baseline Condition

The baseline condition for retrofit situations is an electric convection oven.

High-Efficiency Condition

Eligible equipment must be compliant with the current ENERGY STAR® v2.2 specification, effective October 7, 2015. Qualified products must meet the minimum energy efficiency and idle energy rate requirements from Table 123.

Table 123. Convection Oven Cooking Energy Efficiency and Idle Energy Requirements

Oven capacity	Idle rate (W)	Cooking energy efficiency (%)
Full-Size	≤ 1,600	≥ 71
Half-Size	≤ 1,000	≥ 71

Energy and Demand Savings Methodology

Savings Calculations and Input Variables

The deemed savings from these ovens are based on the following algorithms:

$$Energy\ [kWh] = (E_{base} - E_{HE}) \times \frac{days}{1000}$$

Equation 91

$$Peak\ Demand\ [kW] = \frac{(E_{base} - E_{HE})}{T_{on}} \times \frac{CF}{1000}$$

Equation 92

$$E_{base} = \frac{LB \times E_{Food}}{EFF_{base}} + \left[IDLE_{base} \times \left(T_{on} - \frac{LB}{PC_{base}}\right)\right]$$

Equation 93

$$E_{HE} = \frac{LB \times E_{Food}}{EFF_{HE}} + \left[IDLE_{HE} \times \left(T_{on} - \frac{LB}{PC_{HE}}\right)\right]$$

Equation 94

Where:

E_{base}	=	*Baseline daily energy consumption (kWh/day)*
E_{HE}	=	*High efficiency daily energy consumption (kWh/day)*
LB	=	*Pounds of food cooked per day [lb/day]*
Days	=	*Number of operating days per year [days/yr]*
CF	=	*Coincidence Factor*
Efood	=	*ASTM energy to food of energy absorbed by food product during cooking [Wh/lb]*
EFF_{base}	=	*Baseline heavy load cooking energy efficiency [%]*
EFF_{HE}	=	*High efficiency heavy load cooking energy efficiency [%]*
$IDLE_{base}$	=	*Baseline idle energy rate [kW]*
$IDLE_{HE}$	=	*High efficiency idle energy rate [kW]*
T_{on}	=	*Operating hours per day [hrs./day]*
PC_{base}	=	*Baseline production capacity [lbs./hr]*
PC_{HE}	=	*High efficiency production capacity [lbs/hr]*

Table 124. Deemed Variables for Energy and Demand Savings Calculations[229]

Variable	Full-size	Half-size
LB[231]	100	
Days	365	
CF[230]	0.92	
E_{food}[231]	73.2	
EFF_{base}[231]	65%	68%
EFF_{HE}[231]	71%	
$IDLE_{base}$[231]	2,000	1,030
$IDLE_{HE}$[231]	1,600	1,000
T_{on}	12	
PC_{base}[231]	90	45
PC_{HE}[231]	90	50

Deemed Energy and Demand Savings Tables

The energy and demand savings of high efficiency convection ovens are deemed values based on the assumed capacity for an average convection oven installed. The following tables provide these deemed values.

Table 125. Deemed Energy and Demand Savings Values

Oven size	Annual energy savings (kWh)	Peak demand savings (kW)
Full-Size	1,937	0.410
Half-Size	192	0.040

Claimed Peak Demand Savings

Refer to Volume 1, Section 4 for further details on peak demand savings and methodology.

Measure Life and Lifetime Savings

The EUL has been defined for this measure as 12 years, consistent with ENERGY STAR® research and with the DEER 2014 EUL update (EUL ID—Cook-ElecConvOven).

229 ENERGY STAR®. Savings Calculator for ENERGY STAR® Qualified Commercial Kitchen Equipment. Calculator: http://www.energystar.gov/buildings/sites/default/uploads/files/Commercial_kitchen_equipment_calculator.xlsx. Accessed 07/2020.

230 California End Use Survey (CEUS), Building workbooks with load shapes by end use. Accessed 07/12/2012.

231 Default values in ENERGY STAR® calculator for Convection Ovens.

Program Tracking Data and Evaluation Requirements

The following primary inputs and contextual data should be specified and tracked within the program database to inform the evaluation and apply the savings properly.

- High efficiency equipment manufacturer and model number
- High efficiency equipment heavy load cooking efficiency
- High efficiency equipment idle rate
- Oven size
- Copy of ENERGY STAR® certification
- Copy of proof of purchase including date of purchase, manufacturer, and model number

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

- ENERGY STAR® requirements for Commercial Ovens. http://www.energystar.gov/index.cfm?c=ovens.pr_crit_comm_ovens. Accessed 07/2020.
- ENERGY STAR® list of Qualified Commercial Ovens. https://www.energystar.gov/productfinder/product/certified-commercial-ovens/results. Accessed 07/2020.
- DEER 2014 EUL update.

