2.7.5 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[509], and assume baseline computer settings never enter sleep mode, and 60% of computers are turned off each night.[510]

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

[510] 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.[511]

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

$$kWh_{savings} = \frac{W_{active}\left(hrs_{active_{pre}} - hrs_{active_{post}}\right) + W_{sleep}\left(hrs_{sleep_{pre}} - hrs_{sleep_{post}}\right) + W_{off}\left(hrs_{off_{pre}} - hrs_{off_{post}}\right)}{1{,}000}$$

Equation 221

$$Summer\ kW_{savings} = \left(W_{active} - W_{sleep}\right) \times CF_{inactive}$$

Equation 222

$$Winter\ kW_{savings} = 0$$

Equation 223

Where:

W_{active} = *Total wattage of the equipment, including computer and monitor, in active/idle mode (see Table 243)*

$hrs_{active_{pre}}$ = *Annual number of hours the computer is in active/idle mode before computer management software is installed (see Table 244)*

$hrs_{active_{post}}$ = *Annual number of hours the computer is in active/idle mode after computer management software is installed (see Table 244)*

W_{sleep} = *Total wattage of the equipment, including computer and monitor, in sleep mode (see Table 243)*

$hrs_{sleep_{pre}}$ = *Annual number of hours the computer is in sleep mode before computer management software is installed (see Table 244)*

511 Based on 2015 custom project metering from El Paso Electric.

$hrs_{sleep_{post}}$	=	*Annual number of hours the computer is in sleep mode after computer management software is installed (see Table 244)*
W_{off}	=	*Total wattage of the equipment, including computer and monitor, in off mode (see Table 243)*
$hrs_{off_{pre}}$	=	*Annual number of hours the computer is in off mode before computer management software is installed (see Table 244)*
$hrs_{off_{post}}$	=	*Annual number of hours the computer is in off mode after computer management software is installed (see Table 244)*
1,000	=	*Conversion factor: 1 kW / 1,000 W*
CF	=	*Coincidence factor (see Table 245)*

Table 243. Computer Power Management—Equipment Wattages[512]

Equipment	W_{active}	W_{sleep}	W_{off}
Conventional monitor[513]	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 244. Computer Power Management—Operating Hours[514]

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	4,213	727	0	1,970	4,547	6,063

[512] 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_productshttps://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/save-energy/purchase-energy-saving-products.

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

[514] 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.

Building activity type	$hrs_{active_{pre}}$	$hrs_{active_{post}}$	$hrs_{sleep_{pre}}$	$hrs_{sleep_{post}}$	$hrs_{off_{pre}}$	$hrs_{off_{post}}$
(8 hours/day, 5 days/week, 113 non-school days/year)						

Table 245. Computer Power Management—Coincidence Factors, All Activity Types

Climate zone	Summer CF		Winter CF	
	Active	Inactive	Active	Inactive
1	0.65	0.35	0.11	0.89
2	0.62	0.38	0.12	0.88
3	0.66	0.34	0.12	0.88
4	0.62	0.38	0.14	0.86
5	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 243, Table 244, and Table 245. The following tables provide these deemed values.

Table 246. Computer Power Management—Deemed Energy Savings Values, All Climate Zones

Equipment	Office or school kWh
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 247. Computer Power Management—Deemed Demand Savings Values, Office, or School

Equipment	Zone 1		Zone 2		Zone 3		Zone 4		Zone 5	
	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	0.007	0	0.006	0	0.007	0	0.004	0
Conventional computer	0.016	0	0.017	0	0.015	0	0.017	0	0.011	0

Equipment	Zone 1		Zone 2		Zone 3		Zone 4		Zone 5	
	Summer (kW)	Winter (kW)	Summer (kW)	Winter (kW)	Summer (kW)	Winter (kW)	Summer (kW)	Winter (kW)	Summer (kW)	Winter (kW)
Conventional notebook	0.005	0	0.005	0	0.005	0	0.005	0	0.003	0
ENERGY STAR® monitor	0.005	0	0.006	0	0.005	0	0.006	0	0.004	0
ENERGY STAR® computer	0.009	0	0.010	0	0.009	0	0.010	0	0.006	0
ENERGY STAR® notebook	0.003	0	0.003	0	0.003	0	0.003	0	0.002	0

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.[515]

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.

[515] 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.

Relevant Standards and Reference Sources

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

Not applicable.

Document Revision History

Table 248. Nonresidential 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.
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 revisions.

2.7.6 Premium Efficiency Motors Measure Overview

TRM Measure ID: NR-MS-PM

Market Sector: Commercial

Measure Category: Miscellaneous

Applicable Building Types: Commercial

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 253. 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).[516]

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

[516] 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)[517] (see Table 252) 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)[518], as listed in Table 254.

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 252.

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.

[517] 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.

[518] 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 249 or Table 250 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 224

Demand Savings Algorithms

HVAC Applications:

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

Equation 225

Industrial Applications[519]:

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

Equation 226

Where:

hp = *Nameplate horsepower data of the motor*

0.746 = *hp-to-kWh conversion Factor (kW/hp)*[520]

LF = *Estimated load factor (if unknown, see Table 249 or Table 250)*

[519] Assumes three-shift operating schedule

[520] 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 252)*[521]
η_{post}	=	*Efficiency of the newly installed motor [%]*
Hrs	=	*Estimated annual operating hours (if unknown, see Table 249 or Table 250)*
CF	=	*Coincidence factor (see Table 249)*
$kWh_{savings,ROB}$	=	*Total energy savings for a new construction or ROB project*
$kW_{savings,ROB}$	=	*Total demand savings for a new construction or ROB project*

Table 249. Premium Efficiency Motors—HVAC Assumptions by Building Type

Building type	Load factor[522]	CF[523]	HVAC fan hours[524]
Hospital	0.75	1.00	8,760
Large office (>30k SqFt)			4,424
Small office (≤30k SqFt)			4,006
K-12 school			4,173
College			4,590
Retail			5,548
Restaurant (fast-food)			6,716
Restaurant (sit-down)			5,256

521 In the case of rewound motors, in-situ efficiency may be reduced by a percentage as found in Table 251.

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

523 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

524 Factors are equivalent to Table 88 Yearly Motor Operation Hours by Building Type for HVAC Frequency Drives

Table 250. Premium Efficiency Motors—Industrial Assumptions by Building Type

Industrial processing	Load factor[525]	Hours[526]					
		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 251. Rewound Motor Efficiency Reduction Factors[527]

Motor horsepower	Efficiency reduction factor
< 40	0.010
≥ 40	0.005

Table 252. Premium Efficiency Motors—New Construction and Replace-on-Burnout Baseline Efficiencies by Motor Size (%)[516,520,528]

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

525 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

526 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

527 U.S. 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.

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

hp	Open motors: $\eta_{baseline,ROB}$			Closed motors: $\eta_{baseline,ROB}$		
	6-pole	4-pole	2-pole	6-pole	4-pole	2-pole
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
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	N/A	95.8	95.8	N/A	96.2	95.8
450	N/A	96.2	96.2	N/A	96.2	95.8
500	N/A	96.2	96.22	N/A	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 253); 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 253. Remaining Useful Life (RUL) of Replaced Motor[529]

Age of replaced motor (years)	RUL (years)
1	13.9
2	12.9
3	11.9
4	10.9
5	9.9
6	8.9
7	7.9
8	6.9
9	5.9
10	5.0
11	4.2
12	3.6
13	3.0
14	2.5
15	2.0
16	1.0
17[530]	0.0

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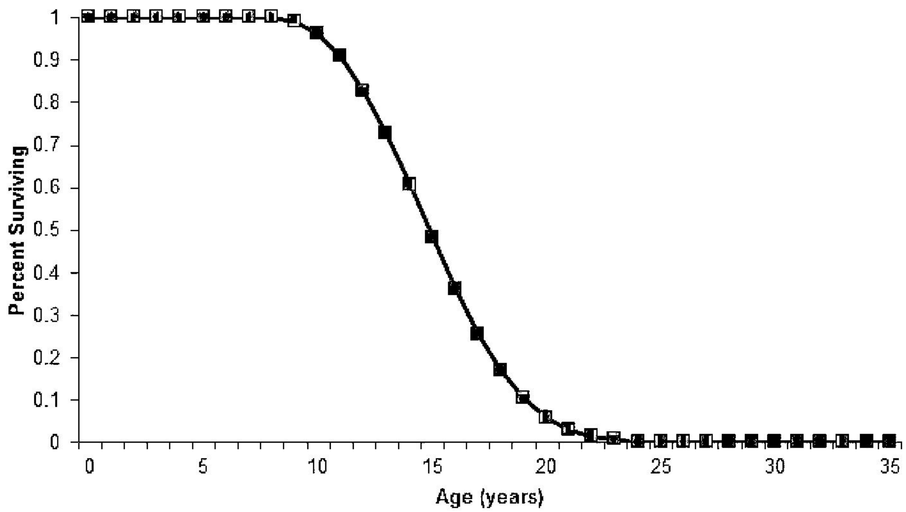
Derivation of RULs

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.

529 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.

530 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. Survival Function for Premium Efficiency Motors[531]



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 227

[531] 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 228

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 229

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 230

Industrial Applications

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

Equation 231

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 232

Industrial Applications

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

Equation 233

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 234

Where:

$\eta_{baseline,ER}$ = *Assumed original motor efficiency for remaining EUL time period (Table 254 or Table 255)*[532]

$kWh_{savings,RUL}$ = *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 254. Premium Efficiency Motors—Early Retirement Baseline Efficiencies by Motor Size (%)[518,533]

hp	Open motors: $\eta_{baseline,ER}$			Closed motors: $\eta_{baseline,ER}$		
	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

532 Ibid.

533 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
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
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	N/A	95.4	95.4	N/A	95.4	95.4
450	N/A	95.8	95.8	N/A	95.4	95.4
500	N/A	95.8	95.8	N/A	95.8	95.4

Table 255. Premium Efficiency Motors—Early Retirement Baseline Efficiencies by Motor Size for 250-500 hp Motors Manufactured Prior to June 1, 2016 (%)[534,535]

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	N/A	95.4	95.4	N/A	95.4	95.4
450	N/A	95.8	95.8	N/A	95.4	95.4
500	N/A	95.8	95.8	N/A	95.8	95.4

534 Federal Standards for Electric Motors, Table 4,
535 For unlisted motor horsepower values, round down to the next lowest horsepower value.

