Step 3 - Calculate kW_{full} using the hp from the motor nameplate, load factor and the applicable motor efficiency. 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 255

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

Equation 256

Where:

$\%power_i$	=	*Percentage of full load pump power needed at the i^{th} hour calculated by an equation based on the control type*
kW_{full}	=	*Fan motor demand operating at typical design conditions*
kW_i	=	*Pump real-time power at the i^{th} hour of the year*
HP	=	*Rated horsepower of the motor*
LF	=	*Load factor—ratio of the operating load to the nameplate rating of the motor; default assumption is 75%*
0.746	=	*Constant to convert from hp to kW*
η	=	*Motor efficiency of a standard efficiency motor (see Table 292)*

Table 292. Water Pumping VFDs—Motor Efficiencies[576]

Motor hp	Full load efficiency	Motor hp	Full load efficiency
1	0.855	25	0.936
2	0.865	30	0.941
3	0.895	40	0.941
5	0.895	50	0.945
7.5	0.910	60	0.950
10	0.917	75	0.950
15	0.930	100	0.954
20	0.930		

576 Code of Federal Regulations, Title 10, Chapter II, Subchapter D, Part 431.25 Table 1, Nominal Full-Load efficiencies of General Purpose Electric Motors (Subtype 1), 4 pole motors. https://www.ecfr.gov/cgi-bin/retrieveECFR?n=pt10.3.431#se10.3.431_125.

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.

Hourly and Peak Demand Savings Calculations

$$kW_{i,Saved} = kW_{i,Baseline} - kW_{i,VFD}$$

Equation 257

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

Equation 258

Where:

PDPF = *Winter peak demand probability factor from the applicable climate zone table in Volume 1; there are no summer demand savings for this measure*

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:

$$Enegy\ Savings\ [\Delta kWh] = \sum_{i=1}^{8,760}(kW_i)$$

Equation 259

Where:

8,760 = *Total number of hours in a year*

Step 2 – Subtract Annual kWh_{new} from Annual $kWh_{baseline}$ to get the energy savings:

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

Equation 260

Deemed Energy and Demand Savings Tables

Table 334 presents the deemed summer and winter peak kilowatt savings per motor horsepower.

Table 293. Water Pumping VFDs—Energy and Peak Demand Savings per Motor HP

Climate zone	kWh savings per motor HP	Winter peak demand kW savings per motor HP
Climate Zone 1: Amarillo	1,389	0.097
Climate Zone 2: Dallas		0.069
Climate Zone 3: Houston		0.067

Climate zone	kWh savings per motor HP	Winter peak demand kW savings per motor HP
Climate Zone 4: Corpus Christi		0.138
Climate Zone 5: El Paso		0.106

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) is 12.5 years, which is the average EUL for pump VSD applications as specified in the California Database of Energy Efficiency Resources (DEER) READI tool.[577]

Program Tracking Data and Evaluation Requirements

The list below 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.

- Climate zone or county
- Unit quantity
- Motor horsepower

References and Efficiency Standards

Petitions and Rulings

- This section not applicable.

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

Document Revision History

Table 294. Water Pumping VFDs—Revision History

TRM version	Date	Description of change
v9.0	10/2021	TRM v9.0 origin.
v10.0	10/2022	TRM v10.0 update. General text edits.
v11.0	10/2023	TRM v11.0 update. No revision.
v12.0	10/2024	TRM v12.0 update. No revision.

[577] DEER READI (Remote Ex-Ante Database Interface). http://www.deeresources.com/index.php/readi.

2.7.2 Water Pumps Measure Overview

TRM Measure ID: NR-MS-WP

Market Sector: Commercial

Measure Category: Miscellaneous

Applicable Building Types: CAll commercial

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 measure is defined as the installation of a clean water pump with pump energy index (PEI) as specified below. This document presents the methodology for calculating the savings realized from installing efficient commercial water pumps.

Eligibility Criteria

Clean water pumps that are intended for agricultural, commercial, and industrial sectors with a nominal pump motor horsepower rating of ≤250 must meet the pump energy index (PEI) requirements specified in **Error! Reference source not found.** below. Additionally, the PEI should be confirmed on the Hydraulic Institute (HI) database (https://er.pumps.org/ratings/search).

Any of the following clean water rotodynamic pump classes are eligible:

- End Suction Frame Mount (ESFM)
- End Suction Close Coupled (ESCC)
- In-line (IL)
- Radially Split multi-stage vertical in-line diffuser casing (RSV)
- Vertical Turbine Submersible (ST)

For variable speed pumps, programs must verify that the pumps are operating at variable speed to achieve variable flow. Verification process includes providing photographs of the pump controls, pump management system, and/or written description of the pump control strategy.

Baseline Condition

The baseline condition for this measure is a clean water pump with a PEI rating specified in **Error! Reference source not found.** below. Under Title 10 Section 431.462 the U.S. Department of Energy (DOE) developed the Energy Conservation Standard (ECS) for commercial, industrial, and agricultural clean water pumps.[578] As of January 2020, all clean water pumps sold are required to have an ECS label with a pump energy index (PEI) rating ≤ 1.0.

These baseline values were calculated from a database of performance data collected from major manufacturers and the Hydraulic Institute (HI). The baseline PEI ratings are representative of the most commonly available (mode) of the data set for each control strategy and pump motor horsepower range.

High-Efficiency Condition

The high-efficiency condition is a constant speed or variable speed clean water pump that meets or exceeds the conditions in **Error! Reference source not found.** below.

Table 295. Water Pumps—Baseline and High-Efficiency Conditions

Pump Motor Horsepower	Control Strategy	Baseline PEI	Efficient PEI
1 ≤ hp ≤ 15	Variable Speed	0.47	≤ 0.45
1 ≤ hp ≤ 15	Constant Speed	0.94	≤ 0.92
15 < hp ≤ 50	Variable Speed	0.49	≤ 0.47
15 < hp ≤ 50	Constant Speed	0.94	≤ 0.92
50 < hp ≤ 250	Variable Speed	0.49	≤ 0.47
50 < hp ≤ 250	Constant Speed	0.95	≤ 0.93

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy Savings Algorithms

The energy savings analysis was adopted from the pump savings analysis approved by the Regional Technical Forum for the Northwest Energy Efficiency Alliance (NEEA) Efficient Commercial and Industrial Pumps (ECIP) Project.[579] This analysis was approved in April 2022, and included extensive pump modeling, DOE database information, and customer/vendor field data.

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578 Code of Federal Regulations at 10 CFR Subpart Y. https://www.caetrm.com/media/reference-documents/CFR-2018-title10-vol3-sec431-462.pdf.

579 Northwest Regional Technical Forum (RTF). 2016. "Research Strategy for Efficient Pumps." December 6.

The energy savings from retrofitting a base case pump to a more efficient measure case pump is based on the NEEA modification of the Hydraulic Institute (HI) pump energy savings calculation.[580] The HI energy savings calculation assumes a conservative base case efficiency scenario and does not include adjustment factors to account for pump nominal power and actual pump performance variances. The NEEA modifications of the HI calculation considered baseline market average pump efficiencies and adjustment factors that consider nominal versus actual power draw and actual pump system curves.

The energy savings analysis NEEA was streamlined for this measure. The electric energy savings for installing high efficiency pumps is calculated using the equation below.

$$Energy\ Savings\ [\Delta kWh] = \frac{P_{Pump}}{P_{Motor}} \times (PEI_{base} - PEI_{eff}) \times AOH \times AF_{OPHr} \times 0.746$$

Equation 261

Where:

HRS_{OPYr} = *Annual operating hours, see* Table 332

AF_{OPHr} = *Final load profile adjustment factors by application and speed control case, see* Table 332

P_{Pump} = *Nominal pump size in horsepower (hp)*

P_{Motof} = *Nominal motor size in horsepower (hp)*

PEI_{base} = *Base PEI of the pump, see Table 295*

PEI_{Eff} = *Efficient PEI of the pump*

AOH = *Annual operating hours, see* Table 332

AF = *Final load profile adjustment factors by application and speed control case, see* Table 332

0.746 = *Constant to convert from hp to kW*

Table 296. Water Pumps – Annual Operating Hours and Adjustment Factors[581]

Control Strategy	Sector	AOH	AF
Constant Speed	Agricultural	2,358	1.325
	Commercial	3,753	1.250
	Industrial	6,175	1.310
Variable Speed	Agricultural	2,358	1.845
	Commercial	3,753	1.000
	Industrial	6,175	1.214

580 https://www.caetrm.com/measure/SWWP004/03/.

581 Pacific Gas and Electric Company (PG&E). 2023. "SWWP004 Savings_and_Cost_Analysis_12-14-2023.xlsm"

Summer Peak Demand Savings

There are no summer peak demand savings for this measure.

Winter Peak Demand Savings

There are no winter peak demand savings 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 estimated useful life (EUL) is 15 years as specified in DEER 2008.[582]

Program Tracking Data and Evaluation Requirements

The below list of primary inputs and contextual data should be specified and tracked within the program database to inform the evaluation and apply the savings properly:

- Quantity
- Application type (agricultural, commercial, industrial)
- Pump model number
- Efficient pump horsepower
- Efficient motor horsepower
- Control strategy
  - For variable speed, provide photos of the pump controls and pump management system
- Efficient pump PEI rating
- Proof of purchase (e.g., invoices, commissioning reports, photos)

References and Efficiency Standards

Petitions and Rulings

Not applicable.

[582] www.deeresources.com

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

Document Revision History

Table 297. Water Pumps—Revision History

TRM version	Date	Description of change
v12.0	10/2024	TRM v12.0 origin

~~2.7.2~~2.7.3 Premium Efficiency Motors Measure Overview

TRM Measure ID: NR-MS-PM

Market Sector: Commercial

Measure Category: Miscellaneous

Applicable Building Types: All cCommercial

Fuels Affected: Electricity

Decision/Action Type: Retrofit, early retirement, new construction

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

Currently a wide variety of NEMA premium efficiency motors from 1 to 500 horsepower (hp) are available. Deemed saving values for demand and energy savings associated with this measure must be for electric motors with an equivalent operating period (hours x load factor) over 1,000 hours.

Eligibility Criteria

To qualify for early retirement, the premium efficiency unit must replace an existing, full-size unit with a maximum age of 16 years. To determine the remaining useful life of an existing unit, see Table 302. To receive early retirement savings, the unit to be replaced must be functioning at the time of removal.

Baseline and High-Efficiency Conditions

New Construction or Replace-on-Burnout

EISA 2007 Sec 313 adopted new federal standards for motors manufactured in the United States from December 19, 2010, to before June 1, 2016, with increased efficiency requirements for 250-500 hp motors as of June 1, 2016. These standards replace legislation commonly referred to as EP Act 1992 (the Federal Energy Policy Act of 1992). The standards can also be found in section 431.25 of the Code of Federal Regulations (10 CFR Part 431).[583]

With these changes, motors ranging from one to 500 hp bearing the “NEMA Premium" trademark will align with national energy efficiency standards and legislation. The Federal

[583] Federal Standards for Electric Motors, Table 1: Nominal Full-load Efficiencies of General Purpose Electric Motors (Subtype I), Except Fire Pump Electric Motors, https://www.ecfr.gov/cgi-bin/retrieveECFR?n=pt10.3.431#sp10.3.431.b. Accessed July 2020.

Energy Management Program (FEMP) adopted NEMA MG 1-2006 Revision 1 2007 in its Designated Product List for federal customers.

Additionally, NEMA premium standards include general purpose electric motors, subtype II (i.e., motors ranging from 1-200 hp and 200-500 hp) including:

- U-frame motors
- Design C motors
- Close-coupled pump motors
- Footless motors
- Vertical solid shaft normal thrust (tested in a horizontal configuration)
- 8-pole motors
- All poly-phase motors up to 600 volts (minus 230/460 volts, covered EPAct-92)

Under these legislative changes, 200-500 hp and subtype II motor baselines will be based on the minimum efficiency allowed under the Federal Energy Policy Act of 1992 (EPAct)[584] (see Table 301) and are thus no longer equivalent to pre-1992/pre-EPAct defaults.

Early Retirement

The baseline for early retirement projects is the nameplate efficiency of the existing motor to be replaced, if known. If the nameplate is illegible and the in-situ efficiency cannot be determined, then the baseline should be based on the minimum efficiency allowed under the Federal Energy Policy Act of 1992 (EPAct)[585], as listed in Table 303.

NEMA premium efficiency motor levels continue to be industry standard for minimum-efficiency levels. The savings calculations assume that the minimum motor efficiency for replacement motors for both replace-on-burnout and early retirement projects exceeds that listed in Table 301.

For early retirement, the maximum age of eligible equipment is capped at the expected 75 percent of the equipment failure (17 years). ROB savings should be applied when age of the unit exceeds 75 percent failure age. This cap prevents early retirement savings from being applied to projects where the age of the equipment greatly exceeds the estimated useful life of the measure. 1-200 hp motors manufactured as of December 19, 2010 and 250-500 hp motors manufactured as of June 1, 2016 are not eligible for early retirement.

[584] Federal Standards for Electric Motors, Table 4: Nominal Full-load Efficiencies of NEMA Design B General Purpose Electric Motors (Subtype I and II), Except Fire Pump Electric Motors, https://www.ecfr.gov/cgi-bin/retrieveECFR?n=pt10.3.431#sp10.3.431.b.

[585] Federal Standards for Electric Motors, Tables 3 (≤ 200 hp), and 4 (> 200hp), https://www.ecfr.gov/cgi-bin/retrieveECFR?n=pt10.3.431#sp10.3.431.b.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Actual motor operating hours are expected to be used to calculate savings. Short and/or long-term metering can be used to verify estimates. If metering is not possible, interviews with facility operators and review of operations logs should be conducted to obtain an estimate of actual operating hours. If there is not sufficient information to accurately estimate operating hours, then the annual operating hours in Table 298 or Table 299 can be used.

New Construction or Replace-on-Burnout

Energy Savings Algorithms

$$kWh_{savings,ROB} = HP \times 0.746 \times LF \times \left(\frac{1}{\eta_{baseline,ROB}} - \frac{1}{\eta_{post}}\right) \times Hrs$$

Equation 262

Demand Savings Algorithms

HVAC Applications:

$$kW_{savings,ROB} = \left(\frac{kWh_{savings,ROB}}{Hrs}\right) \times CF$$

Equation 263

Industrial Applications[586]:

$$kW_{savings,ROB} = \left(\frac{kWh_{savings,ROB}}{8{,}760\ hours}\right)$$

Equation 264

Where:

HP	=	*Nameplate horsepower data of the motor*
0.746	=	*Constant to convert from hp to kWh*[587]
LF	=	*Estimated load factor (if unknown, see Table 298 or Table 299)*

[586] Assumes three-shift operating schedule

[587] U.S. DOE, Technical Support Document, "Energy Efficiency Program for Commercial Equipment: Energy Conservation Standards for Electric Motors, 10.2.2.1 Motor Capacity". Download TSD at: https://www.mercatus.org/system/files/1904-AC28-TSD-Electric-Motors.pdf.

$\eta_{baseline,ROB}$	=	*Assumed original motor efficiency [%] (see Table 301)*[588]
η_{post}	=	*Efficiency of the newly installed motor [%]*
Hrs	=	*Estimated annual operating hours (if unknown, see Table 298 or Table 299)*
CF	=	*Peak coincidence factor (see Table 298)*
$kWh_{savings,ROB}$	=	*Total energy savings for a new construction or ROB project*
$kW_{savings,ROB}$	=	*Total demand savings for a new construction or ROB project*

Table 298. Premium Motors—HVAC Input Assumptions

Building type	Load factor[589]	CF[590]	HVAC fan hours[591]
~~Healthcare: Inpatient~~ Education: K-12 school	0.75	1.00	4,173~~8,760~~
Education: College/university			4,590
Food service: Quick-service restaurant			6,716
Food service: Full-service restaurant			5,256
Healthcare: Inpatient			8,760
Mercantile: All retail			5,548
Office: Large (>30k sq. ft.)			4,424
Office: Small (≤30k sq. ft.)			4,006

588 In the case of rewound motors, in-situ efficiency may be reduced by a percentage as found in Table 300.

589 Itron 2004-2005 DEER Update Study, Dec 2005; Table 3-25. http://deeresources.com/files/deer2005/downloads/DEER2005UpdateFinalReport_ItronVersion.pdf

590 Commercial Prototype Building Models HVAC operating schedules for hours ending 15-18. U.S. Department of Energy. https://www.energycodes.gov/development/commercial/prototype_models

591 Factors are equivalent to Table 92 Yearly Motor Operation Hours by Building Type for HVAC Frequency Drives

Table 299. Premium Motors—Industrial Input Assumptions

Industrial processing	Load factor[592]	Hours[593]					
		Chem	Paper	Metals	Petroleum refinery	Food production	Other
1-5 hp	0.54	4,082	3,997	4,377	1,582	3,829	2,283
6-20 hp	0.51	4,910	4,634	4,140	1,944	3,949	3,043
21-50 hp	0.60	4,873	5,481	4,854	3,025	4,927	3,530
51-100 hp	0.54	5,853	6,741	6,698	3,763	5,524	4,732
101-200 hp	0.75	5,868	6,669	7,362	4,170	5,055	4,174
201-500 hp	0.58	5,474	6,975	7,114	5,311	3,711	5,396
501-1,000 hp		7,495	7,255	7,750	5,934	5,260	8,157
> 1,000 hp		7,693	8,294	7,198	6,859	6,240	2,601

Table 300. Premium Motors—Rewound Motor Efficiency Reduction Factors[594]

Motor horsepower	Efficiency reduction factor
< 40	0.010
≥ 40	0.005

Table 301. Premium Motors—NC/ROB Baseline Efficiencies by Motor Size (%)[583,587,599]

hp	Open motors: $\eta_{baseline, ROB}$			Closed motors: $\eta_{baseline, ROB}$		
	6-pole	4-pole	2-pole	6-pole	4-pole	2-pole
1	82.5	85.5	77.0	82.5	85.5	77.0
1.5	86.5	86.5	84.0	87.5	86.5	84.0
2	87.5	86.5	85.5	88.5	86.5	85.5
3	88.5	89.5	85.5	89.5	89.5	86.5
5	89.5	89.5	86.5	89.5	89.5	88.5
7.5	90.2	91.0	88.5	91.0	91.7	89.5
10	91.7	91.7	89.5	91.0	91.7	90.2
15	91.7	93.0	90.2	91.7	92.4	91.0

592 United States Industrial Electric Motor Systems Market Opportunities Assessment, Dec 2002; Table 1-19. https://www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/mtrmkt.pdf

593 United States Industrial Electric Motor Systems Market Opportunities Assessment, Dec 2002; Table 1-15. https://www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/mtrmkt.pdf

594 US DOE, Technical Support Document, "Energy Efficiency Program for Commercial Equipment: Energy Conservation Standards for Electric Motors, 8.2.2.1 Annual Energy Consumption". Download TSD at: https://www.mercatus.org/system/files/1904-AC28-TSD-Electric-Motors.pdf.

hp	Open motors: $\eta_{baseline, ROB}$			Closed motors: $\eta_{baseline, ROB}$		
	6-pole	4-pole	2-pole	6-pole	4-pole	2-pole
20	92.4	93.0	91.0	91.7	93.0	91.0
25	93.0	93.6	91.7	93.0	93.6	91.7
30	93.6	94.1	91.7	93.0	93.6	91.7
40	94.1	94.1	92.4	94.1	94.1	92.4
50	94.1	94.5	93.0	94.1	94.5	93.0
60	94.5	95.0	93.6	94.5	95.0	93.6
75	94.5	95.0	93.6	94.5	95.4	93.6
100	95.0	95.4	93.6	95.0	95.4	94.1
125	95.0	95.4	94.1	95.0	95.4	95.0
150	95.4	95.8	94.1	95.8	95.8	95.0
200	95.4	95.8	95.0	95.8	96.2	95.4
250	95.8	95.8	94.0	95.8	96.2	95.8
300	95.8	95.8	95.4	95.8	96.2	95.8
350	95.8	95.8	95.4	95.8	96.2	95.8
400	–	95.8	95.8	–	96.2	95.8
450	–	96.2	96.2	–	96.2	95.8
500	–	96.2	96.22	–	96.22	95.8

Early Retirement

Annual energy (kWh) and peak demand (kW) savings must be calculated separately for two time periods:

1. The estimated remaining life of the equipment that is being removed, designated the remaining useful life (RUL), and
2. The remaining time in the EUL period (EUL – RUL)

Annual energy and peak demand savings are calculated by weighting the early retirement and replace-on-burnout savings by the RUL of the unit and the remainder of the EUL period, as outlined in the Volume 3 appendices.