Document Revision History

Table 126. Nonresidential ENERGY STAR® Convection Oven Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. No revisions.
v3.0	04/10/2015	TRM v3.0 update. Updated to newer ENERGY STAR® Commercial Ovens Program Requirements Version 2.1. Simplified calculation methodology to a single representative building type consistent with the ENERGY STAR® Commercial Kitchen Equipment Savings Calculator.
v3.1	11/05/2015	TRM v3.1 update. Updated title to reflect ENERGY STAR® Measure.
v4.0	10/10/2016	TRM v4.0 update. No revisions.
v5.0	10/2017	TRM v5.0 update. No revisions.
v6.0	10/2018	TRM v6.0 update. No revisions.

TRM version	Date	Description of change
v7.0	10/2019	TRM v7.0 update. Corrected convection oven definitions. Program tracking requirements updated.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits. Removed EStar qualification requirement and defers to meeting criteria.

2.4.3 ENERGY STAR® Commercial Dishwashers Measure Overview

TRM Measure ID: NR-FS-DW

Market Sector: Commercial

Measure Category: Food Service Equipment

Applicable Building Types: See Eligibility Criteria

Fuels Affected: Electricity

Decision/Action Type: Retrofit, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This document presents the deemed savings methodology for the installation of an ENERGY STAR® commercial dishwasher. Commercial dishwashers that have earned the ENERGY STAR® label are, on average, 25 percent more energy-efficient and 25 percent more water-efficient than standard models. The energy savings associated with ENERGY STAR® commercial dishwashers are primarily due to reduced water use and reduced need to heat water. A commercial kitchen may have external booster water heaters, or booster water heaters may be internal to specific equipment. Both primary and booster water heaters may be either gas or electric; therefore, dishwasher programs need to ensure the savings calculations used are appropriate for the water heating equipment installed at the participating customer's facility. The energy and demand savings are determined on a per-dishwasher basis.

Eligibility Criteria

The dishwasher must be ENERGY STAR® certified and fall under one of the following categories, and are described in Table 127:

- Under counter dishwasher
- Stationary rack, single tank, door type dishwasher
- Single tank conveyor dishwasher
- Multiple tank conveyor dishwasher
- Pot, pan, and utensil

Eligible building types include independent restaurants, chain restaurants, elementary and secondary schools, colleges and universities, corporate foodservice operations, healthcare, hospitality, and supermarkets.[232]

Dishwashers intended for use in residential or laboratory applications are not eligible for ENERGY STAR® under this product specification. Steam, gas, and other non-electric models also do not qualify.

Additionally, though Single and Multiple Tank Flight Type Conveyor dishwashing machines (where the dishes are loaded directly on the conveyor rather than transported within a rack – also referred to as a rackless conveyor) are eligible as per the version 2.0 specification[233], they are considered ineligible for this measure, since default values are not available for Flight Type dishwashers in the Savings Calculator for ENERGY STAR® Qualified Commercial Kitchen Equipment[234].

Table 127. Nonresidential ENERGY STAR® Commercial Dishwashers Descriptions

Equipment type	Equipment description
Under Counter Dishwasher	A machine with an overall height of 38" or less, in which a rack of dishes remains stationary within the machine while being subjected to sequential wash and rinse sprays and is designed to be installed under food preparation workspaces. Under counter dishwashers can be either chemical or hot water sanitizing, with an internal booster heater for the latter. For purposes of this specification, only those machines designed for wash cycles of ten minutes or less can qualify for ENERGY STAR®.
Stationary Rack, Single Tank, Door Type Dishwasher	A machine in which a rack of dishes remains stationary within the machine while subjected to sequential wash and rinse sprays. This definition also applies to machines in which the rack revolves on an axis during the wash and rinse cycles. Subcategories of stationary door type machines include single and multiple wash tank, double rack, pot, pan and utensil washers, chemical dump type, and hooded wash compartment ("hood type"). Stationary rack, single tank, door type models are covered by this specification and can be either chemical or hot water sanitizing, with an internal or external booster heater for the latter.
Single Tank Conveyor Dishwasher	A washing machine that employs a conveyor or similar mechanism to carry dishes through a series of wash and rinse sprays within the machine. Specifically, a single tank conveyor machine has a tank for wash water followed by a final sanitizing rinse and does not have a pumped rinse tank. This type of machine may include a pre-washing section before the washing section. Single tank conveyor dishwashers can either be chemical or hot water sanitizing, with an internal or external booster heater for the latter.

[232] CEE Commercial Kitchens Initiative's overview of the Food Service Industry: http://library.cee1.org/sites/default/files/library/4203/CEE_CommKit_InitiativeDescription_June2014.pdf. Accessed 04/30/2015.

[233] ENERGY STAR® Program Requirements Product Specification for Commercial Dishwashers, Version 2.0. https://www.energystar.gov/products/commercial_food_service_equipment/commercial_dishwashers.

[234] ENERGY STAR®. "Savings Calculator for ENERGY STAR® Qualified Commercial Kitchen Equipment." Accessed 07/2020.