Deemed Energy and Demand Savings Tables

Not applicable

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.[536]

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:

- Number of units installed
- 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

[536] 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

Relevant Standards and Reference Sources

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

- Federal Energy Policy Act of 1992 (EPAct)
    - Defaults prior to EPAct 1992 from the DOE's *MotorMaster+* database (circa 1992)
- 2007 Energy Independence and Security Act (EISA)
- The applicable version of the Technical Support Document for electric motors

Document Revision History

Table 256. Nonresidential Premium Efficiency 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.

2.7.7 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 an Level 2 EVSE compliant with ENERGY STAR® compliant Level 2 EVSE Version 1.1 sSpecification version 1.1, effective March 31, 2021.[537]

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

$$ENERGY\ STAR\ Idle\ Consumption\ [kWh] = \frac{(hrs_{plug} \times W_{plug} + hrs_{unplug\_C} \times W_{unplug}) \times days_C + hrs_{unplug\_NC} \times W_{unplug} \times days_{NC}}{1000}$$

Equation 235

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

Equation 236

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

Equation 237

$$Demand\ Savings\ [kW] = \frac{Annual\ Energy\ Savings\ (kWh)}{hrs_{unplug\_C} \times days_C + hrs_{unplug\_NC} \times days_{NC}} \times PDPF$$

Equation 238

Where:

hrs_{plug} = *Hours per day the vehicle is plugged into the EVSE and not charging, 2.8 hrs*[538]

W_{plug} = *Wattage of the EVSE when the vehicle is plugged into the EVSE but not charging, 6.9 W*[539]

537 ENERGY STAR® Program Requirements for Electric Vehicle Supply Equipment Eligibility Criteria Version 1.1. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20V1.1%20DC%20EVSE%20Final%20Specification_0.pdf.

538 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.

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

hrs_{unplug_C} = *Hours per day the vehicle is not plugged into the EVSE on a charging day, 19.0 hrs*[540]

hrs_{unplug_NC} = *Hours per day the vehicle is not plugged into the EVSE on a non-charge day, 24 hrs*

W_{unplug} = *Wattage of the EVSE when the vehicle is not plugged into the EVSE, 3.3 W*[541]

$days_C$ = *Number of charging days per year, 204 days*[542]

$days_{NC}$ = *Number of non-charging days per year, 161 days*

1000 = *Constant to convert from W to kW*

0.6 = *Efficiency adjustment factor*[543]

PDPF = *Peak demand probability factor (see Table 257)*

Table 257. EVSE Peak Demand Probability Factors[544]

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

Deemed Energy and Demand Savings Tables

Table 258 presents the deemed annual energy savings per EVSE.

540 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.

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

542 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.

543 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.

544 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 258. EVSE Annual Energy Savings

Annual energy savings (kWh) (all location types)
19.7

Table 259 presents the deemed summer and winter peak kW savings per EVSE.

Table 259. 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
Zone 1: Amarillo	0.0012	0.0012	0.0022	0.0019	0.0008	0.0012
Zone 2: Dallas	0.0012	0.0012	0.0022	0.0019	0.0006	0.0012
Zone 3: Houston	0.0012	0.0011	0.0022	0.0017	0.0007	0.0010
Zone 4: Corpus Christi	0.0012	0.0013	0.0022	0.0020	0.0007	0.0014
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.[545]

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:

- ~~Quantity~~
- Climate zone
- Location Type (public, workplace, or fleet)[546]

[545] 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.

[546] Refer to Eligibility Criteria section for location type definitions.

- EVSE quantity
- 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.

~~The applicable version of the ENERGY STAR® specifications and requirements for electric vehicle supply equipment.~~

Document Revision History

Table 260. Nonresidential Electric Vehicle Supply Equipment 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.

2.7.8 Variable Frequency Drives for Water Pumping Measure Overview

TRM Measure ID: NR-MS-WP

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

This measure involves the installation of a variable frequency drive (VFD) in a water pumping application such as for domestic water supply, wastewater treatment, and conveyance.

Eligibility Criteria

Water pumps must be less than or equal to 100 hp. New construction systems are ineligible. Equipment used for irrigation or process loads are ineligible.

Baseline Condition

The baseline condition is a water pump with no variable speed-control ability.

High-Efficiency Condition

The high-efficiency condition is the installation of a VFD on a water pump.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

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

<u>Step 1</u>: Determine the percentage flow rate for each of the year (*i*)

<u>Baseline Technology</u>[547]:

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

Equation 239

Where:

%GPM = *Percentage flow rate (see Table 261)*

i = *Each hour of the year*

Table 261. VFD for Water Pumping—Water Demand Profile[548]

Hour ending	Percentage flow rate
1	0.078
2	0.039
3	0.010
4	0.010
5	0.039
6	0.275
7	0.941
8	1.000
9	0.961
10	0.843
11	0.765
12	0.608
13	0.529
14	0.471
15	0.412
16	0.471
17	0.549
18	0.725
19	0.863
20	0.824

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

[548] NREL, Development of Standardized Domestic Hot Water Event Schedules for Residential Buildings, Fig. 2 Combined domestic hot water use profile for the Benchmark, representing average use. https://www.nrel.gov/docs/fy08osti/40874.pdf.

Hour ending	Percentage flow rate
21	0.745
22	0.608
23	0.529
24	0.294

VFD Technology[549]:

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

Equation 240

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 241

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

Equation 242

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 the pump typical design point*
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	=	*HP to kW conversion factor*
η	=	*Motor efficiency of a standard efficiency motor (see Table 262)*

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

Table 262. Motor Efficiencies[550]

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

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 243

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

Equation 244

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*

550 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.

Energy Savings are calculated in the following manner:

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

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

Equation 245

Where:

8760 = *Total number of hours in a year*

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

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

Equation 246

Deemed Energy and Demand Savings Tables

Table 259 presents the deemed summer and winter peak kW savings per ~~EVSE~~motor horsepower.

Table 263. Water Pump VFD Savings per Motor HP

Climate zone	Annual kWh savings per motor HP	Winter peak demand kW savings per motor HP
Zone 1: Amarillo	1,389	0.097
Zone 2: Dallas		0.069
Zone 3: Houston		0.067
Zone 4: Corpus Christi		0.138
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.[551]

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

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
- Climate zone
- 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.

~~None~~

Document Revision History

Table 264. Nonresidential Water Pumping VFD 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.

2.7.9 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

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

Equation 247

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

Equation 248

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

Equation 249

$$Peak\ Demand\ Savings\ (kW) = \frac{Annual\ Energy\ Savings\ (kWh)}{Hours} \times DF$$

Equation 250

Where:

$E_{water\ supply}$	=	*Water supply energy factor: 2,300 kWh/million gallons*
S_L	=	*Average steam loss per trap (lb/hr) (see Table 265)*
Hours	=	*Annual hours when steam system is operational, equal to heating degree days by climate zone (see Table 266)*
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 265*
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 265)*
P_{atm}	=	*Atmospheric pressure, 14.7 psia*

D	=	*Diameter of orifice (inches), use actual if possible, or defaults in Table 265*
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*
DF	=	*Demand factor, assume value of 1 for industrial and process steam applications; for commercial heating applications, see Table 35 through Table 39 in Section 2.2.2; for commercial dry cleaners, use DF for stand-alone retail*

Table 265. Steam Traps—Default Inputs[552]

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 heating LPS	-	-	100%	6.9	Table 266	0.27

[552] 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 266. Steam Trap—Hours

Climate zone	Hours (HDD)[553]
1	4,565
2	2,567
3	1,686
4	1,129
5	2,677

Deemed Energy and Demand Savings Tables

Table 267. Steam Trap—Annual 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 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

553 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 268. Steam Trap—Peak Demand Savings, Without Audit

Steam type	Building type	Principal building activity	one 1	one 2	one 3	one 4	one 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 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	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

Steam type	Building type	Principal building activity	one 1	one 2	one 3	one 4	one 5
	Food service	Full-service restaurant	2.21E-04	2.57E-04	2.26E-04	1.80E-04	1.44E-04
		24-hour full-service	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	2.47E-04	3.09E-04	2.57E-04	1.75E-04	1.34E-04
	Healthcare	Hospital	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
		Outpatient healthcare	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
	Retail	Stand-alone retail	5.09E-04	2.83E-04	2.21E-04	1.13E-04	1.34E-04
		24-hour stand-alone 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
	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

Steam type	Building type	Principal building activity	Climate Zzone 1	Climate Zzone 2	Climate Zzone 3	Climate Zzone 4	Climate Zzone 5
	Service	Service	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	1.39E-04	1.44E-04	9.77E-05	4.12E-05	2.06E-05

Table 269. Steam Trap—Peak Demand Savings, With Audit

Steam type	Building type	Principal building activity	Climate Zzone 1	Climate Zzone 2	Climate Zzone 3	Climate Zzone 4	Climate Zzone 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 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

Steam type	Building type	Principal building activity	one 1	one 2	one 3	one 4	one 5
	Food sales	Convenience	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	8.19E-04	9.53E-04	8.38E-04	6.67E-04	5.33E-04
		24-hour full-service	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	9.14E-04	1.14E-03	9.53E-04	6.48E-04	4.95E-04
	Healthcare	Hospital	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
		Outpatient healthcare	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
	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
		Strip mall	7.43E-04	1.05E-03	8.00E-04	4.00E-04	5.14E-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

Steam type	Building type	Principal building activity	one 1	one 2	one 3	one 4	one 5
	Religious worship	Religious worship	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Service	Service	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.[554]

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 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.

~~None~~

Document Revision History

Table 270. Nonresidential Steam Trap Repair and Replacement 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 revisions.

[554] EULs 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

2.7.10 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

$$Annual\ Energy\ Savings\ (kWh) = HP_{motor} \times 0.746 \times \frac{LF}{n} \times hours \times EI$$

Equation 251

Where:

HP_{motor}	=	*Horsepower of the motor, actual nameplate*
0.746	=	*Conversion factor, kW/hp*
LF	=	*Motor load factor, 75%*[555]
n	=	*Motor efficiency, actual or default to value in Table 271*
hours	=	*Operating hours per year, actual*
EI	=	*Efficiency increase, 1.0% per gear mesh*[556]

Table 271. Motor Efficiencies[557]

Motor horsepower	Full load efficiency
1	0.855
2	0.865
3	0.895
5	0.895
7.5	0.910
10	0.917
15	0.930
20	0.930
25	0.936
30	0.941
40	0.941
50	0.945

555 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.