Where:

RUL	=	*Remaining useful life (see Table 302); if unknown, assume the age of the replaced unit is equal to the EUL resulting in a default RUL of 2.0 years*
EUL	=	*Estimated useful life = 15 years*

Table 302. Premium Motors—RUL of Early Retirement Motors[595]

Age of replaced motor (years)	RUL (years)	Age of replaced motor (years)	RUL (years)
1	13.9	10	5.0
2	12.9	11	4.2
3	11.9	12	3.6
4	10.9	13	3.0
5	9.9	14	2.5
6	8.9	15	2.0
7	7.9	16	1.0
8	6.9	17[596]	0.0
9	5.9		

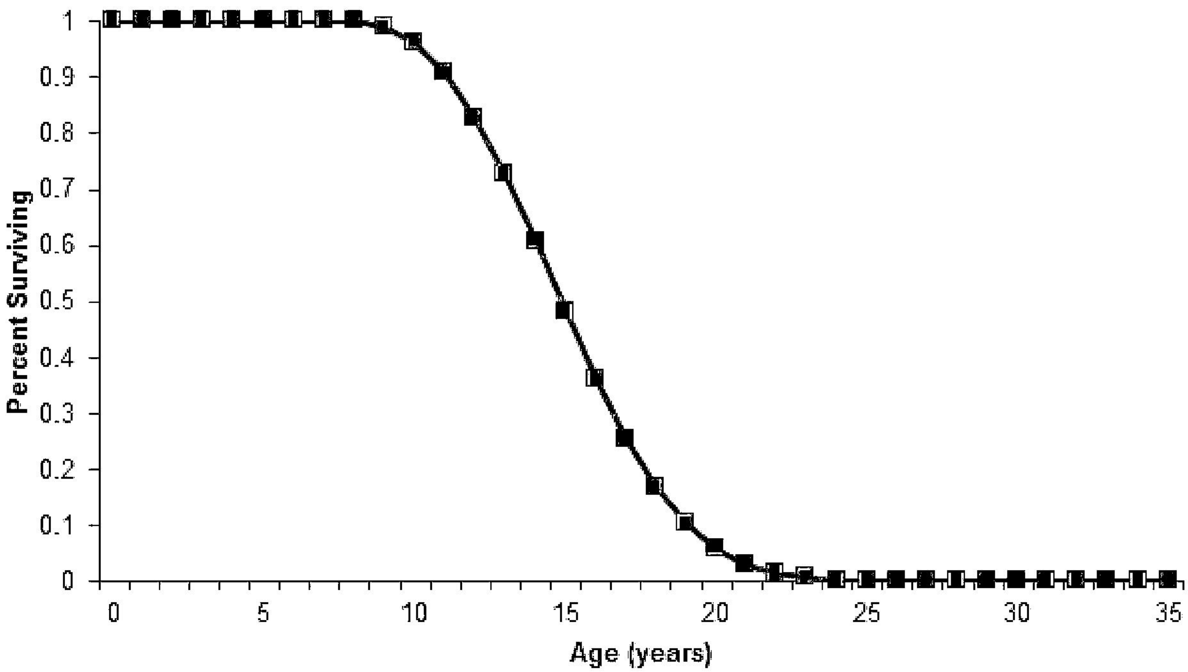
Derivation of RULs

Premium Efficiency Motors have an estimated useful life of 15 years. This estimate is consistent with the age at which approximately 50 percent of the motors installed in a given year will no longer be in service, as described by the survival function for a general fan or air compressor application in Figure 7.

595 Current federal standard effective date is 12/19/2010. Existing systems manufactured after this date are not eligible to use the early retirement baseline and should use the ROB baseline instead.

596 RULs are capped at the 75th percentile of equipment age, 17 years, as determined based on DOE survival curves (see Figure 7). Systems older than 17 years should use the ROB baseline. See the January 2015 memo, “Considerations for early replacement of residential equipment,” for further detail.

Figure 7. Premium Motors—Survival Function for Premium Efficiency Motors[597]



The method to estimate the remaining useful life (RUL) of a replaced system uses the age of the existing system to re-estimate the projected unit lifetime based on the survival function shown in Figure 7. The age of the motor being replaced is found on the horizontal axis, and the corresponding percentage of surviving motors is determined from the chart. The surviving percentage value is then divided in half, creating a new estimated useful lifetime applicable to the current unit age. Then, the age (year) that corresponds to this new percentage is read from the chart. RUL is estimated as the difference between that age and the current age of the system being replaced.

For example, assume a motor being replaced is 15 years old (the estimated useful life). The corresponding percent surviving value is approximately 50 percent. Half of 50 percent is 25 percent. The age corresponding to 25 percent on the chart is approximately 17 years. Therefore, the RUL of the motor being replaced is (17 – 15) = 2 years.

Energy Savings Algorithms

For the RUL time period:

$$kWh_{savings,RUL} = hp \times 0.746 \times LF \times \left(\frac{1}{\eta_{baseline,ER}} - \frac{1}{\eta_{post}}\right) \times Hrs$$

Equation 265

[597] Department of Energy, Federal Register, 76 Final Rule 57516, Technical Support Document: 8.2.3.1 Estimated Survival Function. September 15, 2011. http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/refrig_finalrule_tsd.pdf.

For the remaining time in the EUL period, calculate annual savings as you would for a replace-on-burnout project.

$$kWh_{savings,EUL} = hp \times 0.746 \times LF \times \left(\frac{1}{\eta_{baseline,ROB}} - \frac{1}{\eta_{post}}\right) \times Hrs$$

Equation 266

It follows that total lifetime energy savings for early retirement projects are then determined by adding the savings calculated under the two preceding equations:

$$kWh_{savings,ER} = kWh_{savings,RUL} \times RUL + kWh_{savings,EUL} \times (EUL - RUL)$$

Equation 267

Demand Savings Algorithms

To calculate demand savings for the early retirement of a motor, a similar methodology is used as for replace-on-burnout installations, with separate savings calculated for the remaining useful life of the unit, and the remainder of the EUL as outlined in the section above.

For the RUL time period:

HVAC Applications

$$kW_{savings,RUL} = \frac{kWh_{savings,RUL}}{Hrs} \times CF$$

Equation 268

Industrial Applications

$$kW_{savings,RUL} = \frac{kWh_{savings,RUL}}{8{,}760\ hours}$$

Equation 269

For the remaining time in the EUL period., calculate annual savings as you would for a replace-on-burnout project:

HVAC Applications

$$kW_{savings,EUL} = \frac{kWh_{savings,EUL}}{Hrs} \times CF$$

Equation 270

Industrial Applications

$$kW_{savings,EUL} = \frac{kWh_{savings,EUL}}{8{,}760\ hours}$$

Equation 271

Annual deemed peak demand savings are calculated by weighting the early retirement and replace-on-burnout savings by the RUL of the unit and the remainder of the EUL period, as outlined in the Volume 3 appendices.

$$kW_{savings,ER} = kW_{savings,RUL} \times RUL + kW_{savings,EUL} \times (EUL - RUL)$$

Equation 272

Where:

$\eta_{baseline,ER}$ = *Assumed original motor efficiency for remaining EUL time period (Table 303 or Table 304)*[598]

$kWh_{savings,RUL}$ = *Energy savings for RUL time period in an ER project*

$kWh_{savings,EUL}$ = *Energy savings for remaining EUL time period in an ER project*

$kW_{savings,RUL}$ = *Demand savings for RUL time period in an ER project*

$kW_{savings,EUL}$ = *Demand savings for remaining EUL time period in an ER project*

$kWh_{savings,ER}$ = *Total energy savings for an ER project*

$kW_{savings,ER}$ = *Total demand savings for an ER project*

Table 303. Premium Motors—ER Baseline Efficiencies by Motor Size (%)[585,599]

	Open motors: $\eta_{baseline, ER}$			Closed motors: $\eta_{baseline, ER}$		
hp	6-pole	4-pole	2-pole	6-pole	4-pole	2-pole
1	80.0	82.5	75.5	80.0	82.5	75.5
1.5	84.0	84.0	82.5	85.5	84.0	82.5
2	85.5	84.0	84.0	86.5	84.0	84.0
3	86.5	86.5	84.0	87.5	87.5	85.5
5	87.5	87.5	85.5	87.5	87.5	87.5
7.5	88.5	88.5	87.5	89.5	89.5	88.5
10	90.2	89.5	88.5	89.5	89.5	89.5
15	90.2	91.0	89.5	90.2	91.0	90.2
20	91.0	91.0	90.2	90.2	91.0	90.2
25	91.7	91.7	91.0	91.7	92.4	91.0
30	92.4	92.4	91.0	91.7	92.4	91.0
40	93.0	93.0	91.7	93.0	93.0	91.7

598 Ibid.

599 For unlisted motor horsepower values, round down to the next lowest horsepower value.

hp	Open motors: $\eta_{baseline, ER}$			Closed motors: $\eta_{baseline, ER}$		
	6-pole	4-pole	2-pole	6-pole	4-pole	2-pole
50	93.0	93.0	92.4	93.0	93.0	92.4
60	93.6	93.6	93.0	93.6	93.6	93.0
75	93.6	94.1	93.0	93.6	94.1	93.0
100	94.1	94.1	93.0	94.1	94.5	93.6
125	94.1	94.5	93.6	94.1	94.5	94.5
150	94.5	95.0	93.6	95.0	95.0	94.5
200	94.5	95.0	94.5	95.0	95.0	95.0
250	95.4	95.4	94.5	95.0	95.0	95.4
300	95.4	95.4	95.0	95.0	95.4	95.4
350	95.4	95.4	95.0	95.0	95.4	95.4
400	–	95.4	95.4	–	95.4	95.4
450	–	95.8	95.8	–	95.4	95.4
500	–	95.8	95.8	–	95.8	95.4

Table 304. Premium Motors—ER Baseline Efficiencies by Motor Size for 250-500 hp Motors Manufactured Prior to June 1, 2016 (%)[600,601]

hp	Open motors: $\eta_{baseline, ER}$			Closed motors: $\eta_{baseline, ER}$		
	6-pole	4-pole	2-pole	6-pole	4-pole	2-pole
250	95.4	95.4	94.5	95.0	95.0	95.4
300	95.4	95.4	95.0	95.0	95.4	95.4
350	95.4	95.4	95.0	95.0	95.4	95.4
400	–	95.4	95.4	–	95.4	95.4
450	–	95.8	95.8	–	95.4	95.4
500	–	95.8	95.8	–	95.8	95.4

Deemed Energy and Demand Savings Tables

Not applicable.

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600 Federal Standards for Electric Motors, Table 4.

601 For unlisted motor horsepower values, round down to the next lowest horsepower value.

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) is 15 years.[602]

Program Tracking Data and Evaluation Requirements

Primary inputs and contextual data that should be specified and tracked by the program database to inform the evaluation and apply the savings properly are:

- Unit quantity
- The project type of the installation (new construction, replace-on-burnout, or early retirement)
- Horsepower
- Estimated annual operating hours and estimated load factor
- Number of poles in and horsepower of original motor
- Newly-installed motor efficiency (%)
- Description of motor service application
- Photograph demonstrating functionality of existing equipment and/or customer responses to survey questionnaire documenting the condition of the replaced unit and their motivation for measure replacement for early retirement eligibility determination (early retirement only)

References and Efficiency Standards

Petitions and Rulings

Not applicable

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

[602] US 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

Document Revision History

Table 305. Premium Motors—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. Replace-on-burnout and Early Retirement clarifications.
v9.0	10/2021	TRM v9.0 update. General reference checks and text edits.
v10.0	10/2022	TRM v10.0 update. Added guidance for rounding down motor size in the baseline efficiency lookup table. Incremented RUL table for code compliance.
v11.0	10/2023	TRM v11.0 update. Aligned building type names across all commercial measures. Incremented RUL table for code compliance.
v12.0	10/2024	TRM v12.0 update. Updated early retirement age eligibility.

~~2.7.3~~2.7.4 Pump-Off Controllers Measure Overview

TRM Measure ID: NR-MS-PC

Market Sector: Commercial

Measure Category: Controls

Applicable Building Types: Industrial

Fuels Affected: Electricity

Decision/Action Type: Retrofit

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Field study, engineering algorithms, and estimates

Measure Description

Pump-off controllers (POC) are micro-processor-based devices that continuously monitor pump down conditions (i.e., when the fluid in the well bore is insufficient to warrant continued pumping). These controllers are used to shut down the pump when the fluid falls below a certain level and "fluid pounding"[603] occurs. POCs save energy by optimizing the pump run-times to match the flow conditions of the well.

Eligibility Criteria

The POC measure is only available as a retrofit measure for existing wells (wells with an existing API number[604] prior to September 11th, 2014) with rod pumps using 15 hp or larger motors operating on time clock controls or less efficient devices. These cannot be integrated with a variable frequency drive and only apply to POCs using load cells, which measure the weight on the rod string for greater precision. Additionally, the POC must control a *conventional* well (above ground or vertical, with a standard induction motor of 480V or less).

Baseline Condition

The baseline condition is an existing conventional well (with an API number prior to September 11, 2014) with rod pumps operating on time clock controls or less efficient control devices.

603 Fluid pounding occurs when the downhole pump rate exceeds the production rate of the formation. The pump strikes the top of the fluid column on the down stroke causing extreme shock loading of the components which can result in premature equipment failure.

604 The API number is a unique, permanent identifier assigned by the American Petroleum Institute. The API number should correspond to a well that was in existence prior to the date of PUCT Docket 42551.

High-Efficiency Condition

The efficient condition is the same well, retrofitted with a pump-off controller.

Energy and Demand Savings Methodology

Two main sources were referenced to develop the savings methods for the POC measure: *Electrical Savings in Oil Production*[605] (SPE 16363), which identified a relationship between volumetric efficiency and pump run times and the *2006-2008 Evaluation Report for PG&E Fabrication, Process, and Manufacturing Contract Group,*[606] which showed a reduction in savings from the SPE 16363 paper. These two methods were the basis of the current savings calculations and deemed inputs listed below. To develop Texas-specific stipulated values, field and metering data will be collected when there is sufficient uptake in the measure and used to calibrate and update the savings calculation methods and input variables for a future version of the TRM.[607]

Savings Algorithms and Inputs

The energy and demand algorithms and associated input variables are listed below:

$$Energy\ Savings\ [\Delta kWh] = kW_{avg} \times (TimeClock\%On - POC\%On) \times 8{,}760$$

Equation 273

$$Demand\ Savings\ [\Delta kW] = \frac{kWh_{savings}}{8{,}760}$$

Equation 274[608]

The inputs for the energy and peak coincident demand savings are listed below:

$$kW_{avg} = HP \times 0.746 \times \frac{\frac{LF}{ME}}{SME}$$

Equation 275

605 Bullock, J.E. "SPE 16363 *Electrical Savings in Oil Production",* (paper presented at the Society of Petroleum Engineers California Regional Meeting held in Ventura, California, April 8-10, 1987).

606 *2006-2008 Evaluation Report for PG&E Fabrication, Process and Manufacturing Contract Group.* CALMAC Study ID: CPU0017.01. Itron, Inc. Submitted to California Public Utilities Commission. February 3, 2010.