Equipment type	Equipment description
Multiple Tank Conveyor Dishwasher	A conveyor type machine that has one or more tanks for wash water and one or more tanks for pumped rinse water, followed by a final sanitizing rinse. This type of machine may include one or more pre-washing sections before the washing section. Multiple tank conveyor dishwashers can be either chemical or hot water sanitizing, with an internal or external hot water booster heater for the latter.
Pot, Pan, and Utensil	A stationary rack, door type machine designed to clean and sanitize pots, pans, and kitchen utensils.

Baseline Condition

Baseline equipment is either a low-temperature[235] or high temperature[236] machine as defined by Table 127, which is not used in a residential or laboratory setting. For low-temperature units, the DHW is assumed to be electrically heated. For high-temperature units, the DHW can either be heated by electric or natural gas methods. For units heated with natural gas, the unit shall have an electric booster heater attached to it.

High-Efficiency Condition

Qualifying equipment must be compliant with the current ENERGY STAR® v2.0 specification, effective February 1, 2013. High-temperature equipment sanitizes using hot water and requires a booster heater. Booster heaters must be electric. Low-temperature equipment uses chemical sanitization and does not require a booster heater. Qualified products must be less than or equal to the maximum idle energy rate and water consumption requirements from Table 128.

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235 Low temperature machines apply a chemical sanitizing solution to the surface of the dishes to achieve sanitation.

236 High temperature machines apply only hot water to the surface of the dishes to achieve sanitation.

Table 128. High-Efficiency Requirements for Commercial Dishwashers[237]

Machine type	Low-temperature efficiency requirements		High-temperature efficiency requirements	
	Idle energy rate (kW)	Water consumption (gal/rack)	Idle energy rate (kW)	Water consumption (gal/rack)
Under Counter	≤ 0.50	≤ 1.19	≤ 0.50	≤ 0.86
Stationary Single Tank Door	≤ 0.60	≤ 1.18	≤ 0.70	≤ 0.89
Single Tank Conveyor	≤ 1.50	≤ 0.79	≤ 1.50	≤ 0.70
Multiple Tank Conveyor	≤ 2.00	≤ 0.54	≤ 2.25	≤ 0.54
Pot, Pan, and Utensil	< 1.00	≤0.58[238]	≤ 1.20	≤ 0.58[238]

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Deemed savings values are calculated using the following algorithms:

$$\begin{aligned} Energy\ Savings\ [kWh] &= (V_{waterB} - V_{waterP}) \times \left(\frac{\Delta T_{DHW} + \Delta T_{boost}}{\eta_{DHW}}\right) \times \rho_{water} \times C_p \times \frac{1\ W}{3{,}412\ kBtuh} \\ &+ (Idle_{base} - Idle_{post}) \times \left(t_{days} \times t_{hours} - t_{days} \times N_{racks} \times \frac{Wash\ Time}{60}\right) \end{aligned}$$

Equation 95

$$Peak\ Demand\ [kW] = \frac{\Delta kWh}{t_{hrs} \times t_{days}} \times CF$$

Equation 96

$$V_{waterB} = t_{days} \times N_{racks} \times V_{galrackB}$$

Equation 97

$$V_{waterP} = t_{days} \times N_{racks} \times V_{galrackP}$$

Equation 98

[237] Table 128 values are provided in the ENERGY STAR® Program Requirements Product Specification for Commercial Dishwashers, Version 2.0. https://www.energystar.gov/products/commercial_food_service_equipment/commercial_dishwashers. Accessed 07/2020.

[238] Water Consumption for pot, pan and utensil is specified in gallons per square foot rather than gallons per rack.

Where:

V_{waterB}	=	*Baseline volume of water consumed per year [gallons]*
V_{waterP}	=	*Post measure volume of water consumed per year [gallons]*
t_{days}	=	*Facility operating days per year [days]*
t_{hours}	=	*Equipment operating hours per day [hours]*
N_{racks}	=	*Number of racks washed per days*
CF	=	*Peak coincidence factor*
$V_{galrack,B}$	=	*Gallons of water used per rack of dishes washed for conventional dishwashers [gallons]*
$V_{galrack,P}$	=	*Gallons of water used per rack of dishes washed for ENERGY STAR® dishwashers [gallons]*
ρ_{water}	=	*Density of water [lbs/gallon]*
C_p	=	*Specific heat of water [Btu/lb °F]*
ΔT_{DHW}	=	*Inlet water temperature increase for building water heater [°F]*
η_{DHW}	=	*Building electric water heater and booster heater efficiency [%]*
ΔT_{boost}	=	*Inlet water temperature for booster water heater [°F]*
$Idle_{base}$	=	*Baseline Idle Energy Rate [kW]*
$Idle_{post}$	=	*High Efficiency Idle Energy Rate [kW]*
Wash Time	=	*Wash time per Rack*