556 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.

557 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.

Motor horsepower	Full load efficiency
60	0.950
75	0.950
100	0.954

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 equipment that the lubricant is used with.[558]

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.

~~None~~

[558] 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.

Document Revision History

Table 272. Nonresidential 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 revisions.

2.7.11 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

$$Annual\ Energy\ Savings\ (kWh) = HP_{motor} \times 0.746 \times \frac{LF}{n} \times hours \times EI$$

Equation 252

Where:

HP_{motor}	=	*Horsepower of the motor, actual nameplate*
0.746	=	*Conversion factor, kW/hp*
LF	=	*Motor load factor, 75%*[559]
n	=	*Motor efficiency, actual or default to value in Table 273*
hours	=	*Operating hours per year, actual*
EI	=	*Efficiency increase, 3.2%*[560]

Table 273. Motor Efficiencies[561]

Motor horsepower	Full load efficiency
1	0.855
2	0.865
3	0.895
5	0.895
7.5	0.910
10	0.917
15	0.930
20	0.930
25	0.936

559 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.

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

561 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.

Motor horsepower	Full load efficiency
30	0.941
40	0.941
50	0.945
60	0.950
75	0.950
100	0.954

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.[562]

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.

[562] 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

Relevant Standards and Reference Sources

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

~~None~~

Document Revision History

Table 274. Nonresidential 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 revisions.

2.7.12 Hand Dryers Measure Overview

TRM Measure ID: NR-MS-HD

Market Sector: Commercial

Measure Category: Miscellaneous

Applicable Building Types: Retail, commercial, and industrial settings

Fuels Affected: Electricity

Decision/Action Type: Retrofit

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

This 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, existing hand dryer equipment must currently utilize more than 5 Wh or more per use and replacement hand dryers must consume no more than 5 Wh per use. This measure is applicable in retail, commercial and industrial settings.

Baseline Condition

The baseline efficiency case is a hand dryer which utilizes more than 5 Wh or more per use. These hand dryers are often push-button activated.

High-Efficiency Condition

Eligible high-efficiency equipment is a hand dryer equipped with motion sensors that uses 5 Wh or less per use.

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 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:

$$kWh_{Savings} = \frac{UPD \times DPY \times \Delta Wh}{1{,}000} \times IEF_E$$

Equation 253

$$\Delta Wh = Wh_{Baseline} - Wh_{Efficient}$$

Equation 254

Where:

UPD = *Number of uses per day, see* $kW_{Savings} = \frac{kWh_{Savings}}{AOH} \times CF \times IEF_D$

Equation 255

Where:

AOH = Annual operating hours, see Table 276

CF = *Coincidence Factor, see Table 276*

$IEFD$ = *Interactive effects factor for demand, see Table 275*

Table *276*

DPY = *Number of days the facility operates per year (if unknown, see* $kW_{Savings} = \frac{kWh_{Savings}}{AOH} \times CF \times IEF_D$

Equation 255

Where:

AOH = Annual operating hours, see Table 276

CF = *Coincidence Factor, see Table 276*

$IEFD$ = *Interactive effects factor for demand, see Table 275*

Table *276)*

IEF_E = *Interactive effects factor for energy, see Table 275*

Table 275. Deemed Energy and Demand Interactive Factors for Hand Dryers[563]

Space conditioning type	IEF_E	IEF_D
Refrigerated air	1.05	1.10
Evaporative cooling	1.02	1.04
None (unconditioned/uncooled)	1.00	1.00

$Wh_{Baseline}$ = Baseline energy consumption in watt-hours, 20.65[564]

$Wh_{Efficient}$ = Efficient energy consumption in watt-hours, 3.94[565]

$$kW_{Savings} = \frac{kWh_{Savings}}{AOH} \times CF \times IEF_D$$

Equation 255

Where:

AOH = *Annual operating hours, see Table 276*

CF = *Coincidence Factor, see Table 276*

IEF_D = *Interactive effects factor for demand, see Table 275*

563 Texas Technical Reference Manual, Volume 2 – 2.1 Nonresidential Lighting. Table 11.

564 Baseline and efficient Wh per use 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.

565 Ibid.

Table 276. Hand Dryer Assumed Variables by Building Type

Usage Level	Building Type	Coincidence Factor[566]					AOH[567]	UPD[568]	DPY[569]
		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	250	365
	Restaurant	0.90	0.90	0.90	0.90	0.90			
	Retail	0.90	0.90	0.90	0.90	0.90			
High	Conference Center	0.65	0.65	0.65	0.65	0.65	339	500	200
	School[570]	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			

Deemed Energy and Demand Savings Tables

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

Table 277. Hand Dryer Deemed Energy Savings

Usage Level	Building Type	Deemed Energy Savings
Low	Office	217

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

567 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 276), then converted to hours by dividing this product by 3,600.

568 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)

569 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.

570 Assuming K-12 without summer session

Usage Level	Building Type	Deemed Energy Savings
	Warehouse	217
Medium/Moderate	Restaurant	1,585
	Small grocery	1,585
	Retail	1,585
High	School[571]	1,737
	University	1,737
	Theater	1,737
	Conference Center	1,737
	Stadium	1,737
High (Grocery)	Large Grocery/Retail	3,170
Heavy Duty/Extreme	Transportation Center	15,852
	Airport	15,852

Table 278. Hand Dryer Deemed Demand Savings

Usage Level	Building Type	Deemed Demand Savings				
		CZ 1	CZ 2	CZ 3	CZ 4	CZ 5
Low	Office	2.18	2.20	2.15	2.25	2.25
	Warehouse	1.98	2.03	1.98	2.00	2.13
Medium/Moderate	Restaurant	2.25	2.25	2.25	2.25	2.25
	Small grocery	2.25	2.25	2.25	2.25	2.25
	Retail	2.25	2.25	2.25	2.25	2.25
High	School[572]	0.98	0.98	2.25	2.18	1.00
	University	2.25	2.25	2.25	2.25	2.25
	Theater	1.63	1.63	1.63	1.63	1.63
	Conference Center	1.63	1.63	1.63	1.63	1.63
	Stadium	1.63	1.63	1.63	1.63	1.63
High (Grocery)	Large Grocery/Retail	2.25	2.25	2.25	2.25	2.25
Heavy Duty/Extreme	Transportation Center	2.25	2.25	2.25	2.25	2.25
	Airport	2.25	2.25	2.25	2.25	2.25

571 Assuming K-12 without summer session
572 Assuming K-12 without summer session

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[573] for efficient hand dryers.

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
- Building type

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 279. Nonresidential Hand Dryers Revision History

TRM version	Date	Description of change
v10.0	10/2022	TRM v10.0 origin

[573] 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).

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 256

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

Equation 257

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 258

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

Equation 259

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

Equation 260

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

Equation 261

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*[574]
$kW_{baseline}$	=	*Demand of the second-tier baseline system, usually the baseline ROB system*[575]
$kW_{installed}$	=	*Demand of the replacement system*[576]
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*[574]
$kWh_{baseline}$	=	*Energy usage of the second-tier baseline system, usually the baseline ROB system*[575]
$kWh_{installed}$	=	*Energy usage of the replacement system*[576]

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 262

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

Equation 263

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

Equation 264

574 Retired system refers to the existing equipment that was in use before the retrofit has occurred.
575 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).
576 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 265

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* [577]
d	=	*Discount rate weighted average cost of capital (per utility)* [577]
AC_{kW}	=	*Avoided cost per kW ($/kW)* [577]
AC_{kWh}	=	*Avoided cost per kWh ($/kWh)* [577]
ML_{FT}	=	*First-tier measure life (calculated in Equation 256)*
ML_{ST}	=	*Second-tier measure life (calculated in Equation 257)*

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

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

Equation 266

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

Equation 267

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*

[577] 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 268

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

Equation 269

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:

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

Equation 270

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

Equation 271

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 Equation 266*

$NPV_{Total,\ kWh}$ = *Total energy contributions to NPV of both ER and ROB component, calculated in Equation 267*

$NPV_{EUL,\ kW}$ = *Capacity contributions to NPV without weighting, using original EUL, calculated in Equation 268*

$NPV_{EUL,\ kWh}$ = *Energy contributions to NPV without weighting, using original EUL, calculated in Equation 269*

Option 2—Weighting Measure Life and Holding First Year Savings Constant

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:

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

Equation 272

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

Equation 273

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.

The following files are not convertible:

TRMv10.0 Vol 4 MV_2022-10-03_EEIP.pdf

Please see the ZIP file for this Filing on the PUC Interchange in order to access these files.

Contact centralrecords@puc.texas.gov if you have any questions.

Public Utility Commission of Texas

Texas Technical Reference Manual

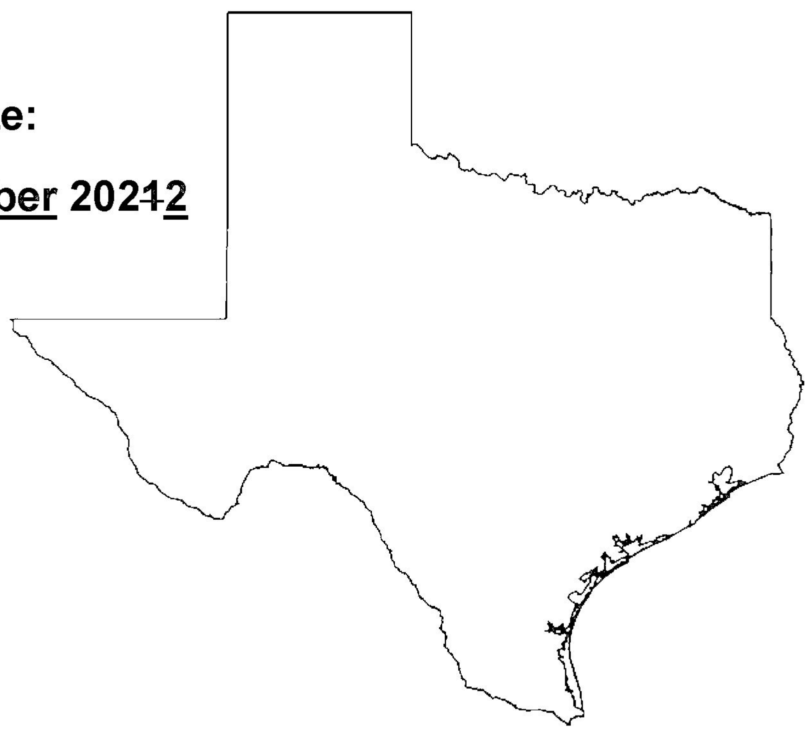
Version ~~9~~10.0

Volume 5: Implementation Guidance

Program Year 202~~2~~3

Last Revision Date:

~~December~~November 202~~1~~2



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Acknowledgments

The Texas Technical Reference Manual (TRM) is maintained by the Public Utility Commission of Texas' (PUCT) independent evaluation, monitoring, and verification (EM&V) contractor, Tetra Tech.