607 The EM&V Team will work with SPS/Xcel Energy in developing the sample plan for the field data collection effort.

608 The equations in the petition for peak demand simplify to the equation shown.

$$POC\%On = \frac{Run_{Constant} + Run_{Coefficient} \times VolumetricEfficiency\% \times TimeClock\%On \times 100}{100}$$

Equation 276[609]

Where:

kW_{avg}	=	*The demand used by each rod pump*
HP	=	*Rated pump-motor horsepower*
0.746	=	*Constant to convert from hp to kW*
LF	=	*Motor load factor—ratio of average demand to maximum demand (see Table 306)*
ME	=	*Motor efficiency, based on NEMA Standard Efficiency Motor (see Table 307)*
SME	=	*Mechanical efficiency of sucker-rod pump (see Table 306)*
Time Clock%On	=	*Stipulated-baseline time clock setting (see Table 306)*
$Run_{constant}$, $Run_{coefficient}$	=	*8.336, 0.956, derived from SPE 16363* [610]
VolumetricEfficiency%	=	*Average well gross production divided by theoretical production (provided on rebate application)*
8,760	=	*Total hours per year*

[609] This equation from the petition deviates from that in SPE 16363 but will provide conservative savings estimates. The equation will be updated and made consistent when this measure is updated with field data. The correct equation term is ($Run_{contstant}$ + $Run_{coefficient}$ x VolumetricEfficiency%) with the volumetric efficiency expressed as percent value not a fraction (i.e., 25 not 0.25 for 25 percent).

[610] Bullock, J.E. "SPE 16363 Electrical Savings in Oil Production, (paper presented at the Society of Petroleum Engineers California Regional Meeting held in Ventura, California, April 8-10, 1987).

Deemed Energy and Demand Savings Tables

Table 306. Pump-Off Controllers—Savings Calculation Input Assumptions

Variable	Stipulated/deemed values
LF (Load factor)	25%[611]
ME (motor efficiency)	See Table 2-137
SME (pump mechanical efficiency)	95%[612]
Time clock%On	65%[613]

Table 307. Pump-Off Controllers—NEMA Premium Efficiency Motor Efficiencies[614]

Motor horsepower	Nominal full-load efficiency					
	Open motors (ODP)			Enclosed motors (TEFC)		
	6 poles	4 poles	2 poles	6 poles	4 poles	2 poles
	1200 rpm	1800 rpm	3600 rpm	1200 rpm	1800 rpm	3600 rpm
15	91.7%	93.0%	90.2%	91.7%	92.4%	91.0%
20	92.4%	93.0%	91.0%	91.7%	93.0%	91.0%
25	93.0%	93.6%	91.7%	93.0%	93.6%	91.7%
30	93.6%	94.1%	91.7%	93.0%	93.6%	91.7%
40	94.1%	94.1%	92.4%	94.1%	94.1%	92.4%
50	94.1%	94.5%	93.0%	94.1%	94.5%	93.0%
60	94.5%	95.0%	93.6%	94.5%	95.0%	93.6%
75	94.5%	95.0%	93.6%	94.5%	95.4%	93.6%
100	95.0%	95.4%	93.6%	95.0%	95.4%	94.1%
125	95.0%	95.4%	94.1%	95.0%	95.4%	95.0%
150	95.4%	95.8%	94.1%	95.8%	95.8%	95.0%
200	95.4%	95.8%	95.0%	95.8%	96.2%	95.4%

[611] Comprehensive Process and Impact Evaluation of the (Xcel Energy) Colorado Motor and Drive Efficiency Program, FINAL. Tetra Tech. March 28, 2011. Adjusted based on Field Measurements provided by ADM Associates, based on 2010 custom projects.

[612] Engineering estimate for standard gearbox efficiency.

[613] A Time Clock%On of 80 percent is typical from observations in other jurisdictions, but that was adjusted to 65 percent for a conservative estimate. This value will be reevaluated once Texas field data is available.

[614] DOE Final Rule regarding energy conservation standards for electric motors. 79 FR 30933. Full-load Efficiencies for General Purpose Electric Motors [Subtype I] https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=6&action=viewlive.

Claimed Peak Demand Savings

Because the operation of the POC coincident with the peak demand period is uncertain, a simple average of the total savings over the full year (8,760 hours) is used, as shown in Equation 274.

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) is 15 years.[615]

Program Tracking Data and Evaluation Requirements

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

- Motor manufacturer
- Motor model number
- Rated motor horsepower
- Motor type (TEFC or ODP)
- Rated motor RPM
- Baseline control type and time clock percent on time (or actual on-time schedule)
- Volumetric efficiency
- Field data on actual energy use and post-run times[616]

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 42551—Provides energy and demand savings calculations and EUL

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

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[615] CPUC 2006-2008 Industrial Impact Evaluation "SCIA_06-08_Final_Report_Appendix_D-5": An EUL of 15 years was used for the ex-post savings, consistent with the SPC—Custom Measures and System Controls categories in the CPUC Energy Efficiency Policy Manual (Version 2) and with DEER values for an energy management control system.

[616] Per PUCT Docket 42551, Southwestern Public Service Company (SPS)/Xcel Energy has agreed to collect field data in 2015 on post-run times for a sample of wells to improve the accuracy of POC saving estimates.

Document Revision History

Table 308. Pump-Off Controllers—Revision History

TRM version	Date	Description of change
v2.1	01/30/2015	TRM v2.1 origin.
v3.0	04/10/2015	TRM v3.0 update. No revision.
v4.0	10/10/2016	TRM v4.0 update. No revision.
v5.0	10/2017	TRM v5.0 update. No revision.
v6.0	10/2018	TRM v6.0 update. No revision.
v7.0	10/2019	TRM v7.0 update. No revision.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits.
v9.0	10/2021	TRM v9.0 update. General reference checks and text edits.
v10.0	10/2022	TRM v10.0 update. No revision.
v11.0	10/2023	TRM v11.0 update. No revision.
v12.0	10/2024	TRM v12.0 update. No revision.

~~2.7.4~~2.7.5 ENERGY STAR® Pool Pumps Measure Overview

TRM Measure ID: NR-MS-PP

Market Sector: Commercial

Measure Category: Appliances

Applicable Building Types: All ~~C~~commercial

Fuels Affected: Electricity

Decision/Action Type(s): Retrofit

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure involves the replacement of a single-speed pool pump with an ENERGY STAR certified variable speed pool pump.

Eligibility Criteria

This measure applies to all commercial applications, indoor or outdoor, with a pump size up to 3 hp; larger sizes should be implemented through a custom program. Motor-only retrofits are not eligible. Ineligible pump products include waterfall, integral cartridge filter, integral sand filter, storable electric spa, and rigid electric spa[617].

Multi-speed pool pumps are not permitted. The multi-speed pump uses an induction motor that functions as two motors in one, with full-speed and half-speed options. Multi-speed pumps may enable significant energy savings. However, if the half-speed motor is unable to complete the required water circulation task, the larger motor will operate exclusively. Having only two speed-choices limits the ability of the pump motor to fine-tune the flow rates required for maximum energy savings.[618] The default pump curves provided in the ENERGY STAR Pool Pump Savings Calculator indicate that the motor operating at half-speed will be unable to meet the minimum turnover requirements for commercial pool operation as mandated by Texas Administrative Code.

[617] These pump products are ineligible for ENERGY STAR v3.0 certification: https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Version%203.1%20Pool%20Pumps%20Final%20Specification.pdf

[618] Hunt, A. and Easley, S., "Measure Guideline: Replacing Single-Speed Pool Pumps with Variable Speed Pumps for Energy Savings." Building America Retrofit Alliance (BARA), U.S. DOE. May 2012. http://www.nrel.gov/docs/fy12osti/54242.pdf.

Baseline Condition

The baseline is assumed to be a new pool pump that is compliant with the current federal standard, effective July 19, 2021.[619] Weighted Energy Factor (WEF) requirements are based on rated hydraulic horsepower (hhp).

Table 309. Baseline Condition—-–Federal Standard Effective July 19, 2021

Pump Sub-Type	Size Class	WEF
Self-priming (inground) pool pumps	Extra Small (hhp ≤ 0.13)	WEF = 5.55
	Small (hhp > 0.13 to < 0.711)	WEF = -1.30 x ln(hhp) + 2.90
	Standard (hhp ≥ 0.711)	WEF = -2.30 x ln(hhp) + 6.59

The baseline condition is a 1 to 5 horsepower (hp) standard efficiency single-speed pool pump. This measure is only applicable to retrofit applications. New construction applications are not eligible as of July 19, 2021.[620]

High-Efficiency Condition

The high-efficiency condition is a 1 to 5 hp variable speed pool pump that is compliant with the current ENERGY STAR Version 3.1 Specification, effective July 19, 2021.[621]

Table 310. ENERGY STAR Pool Pumps—-–Energy Efficiency Level

Pump Subtype	Size class	ENERGY STAR
Self-priming (inground) pool pumps	Extra small (hhp ≤ 0.13)	WEF ≥ 13.40
	Small (hhp > 0.13 to < 0.711)	WEF ≥ -2.45 x ln(hhp) + 8.40
	Standard (hhp ≥ 0.711)	

Energy and Demand Savings Methodology

Savings for this measure are based on methods and input assumptions from the ENERGY STAR Pool Pump Savings Calculator.

619 Federal standard for dedicated purpose pool pumps. https://www.ecfr.gov/current/title-10/section-431.465.

620 Federal standard for dedicated-purpose pool pumps. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=67.

621 ENERGY STAR Program Requirements Product Specification for Pool Pumps https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Version%203.1%20Pool%20Pumps%20Final%20Specification.pdf

Savings Algorithms and Input Variables

Energy Savings Algorithms

Energy savings for this measure were derived using the ENERGY STAR Pool Pump Savings Calculator with Texas selected as the applicable location, so Texas-specific assumptions were used.[622]

$$Energy\ Savings\ [\Delta kWh] = kWh_{conv} - kWh_{ES}$$

Equation 277

Where:

kWh_{conv} = *Conventional single-speed pool pump energy [kWh]*

kWh_{ES} = *ENERGY STAR variable-speed pool pump energy [kWh]*

Algorithms to calculate the above parameters are defined as:

$$kWh_{conv} = \frac{PFR_{conv} \times 60 \times hours \times days}{WEF_{conv} \times 1{,}000}$$

Equation 278

$$kWh_{ES} = \frac{V \times TO \times days}{WEF_{ES} \times 1{,}000}$$

Equation 279

Where:

PFR_{conv} = *Conventional single-speed pump flow rate [gal/min] (see Table 311)*

WEF_{conv} = *Conventional single-speed pump weighted energy factor [gal/W·hr] (see Table 311)*

WEF_{ES} = *ENERGY STAR-weighted energy factor [gal/W·hr] (see* Table 312***Error! Reference source not found.***)

hours = *Conventional single-speed pump daily operating hours (see Table 311)*

days = *Operating days per year = year-round operation: 365 days; seasonal operation: 7 months x 30.4 days/month = 212.8 days (default)*

[622] The ENERGY STAR Pool Pump Savings Calculator, updated ~~February~~ April 2020~~2013~~, can be found on the ENERGY STAR website at:https://www.energystar.gov/productfinder/product/certified-pool-pumps/results.

V	=	*Pool volume [gal] (use actual or see Table 312)*
TO	=	*Turnovers per day, number of times the volume of the pool is run through the pump per day (see Table 312)*
60	=	*Constant to convert between minutes and hours*
1,000	=	*Constant to convert from kilowatts to watts*

Table 311. Pool Pumps—Conventional Pump Input Assumptions[623]

New pump HP	Reference HP	Reference HHP[624]	Hours, limited[625]	Hours, 24/7	PFR_{conv} (gal/min)	EF_{conv} (gal/W-h)
≤ 1.25	1.0	0.533	12	24	75.5000	2.5131
1.25 < hp ≤ 1.75	1.5	0.800			78.1429	2.2677
1.75 < hp ≤ 2.25	2.0	1.066			88.6667	2.2990
2.25 < hp ≤ 2.75	2.5	1.333			93.0910	2.1812
2.75 < hp ≤ 5	3.0	1.599			101.6667	1.9987

Table 312. Pool Pumps—ENERGY STAR Pump Input Assumptions[626,627]

New pump HP	TO, limited	TO, 24/7	V [gal]	EF_{ES} (gal/W-h)
≤ 1.25	2.7	5.4	20,000	8.7
1.25 < hp ≤ 1.75	2.8	5.6	20,000	8.9
1.75 < hp ≤ 2.25	2.9	5.8	22,000	9.3
2.25 < hp ≤ 2.75	2.7	5.4	25,000	7.4
2.75 < hp ≤ 5	2.6	5.2	28,000	7.1

Demand Savings Algorithms

$$Peak\ Demand\ Savings\ [\Delta kW] = \frac{kWh_{conv} - kWh_{ES}}{hours} \times \frac{CF_{S/W}}{days}$$

Equation 280

623 Conventional pump PFR and EF values are taken from pump curves found in the ENERGY STAR Pool Pump Savings Calculator. Note: input assumptions will be updated once calculator has been updated for compliance with the current specification.

624 Hhp not available in ENERGY STAR calculator. Assumed hhp calculated as follows: Reference horsepower x AF. AF = 0.533 based on ratio of hhp to hp from ENERGY STAR qualified product listing.

625 Limited hours assumes that pump operating hours are 12 hours per day, based on 2016 Commercial pool pump program data reviewed by the Texas Evaluation Contractor. Note: input assumptions will be updated once calculator has been updated for compliance with the current specification.

626 ENERGY STAR® turnover and EF values are taken from pump curves found in the ENERGY STAR® Pool Pump Savings Calculator.

627 Turnovers calculated as TO = hours x 60 x PFR_{conv} ÷ V.

Where:

$CF_{S/W}$ = *Summer/winter seasonal peak coincidence factor (see Table 313)*

Table 313. Pool Pumps—Coincidence Factors[628]

Operation	Summer CF	Winter CF
24/7 operation	1.0	1.0
Seasonal/limited hours	1.0	0.5

Deemed Energy and Demand Savings Tables

Table 314. Pool Pumps—Energy Savings[629]

	Year-round operation		Seasonal operation (7 months)
	24/7 operation	Limited hours	
New pump HP	kWh savings	kWh savings	kWh savings
≤ 1.25	6,682~~11,259~~	3,341~~5,630~~	1,948~~3,282~~
1.25 < hp ≤ 1.75	1,191~~13,518~~	596~~6,759~~	347~~3,941~~
1.75 < hp ≤ 2.25	1,580~~15,263~~	790~~7,632~~	461~~4,449~~
2.25 < hp ≤ 2.75	1,895~~15,773~~	947~~7,887~~	552~~4,598~~
2.75 < hp ≤ 5	2,327~~19,250~~	1,163~~9,625~~	678~~5,612~~

Table 315. Pool Pumps—Summer Peak Demand Savings

New pump (HP)	All Schedules
≤ 1.25	0.763
1.25 < hp ≤ 1.75	0.136
1.75 < hp ≤ 2.25	0.180
2.25 < hp ≤ 2.75	0.216
2.75 < hp ≤ 5	0.266

628 Based on 2016 Commercial pool pump program data reviewed by the Texas Evaluation Contractor.

629 The results in this table may vary slightly from results produced by the ENERGY STAR® Calculator because of rounding of default savings coefficients throughout the measure and pool volume.

Table 316. Pool Pumps—Winter Peak Demand Savings

New pump HP	24/7	Limited & Seasonal
≤ 1.25	0.763	0.381
1.25 < hp ≤ 1.75	0.136	0.068
1.75 < hp ≤ 2.25	0.180	0.090
2.25 < hp ≤ 2.75	0.216	0.108
2.75 < hp ≤ 5	0.266	0.133

Claimed Peak Demand Savings

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

Additional Calculators and Tools

ENERGY STAR Pool Pump Savings Calculator, updated May 2020, can be found on the ENERGY STAR website at https://www.energystar.gov/productfinder/product/certified-pool-pumps/results.

Measure Life and Lifetime Savings

The estimated useful life (EUL) is 10 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID OutD-PoolPump.[630]

Program Tracking Data and Evaluation Requirements

Primary inputs and contextual data that should be specified and tracked by the program database to inform the evaluation and apply the savings properly are:

- For all projects
  - Climate zone or county
  - Pool pump rated horsepower
  - Proof of purchase including quantity, make, and model information
  - Copy of ENERGY STAR certification
  - Facility operation type: 24/7, year-round limited hours, seasonal
  - Pool volume in gallons (only required when calculating site-specific savings in lieu of deemed savings)

[630] DEER READI (Remote Ex-Ante Database Interface). http://www.deeresources.com/index.php/readi.

- For a significant sample of projects where attainable (e.g., those projects that are selected for inspection, not midstream or retail programs)
    - Items listed above for all projects
    - Decision/action type: early retirement, replace-on-burnout, or new construction
    - Rated horsepower of existing pool pump
    - Existing and new pump operating hours

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 47612—Provides deemed savings for ENERGY STAR pool pumps

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

Document Revision History

Table 317. Pool Pumps—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 revision.
v7.0	10/2019	TRM v7.0 update. Added ineligible products list. Program tracking requirements updated.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits.
v9.0	10/2021	TRM v9.0 update. General text edits. Corrected turnovers/day values in the assumptions table.
v10.0	10/2022	TRM v10.0 update. Updated for ENERGY STAR Version 3.0 Specification. Increased upper limit for pump horsepower to 5 to better reflect product availability.
v11.0	10/2023	TRM v11.0 update. No revision.
v12.0	10/2024	TRM v120.0 update. Updated baseline condition and deemed savings to reflect current federal standard.

~~2.7.5~~2.7.6 Lodging Guest Room Occupancy-Sensor Controls Measure Overview

TRM Measure ID: NR-MS-LC

Market Sector: Commercial

Measure Category: HVAC, indoor lighting

Applicable Building Types: Hotel/motel guestrooms, schools/colleges (dormitory)

Fuels Affected: Electricity

Decision/Action Type: Retrofit

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: Energy modeling

Measure Description

This measure, commonly referred to as a guest room energy management (GREM) system, captures the potential energy and demand savings resulting from occupancy sensor control of HVAC and lighting in unoccupied hotel/motel guest rooms. Hotel and motel guest room occupancy schedules are highly variable, and guests often leave HVAC equipment and lighting on when they leave the room. Installation of occupancy controls can reduce the unnecessary energy consumption in unoccupied guest rooms. Savings have also been developed for the use of this measure in college dormitories.[631]

Eligibility Criteria

To be eligible for HVAC savings, controls must be capable of either a 5ºF or 10ºF temperature offset. To be eligible for lighting savings, at least 50 percent of all the lighting fixtures in a guest room—both hardwired and plug-load lighting—must be actively controlled.