This version of the TRM was primarily developed from program documentation and measure savings calculators used by the Texas electric utilities and their energy efficiency services providers (EESPs) to support their energy efficiency efforts, and original source material from petitions filed with the Public Utility Commission of Texas by the utilities, their consultants, and EESPs such as Frontier Associates (TXu 1-904-705), ICF, CLEAResult, and Nexant. Portions of the TRM are copyrighted 2001–2017 by the Electric Utility Marketing Managers of Texas (EUMMOT), while other portions are copyrighted 2001–2018 by Frontier Energy. Certain technical content and updates were added by the EM&V team to provide further explanation and direction as well as consistent structure and level of information.

TRM Technical Support

Technical support and questions can be emailed to the EM&V team's project manager (lark.lee@tetratech.com) and PUCT staff (therese.harris@puct.texas.gov).

1. INTRODUCTION

This volume of the technical reference manual (TRM) contains evaluation, measurement, and verification (EM&V) team recommendations regarding program implementation that may affect claimed savings. The EM&V contractor drafts guidance memos for the electric utilities' energy efficiency programs to provide clear direction on calculating or claiming savings. Guidance memos are consistent with the Energy Efficiency Rule P.U.C. SUBSET. R. 25.181 (16 TAC §25.181) and the TRM but address areas where additional direction is needed for consistency and transparency across utilities' claimed savings from the programs. This volume compiles the various guidance memos produced during the EM&V effort.

Implementation guidance contained in this volume is summarized by sector below:

Commercial

- Project documentation
- Additional savings
- New construction

Residential

- Low-Income Income-Eligible verification forms

Cross-Sector

- Load management programs
- Commercial and residential HVAC split-systems without AHRI certification
- Measurement and verification claimed savings
- Upstream/midstream program cross-sector savings
- Data model

2. COMMERCIAL

2.1 PROJECT DOCUMENTATION

This section summarizes the progress and current status of the evaluation, measurement, and verification (EM&V) team's assessment of the utilities' efforts to meet and conform to project documentation standards and provides additional guidance for areas still in need of improvement as part of the annual EM&V statewide report.

2.1.1 Background

For all energy efficiency programs, critical inputs and methodologies needed to replicate claimed savings calculations are captured in a combination of the TRM, program manuals, program tracking data systems, and individual project documentation. Project-level documentation is critical to the transparency of claimed savings and facilitates efficient third-party EM&V at the project, program, and portfolio levels. This section specifically addresses individual project documentation needs; individual project documentation includes all relevant site-specific details (e.g., audit reports, worksheets, program applications, invoices, project overviews and descriptions, photos, installation reports).

We provide detail on documentation best practices currently incorporated into many Texas programs (based on information gathered during PY2014 evaluation activities) and recommendations for improvement. The objective is to support the utilities in achieving industry-standard degrees of documentation rigor, clarity, and efficacy; these standards are necessary to organize and manage such information to yield transparency and facilitate efficient and effective evaluation.

2.1.2 Additional Documentation Guidance

In this section, we provide guidance geared specifically to help improve CSOP program documentation scores. However, the guidance may also be used to support the continued improvement of program documentation for other programs.

Recommendation 1: Clearly organize project files.

Organized project files are critical for many reasons, including:

- clear and transparent reporting of documentation used to support claimed savings,
- ease of identification of related program project files that may not have made the data transfer,
- backup support for information within tracking data systems,
- support custom parameter usage, and
- support deviation or enhancement of methodologies to gain greater accuracy.

An important part of organized project folders, files, and documents is clear naming conventions; this helps keep files organized and improves consistency in document placement and locating critical documents to support the EM&V efforts. Below are some examples of the difficulty the EM&V team has had with project-level folders and files received:

- The project folders often contained inconsistencies regarding file and document names, locations, and contents. Files with similar names often contained disparate information, while seemingly identical files contained dissimilar information.
- The project folders included multiple copies of project documents. Locating the final documents used to support the reported savings proved difficult for many projects. For example, when numerous photos are provided, locating those that support the key savings assumptions is difficult. Distinguishing between pre- and post-equipment photos was also, at times, difficult.
- Project folders contained documents labeled as verification reports when they were still actually measurement and verification (M&V) plans with no completed verification data. Such plans provided the methodology to verify project savings estimates yet did not document that project savings estimates were complete.

The project file organization example below provides a list of potential project subfolders and documents that would be ideal for collecting information to determine whether a pre- and post-inspection has been completed. Many documents listed are key elements necessary to support custom project assumptions and review.

Table 1. Project File Organization Example

Stage	Retrofit and new construction
Pre-project*	• Pre-project calculator • Plans (e.g., drawings, fixture list) • Pre-project inspection photos • Pre-project audit reports • Project descriptions, sponsor agreements, etc.
Post-project	• Post-project inspection calculator • Post-inspection field notes • Post-project inspection photos • As-built plans • Installation reports
Supporting documents	• Calculators (old and archived) • Spreadsheets or other backup documentation (especially those to support custom calculations) • Specifications, cut sheets, certifications • Check requests to utility • Partner letters or savings summaries • Material purchase orders and invoices • Email communication • M&V plan for custom key input assumptions (e.g., operating hours) or custom savings methodologies
Final documents**	• Final calculator • Final M&V plan for custom projects • Final verification documents for custom projects • Final project notes

* New construction projects may not necessarily include these documents.
** These documents also support EM&V on-site minimum requirements for data collection needs.

Recommendation #2: Use photo verifications to support key measure assumptions.

When on-site fieldwork is complete—whether by trade allies, implementation staff, or utility staff—representative photos can help document and support key measure attributes and assumptions. Most programs include some form of photo documentation to support projects. Some programs in Texas even use tablets in the field whereby the project site and equipment photos are taken by trade allies and automatically uploaded to tracking systems and project folders. The table below outlines how photos can support project documentation for some of the most common commercial project types (i.e., lighting- and HVAC-based projects).

Table 2. Project Verification Applications and Examples

Stage	Lighting projects*	HVAC projects
Pre-project	• Existing lighting system types (e.g., lamp, ballast, fixture) • Existing lighting equipment quantities • Existing control type • Existing lighting equipment operability and inoperability • Building type • Air conditioning type	• Existing HVAC equipment types and sizes • Existing HVAC equipment quantities • Existing HVAC equipment operability and inoperability (e.g., setpoint, load display shots) • Building type
Post-project	• New lighting system types (e.g., lamp, ballast, fixture) • New lighting equipment quantities • New control type • New control schedule automation (e.g., building and lighting automation system screenshots) • New lighting equipment operability • Building type • Air conditioning type	• New HVAC equipment types and sizes • New HVAC equipment quantities • New HVAC equipment operability (e.g., setpoint, load display shots) • Building type

* Note that some of these project parameters may not be possible to capture for all lighting quantities for large lighting projects. In these cases, alternative project documentation types may be preferred.

Recommendation #3: Include clear descriptors of measure type as well as quality assurance/quality control (QA/QC) inspections in the tracking system.

Different projects (e.g., retrofit versus new construction projects, inspected versus not inspected sites) have different documentation needs. Capturing participant descriptors can aid evaluation efforts immensely, keep cost burdens low, and facilitate transparency.

Many commercial programs continue to track and describe measure-level savings at the measure-category level (or savings calculator level) instead of the measure-specific level. For example, the tracking system will document the savings associated with a lighting project captured within a lighting calculator (e.g., Lighting Equipment Survey Form version 9.02). However, the calculator includes many different lighting fixture types, effective useful lives, and related savings. Tracking project data at the measure-specific level (e.g., integrated-ballast LED lamps, linear fluorescent, lighting controls) rather than the measure-category level will improve the data's transparency to readily assess measure types and individual claimed savings. This structure also supports ease for calculating cost-effectiveness.

As another example, new construction projects may not have pre-inspection forms or field notes. In contrast, retrofit projects may have many pre-project documentation types (e.g., pre-project calculator, pre-project plans, pre-inspection photos). Providing information regarding "greenfield" or complete demolition and rebuild projects as a differentiator from retrofits and small remodels upfront is a valuable population segmenting descriptor. When tracking systems use descriptors like these, they become a valuable screening tool; they can inform evaluators not to request certain documentation (that may not exist), which can misdirect time and resources. It also allows better budgeting and allocation of resources, improving overall efficacy. Another example is those sites or program participants that receive internal QA/QC versus those that do not. Some programs have modified their tracking systems to begin logging this data and provide a list as part of the EM&V data collection process; this list notifies the EM&V team that a site will not have specific project-level documentation because it was not site-inspected or verified, etc.

Recommendation #4: Complete M&V plans and reports needed for custom projects.

The industry standard for M&V plans and reports is based on the guidelines of Efficiency Valuation Organizations (EVO) International Performance Measurement and Verification Protocol (IPMVP). IPMVP Core Concepts EVO 10000-1:2022 is the current version available; it includes clear recommendations for meeting the minimum information requirements for complying with IPMVP protocols, including those specific to the M&V plan contents summarized in Chapter 5 and M&V reporting summarized in Chapter 6.

Utilities and their implementation contractors are encouraged to engage and collaborate with the EM&V team to discuss issues and options, obstacles, and possible solutions for M&V plans as new technologies or offerings become part of the Texas portfolios.

2.2 INCENTIVES AND CLAIMED SAVINGS

This section provides guidance on claiming savings when a financial incentive does not cover all project savings during the implementation of energy efficiency measures.[1]

2.2.1 Background

To meet various program objectives, it is common practice for utilities to set a ceiling or cap for the financial incentive any one energy efficiency service provider (EESP) or project can receive. These "individual incentive caps" are set as an overall percentage of the total incentive budget or as a dollar amount. The established caps vary by utility and are noted in their program manuals.

Individual incentive caps are different from a "set incentive." During the application phase, utilities calculate a project incentive based on pre-installation estimated savings; reserving incentive funds are at that time. Once the project is complete, there may be some variation in the initial agreed-upon savings estimates while setting the incentive and the actual post-installation savings. This variation is due to changes in efficiency levels, quantities, or equipment types that take place between the project planning phase and the project implementation phase.

2.2.2 Considerations

In the case of incentive caps, the EM&V team has some concerns regarding claiming all project savings when reaching an incentive cap. Since all project savings are not being incentivized at the project planning phase, claiming all project savings may result in increased free-ridership. A free-rider is "a program participant who would have implemented the program measure or practice in the absence of the program." (16 TAC § 25.181 (c) (24)).[2]

In the case of set incentives, the EM&V team has some concerns that spillover could be claimed incorrectly during post-project inspections. Spillover is "reductions in energy consumption and demand caused by the presence of an energy efficiency program, beyond the program-related gross savings of the participants and without financial or technical assistance from the program." ((16 TAC § 25.181 (c) (53)). Spillover is a component of net savings, and claimed savings are based on gross savings. Therefore, spillover should not be included in claimed savings if found on-site during post-project inspections.

[1] This guidance does not apply to behavioral, code or other market transformation programs where the primary program strategy is technical assistance and/or education that results in behavioral or operational changes for energy and demand savings.

[2] In addition to the incentive caps or set incentives at the individual EESP or customer-level, utilities may also set caps on incentives a customer can receive at the measure level. For example, a utility may cap lighting incentives at 50 percent of the total project incentive. The EM&V team does not have the same concerns regarding free-ridership for measure-level caps and the recommendations in this memo do not apply to these situations.

2.2.3 Recommendations

Establish greater consistency in the treatment of projects where claimed savings exceed incentive amounts and most accurately represent the savings results from these projects. The EM&V team recommends utilities either only claim the savings from the incentivized measures or the utilities apply the most updated net-to-gross (NTG) research[3] to the total project savings for the claimed savings[4] as follows:

For projects where the *claimed savings are more than 10 percent higher than the "set incentive*," the NTG ratio inclusive of free-ridership and spillover should be applied to the total project savings. No NTG ratio should be applied for projects where the set incentive and claimed savings differ by 10 percent or less to allow for normal variation between project planning and implementation.

For projects where *claimed savings exceed the "incentive cap" savings up to 20 percent of incentivized savings*, the NTG ratio inclusive of free-ridership and spillover should be applied to the total project savings.

$$NTG\ ratio_{projects\ exceeding\ set\ incentive} = 1 - Free\ Ridership + Spillover$$

Equation 1

For projects where total *claimed savings exceed the "incentive cap" by more than 20 percent of incentivized savings*, the NTG ratio only accounting for free-ridership should be applied to the total project savings. Applying the NTG ratio that is also inclusive of spillover to projects that exceed incentive amounts by a percentage of incentivized savings this large would likely result in double-counting spillover.

$$NTG\ ratio_{projects\ exceeding\ incentive\ cap} = 1 - Free\ Ridership$$

Equation 2

The PY2021~~17~~ EM&V research updated NTG ratios for the commercial standard offer (CSOP) and market transformation programs (CMTPs). The PY2021~~17~~ NTG research accounts for~~ both~~ free-riders; spillover rates were derived from the PY2017 EM&V research~~ and spillovers~~. The CSOP NTG ratio is 100~~91~~ percent for kWh and 9~~8~~9 percent for kW. The CMTP NTG ratio is 100~~86~~ percent for kWh and~~ 99 percent for~~ kW.

Table 3. PY20~~17~~21 Commercial Statewide NTG Ratios by Program Type

Program type/weighting	Free-ridership	Spillover	NTG
CSOP kWh	2~~3~~3%	24%	100%~~91~~
CSOP kW	2~~3~~2%	21%	9~~8~~9%
CMTP kWh	19%~~36~~	22%	100%~~86~~
CMTP kW	20%~~33~~	32%	100%~~99~~

[3] The use of a net to gross adjustment to account for free-riders is addressed in § 25.181 (e)(5)(B)(ii).

[4] This recommendation does not apply to behavioral, code or other market transformation programs where the primary program strategy is technical assistance and education that results in behavioral or operational changes for energy and demand savings.

Projects might have multiple measures with different effective useful lives (EULs) that are taken into account when calculating lifetime savings; for these cases, the EM&V team provides the following additional guidance for adjusting claimed savings that exceed incentive levels:

1. Determine the total calculated savings by EUL.
2. Determine the percent of total project savings attributed to each EUL.
3. Adjust savings as recommended above.
4. Distribute adjusted savings to various project EULs using the percentages calculated in step 2.

The following is an example of a project with 50 kW and 50,000 kWh of calculated savings. An RTU HVAC project with a 15-year EUL attributes twenty percent of those savings, and a chiller project with a 25-year EUL attributes the remaining 80 percent. The adjusted savings are 40 kW and 40,000 kWh. Those adjusted savings would be attributed to each EUL as follows:

1. 40 kW x 20% = 8 kW and 40,000 kWh x 20% = 8,000 kWh attributed to the 15-year EUL
2. 40 kW x 80% = 32 kW and 40,000 kWh x 80% = 32,000 kWh attributed to the 25-year EUL

2.3 NEW CONSTRUCTION

This section provides additional guidance to select the appropriate baseline for commercial new construction projects.

2.3.1 Overview

Utility programs include incentives for a variety of projects applicable to commercial new construction such as lighting, HVAC, and roofs. To effectively implement new construction energy efficiency projects, utility programs need to reach decision-makers during the project design phase. However, it is common for several years to pass between the project design phase and project completion in commercial new construction. Since baselines change, this situation raises the question of what baseline utilities should use commercial new construction projects to claim savings. For example, in PY2016, Texas' new construction baseline was IECC 2009 based on the state code in effect at that time. In PY201823, the baseline is now IECC 2015 based on the state code in effect.

2.3.2 Recommendation

For commercial new construction projects, utilities should use the building permit date to determine the applicable version of the Texas TRM and baseline to calculate savings.

3. LOW-INCOME

3.1 LOW-INCOME INCOME-ELIGIBLE VERIFICATION FORMS

This section provides implementation recommendations for the Program Year (PY) 20223 eligibility verification for low-income and hard-to-reach programs.

3.1.1 Background

Texas utilities provide energy efficiency services to low-income customers through a combination of hard-to-reach and low-income programs as specified in 16 Tex. Admin. Code (TAC) § 25.181, relating to the energy efficiency goal. All regulated Texas electric utilities are required to achieve no less than 5 percent of their total demand reduction goal through programs serving hard-to-reach customers (16 TAC § 25.181(e)(3)(F)). In addition, the ERCOT utilities are required to spend no less than 10% of each program year's energy efficiency budget on a targeted low-income efficiency program (16 TAC § 25.181(r)). The qualifying income level of 200% federal poverty level is the same for hard-to-reach and low-income programs though the programs are implemented differently.

The utilities use program eligibility certification forms maintained by the PUCT on their website. The forms differ by single-family and multi-family, but both include a way to qualify for the programs through other low-income programs and services (Category 1) as well as through self-reported income (Category 2). The PUCT has revised the income eligibility annually based on updated federal poverty level information, but the forms have not had major changes for over a decade. Due to the importance of these forms in determining program eligibility, PUCT Staff and the EM&V team agreed to incorporate the forms into Volume 5 of the Texas Technical Reference Manual (TRM) starting with program year (PY) 2022. Forms will be updated as part of the annual TRM update process. As part of integrating the eligibility certification forms into the TRM, PUCT Staff and the EM&V team worked with the utilities to review the forms and certification processes in-depth. Appendix A contains the Single-Family and Multifamily Income Eligibility for Full-Incentive Energy Efficiency Services forms.

The objectives of the in-depth process review were to, "Revise low-income/hard-to-reach eligibility verification to increase the confidence program services are going to intended customers, improve program outreach and address participation barriers, and develop efficient administration processes," as presented at the March 2021 Energy Efficiency Implementation Project (EEIP) meeting. The PY20223 TRM forms expand Category 1 options to support streamlined participation through an expanded list of qualifying programs and services (1A), direct social service or community action agency qualification (1B), and geographic qualification (1C). If a customer does not qualify through any of the three options, income information may be used to determine eligibility (Category 2). Both Category 1A and Category 2 require customers to submit supporting documentation. Because Category 2 requires income information, all parties recognize this information can be more sensitive for customers to provide and for service providers to store securely although all personal identifying information (PII) should be redacted, except name and address of customer. Given concerns about income information as a participation barrier, Category 1 is the preferred method to verify customer eligibility whenever possible.

3.1.2 Quality Assurance/Quality Control (QA/QC)

Utilities should audit a minimum of 10% of all program year projects submitted through each category (1A, 1B, 1C and 2) to ensure the processes are working correctly and the required documentation was submitted and verified to be correct. In the cases where utilities find an error in the process or documentation during their QA/QC processes, utilities should identify a solution to remedy the error. The EM&V team encourages utilities to integrate the program eligibility audit into their existing QA/QC practices to the extent possible to facilitate the most streamlined and effective implementation of this recommendation.

While utilities are not required to store customer documentation on their systems audited as part of the QA/QC process, they should provide contact information of the auditor who has verified the documentation through a visual inspection.

While audit processes can differ to best integrate with utilities' current QA/QC processes, the following are recommended practices by category:

- Category 1A: Verify form is completed and supporting program documentation was provided
- Category 1B: Verify form is completed and signed by social service or community action agency
- Category 1C: Verify address of serviced home is within one of the two qualifying geographic designations; forms are not required for geographical qualification under 1C as long as the relevant information is in the tracking data (service address, geographic qualifier)
- Category 2: Verify form is completed and supporting income information was submitted to service provider/landlord/property manager

Utilities can either conduct the audits themselves or hire a third-party to do so on their behalf. The EM&V team will request a summary of audit results at the end of each program year. The audit result summary should identify solutions to address any errors found during the audit.

A. Program Tracking and Documentation

Utilities should add a field(s) to their program tracking data to clearly track how a low-income and hard-to-reach participant was qualified for the program (Category 1A, 1B, 1C and 2). This will allow both the utility and the EM&V team to sample projects from each category for auditing purposes.

For Category 1A, 1B and 2, all completed forms and supporting documentation, if applicable, should be stored for all projects. Forms are not required for geographical qualification under 1C as long as the relevant information is in the tracking data (service address, geographic qualifier). Forms and supporting documentation should be maintained for a minimum of 24 months.