Baseline Condition

The baseline condition is a guest room or dorm room without occupancy controls.

High-Efficiency Condition

The high-efficiency condition is a guest room or dorm room with occupancy controls. The occupancy sensors can control either the HVAC equipment only or the HVAC equipment and

[631] The original petition also includes savings for HVAC-only control in master-metered multifamily individual dwelling units. These values are not reported here because the permanent occupation of a residential unit is significantly different from the transitory occupation of hotel/motels and even dormitories. This measure is not currently being implemented and is not likely to be used in the future, but it can be added to a future TRM if warranted.

the interior lighting (including plug-in lighting).

The occupancy-based control system must include, but not be limited to, infrared sensors, ultrasonic sensors, door magnetic strip sensors, and/or card-key sensors. The controls must be able to either completely shut-off the HVAC equipment serving the space and/or place it into an unoccupied temperature setback/setup mode.

Energy and Demand Savings Methodology

Energy and demand savings are deemed values based on energy simulation runs performed using EnergyPro Version 5. Building prototype models were developed for a hotel, motel, and dormitory building types. The base case for each prototype model assumed a uniform temperature setting and was calibrated to a baseline energy use. Occupancy patterns based on both documented field studies[632] and prototypical ASHRAE 90.1-1999 occupancy schedules were used in the energy simulation runs to create realistic vacancy schedules. The prototype models were then adjusted to simulate an occupancy control system, which was compared to the baseline models.[633]

Savings Algorithms and Inputs

A building simulation approach was used to produce savings estimates.

Deemed Energy and Demand Savings Tables

Energy and demand savings are provided by region, for HVAC-only, HVAC + lighting control configurations, and for three facility types: motel guest rooms, hotel guest rooms, and dormitory rooms.

Table 318. Lodging Occupancy Sensors—Motel per Room Energy and Peak Demand Savings

Climate zone[634]	Heat pump				Electric resistance heat			
	HVAC only		HVAC and lighting		HVAC only		HVAC and lighting	
	kW	kWh	kW	kWh	kW	kWh	kW	kWh
5-degree setup/setback offset								
Climate Zone 1: Amarillo	0.059	267	0.075	380	0.059	341	0.075	441
Climate Zone 2: Dallas	0.076	315	0.091	443	0.076	365	0.091	485

632 HVAC occupancy rates appear to be based on a single HVAC study of three hotels, but not dorms or multifamily buildings. For the lighting study, a typical guest room layout was used as the basis for the savings analysis. Hotel guest rooms are quite different from either dorms or multifamily units.

633 A more detailed description of the modeling assumptions can be found in Docket 40668 Attachment A, pages A-46 through A-58.

634 Regions used in the original petition were mapped to current TRM representative weather stations and regions as follows: Amarillo was "Panhandle", Dallas-Ft Worth was "North", Houston was "South Central", El Paso was "Big Bend", and Corpus Christi was "Rio Grande Valley" using McAllen as a reference city.

Climate zone[634]	Heat pump				Electric resistance heat			
	HVAC only		HVAC and lighting		HVAC only		HVAC and lighting	
	kW	kWh	kW	kWh	kW	kWh	kW	kWh
Climate Zone 3: Houston	0.082	324	0.097	461	0.082	351	0.097	484
Climate Zone 4: Corpus Christi	0.086	354	0.103	500	0.086	369	0.103	513
Climate Zone 5: El Paso	0.063	251	0.078	379	0.063	283	0.078	406
10-degree setup/setback offset								
Climate Zone 1: Amarillo	0.111	486	0.126	598	0.111	627	0.126	726
Climate Zone 2: Dallas	0.146	559	0.161	686	0.146	640	0.161	761
Climate Zone 3: Houston	0.151	559	0.166	695	0.151	602	0.166	735
Climate Zone 4: Corpus Christi	0.163	617	0.179	761	0.163	650	0.179	792
Climate Zone 5: El Paso	0.118	432	0.133	561	0.118	482	0.133	607

Table 319. Lodging Occupancy Sensors—Hotel per Room Energy and Peak Demand Savings

Climate zone[634]	Heat pump				Electric heat			
	HVAC only		HVAC and lighting		HVAC only		HVAC and lighting	
	kW	kWh	kW	kWh	kW	kWh	kW	kWh
5-degree setup/setback offset								
Climate Zone 1: Amarillo	0.053	232	0.072	439	0.053	303	0.072	530
Climate Zone 2: Dallas	0.073	258	0.093	452	0.073	303	0.093	505
Climate Zone 3: Houston	0.074	242	0.094	430	0.074	260	0.094	450
Climate Zone 4: Corpus Christi	0.081	260	0.102	451	0.081	267	0.102	459
Climate Zone 5: El Paso	0.056	178	0.075	360	0.056	196	0.075	380
10-degree setup/setback offset								
Climate Zone 1: Amarillo	0.102	426	0.121	568	0.102	557	0.121	684
Climate Zone 2: Dallas	0.134	452	0.154	617	0.134	517	0.154	676
Climate Zone 3: Houston	0.136	423	0.156	599	0.136	446	0.156	621

Climate zone[634]	Heat pump				Electric heat			
	HVAC only		HVAC and lighting		HVAC only		HVAC and lighting	
	kW	kWh	kW	kWh	kW	kWh	kW	kWh
Climate Zone 4: Corpus Christi	0.149	467	0.169	652	0.149	483	0.169	667
Climate Zone 5: El Paso	0.106	312	0.126	479	0.106	338	0.126	501

Table 320. Lodging Occupancy Sensors—Dormitory per Room Energy and Peak Demand Savings

Climate zone[634]	Heat pump				Electric heat			
	HVAC only		HVAC and lighting		HVAC only		HVAC and lighting	
	kW	kWh	kW	kWh	kW	kWh	kW	kWh
5-degree setup/setback offset								
Climate Zone 1: Amarillo	0.034	136	0.061	319	0.034	152	0.061	316
Climate Zone 2: Dallas	0.048	214	0.076	425	0.048	223	0.076	428
Climate Zone 3: Houston	0.051	242	0.078	461	0.051	244	0.078	462
Climate Zone 4: Corpus Christi	0.053	265	0.081	492	0.053	266	0.081	492
Climate Zone 5: El Paso	0.031	110	0.059	327	0.031	110	0.059	326
10-degree setup/setback offset								
Climate Zone 1: Amarillo	0.073	261	0.084	404	0.073	289	0.084	417
Climate Zone 2: Dallas	0.078	293	0.105	505	0.078	304	0.105	511
Climate Zone 3: Houston	0.081	326	0.108	543	0.081	328	0.108	545
Climate Zone 4: Corpus Christi	0.088	368	0.114	591	0.088	370	0.114	593
Climate Zone 5: El Paso	0.045	151	0.060	448	0.045	153	0.060	450

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) is 10 years based on the value for retrofit energy management system (EMS) HVAC control from the Massachusetts Joint Utility Measure Life Study[635]. This value is also consistent with the EUL for lighting control and HVAC control measures in PUCT Docket Nos. 36779 and 40668.

Program Tracking Data and Evaluation Requirements

The below list of 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
- HVAC system and equipment type
- Heating type (heat pump, electric resistance)
- Temperature offset category (5 or 10° F)
- Control type (HVAC only, HVAC and lighting)
- Building type (hotel, motel, dormitory)
- Number of rooms

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 40668—Provides deemed energy and demand savings values under "Guestroom, Dormitory and Multi-family Occupancy Controls for HVAC and Lighting Systems," page 25 and Attachment pages A-46 through A-58.
- PUCT Docket 36779—Provides EULs for commercial measures.

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

Document Revision History

Table 321. Lodging Occupancy Sensors—Revision History

TRM version	Date	Description of change
v2.0	04/18/2014	TRM v2.0 origin.
v3.0	04/10/2015	TRM v3.0 update. No revision.
v4.0	10/10/2016	TRM v4.0 update. No revision.

635 Energy and Resource Solutions (2005). *Measure Life Study.* Prepared for the Massachusetts Joint Utilities; Table 1-1, Prescriptive Common Measure Life Recommendations, Large C&I retrofit, HVAC Controls, EMS.

TRM version	Date	Description of change
v5.0	10/2017	TRM v5.0 update. No revision.
v6.0	10/2018	TRM v6.0 update. No revision.
v7.0	10/2019	TRM v7.0 update. No revision.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits.
v9.0	10/2021	TRM v9.0 update. No revision.
v10.0	10/2022	TRM v10.0 update. Changed Climate Zone 4 reference city from McAllen to Corpus Christi.
v11.0	10/2023	TRM v11.0 update. No revision.
v12.0	10/2024	TRM v12.0 update. No revision.

~~2.7.6~~2.7.7 Vending Machine Controls Measure Overview

TRM Measure ID: NR-MS-VC

Market Sector: Commercial

Measure Category: Miscellaneous

Applicable Building Types: All building types ~~applicable~~

Fuels Affected: Electricity

Decision/Action Type: Retrofit

Program Delivery Type: Prescriptive

Deemed Savings Type: Look-up tables

Savings Methodology: M&V

Measure Description

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

Eligibility Criteria

This measure applies to refrigerated beverage vending machines manufactured and purchased prior to August 31, 2012. Refrigerated beverage vending machines manufactured after this date must already comply with current federal-standard maximum daily-energy consumption requirements.

All non-refrigerated snack machines are eligible if controls are installed on equipment consistent with the baseline condition below. Display lighting must not have been permanently installed.

Baseline Condition

The baseline condition is a 120-volt single phase refrigerated beverage or non-refrigerated snack vending machine without any controls.

High-Efficiency Condition

The high-efficiency condition is a 120-volt single-phase refrigerated beverage or non-refrigerated-snack vending machine with occupancy controls and compliant with the current federal standard, effective January 8, 2019.[636]

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Energy savings are deemed based on a metering study completed by Pacific Gas & Electric (PG&E). Delta load shapes for this measure are taken from a Sacramento Municipal Utility District (SMUD) metering study. Demand savings for refrigerated cold drink units are calculated based on a probability-weighted analysis of hourly consumption impacts, and demand savings for other unit types are adjusted proportionally based on differences in rated product wattage.

Deemed Energy and Demand Savings Tables

Energy and demand savings are specified by unit type and climate zone in the following tables:

Table 322. Vending Controls—Refrigerated Cold Drink Energy and Peak Savings[637]

Climate zone	kWh savings	Summer kW savings[638]	Winter kW savings
Climate Zone 1: Amarillo	1,612	0.023	0.060
Climate Zone 2: Dallas		0.021	0.063
Climate Zone 3: Houston		0.022	0.060
Climate Zone 4: Corpus Christi		0.022	0.064
Climate Zone 5: El Paso		0.015	0.068

636 Appliance Standards for Refrigerated Beverage Vending Machines. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=29#current_standards.
637 Pacific Gas and Electric, Work Paper VMCold, Revision 3, August 2009, Measure Code R97.
638 Chappell, C., Hanzawi, E., Bos, W., Brost, M., and Peet, R. (2002). "Does It Keep the Drinks Cold and Reduce Peak Demand? An Evaluation of a Vending Machine Control Program," 2002 ACEEE Summer Study on Energy Efficiency in Buildings Proceedings, pp. 10.47-10.56. https://www.eceee.org/static/media/uploads/site-2/library/conference_proceedings/ACEEE_buildings/2002/Panel_10/p10_5/paper.pdf.

Table 323. Vending Controls—Refrigerated Reach-In Energy and Peak Demand Savings[639]

Climate zone	kWh savings	Summer kW savings	Winter kW savings
Climate Zone 1: Amarillo	1,086	0.026	0.069
Climate Zone 2: Dallas		0.024	0.073
Climate Zone 3: Houston		0.026	0.068
Climate Zone 4: Corpus Christi		0.026	0.074
Climate Zone 5: El Paso		0.017	0.078

Table 324. Vending Controls—Non-Refrigerated Snack Energy and Peak Demand Savings[640]

Climate zone	kWh savings	Summer kW savings	Winter kW savings
Climate Zone 1: Amarillo	387	0.005	0.013
Climate Zone 2: Dallas		0.004	0.013
Climate Zone 3: Houston		0.005	0.013
Climate Zone 4: Corpus Christi		0.005	0.014
Climate Zone 5: El Paso		0.003	0.014

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) is 5 years, as specified in the California Database of Energy Efficiency Resources (DEER) READI tool for EUL ID Plug-VendCtrler.[641]

Program Tracking Data and Evaluation Requirements

The below list of primary inputs and contextual data should be specified and tracked within the program database to inform the evaluation and apply the savings properly:

- Vending machine type (refrigerated cold drink unit, refrigerated reach-in unit, or non-refrigerated snack unit with lighting)
- Vending machine manufacture date

639 Pacific Gas and Electric, Work Paper VMReach, Revision 3, August 2009, Measure Code R143.
640 Pacific Gas and Electric, Work Paper VMSnack, Revision 3, August 2009, Measure Code R98.
641 DEER READI (Remote Ex-Ante Database Interface). http://www.deeresources.com/index.php/readi.

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 40669—Provides energy and demand savings and measure specifications. Appendix A: https://interchange.puc.texas.gov/Documents/40669_3_735684.PDF.
- PUCT Docket 36779—Provides EUL for Vending Machine Controls.

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

Document Revision History

Table 325. Vending Controls—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 revision.
v3.0	04/10/2015	TRM v3.0 update. No revision.
v4.0	10/10/2016	TRM v4.0 update. No revision.
v5.0	10/2017	TRM v5.0 update. No revision.
v6.0	10/2018	TRM v6.0 update. No revision.
v7.0	10/2019	TRM v7.0 update. No revision.
v8.0	10/2020	TRM v8.0 update. Clarified baseline condition and updated demand savings for compliance with current peak definition.
v9.0	10/2021	TRM v9.0 update. General text edits.
v10.0	10/2022	TRM v10.0 update. No revision.
v11.0	10/2023	TRM v11.0 update. No revision.
v12.0	10/2024	TRM v12.0 update. No revision.

~~2.7.7~~2.7.8 Computer Power Management Measure Overview

TRM Measure ID: NR-MS-CP

Market Sector: Commercial

Measure Category: Miscellaneous

Applicable Building Types: All building types ~~applicable~~

Fuels Affected: Electricity

Decision/Action Type: Retrofit

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed value (per machine)

Savings Methodology: Algorithms

Measure Description

This measure presents deemed savings for implementation of computer power management strategies. Computer power management includes the use of operational settings that automate the power management features of computer equipment, including automatically placing equipment into a low power mode during periods of inactivity. This may be done either with built-in features integral to the computer operating system or through an add-on software program. Typically, this measure is implemented across an entire network of computers.

Eligibility Criteria

To be eligible for this measure, computers must not have any automatic sleep or other low power setting in place. Both conventional and ENERGY STAR computer equipment are eligible for this measure. Applicable building types include offices and schools.

Baseline Condition

The baseline conditions are the estimated number of hours that the computer spends in active, sleep, and off modes before the power settings are actively managed. Operating hours may be estimated from metering, or the default hours provided in the calculation of deemed savings may be used. The default baseline hours are taken from the ENERGY STAR modeling study assumptions contained in the Low Carbon IT Savings Calculator[642], and assume baseline computer settings never enter sleep mode, and 60% of computers are turned off each night.[643]

[642] ENERGY STAR Low Carbon IT Calculator available for download at: https://www.energystar.gov/products/low_carbon_it_campaign/put_your_computers_sleep.

[643] Based on 2015 custom project metering from El Paso Electric.

High-Efficiency Condition

The efficient conditions are the estimated number of hours that the computer spends in active, sleep, and off modes after the power settings are actively managed. Operating hours may be estimated from metering, or the default hours provided in the calculation of deemed savings may be used. The default efficient hours are taken from the ENERGY STAR modeling study assumptions contained in the Low Carbon IT Savings Calculator and assume managed computer settings enter sleep mode after 15 minutes of inactivity, and 80% of computers are turned off each night.[644]

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

$$Energy\ Savings\ [\Delta kWh] = \frac{W_{active}\left(Hrs_{active,pre} - Hrs_{active,post}\right) + W_{sleep}\left(Hrs_{sleep,pre} - Hrs_{sleep,post}\right) + W_{off}\left(Hrs_{off,pre} - Hrs_{off,post}\right)}{1{,}000}$$

Equation 281

$$Summer\ Peak\ Demand\ Savings\ [\Delta kW] = \left(W_{active} - W_{sleep}\right) \times CF_{inactive,S}$$

Equation 282

$$Winter\ Peak\ Demand\ Savings\ [\Delta kW] = 0$$

Equation 283

Where:

W_{active} = *Total wattage of the equipment, including computer and monitor, in active/idle mode (see Table 326)*

$Hrs_{active,pre}$ = *Annual number of hours the computer is in active/idle mode before computer management software is installed (see Table 327)*

$Hrs_{active,post}$ = *Annual number of hours the computer is in active/idle mode after computer management software is installed (see Table 327)*

W_{sleep} = *Total wattage of the equipment, including computer and monitor, in sleep mode (see Table 326)*

$Hrs_{sleep,pre}$ = *Annual number of hours the computer is in sleep mode before computer management software is installed (see Table 327)*

$Hrs_{sleep,post}$ = *Annual number of hours the computer is in sleep mode after computer management software is installed (see Table 327)*

[644] Based on 2015 custom project metering from El Paso Electric.

W_{off}	=	*Total wattage of the equipment, including computer and monitor, in off mode (see Table 326)*
$Hrs_{off,pre}$	=	*Annual number of hours the computer is in off mode before computer management software is installed (see Table 327)*
$Hrs_{off,post}$	=	*Annual number of hours the computer is in off mode after computer management software is installed (see Table 327)*
1,000	=	*Constant to convert from W to kW*
$CF_{inactive,S}$	=	*Inactive summer peak coincidence factor (see Table 328)*

Table 326. Computer Power Management—Equipment Wattages[645]

Equipment	W_{active}	W_{sleep}	W_{off}
Conventional monitor[646]	18.3	0.30	0.30
Conventional computer	48.11	2.31	0.96
Conventional notebook (including display)	14.82	1.21	0.61
ENERGY STAR monitor	15.0	0.26	0.26
ENERGY STAR computer	27.11	1.80	0.81
ENERGY STAR notebook (including display)	8.61	0.89	0.46

Table 327. Computer Power Management—Operating Hours[647]

Building activity type	$Hrs_{active,pre}$	$Hrs_{active,post}$	$Hrs_{sleep,pre}$	$Hrs_{sleep,post}$	$Hrs_{off,pre}$	$Hrs_{off,post}$
Typical office (8 hours/day, 5 days/week, 22 non-workdays/year)	4,650	1,175	0	2,105	4,110	5,480
Typical school (8 hours/day, 5 days/week, 113 non-school days/year)	4,213	727	0	1,970	4,547	6,063

645 Equipment wattages taken from the ENERGY STAR Office Equipment Calculator, updated October 2016. Available for download at https://www.energystar.gov/buildings/save_energy_commercial_buildings/ways_save/energy_efficient_products.