B. Claiming Master-Metered Savings

Because master-metered complexes are a commercial rate class, costs and savings should be claimed in the commercial sector. However, if the master-metered complex qualifies for hard-to-reach or low-income program services, these costs and savings may be counted toward the utilities' goals (5 percent of total demand reduction goal for hard-to-reach customers (16 TAC §

25.181(e)(3)(F)), and no less than 10% of each program year's energy efficiency budget on a targeted low-income efficiency program (16 TAC § 25.181(r)).). To avoid double-counting, master-metered projects counted toward the goal should be a separate line item.

3.1.3 New Program Strategies

Some utilities are working on partnerships to distribute energy efficiency measures to low-income and hard-to-reach customers such as distributing LEDs at food banks. In these cases, utilities should meet with the EM&V team to agree on an approach for verifying customer eligibility and claiming savings, which will then be presented to Commission Staff. The goal of these discussions is to support the new strategies in keeping with the overall objective of the in-depth process review stated above.

4. CROSS-SECTOR

4.1 LOAD MANAGEMENT PROGRAMS

This section summarizes guidance from the EM&V team on two load management issues raised by one or more utilities during PY2014–PY2015 EM&V: (1) rounding of demand impacts and (2) meter issues.

4.1.1 Rounding

During the EM&V contractor's evaluation efforts on commercial load management programs, the EM&V contractor has found some differences in rounding in the commercial load management programs' demand impacts. These rounding differences are minor and are not a concern in the accuracy of the reporting of impacts. However, in response to a request for guidance to address rounding consistently, the EM&V team recommends utilities round commercial load management impacts consistently with how incentives are awarded, which is at the customer level.

4.1.2 Meter Issues

Utilities are responsible for calling a test event each program year for the load management programs. The test event has several purposes, including assuring the proper functioning of program meters. Utilities are responsible for maintaining working program meters.

Commercial load management programs. Without complete interval meter data to calculate the baseline and event impacts, savings may not be claimed. However, if a customer has alternate interval meter data available, it can be used in lieu of program meter data to calculate claimed savings. Using customer meters for the load management program savings requires that the data meet interval metering requirements presented in the version of the Texas TRM for the program year. In general, it is recommended that customer-owned interval meters should only be used if utility interval meters fail. Data from each meter should not be combined for claiming savings for a specific event and must cover both the event day data and the baseline data.

The EM&V team requests utilities notify them in these circumstances. All calculations and data stemming from the use of customer meters should be provided as part of the EM&V data request, similar to using program meter data. If requested by the utility, the EM&V team is available to review the use of customer meter data in advance of a program claiming savings from customer meters.

Residential load management programs. If there are random, non-systematic errors in smart meter data for less than one percent of total participants, the average savings from a similar group of participants (e.g., single-family, multifamily) may be used for claimed savings if: (1) the control event technology and intervention are the same and (2) the control event intervention can be confirmed based on standard program practices for event confirmation.

The EM&V team requests utilities notify them in these circumstances to discuss the approach for determining and applying average savings for those customers with incomplete meter data.

4.2 COMMERCIAL AND RESIDENTIAL HVAC SPLIT-SYSTEMS WITHOUT AHRI CERTIFICATION

This section provides guidance in determining efficiency levels of eligible HVAC split systems that do not have AHRI certification. The methodology outlined in this memo can be used starting in PY202~~1~~3.

Constructing AC and heat pump systems can be done using outdoor units and indoor units from different manufacturers; not all these combinations are certified by AHRI. Savings should be calculated and reported consistently across utilities and in agreement with industry-standard practice and the Energy Efficiency Rule 16 TAC § 25.181.

Projects in PY2020 were affected by changes in supply chains due to COVID-19, leading to project equipment and timeline adjustments; supply chain issues are expected to continue into PY202~~1~~3. In addition to the AHRI certification, the process outlined in this guidance memo may guide HVAC project efficiency calculations impacted by supply chain issues. Coordination with the evaluation team for alternate applications of the process is recommended.

4.2.1 Background

Texas TRM ~~7~~10.0 allows air conditioning and heat pump split systems to be either AHRI-certified or listed on the DOE Compliance Certification Management System (CCMS). Split systems consist of an outdoor unit and an indoor unit, which can be made by the same manufacturer or separate manufacturers. The system's efficiency and size are driven primarily by the outdoor unit, although various indoor units can slightly affect the system efficiency.

Texas TRM ~~8~~10.0 clarifies the allowable efficiency levels for outdoor and indoor unit pairs listed in the DOE CCMS and not AHRI-certified. The TRM states that the claimed efficiency for these non-certified pairs should not exceed the AHRI-certified pairs' average. The guidance below provides an example to identify the not-to-exceed value.

4.2.2 Guidance

The following guidance should be applied if paired outdoor and indoor HVAC units are not in the AHRI certification list and only have DOE CCMS testing results. In that case, the high-efficient condition's capacity and efficiency shall not exceed the average of the AHRI-certified pair listing for the matching outdoor (condenser) unit. The DOE CCMS listing provides documentation of the results that are on the AHRI certification listing and can be downloaded and filtered based on listings that use a similar condenser and various indoor units.

The following is an example scenario designed to direct the user on interpreting the guidance in this memo.

Example: A split system is listed in DOE CCMS and is not AHRI certified.

Analysis scenario: A high-efficiency split-system heat pump is installed with a Goodman GSZ16 outdoor unit (condenser) and a third-party indoor unit (air handler). The specific pair is not listed in the AHRI database.

Step 1: Access the DOE CCMS[5] and select the appropriate measure category for the product pair. In this example, it is the *Air Conditioners and Heat Pump – Central* measure category.[6] Search for the critical component to the system's efficiency (the outdoor unit (condenser)), with model number GSZ160241B*. The * is added near the end of the model number to allow for different condenser unit variations.

Step 2: Identify the specific air handler match and record the specifications from the DOE CCMS. In this example, the Airmark GES244 indoor unit pairs with the Goodman GSZ160241B outdoor unit with the following specifications:

Table 4. Specification of an Example Split System

Cooling capacity (Btu/h)	24,000
Heating capacity (Btu/h)	24,000
SEER	16
EER	13
HSPF	9
Link to FTC Energy Guide label	(blank)*

*(blank) indicates the pair is not listed in the AHRI database.

The *Link to FTC Energy Guide Label* column will identify other certifications obtained by this equipment pair. In the example, the column is blank, indicating it is not listed in the AHRI database.

Step 3: Filter the DOE CCMS database to match the specification of the installed pair. Filter the *product code description*, *cooling capacity*, and *Link to FTC Energy Guide Label* to find a representative sample of similar AHRI-listed units. Table 5 details the filter selected for the example. Figure 1 shows the filter on the CCMS database interface.

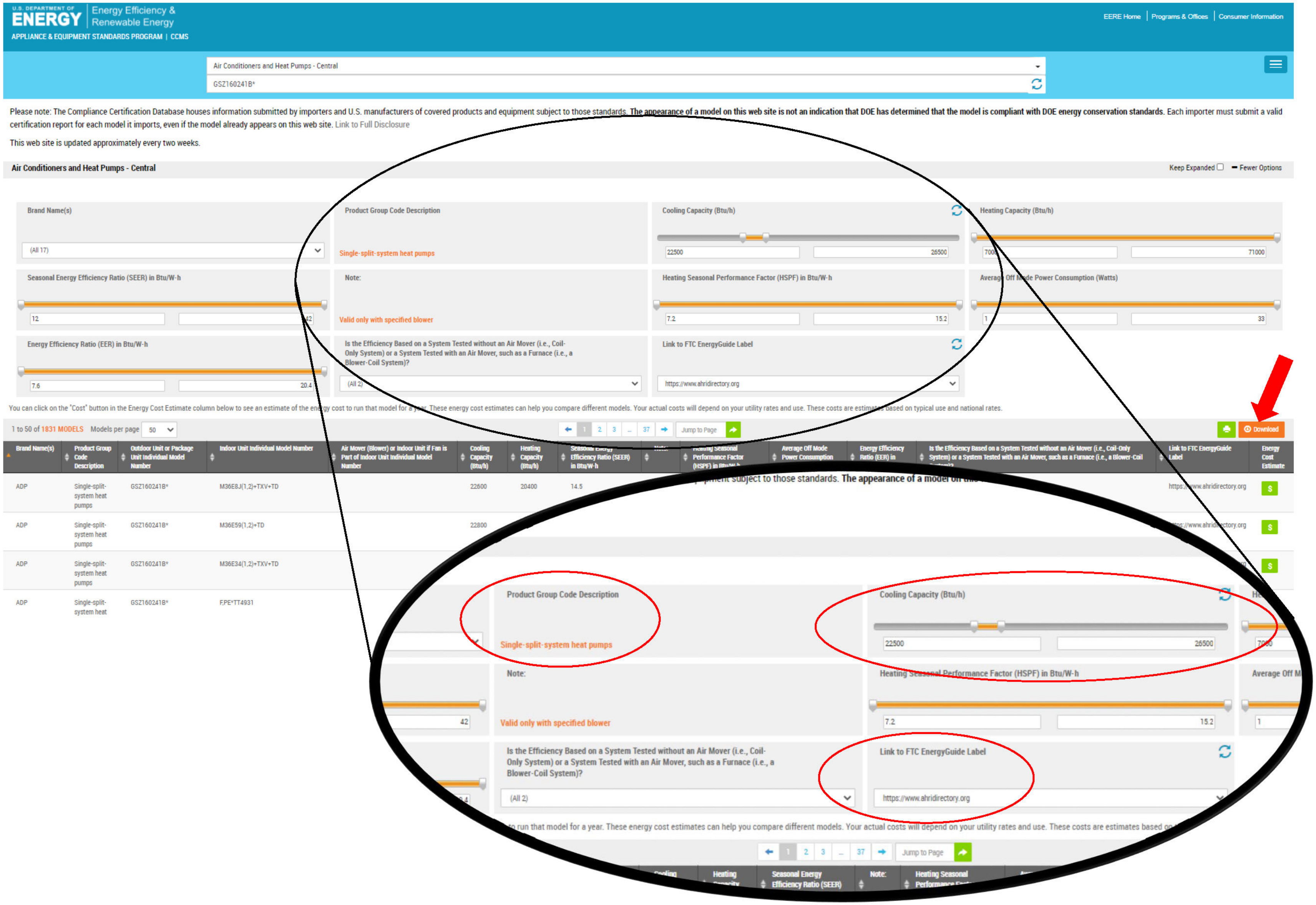
Table 5. Example DOE CCMS Filter to Similar Equipment

Product code description	Single-split-system-heat-pump
Cooling capacity	22,500 to 26,500
Link to FTC Energy Guide Label	www.ahridirectory.org

[5] DOE Compliance Certification Database. https://www.regulations.doe.gov/certification-data/#q=Product_Group_s%3A*

[6] Note that the measure categories are based on technology and not use. The example is for a split system, but the category in the database is central system because the condenser technology meets that definition.