646 Average of 17.0-24.9 inches monitor sizes taken from the ENERGY STAR® Office Equipment Calculator.

647 Hours taken from assumptions in the ENERGY STAR calculator. $Hours_{pre}$ assume baseline computer settings never enter sleep mode, and 36% of computers are turned off each night. $Hours_{post}$ assume managed computer settings enter sleep mode after 15 minutes of inactivity, and 80% of computers are turned off each night.

Table 328. Computer Power Management—Coincidence Factors

Climate zone	Summer CF		Winter CF	
	Active	Inactive	Active	Inactive
Climate Zone 1: Amarillo	0.65	0.35	0.11	0.89
Climate Zone 2: Dallas	0.62	0.38	0.12	0.88
Climate Zone 3: Houston	0.66	0.34	0.12	0.88
Climate Zone 4: Corpus Christi	0.62	0.38	0.14	0.86
Climate Zone 5: El Paso	0.75	0.25	0.28	0.72

Deemed Energy and Demand Savings Tables

Energy and demand savings are deemed values for conventional and ENERGY STAR equipment, based on the input assumptions listed in Table 326, Table 327, and Table 328. The following tables provide these deemed values.

Table 329. Computer Power Management—Energy Savings for Offices & Schools

Equipment	kWh Savings
Conventional LCD monitor	62.6
Conventional computer	161.4
Conventional notebook	48.2
ENERGY STAR monitor	51.3
ENERGY STAR computer	89.5
ENERGY STAR notebook	27.5

Table 330. Computer Power Management—Peak Demand Savings for Offices & Schools

Equipment	Climate Zone 1: Amarillo		Climate Zone 2: Dallas		Climate Zone 3: Houston		Climate Zone 4: Corpus Christi		Climate Zone 5: El Paso	
	Summer (kW)	Winter (kW)	Summer (kW)	Winter (kW)	Summer (kW)	Winter (kW)	Summer (kW)	Winter (kW)	Summer (kW)	Winter (kW)
Conventional LCD monitor	0.006	–	0.007	–	0.006	–	0.007	–	0.004	–
Conventional computer	0.016	–	0.017	–	0.015	–	0.017	–	0.011	–
Conventional notebook	0.005	–	0.005	–	0.005	–	0.005	–	0.003	–
ENERGY STAR monitor	0.005	–	0.006	–	0.005	–	0.006	–	0.004	–
ENERGY STAR computer	0.009	–	0.010	–	0.009	–	0.010	–	0.006	–
ENERGY STAR notebook	0.003	–	0.003	–	0.003	–	0.003	–	0.002	–

Claimed Peak Demand Savings

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

Winter demand savings are not specified for this measure based on an assumption that the reduced operating hours are not achieved during the winter peak period.

Measure Life and Lifetime Savings

The estimated useful life (EUL) of this measure is 3 years, based on the useful life of the computer equipment being controlled.[648]

Program Tracking Data and Evaluation Requirements

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

- Equipment type
  - Conventional or ENERGY STAR
  - Monitor, computer, or notebook
- Application type (office, school)

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

Document Revision History

Table 331. Computer Power Management—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. Incorporated version 2 baseline adjustments and revised savings.

648 Internal Revenue Service, 1.35.6.10, Property and Equipment Capitalization, Useful life for Laptop and Desktop Equipment. July 2016. https://www.irs.gov/irm/part1/irm_01-035-006.

TRM version	Date	Description of change
v9.0	10/2021	TRM v9.0 update. Updated peak demand savings coefficients and deemed savings. Added application type to documentation requirements. Eliminated winter demand savings.
v10.0	10/2022	TRM v10.0 update. No revision.
v11.0	10/2023	TRM v11.0 update. No revision.
v12.0	10/2024	TRM v12.0 update. No revision.

~~2.7.8~~2.7.9 ENERGY STAR® Electric Vehicle Supply Equipment Measure Overview

TRM Measure ID: NR-MS-EV

Market Sector: Commercial

Measure Category: Miscellaneous

Applicable Business Types: All

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 measure applies to the installation of electric vehicle supply equipment (EVSE) meeting the specifications of ENERGY STAR Level 2 at a commercial site. EVSE is the infrastructure that enables plug-in electric vehicles (PEV) to charge onboard batteries. Level 2 EVSE require 240-volt electrical service. This measure provides deemed savings for the energy efficiency improvement of an ENERGY STAR EVSE over a standard or non-ENERGY STAR EVSE.

Eligibility Criteria

Eligible equipment includes ENERGY STAR compliant Level 2 EVSE installed in a commercial application, which includes public, multifamily, workplace, and fleet locations. Public locations are sites where an EVSE is intended to be used by the public or visitors to the site. This includes locations such as retail, education, municipal, hospitality, and other similar locations. For the purposes of this measure, multifamily sites are public locations. Workplace locations include sites where an EVSE is intended to be used by employees to charge their personal vehicles when reporting to the workplace site. Fleet locations include sites where an EVSE is intended to be used to charge a fleet of company vehicles. The EVSE may be installed for use on either an all-battery electric vehicle (BEV) or a plug-in hybrid electric vehicle (PHEV). Savings estimates for this measure are based on studies of light duty vehicles; EVSE for charging heavy duty vehicles should pursue custom M&V.

Baseline Condition

The baseline condition is a non-ENERGY STAR compliant Level 2 EVSE.

High-Efficiency Condition

The high-efficiency condition is a Level 2 EVSE compliant with ENERGY STAR Version 1.1 Specification, effective March 31, 2021.[649]

Energy and Demand Savings Methodology

Savings for EVSE come from efficiency gains of the ENERGY STAR equipment during operating modes when the vehicle is plugged in but not charging and when not plugged in. Deemed savings are calculated according to the following algorithms.

Savings Algorithms and Input Variables

$$ENERGY\ STAR\ Idle\ Consumption\ [kWh] = \frac{\left(Hrs_{plug} \times W_{plug} + Hrs_{unplug,C} \times W_{unplug}\right) \times days_{C} + Hrs_{unplug,NC} \times W_{unplug} \times days_{NC}}{1{,}000}$$

Equation 284

$$Baseline\ Idle\ Consumption\ [kWh] = \frac{ENERGY\ STAR\ Idle\ Consumption}{0.6}$$

Equation 285

$$Energy\ Savings\ [\Delta kWh] = Baseline\ Idle\ Consumption - ENERGY\ STAR\ Idle\ Consumption$$

Equation 286

$$Peak\ Demand\ Savings\ [\Delta kW] = \frac{\Delta kWh}{Hrs_{unplug,C} \times days_{C} + Hrs_{unplug,NC} \times days_{NC}} \times PDPF$$

Equation 287

Where:

Hrs_{plug} = *Time per day the vehicle is plugged into the EVSE and not charging [hours][650] = 2.8*

W_{plug} = *Wattage of the EVSE when the vehicle is plugged into the EVSE but not charging [W][651] = 6.9 W*

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649 ENERGY STAR Program Requirements for Electric Vehicle Supply Equipment Eligibility Criteria v1.1. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20V1.1%20DC%20EVSE%20Final%20Specification_0.pdf.

650 National Renewable Energy Laboratory (NREL), February 2018, "Charging Electric Vehicles in Smart Cities: An EVI-Pro Analysis of Columbus Ohio," page 26, Table 8: Charging Statistics by Location Type and Level, ChargePoint Data. Average across all location types, dwell time minus charging duration.

651 Average Idle Mode Input Power from ENERGY STAR certified EVSE product list as of July 13, 2020.

$Hrs_{unplug,C}$	=	*Time per day the vehicle is not plugged into the EVSE on a charging day [hours]*[652] *=19*
$Hrs_{unplug,NC}$	=	*Time per day the vehicle is not plugged into the EVSE on a non-charge day [hours] = 24*
W_{unplug}	=	*Wattage of the EVSE when the vehicle is not plugged into the EVSE [W]*[653] *= 3.3*
$days_C$	=	*Number of charging days per year [days]*[654] *= 204*
$days_{NC}$	=	*Number of non-charging days per year [days] = 161*
1,000	=	*Constant to convert from W to kW*
0.6	=	*Efficiency adjustment factor*[655]
PDPF	=	*Peak demand probability factor (see Table 332)*

Table 332. EVSE—Peak Demand Probability Factors[656]

Location type	Public		Workplace		Fleet	
Climate zone	Summer PDPF	Winter PDPF	Summer PDPF	Winter PDPF	Summer PDPF	Winter PDPF
Climate Zone 1: Amarillo	0.46526	0.46032	0.87484	0.75271	0.27206	0.44421
Climate Zone 2: Dallas	0.45808	0.47380	0.86213	0.75558	0.22867	0.42040
Climate Zone 3: Houston	0.46134	0.42544	0.87173	0.68222	0.26507	0.34306
Climate Zone 4: Corpus Christi	0.46892	0.49816	0.87553	0.77324	0.25862	0.50077
Climate Zone 5: El Paso	0.42680	0.51324	0.80969	0.92091	0.15042	0.57715

Deemed Energy and Demand Savings Tables

Table 333 presents the deemed annual energy savings per EVSE.

652 NREL "Charging Electric Vehicles in Smart Cities: An EVI-Pro Analysis of Columbus Ohio," page 26, Table 8; 24 hours per day minus average dwell time.

653 Average No Vehicle Mode Input Power from ENERGY STAR certified EVSE product list.

654 NREL "Charging Electric Vehicles in Smart Cities: An EVI-Pro Analysis of Columbus Ohio," page 25; 0.56 charging sessions per day per plug in Austin, Texas. 365 x 0.56 = 204.

655 ENERGY STAR Electric Vehicle Chargers Buying Guidance: "ENERGY STAR certified EV charger… on average use 40% less energy than a standard EV charger when the charger is in standby mode (i.e., not actively charging a vehicle)." https://www.energystar.gov/products/other/evse.

656 Probability weighted peak load factors are calculated according to the method in Section 4 of the Texas TRM Vol 1 using data from NREL "Charging Electric Vehicles in Smart Cities: An EVI-Pro Analysis of Columbus Ohio," page 27, Figure 21: Daily distribution of ChargePoint charging events by EVSE type and day of the week.

Table 333. EVSE—Energy Savings

kWh Savings (all location types)
19.7

Table 334 presents the deemed summer and winter peak kW savings per EVSE.

Table 334. EVSE—Peak Demand Savings

Location type	Public		Workplace		Fleet	
Climate zone	Summer peak kW	Winter peak kW	Summer peak kW	Winter peak kW	Summer peak kW	Winter peak kW
Climate Zone 1: Amarillo	0.0012	0.0012	0.0022	0.0019	0.0008	0.0012
Climate Zone 2: Dallas	0.0012	0.0012	0.0022	0.0019	0.0006	0.0012
Climate Zone 3: Houston	0.0012	0.0011	0.0022	0.0017	0.0007	0.0010
Climate Zone 4: Corpus Christi	0.0012	0.0013	0.0022	0.0020	0.0007	0.0014
Climate Zone 5: El Paso	0.0011	0.0013	0.0021	0.0023	0.0004	0.0016

Claimed Peak Demand Savings

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

Additional Calculators and Tools

Not applicable.

Measure Life and Lifetime Savings

The estimated useful life (EUL) for an EVSE is assumed to be 10 years.[657]

Program Tracking Data and Evaluation Requirements

It is required that the following list of primary inputs and contextual data be specified and tracked by the program database to inform the evaluation and apply the savings properly:

- Climate zone or county
- Location Type (public, workplace, or fleet) [658]
- EVSE quantity

[657] U.S. Department of Energy Vehicle Technologies Office, November 2015, "Costs Associated with Non-Residential Electric Vehicle Supply Equipment" p. 21. https://afdc.energy.gov/files/u/publication/evse_cost_report_2015.pdf.
[658] Refer to Eligibility Criteria section for location type definitions.

- EVSE manufacturer and model number

References and Efficiency Standards

Petitions and Rulings

- This section not applicable.

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

Document Revision History

Table 335. EVSE—Revision History

TRM version	Date	Description of change
v8.0	10/2020	TRM v8.0 origin.
v9.0	10/2021	TRM v9.0 update. General reference checks and text edits.
v10.0	10/2022	TRM v10.0 update. Added reference for ENERGY STAR version.
v11.0	10/2023	TRM v11.0 update. No revision.
v12.0	10/2024	TRM v12.0 update. No revision.

~~2.7.9~~2.7.10 Industrial High-Frequency Battery Chargers Overview

TRM Measure ID: NR-MS-BC

Market Sector: Commercial

Measure Category: Other/miscellaneous

Applicable Building Types: Any commercial

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

Industrial electric vehicle fleets used for material handling, or forklifts, use battery charging systems to convert AC source power into DC power required to charge the vehicle batteries. Traditional charging systems include Ferro resonant (FR) and silicon-controlled rectifier (SCR) charging equipment. This measure is for a single high-frequency battery charger that converts AC to DC power more efficiently than traditional systems due to switch mode operation that reduces heat and power loss throughout the system.

Baseline Condition

The baseline condition is a typical FR or SCR charging system operating in an industrial warehouse setting to power forklifts.

High-Efficiency Condition

There is no federal standard for large industrial battery chargers. Therefore, the efficient condition is the energy efficiency standard for large battery systems in California Appliance Efficiency Regulations, Title 20, which is detailed in the following table.

Table 336. Battery Chargers—Efficiency Requirements[659]

Performance factor		Requirement
Charge return factor	100 percent, 80 percent depth of discharge	≤ 1.10
	40% depth of discharge	≤ 1.15
Power conversion efficiency		≥ 89%
Power factor		≥ 90%
No battery mode power		≤ 10 W

Energy and Demand Savings Methodology

Battery charger systems operate in three modes: *charge*, *maintenance*, and *no battery*. In *charge* mode, the battery is accumulating charge. *Maintenance* mode occurs when the battery is fully charged, and the charger is simply supplying energy to counteract natural discharge. *No battery* mode indicates that the battery has been fully disconnected from the charger.

Savings Algorithms and Input Variables

The deemed savings values area calculated using the following algorithms:

$$hours = DC \times 8{,}760$$

Equation 288

$$Energy\ Savings\ [kWh_{savings}] = hours_C \times \frac{W_{C,pre} - W_{C,post}}{1{,}000} + hours_M \times \frac{W_{M,pre} - W_{M,post}}{1{,}000} + hours_{NC} \times \frac{W_{NC,pre} - W_{NC,post}}{1{,}000}$$

Equation 289

$$Summer\ Peak\ Demand\ Savings\ [kW_{savings}] = \frac{kWh_{savings}}{hours_C + hours_M + hours_{NB}} \times CF_S$$

Equation 290

$$Winter\ Peak\ Demand\ Savings\ [kW_{savings}] = \frac{kWh_{savings}}{hours_C + hours_M + hours_{NB}} \times CF_W$$

Equation 291

Where:

8,760 = *Annual hours per year*

[659] California Appliance Efficiency Regulations, Title 20, Section 1605.3 State Standards for Non-Federally-Regulated Appliances, (w) Battery Chargers and Battery Charger Systems. https://energycodeace.com/content/reference-ace-t20-tool.

$DC_{C/M/NB}$	=	*Duty cycle in charging, maintenance, and no battery mode (see Table 337)*
$hours_{C/M/NB}$	=	*Annual number of hours in charging, maintenance, and no battery mode (see Table 337)*
$W_{C/M/NB}$	=	*Wattage draw in charging, maintenance, and no battery mode (see Table 338)*
$CF_{S/W}$	=	*Seasonal peak coincidence factor (see Table 339)*
1,000	=	*Conversion constant for W to kW*

Table 337. Battery Chargers—Charging and Idle Hours Assumptions[660]

Equipment	DC_C	DC_M	DC_{NB}	$hours_C$	$hours_M$	$hours_{NB}$
Single phase	45%	31%	24%	3,942	2,716	2,102
Three phase	94%	–	6%	8,234	–	526

Table 338. Battery Chargers—Pre/Post Charing and Idle Wattage Assumptions[661]

Equipment	$W_{C,pre}$	$W_{M,pre}$	$W_{NB,pre}$	$W_{c,post}$	$W_{M,post}$	$W_{NB,post}$
Single phase	2,000	50	50	1,767	10	10
Three phase	5,785	89	34	5,111	10	10

Table 339. Battery Charging System—Coincidence Factors[662]

Equipment	Summer	Winter
Single phase	0.19	–
Three phase	1	–

Deemed Energy and Peak Demand Savings Tables

The deemed energy and seasonal peak savings values are presented in the following table.

660 "Analysis of Standard Options for Battery Charger Systems," Ecos Consulting for Title 20 CASE Initiative. Version 2.2.2. October 1, 2010. Table 6. https://www.kannahconsulting.com/wp-content/uploads/2016/08/2010-10-11_Battery_Charger_Title_20_CASE_Report_v2-2-2.pdf.

661 "Analysis of Standard Options for Battery Charger Systems," Ecos Consulting for Title 20 CASE Initiative. Version 2.2.2. October 1, 2010. W_{pre}: Table 7, W_{post}: Table 10. https://www.kannahconsulting.com/wp-content/uploads/2016/08/2010-10-11_Battery_Charger_Title_20_CASE_Report_v2-2-2.pdf.

662 "Analysis of Standard Options for Battery Charger Systems," Ecos Consulting for Title 20 CASE Initiative. Version 2.2.2. October 1, 2010. Table 7 and Table 10. https://www.kannahconsulting.com/wp-content/uploads/2016/08/2010-10-11_Battery_Charger_Title_20_CASE_Report_v2-2-2.pdf.