Figure 1. Example Filter of DOE CCMS Database

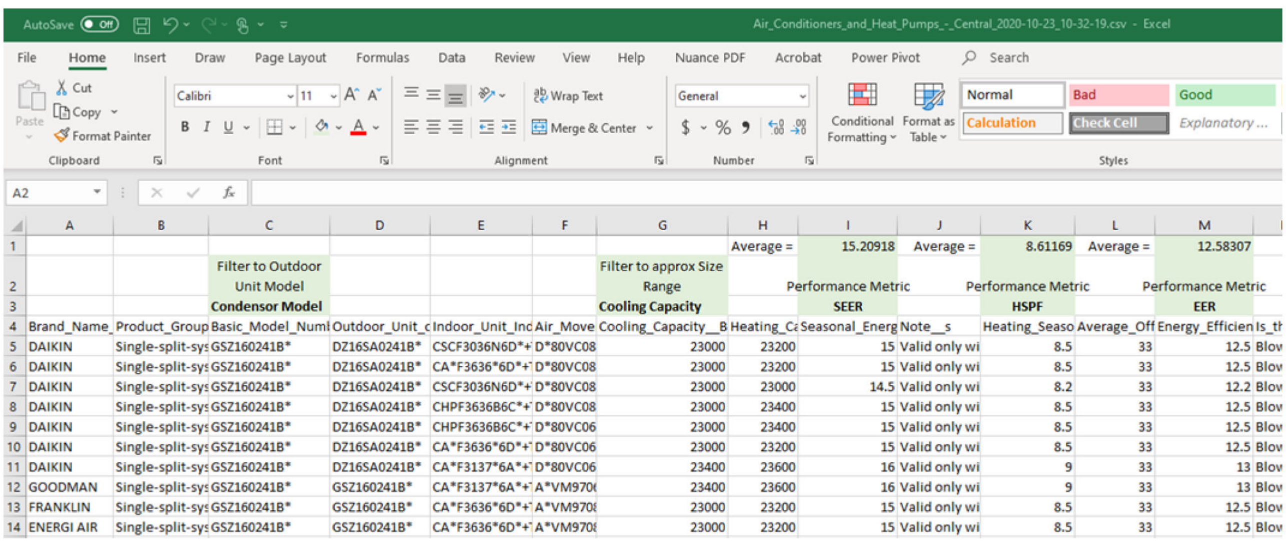


Step 4: Download the filtered database using the *download* button on the right side of the screen. A .csv spreadsheet will download. Project documentation should include a copy of the downloaded .csv file with the download date in the file name. Since the DOE CCMS is constantly updated, this file is the record of the DOE CCMS entries on the date of application review.

Figure 2 below shows the downloaded spreadsheet with three rows added above. Rows 2 and 3 identify the filters and the performance metric columns. Column C is the filter for the outdoor unit in Step 1. Columns G and Q (not shown) are the filters applied in Step 3.

Columns I, K, and M contain the performance metrics for the filtered products and represent the AHRI-certified performance metrics for similar split-system pairs with the matching outdoor unit (condenser).

Figure 2. Sample Downloaded Spreadsheet with Calculation



	A	B	C	D	E	F	G	H	I	J	K	L	M	
1								Average =	15.20918	Average =	8.61169	Average =	12.58307	
2			Filter to Outdoor Unit Model				Filter to approx Size Range		Performance Metric		Performance Metric		Performance Metric	
3			Condensor Model				Cooling Capacity		SEER		HSPF		EER	
4	Brand_Name_	Product_Group	Basic_Model_Numb	Outdoor_Unit_c	Indoor_Unit_Inc	Air_Move	Cooling_Capacity__B	Heating_Ca	Seasonal_Energ	Note__s	Heating_Seaso	Average_Off	Energy_Efficien	Is_th
5	DAIKIN	Single-split-sys	GSZ160241B*	DZ16SA0241B*	CSCF3036N6D*+	D*80VC08	23000	23200	15	Valid only wi	8.5	33	12.5	Blov
6	DAIKIN	Single-split-sys	GSZ160241B*	DZ16SA0241B*	CA*F3636*6D*+	D*80VC08	23000	23200	15	Valid only wi	8.5	33	12.5	Blov
7	DAIKIN	Single-split-sys	GSZ160241B*	DZ16SA0241B*	CSCF3036N6D*+	D*80VC08	23000	23000	14.5	Valid only wi	8.2	33	12.2	Blov
8	DAIKIN	Single-split-sys	GSZ160241B*	DZ16SA0241B*	CHPF3636B6C*+	D*80VC08	23000	23400	15	Valid only wi	8.5	33	12.5	Blov
9	DAIKIN	Single-split-sys	GSZ160241B*	DZ16SA0241B*	CHPF3636B6C*+	D*80VC06	23000	23400	15	Valid only wi	8.5	33	12.5	Blov
10	DAIKIN	Single-split-sys	GSZ160241B*	DZ16SA0241B*	CA*F3636*6D*+	D*80VC06	23000	23200	15	Valid only wi	8.5	33	12.5	Blov
11	DAIKIN	Single-split-sys	GSZ160241B*	DZ16SA0241B*	CA*F3137*6A*+	D*80VC06	23400	23600	16	Valid only wi	9	33	13	Blov
12	GOODMAN	Single-split-sys	GSZ160241B*	GSZ160241B*	CA*F3137*6A*+	A*VM970	23400	23600	16	Valid only wi	9	33	13	Blov
13	FRANKLIN	Single-split-sys	GSZ160241B*	GSZ160241B*	CA*F3636*6D*+	A*VM970	23000	23200	15	Valid only wi	8.5	33	12.5	Blov
14	ENERGI AIR	Single-split-sys	GSZ160241B*	GSZ160241B*	CA*F3636*6D*+	A*VM970	23000	23200	15	Valid only wi	8.5	33	12.5	Blov

Column I, K, and M are the DOE CCMS logged values of SEER, HSPF, and EER, respectively. Row 1 uses the =*Average()* function in Microsoft Excel to identify the average performance metrics from the data in the database. Record these values rounded to one decimal point.

Table 6. Average Performance Metrics of Similar Certified Units

SEER (AHRI average)	15.2
EER (AHRI average)	12.6
HSPF (AHRI average)	8.6

Step 5: Identify the performance metrics used for TRM energy efficiency calculations. The installed unit pair's performance metrics for the calculation shall not exceed the similar-sized unit pair's performance metrics in the AHRI database.

Table 7. TRM Calculation Performance Metrics Determination

Performance metric	DOE CCMS (actual)	AHRI certification average	TRM calculation value[7]
SEER	16	15.2	15
EER	13	12.6	12.5
HSPF	9	8.6	8.6

Step 6: Complete the TRM energy savings calculation using the TRM calculation values determined in Table 7.

Include (1) the additional documentation of the original downloaded .csv file and (2) the average efficiency calculation spreadsheet file with the project documentation required in TRM Volume 2 and Volume 3.

[7] TRM calculation was determined using the rounding for EER and HSPF values to matched deemed tables. If the calculator can handle more detail, using the values rounded to the nearest tenth is acceptable.

4.3 MEASUREMENT AND VERIFICATION CLAIMED SAVINGS

This section provides guidance on claiming savings for projects implemented in one program year with measurement and verification (M&V) methodologies across two program years. This guidance aims to balance the level of savings claimed in the same year as the project activities with savings claimed once the M&V is completed.

4.3.1 Introduction

The annual reporting of program savings poses a challenge to accurately estimate impacts when the M&V methodology requires information across program years (such as 12 months of post-project consumption data to see seasonal effects or summer peak metering to estimate kW reductions). Projects extending beyond program years are a common challenge for behavioral programs and complex custom commercial and industrial projects.

Volume 4 of the TRM includes an M&V protocol for behavioral programs based on 12 months of pre-install and post-install data to determine energy savings accurately. Although savings can be estimated through custom calculations, the final amount of energy savings needs to be *trued-up* once all 12 months of post-install data is collected and analyzed. Trueing-up project savings is also common for custom commercial projects where M&V is required across program years. Utilities have employed the standard practice for custom projects of awarding 40 percent of the incentives and claiming 40 percent of the savings in the first program year based on the initially-estimated savings. In the subsequent program year, when M&V post-install data is fully collected and analyzed, the remaining 60 percent, or *trued-up* amount, is awarded and savings claimed. We refer to this as a *40/60* split though the percentage claimed in the second year may be less than or greater than 60.

In addition to these two common examples, this claimed savings guidance could also apply to any program wanting to claim savings through an M&V protocol as opposed to TRM deemed savings.

4.3.2 Recommendation

We recommend a 40/60 split of incentives and claimed savings is employed whenever M&V spans two program years. In other words, award 40 percent of incentives and savings claimed in the first program year—and the true-up, whether it is greater or less than 60 percent—would be awarded and claimed in the second program year. The true-up is required, whether it is to claim the remainder of the estimated savings or increases and decreases to the previously claimed energy savings. For example, if a project is estimated to reduce the peak kW by 100 kW, the project should claim 40 kW at project completion. Once the M&V is completed, the full savings may be claimed. For this example, we assume the M&V found the peak demand reductions were 110 kW. The true-up claim would be 70 kW in the second program year instead of the 60 kW as initially estimated in the 40/60 split. However, if the completed M&V analysis instead finds the total peak demand reduction is 30 kW, the true-up claim would be negative 10 kW.

This 40/60 split balances the first program year implementation of the measure and its planned savings with what savings are found actually to be in the second year once M&V is complete.

There may be instances when a utility feels a different balance, such as a 50/50 split, which may be more appropriate. The utility should seek the PUCT EM&V contractor's review and approval of a different split of incentives and claimed savings across program years than the standard recommendation of 40/60 in this guidance section.