Table 340. Battery Chargers—Deemed Energy and Demand Savings per Charger

Equipment	kWh savings	Summer kW savings	Winter kW savings
Single phase	1,111	0.02	–
Three phase	5,562	0.63	–

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 high efficiency battery chargers is 15 years.[663]

Program Tracking Data and Evaluation Requirements

It is required that the following list of primary inputs and contextual data be specified and tracked by the program database to inform the evaluation and apply the savings properly:

- Battery charger quantity
- Battery charger manufacturer and model number
- Charger type (single phase, three phase)
- Depth of discharge
- Charge return factor
- Power conversion efficiency
- Power factor
- No battery mode power (W)

Document Revision History

Table 341. Industrial High-Frequency Battery Chargers—Revision History

TRM version	Date	Description of change
v11.0	10/2023	TRM v11.0 origin
v12.0	10/2024	TRM v12.0 update. No revision.

663 "Analysis of Standard Options for Battery Charger Systems," Ecos Consulting for Title 20 CASE Initiative. Version 2.2.2. October 1, 2010. Table 18. https://www.kannahconsulting.com/wp-content/uploads/2016/08/2010-10-11_Battery_Charger_Title_20_CASE_Report_v2-2-2.pdf.

~~2.7.10~~2.7.11 Steam Trap Repair and Replacement Measure Overview

TRM Measure ID: NR-MS-ST

Market Sector: Commercial

Measure Category: Miscellaneous

Applicable Business Types: All

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

Faulty steam traps that allow steam to leak require makeup water to re-generate the lost steam. This measure applies to the replacement or repair of faulty mechanical (thermostatic, thermodynamic, bucket, or fixed orifice) steam traps in industrial and commercial facilities. The measure also covers annual maintenance of venturi steam traps after their deemed 20-year measure life.

Eligibility Criteria

The measure is applicable to failed steam traps in commercial and industrial applications less than 300 pounds per square in gauge (psig). Residential, multifamily, and heating radiator applications are not eligible to claim savings under the methods in this measure.

Baseline Condition

The baseline condition is a faulty (blocked, leaking, or blow-through) mechanical steam trap in need of replacement or repair.

High-Efficiency Condition

The high-efficiency condition is the repair of a faulty steam trap, replacement with a venturi steam trap installed in compliance with ASME PTC 39-2005, or annual maintenance of a venturi steam trap.

A venturi steam trap removes condensate from steam systems by utilizing the thermodynamic pressure properties of water passing through a fixed venturi orifice rather than by the moving parts found in traditional steam traps. There are numerous steam system parameters that influence operating pressure, system load, and system operations. Venturi steam traps are an engineering solution that must be designed and sized by a qualified professional based on specific site conditions.

Annual maintenance of a venturi steam trap after exhausting its deemed 20-year measure life with savings awarded on a year-to-year basis includes the removal, cleaning, and replacement of the trap strainer. Some traps may contain an integrated strainer blowdown valve for improved maintenance.

Energy and Demand Savings Methodology

Electrical energy savings for this measure are calculated based on the energy associated with makeup required to replace water lost due to steam leaks. Savings are presented per trap.

Savings Algorithms and Input Variables

$$Energy\ Savings\ [\Delta kWh] = \Delta Water\ (gallons)/1{,}000{,}000 \times E_{water\ supply}$$

Equation 292

$$\Delta Water = \frac{S_L\ (lb/hr)}{8.33\ (lbs/gal)} \times Hours \times L$$

Equation 293

$$S_L = 24.24 \times P_{ia} \times D^2 \times A \times FF$$

Equation 294

$$Peak\ Demand\ Savings\ [\Delta kW] = \frac{\Delta kWh}{Hours} \times DF$$

Equation 295

Where:

$E_{water\ supply}$	=	*Water supply energy factor: 2,300 kWh/million gallons*
S_L	=	*Average steam loss per trap (lb/hr) (see Table 342)*
Hours	=	*Annual hours when steam system is operational, equal to heating degree days by climate zone (see Table 343)*
L	=	*Percentage leakage, 1 per each leaking trap with a system audit to document leaks; for full system replacement without a system audit, use default values from Table 342*
24.24	=	*Constant lb/(hr-psia-in2)*
P_{ia}	=	*Average steam trap inlet pressure, absolute (psia),* $P_{ig} + P_{atm}$
P_{ig}	=	*Average steam trap inlet pressure, gauge (psig) (see Table 342)*
P_{atm}	=	*Atmospheric pressure, 14.7 psia*

D = *Diameter of orifice (inches), use actual if possible, or defaults in Table 342*

A = *Adjustment factor: 50% for all steam systems; this factor is to account for reducing the maximum theoretical steam flow to the average steam flow (the Enbridge factor)*

FF = *Flow factor for medium- and high-pressure steam systems to address industrial float and thermodynamic style traps where additional blockage is possible*

CF = *Peak coincidence factor, assume value of 1 for industrial and process steam applications; for commercial heating applications, see Table 36 through Table 40 in Section 2.2.2; for commercial dry cleaners, use CF for stand-alone retail*

Table 342. Steam Traps—Savings Calculation Input Assumptions[664]

Steam system	Psig	Diameter of orifice (inches)	Flow factor	Average steam loss, S_L (lb/hr/trap)	Hours	L
Commercial dry cleaners	82.8	0.125	100%	18.5	2,425	0.27
Industrial or process low pressure < 15 psig	-	-		6.9	8,282	0.16
Industrial or process medium pressure > 15 and < 30 psig	16	0.1875	50%	6.5	8,282	0.16
Industrial or process medium pressure > 30 and < 75 psig	47	0.2500		23.4	8,282	0.16
Industrial or process high pressure > 75 and < 125 psig	101			43.8	8,282	0.16
Industrial or process high pressure > 125 and < 175 psig	146			60.9	8,282	0.16
Industrial or process high pressure > 175 and < 250 psig	202			82.1	8,282	0.16
Industrial or process high pressure > 250 and < 300 psig	263			105.2	8,282	0.16
Commercial space heating low pressure steam (LPS)	-	-	100%	6.9	Table 343	0.27

664 Default inputs for the steam trap measure are sourced from the Illinois TRM version 9.0, Volume 2, measure 4.4.16 Steam Trap Replacement or Repair. https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010121_v9.0_Vol_2_C_and_I_09252020_Final.pdf

Table 343. Steam Traps—Commercial Heating Hours

Climate zone	Hours (HDD)[665]
Climate Zone 1: Amarillo	4,565
Climate Zone 2: Dallas	2,567
Climate Zone 3: Houston	1,686
Climate Zone 4: Corpus Christi	1,129
Climate Zone 5: El Paso	2,677

Deemed Energy and Demand Savings Tables

Table 344. Steam Traps—Energy Savings

Steam system	Climate zone	Annual kWh savings (per trap, without audit)	Annual kWh savings (per trap with audit)
Commercial dry cleaners	All	3.3	12.4
Industrial or process low pressure < 15 psig	All	2.5	15.8
Industrial or process medium pressure > 15 and < 30 psig	All	2.4	15.0
Industrial or process medium pressure > 30 and < 75 psig	All	8.6	53.4
Industrial or process high pressure > 75 and < 125 psig	All	16.0	100.2
Industrial or process high pressure > 125 and < 175 psig	All	22.3	139.2
Industrial or process high pressure > 175 and < 250 psig	All	30.0	187.7
Industrial or process high pressure > 250 and < 300 psig	All	38.5	240.5
Commercial space heating LPS	1 Amarillo	2.3	8.7
	2 DFW	1.3	4.9
	3 Houston	0.9	3.2
	4 Corpus	0.6	2.2
	5 El Paso	1.4	5.1

665 Heating degree days are calculated from TMY3 Hourly Weather Data by Climate Zone, available at http://texasefficiency.com/index.php/regulatory-filings/deemed-savings.

Claimed Peak Demand Savings

Table 345. Steam Traps—Peak Demand Savings, Without Audit

Steam type	Building type	Principal building activity	Climate Zone 1	Climate Zone 2	Climate Zone 3	Climate Zone 4	Climate Zone 5
Commercial dry cleaners	Mercantile	Stand-alone retail	1.36E-03	7.57E-04	5.92E-04	3.03E-04	3.58E-04
Low pressure ≤ 15 psig	All	Industrial or process	3.05E-04	3.05E-04	3.05E-04	3.05E-04	3.05E-04
Medium pressure > 15 and < 30 psig	All	Industrial or process	2.89E-04	2.89E-04	2.89E-04	2.89E-04	2.89E-04
Medium pressure ≥ 30 and < 75 psig	All	Industrial or process	1.03E-03	1.03E-03	1.03E-03	1.03E-03	1.03E-03
High pressure ≥ 75 and < 125 psig	All	Industrial or process	1.94E-03	1.94E-03	1.94E-03	1.94E-03	1.94E-03
High pressure ≥ 125 and < 175 psig	All	Industrial or process	2.69E-03	2.69E-03	2.69E-03	2.69E-03	2.69E-03
High pressure ≥ 175 and < 250 psig	All	Industrial or process	3.63E-03	3.63E-03	3.63E-03	3.63E-03	3.63E-03
High pressure ≥ 250 and < 300 psig	All	Industrial or process	4.65E-03	4.65E-03	4.65E-03	4.65E-03	4.65E-03
Commercial space heating LPS	Data center	Data center	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Education	College/ university	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
		Primary school	2.21E-04	3.39E-04	2.57E-04	1.54E-04	1.90E-04
		Secondary school	2.21E-04	3.03E-04	2.78E-04	1.80E-04	2.21E-04
	Food sales	Convenience store	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
		Supermarket	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Food service	Full-service restaurant	2.21E-04	2.57E-04	2.26E-04	1.80E-04	1.44E-04

Steam type	Building type	Principal building activity	Climate Zone 1	Climate Zone 2	Climate Zone 3	Climate Zone 4	Climate Zone 5
		24-hour full-service restaurant	2.21E-04	2.52E-04	2.26E-04	1.85E-04	1.39E-04
		Quick-service restaurant	2.47E-04	3.14E-04	2.62E-04	1.75E-04	1.34E-04
		24-hour quick-service restaurant	2.47E-04	3.09E-04	2.57E-04	1.75E-04	1.34E-04
	Healthcare	Inpatient	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
		Outpatient	1.39E-04	1.44E-04	1.49E-04	4.12E-05	2.06E-05
	Large multifamily	Midrise apartment	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Lodging	Large hotel	4.42E-04	4.22E-04	1.70E-04	1.08E-04	1.08E-04
		Nursing home	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
		Small hotel/motel	1.85E-04	2.16E-04	9.77E-05	5.14E-05	3.09E-05
	Office	Large office	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
		Medium office	3.70E-04	3.39E-04	2.16E-04	1.23E-04	1.39E-04
		Small office	1.49E-04	2.06E-04	1.44E-04	7.20E-05	7.72E-05
	Public assembly	Public assembly	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Religious worship	Religious worship	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Retail	Stand-alone retail	5.09E-04	2.83E-04	2.21E-04	1.13E-04	1.34E-04
		24-hour retail	2.21E-04	2.93E-04	2.11E-04	1.29E-04	1.44E-04
		Strip mall	2.01E-04	2.83E-04	2.16E-04	1.08E-04	1.39E-04
	Service	Service: Excluding food	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Steam type	Building type	Principal building activity	Climate Zone 1	Climate Zone 2	Climate Zone 3	Climate Zone 4	Climate Zone 5
	Warehouse	Warehouse	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Other	Other	1.39E-04	1.44E-04	9.77E-05	4.12E-05	2.06E-05

Table 346. Steam Traps—Peak Demand Savings, With Audit

Steam type	Building type	Principal building activity	Climate Zone 1	Climate Zone 2	Climate Zone 3	Climate Zone 4	Climate Zone 5
Commercial dry cleaners	Mercantile	Stand-alone retail	5.05E-03	2.80E-03	2.19E-03	1.12E-03	1.33E-03
Low pressure ≤ 15 psig	All	Industrial or process	1.91E-03	1.91E-03	1.91E-03	1.91E-03	1.91E-03
Medium pressure > 15 and < 30 psig	All	Industrial or process	1.81E-03	1.81E-03	1.81E-03	1.81E-03	1.81E-03
Medium pressure ≥ 30 and < 75 psig	All	Industrial or process	6.45E-03	6.45E-03	6.45E-03	6.45E-03	6.45E-03
High pressure ≥ 75 and < 125 psig	All	Industrial or process	1.21E-02	1.21E-02	1.21E-02	1.21E-02	1.21E-02
High pressure ≥ 125 and < 175 psig	All	Industrial or process	1.68E-02	1.68E-02	1.68E-02	1.68E-02	1.68E-02
High pressure ≥ 175 and < 250 psig	All	Industrial or process	2.27E-02	2.27E-02	2.27E-02	2.27E-02	2.27E-02
High pressure ≥ 250 and < 300 psig	All	Industrial or process	2.90E-02	2.90E-02	2.90E-02	2.90E-02	2.90E-02
Commercial space heating LPS	Data center	Data center	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Education	College/ university	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
		Primary school	8.19E-04	1.26E-03	9.53E-04	5.72E-04	7.05E-04
		Secondary school	8.19E-04	1.12E-03	1.03E-03	6.67E-04	8.19E-04
	Food sales	Convenience store	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Steam type	Building type	Principal building activity	Climate Zone 1	Climate Zone 2	Climate Zone 3	Climate Zone 4	Climate Zone 5
		Supermarket	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Food service	Full-service restaurant	8.19E-04	9.53E-04	8.38E-04	6.67E-04	5.33E-04
		24-hour full-service restaurant	8.19E-04	9.34E-04	8.38E-04	6.86E-04	5.14E-04
		Quick-service restaurant	9.14E-04	1.16E-03	9.72E-04	6.48E-04	4.95E-04
		24-hour quick-service restaurant	9.14E-04	1.14E-03	9.53E-04	6.48E-04	4.95E-04
	Healthcare	Inpatient	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
		Outpatient	5.14E-04	5.33E-04	5.52E-04	1.52E-04	7.62E-05
	Large multifamily	Midrise apartment	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Lodging	Large hotel	1.64E-03	1.56E-03	6.29E-04	4.00E-04	4.00E-04
		Nursing home	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
		Small hotel/motel	6.86E-04	8.00E-04	3.62E-04	1.91E-04	1.14E-04
	Office	Large office	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
		Medium office	1.37E-03	1.26E-03	8.00E-04	4.57E-04	5.14E-04
		Small office	5.52E-04	7.62E-04	5.33E-04	2.67E-04	2.86E-04
	Public assembly	Public assembly	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Religious worship	Religious worship	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Retail	Stand-alone retail	1.89E-03	1.05E-03	8.19E-04	4.19E-04	4.95E-04
		24-hour stand-alone retail	8.19E-04	1.09E-03	7.81E-04	4.76E-04	5.33E-04

Steam type	Building type	Principal building activity	Climate Zone 1	Climate Zone 2	Climate Zone 3	Climate Zone 4	Climate Zone 5
		Strip mall	7.43E-04	1.05E-03	8.00E-04	4.00E-04	5.14E-04
	Service	Service: Excluding food	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Warehouse	Warehouse	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Other	Other	5.14E-04	5.33E-04	3.62E-04	1.52E-04	7.62E-05

Measure Life and Lifetime Savings

The estimated useful life (EUL) for this measure is 6 years for standard steam traps and 20 years for venturi steam traps.[666]

Program Tracking Data and Evaluation Requirements

The list below 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.

- Application type of steam system
- Climate zone or county if application is commercial heating
- Steam trap quantity
- Type of measure undertaken for each trap: repaired, replaced, or maintained
- Audit documentation, if conducted, including count of leaking or faulty steam traps
- Maintenance documentation, if conducted, indicating strainer maintenance activities undertaken

References and Efficiency Standards

Petitions and Rulings

- This section not applicable.

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

Document Revision History

Table 347. Steam Traps—Revision History

TRM version	Date	Description of change
v9.0	10/2021	TRM 9.0 origin.
v10.0	10/2022	TRM 10.0 update. No revision.

[666] EULs for the steam trap measure are sourced from the Illinois TRM 9.0, volume 2, measure 4.4.16 Steam Trap Replacement or Repair. https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010121_v9.0_Vol_2_C_and_I_09252020_Final.pdf

TRM version	Date	Description of change
v11.0	10/2023	TRM v11.0 update. Aligned building type names across all commercial measures.
v12.0	10/2024	TRM v12.0 update.Building types realigned in tables.

~~2.7.11~~2.7.12 Hydraulic Gear Lubricants Measure Overview

TRM Measure ID: NR-MS-HL

Market Sector: Commercial

Measure Category: Miscellaneous

Applicable Business Types: All

Fuels Affected: Electricity

Decision/Action Type: Retrofit

Program Delivery Type: Prescriptive

Deemed Savings Type: Algorithm

Savings Methodology: Engineering algorithms and estimates

Measure Description

Hydraulic gear lubricants are used in manufacturing. Energy efficient hydraulic gear lubricants offer reduced energy consumption over standard lubricants because they have a lower coefficient of friction which reduces the friction between two moving parts (rotating pump equipment and hydraulic oil). This lower coefficient of friction reduces friction between moving components which in turn reduces the energy requirements. Additionally, efficient lubricants have a high viscosity index which reduces the effect of temperature and allows constant viscosity over a range of operating temperatures which optimizes volumetric and mechanical efficiency.

Eligibility Criteria

The measure is applicable to manufacturing and industrial sites using hydraulic gear lubricants for gearboxes.

Baseline Condition

The baseline condition is a gearbox using standard hydraulic lubricants.

High-Efficiency Condition

The high-efficiency condition is a gearbox using energy-efficiency hydraulic lubricants which have a higher viscosity index than standard lubricants.

Energy and Demand Savings Methodology

Electrical energy savings for this measure are calculated based on the energy reduction associated with a reduced coefficient of friction between moving hydraulic machine parts. There are no demand savings for this measure.

Savings Algorithms and Input Variables

$$Energy\ Savings\ [\Delta kWh] = HP_{motor} \times 0.746 \times \frac{LF}{\eta} \times hours \times EI$$

Equation 296

Where:

HP_{motor}	=	*Horsepower of the motor, actual nameplate*
0.746	=	*Constant to convert from hp to kW*
LF	=	*Motor load factor*[667] *= 75%*
η	=	*Motor efficiency (use default from Table 348 if actual is not available)*
hours	=	*Operating hours per year, actual*
EI	=	*Efficiency increase = 1.0% per gear mesh*[668]

Table 348. Hydraulic Gear Lubricants—Motor Efficiencies[669]

Motor hp	Full load efficiency	Motor hp	Full load efficiency
1	0.855	25	0.936
2	0.865	30	0.941
3	0.895	40	0.941
5	0.895	50	0.945
7.5	0.910	60	0.950
10	0.917	75	0.950
15	0.930	100	0.954
20	0.930		

Deemed Energy and Demand Savings Tables

There are no savings tables for this measure. Reference the savings equation listed above.

667 Assume motor is designed to operate at maximum efficiency, neat 75% of rated load. See DOE Motor Challenge Fact Sheet available at https://www.energy.gov/sites/prod/files/2014/04/f15/10097517.pdf. Accessed August 2021.

668 Illinois TRM v9.0 Volume 2, Measure 4.8.21 Energy Efficient Gear Lubricants, reference 1,354 identifying Exxon Mobil studies. https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010121_v9.0_Vol_2_C_and_I_09252020_Final.pdf. Accessed September 2022.

669 Code of Federal Regulations, Title 10, Chapter II, Subchapter D, Part 431.25 Table 1, Nominal Full-Load efficiencies of General Purpose Electric Motors (Subtype 1), 4 pole motors. https://www.ecfr.gov/cgi-bin/retrieveECFR?n=pt10.3.431#se10.3.431_125.

Claimed Peak Demand Savings

There are no demand savings for this measure.

Measure Life and Lifetime Savings

The estimated useful life (EUL) for this measure is 10 years based on the expect life of the equipment that the lubricant is used with.[670]

Program Tracking Data and Evaluation Requirements

The list below 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:

- Quantity
- Motor horsepower
- Motor operating hours

References and Efficiency Standards

Petitions and Rulings

- This section not applicable.

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

Document Revision History

Table 349. Hydraulic Gear Lubricants—Revision History

TRM version	Date	Description of change
v9.0	10/2021	TRM v9.0 origin.
v10.0	10/2022	TRM v10.0 update. No revision.
v11.0	10/2023	TRM v11.0 update. No revision.
v12.0	10/2024	TRM v12.0 update. No revision.

[670] 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.

~~2.7.12~~2.7.13 Hydraulic Oils Measure Overview

TRM Measure ID: NR-MS-HO

Market Sector: Commercial

Measure Category: Miscellaneous

Applicable Business Types: All

Fuels Affected: Electricity

Decision/Action Type: Retrofit

Program Delivery Type: Prescriptive

Deemed Savings Type: Algorithm

Savings Methodology: Engineering algorithms and estimates

Measure Description

Hydraulic oils are lubricants used in manufacturing. Energy-efficient hydraulic oil lubricants offer reduced energy consumption over standard oils because they have a lower coefficient of friction, which reduces the friction between two moving parts (rotating pump equipment and hydraulic oil). This lower coefficient of friction reduces friction between moving components which, in turn, reduces the energy requirements. Additionally, efficient oils have a high viscosity index which reduces the effect of temperature and allows constant viscosity over a range of operating temperatures, optimizing volumetric and mechanical efficiency at the pumps rated output. Additionally, energy efficient hydraulic oils reduce the operating temperature of the hydraulic system.

Eligibility Criteria

The measure is applicable to manufacturing and industrial sites using hydraulic oil lubricants for hydraulic equipment performance.

Baseline Condition

The baseline condition is hydraulic equipment using standard hydraulic oils.

High-Efficiency Condition

The high-efficiency condition is hydraulic equipment using energy-efficient hydraulic oils which have a higher viscosity index than standard oils.

Energy and Demand Savings Methodology

Electrical energy savings for this measure are calculated based on the energy reduction associated with a reduced coefficient of friction between moving hydraulic machine parts. There are no demand savings for this measure.

Savings Algorithms and Input Variables

$$Energy\ Savings\ [\Delta kWh] = HP_{motor} \times 0.746 \times \frac{LF}{\eta} \times hours \times EI$$

Equation 297

Where:

HP_{motor}	=	*Horsepower of the motor, actual nameplate*
0.746	=	*Constant to convert from hp to kW*
LF	=	*Motor load factor, 75%*[671]
η	=	*Motor efficiency (use default from Table 350 if actual is not available)*
hours	=	*Operating hours per year, actual*
EI	=	*Efficiency increase*[672] *= 3.2%*

Table 350. Hydraulic Oils—Motor Efficiencies[673]

Motor hp	Full load efficiency	Motor hp	Full load efficiency
1	0.855	25	0.936
2	0.865	30	0.941
3	0.895	40	0.941
5	0.895	50	0.945
7.5	0.910	60	0.950
10	0.917	75	0.950
15	0.930	100	0.954
20	0.930		

[671] Assume motor is designed to operate at maximum efficiency, neat 75% of rated load. See DOE Motor Challenge Fact Sheet available at https://www.energy.gov/sites/prod/files/2014/04/f15/10097517.pdf. Accessed August 2021.

[672] Focus on Energy Lubricant Study, https://focusonenergy.com/newsroom/lubricant-improves-efficiency-new-study.

[673] Code of Federal Regulations, Title 10, Chapter II, Subchapter D, Part 431.25 Table 1, Nomincal Full-Load efficiencies of General Purpose Electric Motors (Subtype 1), 4 pole motors. https://www.ecfr.gov/cgi-bin/retrieveECFR?n=pt10.3.431#se10.3.431_125.

Deemed Energy and Demand Savings Tables

There are no savings tables for this measure. Reference the savings equation listed above.

Claimed Peak Demand Savings

There are no demand savings for this measure.

Measure Life and Lifetime Savings

The estimated useful life (EUL) for this measure is 10 years based on the expect life of the motor that the oil is used with.[674]

Program Tracking Data and Evaluation Requirements

The list below 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:

- Quantity
- Motor horsepower
- Motor operating hours

References and Efficiency Standards

Petitions and Rulings

- This section not applicable.

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

Document Revision History

Table 351. Hydraulic Oils—Revision History

TRM version	Date	Description of change
v9.0	10/2021	TRM v9.0 origin.
v10.0	10/2022	TRM v10.0 update. No revision.
v11.0	10/2023	TRM v11.0 update. No revision.

674 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

TRM version	Date	Description of change
v12.0	10/2024	TRM v12.0 update. No revision.

~~2.7.13~~2.7.14 Hand Dryers Measure Overview

TRM Measure ID: NR-MS-HD

Market Sector: Commercial

Measure Category: Miscellaneous

Applicable Building Types: ~~Retail, commercial, and industrial settings~~All commercial

Fuels Affected: Electricity

Decision/Action Type: Retrofit

Program Delivery Type: Prescriptive

Deemed Savings Type: ~~Deemed savings calculation~~Look-up tables

Savings Methodology: Engineering algorithms and estimates

Measure Description

This document presents the methodology for calculating the savings realized from installing efficient hand dryers, which save energy by drying with air movement using motion sensors, thus reducing hand-drying time.

Eligibility Criteria

~~To qualify for this measure, E~~Eexisting hand dryer ~~equipment~~ must ~~currently utilize more than 5 watt-hour (Wh) or more per use and replacement hand dryers must consume no more than 5 Wh per use~~be push-button operated and rated at more than 1,500 W. New hand dryers must be motion sensor operated and rated at 1,500 W or less. ~~This measure is applicable in retail, commercial and industrial settings.~~

Baseline Condition

The baseline efficiency case is a push-button activated hand dryer ~~which utilizes more than 5 Wh or more per use~~rated at more than 1,500 W. ~~These hand dryers are often push-button activated.~~

High-Efficiency Condition

Eligible high-efficiency equipment is a motion sensor operated hand dryer ~~equipped with motion sensors that uses 5 Wh or less per use.~~with a nominal input power of 1,500 W or less.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

The energy savings from the installation of efficient hand dryers are ~~a result of savings~~ due to a decrease in power and ~~or~~ runtime of the efficient hand dryers over the pre-retrofit equipment. The energy and demand savings are calculated using the following equations~~:~~.

AOH, CF, IEF_E, and IEF_D match assumptions from the non-residential lighting measure.[675]

$$\Delta Wh = \frac{(W_{Base} \times CT_{Base}) - (W_{Eff} \times CT_{Eff})}{3{,}600}$$

Equation 298

$$Energy\ Savings\ [\Delta kWh] = \frac{UPD \times AOD\ DPY \times \Delta Wh}{1{,}000} \times IEF_E$$

Equation 299

$$Peak\ Demand\ Savings\ [\Delta kW] = \frac{UPD \times DPY\ AOD \times \Delta Wh}{1{,}000 \times AOH} \times CF \times IEF_D$$

Equation 300

Where:

$W_{Baseline}$	=	*Baseline equipment nominal power ~~in watt-hours, 20.65~~*[676] = *2,155036 W*
CT_{Base}	=	Cycle time of baseline equipment[677] = 3764 seconds
$W_{Efficient}$	=	*Efficient equipment nominal power*[678] = *1,06636293 W*
CT_{Eff}	=	*Cycle time of efficient equipment*[679] = *10172 seconds*
3,600	=	*Constant to convert from seconds to hours*

675 See Volume 3 2.1.1 Lamps and Fixtures. It is assumed building occupancy with respect to lighting is an appropriate proxy for occupant utilization of hand dryers.

676 Baseline and efficient ~~Wh per use~~nominal power and cycle times are averages of ~~the energy consumption of~~ 48 surveyed individual hand dryer units by CLEAResult in Arkansas~~ which consume either greater than 5 Wh or less than 5 Wh per use, respectively. The difference between these equals the assumed Wh savings per use~~.

677 Ibid

678 Ibid

679 Ibid

UPD = Number of uses per day[680] (see Table 352Table 274)

AODDPY = Number of days the facility operates per year[681] (if unknown, see Table 352Table 274)

AOH = Annual building operating hours (see Table 352349Table 294)

CF = Peak coincidence factor (see Table 352Table 294)

IEF_E = Interactive effects factor for energy, 1.05

IEF_D= = Interactive effects factor for demand, 1.10

$$Peak\ Demand\ Savings\ [\Delta kW] = \frac{\Delta kWh}{AOH} \times CF \times IEF_D$$

Equation 269

Where:

Table 294. Hand Dryers—Savings Calculation Input Assumptions

Usage level	Building type	Coincidence factor[682]					AOH[683]	UPD[684]	DPY[685]
		CZ 1	CZ 2	CZ 3	CZ 4	CZ 5			
Low	Office	0.87	0.88	0.86	0.90	0.90	36	50	250
	Warehouse	0.79	0.81	0.79	0.80	0.85			
Medium/moderate	Grocery (small)	0.90	0.90	0.90	0.90	0.90	235	225	365
	Restaurant	0.90	0.90	0.90	0.90	0.90			
	Retail	0.90	0.90	0.90	0.90	0.90			

680 IL TRM 12 Volume 2, 4.8.26 Industry Standard. Medium/Moderate Uses per day is supported by both Excel Dryer Data (Cost Savings with Hand Dryers vs Average Cost of Paper Towels https://www.exceldryer.com/calculator-dial/) and World Dryer Data (http://staging.worlddryer.com/savings-calculator)

681 Technology Data Characterizing Water Heating in Commercial Buildings: Application to End-Use Forecasting, Osman Sezgen and Jonathan G. Koomey, Lawrence Berkeley National Laboratory, December 1995. Table 2. https://eta-publications.lbl.gov/sites/default/files/lbnl-37398e.pdf.

682 Coincidence factors from the Texas TRM Volume 3, Section 2.1, Table 8, Nonresidential Lighting. It is assumed that building occupancy with respect to lighting is an appropriate proxy for occupants' utilization of hand dryers.

683 The assumed annual operating hours per building type are calculated as a simple average of 16 surveyed efficient hand dryers' cycle times multiplied by the assumed uses per day and days per year per usage level (as indicated in Table 294), then converted to hours by dividing this product by 3,600.

684 Industry Standard. Medium/Moderate Uses per day is supported by both Excel Dryer Data (Cost Savings with Hand Dryers vs Average Cost of Paper Towels https://www.exceldryer.com/calculator-dial/) and World Dryer Data (http://staging.worlddryer.com/savings-calculator)

685 Technology Data Characterizing Water Heating in Commercial Buildings: Application to End-Use Forecasting, Osman Sezgen and Jonathan G. Koomey, Lawrence Berkeley National Laboratory, December 1995. Table 2. https://eta-publications.lbl.gov/sites/default/files/lbnl-37398e.pdf.

Usage level	Building type	Coincidence factor[682]					AOH[683]	UPD[684]	DPY[685]
		CZ 1	CZ 2	CZ 3	CZ 4	CZ 5			
High	Conference center	0.65	0.65	0.65	0.65	0.65	339	500	237
	School[686]	0.39	0.39	0.90	0.87	0.40			
	Stadium	0.65	0.65	0.65	0.65	0.65			
	Theater	0.65	0.65	0.65	0.65	0.65			
	University	0.90	0.90	0.90	0.90	0.90			
High (grocery)	Grocery/retail (large)	0.90	0.90	0.90	0.90	0.90		500	365
Heavy duty/extreme	Airport	0.90	0.90	0.90	0.90	0.90	2,614	2,500	365
	Transportation center	0.90	0.90	0.90	0.90	0.90			

[686] Assuming K–12 without summer session

Deemed Energy and Demand Savings Tables

The deemed energy and demand savings for hand dryers with a unknown stipulated number of operating days per year, base/efficient cycles times, and base/efficient unit wattages are as follows:

Table 352. Hand Dryers—Savings Calculation Input Assumptions

Usage level	Building type	UPD[687]	AOD[688]	AOH[689]	Coincidence factor[690]				
					Amarillo	Dallas	Houston	Corpus Christi	El Paso
Low	Office	50	250	3,737	0.87	0.88	0.86	0.90	0.90
	Warehouse	50	250	3,501	0.79	0.81	0.79	0.80	0.85
Medium/ moderate	Food Sales: Non-24-hour supermarket or convenience store	125	365	4,706	0.90	0.90	0.90	0.90	0.90
	Food service: Full-service restaurant	125	365	4,368	0.90	0.90	0.90	0.90	0.90
	Food service: Quick-service restaurant	125	365	6,188	0.90	0.90	0.90	0.90	0.90
	Mercantile: Stand-alone retail	125	365	3,668	0.90	0.90	0.90	0.90	0.90
	Mercantile: Strip mall	125	365	3,965	0.90	0.90	0.90	0.90	0.90

687 IL TRM 12 Volume 2, 4.8.26d~~https://www.exceldryer.com/calculator-long and World Dryer data (http://worlddryer.com/calculate-savings).~~

688 Technology Data Characterizing Water Heating in Commercial Buildings: Application to End-Use Forecasting, Osman Sezgen and Jonathan G. Koomey, Lawrence Berkeley National Laboratory, December 1995. Table 2. https://eta-publications.lbl.gov/sites/default/files/lbnl-37398e.pdf.

689 From 2.1.1 Lamps and Fixtures measure

690 Ibid.

Usage level	Building type	UPD[687]	AOD[688]	AOH[689]	Coincidence factor[690]				
					Amarillo	Dallas	Houston	Corpus Christi	El Paso
High	Education: College, university, vocational, and day care	250	200	3,577	0.90	0.90	0.90	0.90	0.90
	Education: K-12[691]	250	200	3,177	0.42	0.39	0.90	0.90	0.57
	Food Sales: 24-hour supermarket or convenience store	375	365	6,900	0.90	0.90	0.90	0.90	0.90
	Mercantile: Enclosed mall	375	365	4,813	0.90	0.90	0.90	0.90	0.90
	Public Assembly	250	250	2,638	0.65	0.65	0.65	0.65	0.65
Heavy duty/ extreme	Transportation Center	750	365	8,760	1.00	1.00	1.00	1.00	1.00

[691] Assuming K–12 with partial summer session.

Table 353. Hand Dryers—Deemed Energy and Peak Demand Savings

Usage level	Building type	kWh	Summer kW				
			Amarillo	Dallas	Houston	Corpus Christi	El Paso
Low	Office	185	0.05	0.05	0.04	0.05	0.05
	Warehouse	185	0.04	0.04	0.04	0.04	0.05
Medium/ moderate	Food Sales: Non-24-hour supermarket or convenience store	674	0.14	0.14	0.14	0.14	0.14
	Food service: Full-service restaurant	674	0.15	0.15	0.15	0.15	0.15
	Food service: Quick-service restaurant	674	0.10	0.10	0.10	0.10	0.10
	Mercantile: Stand-alone retail	674	0.17	0.17	0.17	0.17	0.17
	Mercantile: Strip mall	674	0.16	0.16	0.16	0.16	0.16
High	Education: College, university, vocational, and day care	739	0.19	0.19	0.19	0.19	0.19
	Education: K-12	739	0.10	0.09	0.22	0.22	0.14
	Food Sales: 24-hour supermarket or convenience store	2,022	0.28	0.28	0.28	0.28	0.28
	Mercantile: Enclosed mall	2,022	0.40	0.40	0.40	0.40	0.40
	Public Assembly	923	0.24	0.24	0.24	0.24	0.24
Heavy duty/ extreme	Transportation Center	4,044	0.48	0.48	0.48	0.48	0.48

Table 295. Hand Dryers—Energy Savings

Usage level	Building type	Deemed energy savings
Low	Office	223
	Warehouse	223
Medium/moderate	Grocery (small)	1,468
	Restaurant	1,468
	Retail	1,468
High	Conference center	2,118
	School[692]	2,118
	Stadium	2,118
	Theater	2,118
	University	2,118
High (grocery)	Grocery/retail (large)	3,262
Heavy duty/extreme	Airport	16,312
	Transportation center	16,312

[692] Assuming K–12 without summer session.

Table 296. Hand Dryers—Peak Demand Savings

Usage level	Building type	Deemed demand savings				
		CZ 1	CZ 2	CZ 3	CZ 4	CZ 5
Low	Office	5.43	5.49	5.37	5.62	5.62
	Warehouse	4.93	5.05	4.93	4.99	5.30
Medium/moderate	Grocery (small)	5.62	5.62	5.62	5.62	5.62
	Restaurant	5.62	5.62	5.62	5.62	5.62
	Retail	5.62	5.62	5.62	5.62	5.62
High	Conference center	4.06	4.06	4.06	4.06	4.06
	School[693]	2.43	2.43	5.62	5.43	2.50
	Stadium	4.06	4.06	4.06	4.06	4.06
	Theater	4.06	4.06	4.06	4.06	4.06
	University	5.62	5.62	5.62	5.62	5.62
High (grocery)	Grocery/retail (large)	8.65	8.65	8.65	8.65	8.65
Heavy duty/extreme	Airport	5.62	5.62	5.62	5.62	5.62
	Transportation center	5.62	5.62	5.62	5.62	5.62

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) is 10 years[694] for efficient hand dryers.

693 Assuming K–12 without summer session.

694 Based on studies conducted by two separate parties; Comparative Environmental Life Cycle Assessment of Hand Drying Systems by Quantis (pg. 2) and Guidelines to Reduce/Eliminate Paper Towel Use by Installing Electric Hand Dryers by Partners in Pollution Prevention P3 (pg. 17).

Program Tracking Data and Evaluation Requirements

The below list of 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
- Building type
- ~~Cooling type~~
- ~~Hand dryer~~Installed quantity
- Efficient h~~H~~and dryer make and model
- Efficient hand dryer nominal input power (W)
- Proof of purchase

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

Please refer to measure citations for relevant standards and reference sources.

Document Revision History

Table 354. Hand Dryers—Revision History

TRM version	Date	Description of change
v10.0	10/2022	TRM v10.0 origin
v11.0	10/2023	TRM v11.0 update. No revision.
v12.0	10/2024	TRM v12.0 update. Updated building type naming convention. Updated peak demand calculation, savings calculation input assumptions, and deemed savings.

~~2.7.14~~2.7.15 Laser Projectors Measure Overview

TRM Measure ID: NR-LT-LP

Market Sector: Commercial

Measure Category: Miscellaneous

Applicable Building Types: Motion picture theaters

Fuels Affected: Electricity

Decision/Action Types: Retrofit

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure is for the replacement of a lamp-based projector with a laser projector. The conversion from a traditional lamp-based projector system to a laser projector benefits from reduced energy consumption via electricity savings and HVAC savings. With advancements in solid-state technology, laser projectors typically require half the electricity to obtain the equivalent light and resolution output as lamp-based projectors. Due to this reduced electricity consumption, laser projectors also benefit from HVAC savings, with significantly less energy wasted as heat. Another benefit of laser projectors is that they do not require the use of lamps, which can be costly from an equipment and operations standpoint.

Despite the various ways laser projectors result in energy savings, this measure solely focuses on the electricity savings for operating the projector. Due to interactive effects unique to each site, this measure will not consider the corresponding HVAC savings, so annual savings estimates are conservative.

Eligibility Criteria

This measure applies to the replacement of any motion picture theater lamp-based projector. At this time, this measure is limited to retrofit applications where the baseline lamp wattage is specified to match site conditions. Eligibility may be extended to new construction applications once sufficient program implementation data can be collected to establish an appropriate baseline.

Baseline Condition

There is no federal standard applicable to lamp-based projectors. The baseline condition is any commercial cinema lamp-based projector that is replaced by a laser projector. The measure does not consider home, office, venue or any projector replacements that are outside of a professional cinema setting.

High-Efficiency Condition

The high-efficiency condition is a professional commercial cinema laser projector with an equivalent (or no greater than 110%) lumen output of the baseline projector being replaced.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

This section describes the deemed savings methodology for both energy and demand savings for laser projectors.

Energy Savings Algorithms

Energy savings for this measure are determined to be the difference in maximum operating input rate for the baseline and efficient projector multiplied by the total yearly operating hours for the facility.

$$Energy\ Savings\ [kWh] = (kW_{pre} - kW_{installed}) \times Hours$$

Equation 301

$$Summer\ Peak\ Demand\ Savings\ [kW_S] = (kW_{pre} - kW_{installed}) \times CF_S$$

Equation 302

$$Winter\ Peak\ Demand\ Savings\ [kW_W] = (kW_{pre} - kW_{installed}) \times CF_W$$

Equation 303

Where:

kW_{pre}	=	*Total kW of existing lamp-based projector*
$kW_{installed}$	=	*Total kW of efficient laser projector*
Hours	=	*Annual operating hours = 3,653 hours*[695] *(use actual hours if known)*
CF_S	=	*Summer peak coincidence factor = 0.65 (all climate zones)*[696]
CF_W	=	*Winter peak coincidence factor = 0 (all climate zones)*[697]

695 "HVAC considerations for lamp and laser projectors in cinema," Barco. July 26, 2021. The reference uses 11.5 hours per day (or 4,200 hours) as an example. This measure assumes 10 hr/day as a conservative assumption, but allows for the use of custom hours based on site conditions. Default hours are calculated as 10 hr/day x 365.25 day/year = 3,653 hours.

696 Refer to Lamps and Fixtures measure for the public assembly building type, which is applicable to motion picture theaters.

697 Ibid.

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) is 10 years for cinema laser projectors.[698,699,700]

Program Tracking Data and Evaluation Requirements

The program database should specify and track the list of primary inputs and contextual data provided below. This will inform the evaluation process and ensure proper application of the savings.

- Building type
- Baseline lamp-based projector manufacturer and model number
- Baseline projector lamp wattage
- Baseline lamp-based projector nameplate photo
- New laser projector manufacturer and model number
- New laser projector wattage
- New projector nameplate photo
- Proof of purchase: invoice showing model number and quantity purchased

Document Revision History

Table 355. Laser Projectors—Revision History

TRM version	Date	Description of change
v11.0	10/2023	TRM v11.0 origin
v12.0	10/2024	TRM v11.0 No revisions.

[698] Average rated life of 18 Barco and Christie cinema laser projectors = 41,667 hours. Dividing by annual operating hours yields EUL.

[699] Barco cinema projector product listing. https://www.barco.com/en/products/projection/overview?facets=barco-dxp%3Aproduct%2Fproduct-category%2Fprojection%2Fcinema-projectors.

[700] Christie cinema projector product listing. https://www.christiedigital.com/products/cinema/projection/.

APPENDIX A: MEASURE LIFE CALCULATIONS FOR DUAL BASELINE MEASURES

The following appendix describes the method to calculate savings for any dual baseline measure, including all early retirement measures. This supersedes the previous Measure Life Savings found in PUCT Dockets 40083 and 40885 and is revised to clarify the understanding of the measure life calculations and reduce any misrepresentation of net present value (NPV) of early retirement projects.

Option 1 provides reduced savings claimed over the full EUL. Option 2 provides higher savings claimed over a reduced EUL. The lifetime savings are the same for both options 1 and 2. Option 1 calculations were originally provided in Docket [43681].

Option 1—Weighting Savings and Holding Measure Life Constant

Step 1: Determine the measure life for first-tier (FT) and second-tier (ST) components of the calculated savings:

$$First\ Tier\ (FT)\ Period = ML_{FT} = RUL$$

Equation 304

$$Second\ Tier\ (ST)\ Period = ML_{ST} = EUL - RUL$$

Equation 305

Where:

RUL	=	*The useful life corresponding with the first tier-savings; for early retirement projects, RUL is the remaining useful life determined from lookup tables based on the age of the replaced unit (or default age when actual age is unknown)*
EUL	=	*The useful life corresponding with the second-tier savings; for early retirement projects, EUL is the estimated useful life as specified in applicable measure from Texas TRM (or approved petition)*

Step 2: Calculate the FT demand and energy savings and the ST demand and energy savings:

$$\Delta kW_{FT} = kW_{retired} - kW_{installed}$$

Equation 306

$$\Delta kW_{ST} = kW_{baseline} - kW_{installed}$$

Equation 307

$$\Delta kWh_{FT} = kWh_{retired} - kWh_{installed}$$

Equation 308

$$\Delta kWh_{ST} = kWh_{baseline} - kWh_{installed}$$

Equation 309

Where:

ΔkW_{FT}	=	*First-tier demand savings*
ΔkW_{ST}	=	*Second-tier demand savings*
$kW_{retired}$	=	*Demand of the first-tier baseline system, usually the retired system*[701]
$kW_{baseline}$	=	*Demand of the second-tier baseline system, usually the baseline ROB system*[702]
$kW_{installed}$	=	*Demand of the replacement system*[703]
ΔkWh_{FT}	=	*First-tier energy savings*
ΔkWh_{ST}	=	*Second-tier energy savings*
$kWh_{retired}$	=	*Energy usage of the first-tier baseline system, usually the retired system**Error! Bookmark not defined.***
$kWh_{baseline}$	=	*Energy usage of the second-tier baseline system, usually the baseline ROB system**Error! Bookmark not defined.***
$kWh_{installed}$	=	*Energy usage of the replacement system**Error! Bookmark not defined.***

Step 3: Calculate the avoided capacity and energy cost contributions of the total NPV for both the ER and ROB components:

$$NPV_{FT,kW} = AC_{kW} \times \frac{1+e}{d-e} \times \left\{1 - \left[\frac{1+e}{1+d}\right]^{ML_{FT}}\right\} \times \Delta kW_{FT}$$

Equation 310

$$NPV_{ST,kW} = AC_{kW} \times \frac{1+e}{d-e} \times \left\{1 - \left[\frac{1+e}{1+d}\right]^{ML_{ST}}\right\} \times \frac{(1+e)^{ML_{FT}}}{(1+d)^{ML_{FT}}} \times \Delta kW_{ST}$$

Equation 311

$$NPV_{FT,kWh} = AC_{kWh} \times \frac{1+e}{d-e} \times \left\{1 - \left[\frac{1+e}{1+d}\right]^{ML_{FT}}\right\} \times \Delta kWh_{FT}$$

Equation 312

701 Retired system refers to the existing equipment that was in use before the retrofit has occurred.
702 Baseline used for a replace-on-burnout project of the same type and capacity as the system being installed in the Early Retirement project (as specified in the applicable measure).
703 Replacement system refers to the installed equipment that is in place after the retrofit has occurred.

$$NPV_{ST,kWh} = AC_{kWh} \times \frac{1+e}{d-e} \times \left\{1 - \left[\frac{1+e}{1+d}\right]^{ML_{ST}}\right\} \times \frac{(1+e)^{ML_{FT}}}{(1+d)^{ML_{FT}}} \times \Delta kWh_{ST}$$

Equation 313

Where:

$NPV_{FT,\ kW}$ = *Net Present Value (kW) of first-tier projects*

$NPV_{ST,\ kW}$ = *Net Present Value (kW) of second-tier projects*

$NPV_{FT,\ kWh}$ = *Net Present Value (kWh) of first-tier projects*

$NPV_{ST,\ kWh}$ = *Net present value (kWh) of second-tier projects*

e = *Escalation rate* [704]

d = *Discount rate weighted average cost of capital (per utility)* ***Error! Bookmark not defined.***

AC_{kW} = *Avoided cost per kW ($/kW)* ***Error! Bookmark not defined.***

AC_{kWh} = *Avoided cost per kWh ($/kWh)* ***Error! Bookmark not defined.***

ML_{FT} = *First-tier measure life (calculated in **Error! Reference source not found.**)*

ML_{ST} = *Second-tier measure life (calculated in **Error! Reference source not found.**)*

Step 4: Calculate the total capacity and energy cost contributions to the total NPV:

$$NPV_{Total,kW} = NPV_{FT,kW} + NPV_{ST,kW}$$

Equation 314

$$NPV_{Total,kWh} = NPV_{FT,kWh} + NPV_{ST,kWh}$$

Equation 315

Where:

$NPV_{Total,\ kW}$ = *Total capacity contributions to NPV of both first-tier and second-tier component*

$NPV_{Total,\ kWh}$ = *Total energy contributions to NPV of both first-tier and second-tier component*

[704] The exact values to be used each year for the escalation rate, discount rate, and avoided costs are established by the PUC in Substantive Rule §25.181 and updated annually, as applicable. Please note that the discount rates are based on a utility's weighted average cost of capital and, as such, will vary by utility and may change each year.

Step 5: Calculate the capacity and energy cost contributions to the NPV without weighting by demand and energy savings for a scenario using the original EUL:

$$NPV_{EUL,kW} = AC_{kW} \times \frac{1+e}{d-e} \times \left\{1 - \left[\frac{1+e}{1+d}\right]^{EUL}\right\}$$

Equation 316

$$NPV_{EUL,kWh} = AC_{kWh} \times \frac{1+e}{d-e} \times \left\{1 - \left[\frac{1+e}{1+d}\right]^{EUL}\right\}$$

Equation 317

Where:

$NPV_{EUL,\ kW}$	=	*Capacity contributions to NPV without weighting, using original EUL*
$NPV_{EUL,\ kWh}$	=	*Energy contributions to NPV without weighting, using original EUL*

Step 6: Calculate the weighted demand and energy savings by dividing the combined capacity and energy cost contributions from the ER and ROB scenarios by the non-savings weighted capacity and energy cost contributions from the single EUL scenario. These weighted savings are claimed over the original measure EUL:

$$Weighted\ kW = \frac{NPV_{Total\ kW}}{NPV_{EUL,kW}}$$
$$= \frac{\left[\left(1 - \left(\frac{1+e}{1+d}\right)^{RUL}\right) \times \left(kW_{retired} - kW_{installed}\right)\right] + \left[\left(1 - \left(\frac{1+e}{1+d}\right)^{EUL-RUL}\right) \times \frac{(1+e)^{RUL}}{(1+d)^{RUL}} \times \left(kW_{baseline} - kW_{installed}\right)\right]}{\left(1 - \left(\frac{1+e}{1+d}\right)^{EUL}\right)}$$

Equation 318

$$Weighted\ kWh = \frac{NPV_{Total.kWh}}{NPV_{EUL,kWh}}$$
$$= \frac{\left[\left(1 - \left(\frac{1+e}{1+d}\right)^{RUL}\right) \times \left(kWh_{retired} - kWh_{installed}\right)\right] + \left[\left(1 - \left(\frac{1+e}{1+d}\right)^{EUL-RUL}\right) \times \frac{(1+e)^{RUL}}{(1+d)^{RUL}} \times \left(kWh_{baseline} - kWh_{installed}\right)\right]}{\left(1 - \left(\frac{1+e}{1+d}\right)^{EUL}\right)}$$

Equation 319

Where:

Weighted kW	=	*Weighted lifetime demand savings*
Weighted kWh	=	*Weighted lifetime energy savings*
$NPV_{Total,\ kW}$	=	*Total capacity contributions to NPV of both ER and ROB component, calculated in* ***Error! Reference source not found.***

$NPV_{Total,\ kWh}$ = *Total energy contributions to NPV of both ER and ROB component, calculated in **Error! Reference source not found.***

$NPV_{EUL,\ kW}$ = *Capacity contributions to NPV without weighting, using original EUL, calculated in **Error! Reference source not found.***

$NPV_{EUL,\ kWh}$ = *Energy contributions to NPV without weighting, using original EUL, calculated in **Error! Reference source not found.***

<u>Option 2—Weighting Measure Life and Holding First Year Savings Constant</u>

Repeat Step 1 through Step 4 from Option 1.

Step 5: Reverse calculate the EUL for the capacity and energy contributions to the NPV for a scenario using the first-tier savings:

$$EUL_{kW} = \frac{ln\left[\frac{NPV_{Total,kW} \times (d-e)}{\Delta kW_{FT} \times AC_{kW} \times (1+e)}\right]}{ln\left[\frac{(1+e)}{(1+d)}\right]}$$

Equation 320

$$EUL_{kWh} = \frac{ln\left[\frac{NPV_{Total,kWh} \times (d-e)}{\Delta kWh_{FT} \times AC_{kWh} \times (1+e)}\right]}{ln\left[\frac{(1+e)}{(1+d)}\right]}$$

Equation 321

Where:

EUL_{kW} = *EUL for capacity contribution to NPV using first-tier savings*

EUL_{kWh} = *EUL for energy contribution to NPV using first-tier savings*

Step 6: Confirm that capacity EUL and energy EUL are equivalent. First-tier savings are claimed over this weighted EUL.

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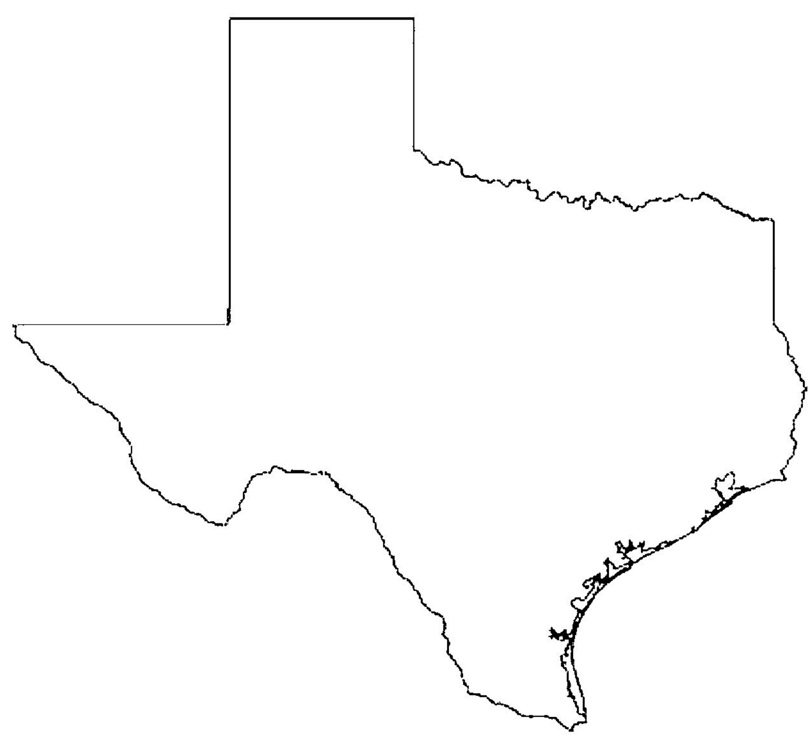

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