4.4 UPSTREAM/MIDSTREAM PROGRAM CROSS-SECTOR SAVINGS

This section provides guidance to calculate and allocate savings at the sector-level for upstream and midstream programs where installation location is not identified. The methodology that was reviewed and approved for use in PY202~~1~~3 is also outlined.

4.4.1 Background

TRM v8.0 updated methods to calculate and allocate savings for lighting equipment sold through participating upstream and midstream programs. The TRM v8.0 method attempted to simplify the process for equipment sold when the installation location is not known, although several unintended consequences require adjustment. The recommendations below apply to programs when installation location must be generalized. If location installation is known at the time of sale, the assumptions for building type and lamp watts from the TRM should be used.

4.4.2 Recommendations

Claimed savings by sector. To account for the cross-over between commercial and residential applications in an upstream or midstream delivery method, the EM&V team recommends that five percent of upstream and midstream lighting program benefits and costs are allocated to commercial customers, with the remaining 95 percent allocated to residential customers. This recommendation ~~replaces the recommendation on page 13 of PY2021 TRM v8 Volume 2 and~~ agrees with the guidance memo put forth by the EM&V team, dated April 28, 2016.

Residential savings. The EM&V team recommends that the calculation methodology outlined in TRM ~~v8~~v10.0 Volume 2 be used for the residential portion of the savings. Savings should be calculated using the TRM stipulated average HOU per year for residential applications, 803 hours, and the coincidence factors summarized in Table 5 and Table ~~14~~11. ~~The blended HOU and coincidence factors summarized in Table 7 and Table 16 of section 2.1.1 and 2.1.2, respectively, should not be used to calculate savings. The EM&V team will clarify these assumptions in the TRM 9.0 update.~~

Residential low-income savings determination. Programs that are able to determine low-income and hard-to-reach eligibility by collecting customer information are permitted to use the 10-year low-income EUL to claim savings. For PY202~~1~~3, utilities should continue documenting low-income accounts using the program eligibility certification forms maintained by the PUCT. Updated requirements are incorporated when implemented.

Commercial savings. The commercial lighting savings per lamp can be determined using commercial midstream assumptions identified in Table 12 ~~and Table 13~~ of PY202~~2~~3 TRM v~~9~~10.0 Volume 3. Thi~~ese~~s table~~s~~ ~~identify~~ identifies the annual operating hours (AOH), coincidence factors, and in-service rates (ISR). Table 8 below is an updated version of Table 12 in PY202~~2~~3 TRM ~~v9~~v10.0 Volume 3 and is recommended to determine assumptions for energy savings calculations.

Table 8. Upstream/Midstream Assumptions by Lamp Type[8]

Lamp type	AOH	Coincidence factors[9]					ISR
		Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	
General service lamp	3,748	0.69	0.69	0.73	0.73	0.71	0.98
Directional/reflector	3,774	0.78	0.79	0.78	0.79	0.82	1.00
LED tube	3,522	0.74	0.75	0.84	0.84	0.76	1.00
High-bay fixture	3,796	0.78	0.79	0.83	0.84	0.80	1.00
Garage	7,884	1.00	1.00	1.00	1.00	1.00	1.00
Outdoor	4,161	0.67	0.71	0.61	0.75	1.00	1.00

The interactive effects should be standardized across all commercial midstream lamp types. All locations should be considered refrigerated air; see Table 9 below (Table 11 from PY202~~2~~3 TRM v~~9~~10.0 Volume 3 of the TRM is unchanged by this guidance).

Table 9. Deemed Energy and Demand Interactive HVAC Factors[10]

Space conditioning type	Energy interactive HVAC factor	Demand interactive HVAC factor
Refrigerated air	1.05	1.10
Evaporative cooling[11]	1.02	1.04
Medium temperature refrigeration (33 to 41ºF)	1.25	1.25
Low-temperature refrigeration (-10 to 10ºF)	1.30	1.30
None (unconditioned/uncooled)	1.00	1.00

[8] 2012 CBECS and 2014 MECS.
[9] Outdoor coincidence factors are specified for winter peak. All other values reference summer peak.
[10] PUCT Docket 39146. Table 7 (page 17) and Table 12 (page 24).
[11] These factors are only applicable for projects in climate zones 1 and 5. They are derived by taking a ratio of total HVAC energy use for spaces with evaporative and refrigerated cooling then applying that ratio against the IEF factors specified for refrigerated air.

4.5 DATA MODEL

With the goal of easing the interpretation of the TRM by database and tracking system developers, the EM&V team worked with EUMMOT and Texas eTRM providers (i.e., Frontier Energy, ANB Systems) to develop a standard data model that outlines common data collected for each prescriptive measure. ~~As of PY2021 TRM v8.0, t~~The data model is for all residential measures in Volume 2~~. A data model for~~ and a ~~limited~~variety of commercial measures in Volume 3, which are not already utilizing savings calculators ~~commercial measures may be completed in the future.~~ ~~.~~

For example, the current data model for an ENERGY STAR® clothes dryer includes weather zone, unit type (front-loading, top-loading, compact), capacity (standard, compact), quantity installed, and date of purchase.

A benefit of a standard data model is to improve program and project analytics across service providers and implementers. A standard data model will also standardize project collection forms (e.g., on-site inspection forms) and reduce the time cleaning large data sets.

For more information, please contact an EUMMOT representative.

APPENDIX A: LOW-INCOME INCOME-ELIGIBLE VERIFICATION FORMS

Single-Family (four or less units or owner-occupied)
Income Eligibility for Full-Incentive Energy Efficiency Services

This statement is made to verify my household income eligibility. The Public Utility Commission of Texas has authorized energy efficiency programs to reduce the utility bills of income-eligible households. Contractors participating in the programs receive higher incentive payments when you are income-eligible. The purpose of the higher payment is to enable the contractor to provide the improvements at a very low cost or no cost to you. **Participating in this program will not affect your eligibility for other program benefits listed below**.

The information provided below will be used solely for the purpose of determining household eligibility and will be kept confidential by the investor-owned utility contractor or other representative and by the Public Utility Commission of Texas and their contractor. It will not be sold or provided to any other party.

Name		
Street Address	Apartment Number	
City	State TX	Zip Code
Phone Number with Area Code ( ) -	Number of Persons in Household	

☐ **Category 1A:** Eligible through other programs or services

At least one member of my household received benefits from one or more of the programs listed below (☑ check all that applies, **digital or paper copy of proof of participation such as award letter required with this form):**

- ☐ Bureau of Indian Affairs (BIA) General Assistance
- ☐ Federal Public Housing Assistance (FPHA)
- ☐ Food Distribution Program on Indian Reservations (FDPIR)
- ☐ Health Benefit Coverage under Child Health Plan (CHIP)
- ☐ Low-Income Energy Assistance Program (LIHEAP) or Comprehensive Energy Assistance Program (CEAP)
- ☐ Medicaid (includes CHIP)
- ☐ Medicare, Qualified Beneficiary
  - QMB (Qualified Medicare Beneficiary)
  - SLMB Specific Low-Income Medicare Beneficiary)
  - QI (Qualified Individual Program)
  - QDWI (Qualified Disabled & Working Individual Program)
- ☐ National School Lunch Program—Free Lunch Program
- ☐ Section 8 Housing Voucher
- ☐ Supplemental Nutrition Assistance Program (SNAP) (Food Stamps)
- ☐ Supplemental Security Income (SSI)
- ☐ Temporary Assistance for Needy Families (TANF)
- ☐ Texas Lifeline Discount
- ☐ Tribal Head Start (only households that meet the income-qualifying standard)
- ☐ Tribal Temporary Assistance for Needy Families (Tribal TANF)
- ☐ Veterans Pension Benefit or Survivors Pension Benefit
- ☐ Veterans Pension or Survivors Benefit Programs

Your signature is required on the last page of this form.

☐ **Category 1B:** Eligible through community action or social service agency
(COMPLETED BY UTILITY, COMMUNITY ACTION, OR SOCIAL SERVICE AGENCY)

I certify the named household participates in one of the programs in Category 1A or other low-income program service (such as Weatherization Assistance), which our agency qualifies participation.

Agency Name	Contact Name	Contact Phone Number with Area Code ( ) -

☐ **Category 1C:** Eligible through geographic location
(COMPLETED BY UTILITY OR THEIR REPRESENTATIVE OR PROVIDER)

(☑ check box if applicable): Form is not required for geographical qualification as long as the relevant information is in the utility's tracking data (service address, geographic qualifier)

☐ Housing and Urban Development (HUD) Low-Income Housing-Qualified Census Tract or Block—GEO ID:______________

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Single-Family (four or less units or owner-occupied)
Income Eligibility for Full-Incentive Energy Efficiency Services

☐ **Category 2:** Eligible through income verification
(DO NOT COMPLETE IF 1A, 1B, OR 1C COMPLETED ABOVE)

*To accurately determine your **household income**, you must include the income of all persons residing in your home from all sources. To determine the amount of income in each category, enter the amount(s) on the check or benefit statement.* **Supporting documentation must be provided (all personal identifying information may be redacted except name and address).**

STEP 1: Fill out the Income Calculation table below.

Amounts listed are shown (☑check one): ☐ Annually ☐ Monthly ☐ Weekly

Income Calculation Table

Source of income	Amount ($)
Wages from full- or part-time employment as shown on a paystub or W-2 form	
Unemployment or worker's compensation	
Social security	
Retirement income	
Child support or alimony	
All other earnings	
Total household income *(add the amount entered on each line to figure your total household income)*	

STEP 2: Compare your total household income per week, month, or year to the amount shown in the table below for the number of persons in your household.

If your total household income is equal to or less than the amount shown in the table, you are income-eligible.

200 Percent of Health and Human Services (HHS) Poverty Guidelines

Size of family unit	Annual income	Monthly income	Weekly income
1	$ 27,180	$ 2,265	$ 523
2	$ 36,620	$ 3,052	$ 704
3	$ 46,060	$ 3,838	$ 886
4	$ 55,500	$ 4,625	$ 1,068
5	$ 64,940	$ 5,412	$ 1,249
6	$ 74,380	$ 6,198	$ 1,431
7	$ 83,820	$ 6,985	$ 1,612
8	$ 93,260	$ 7,772	$ 1,794
Each additional person, add:	$ 9,440	$787	$ 182

* **Notice:** Income ceilings are for February 1, 2022—January 31, 2023.
Annual updates are posted on http://www.puc.texas.gov/industry/electric/forms/

(Electronic) By typing my name below, I certify the above statements to be true and correct to the best of my knowledge, and that this information can be used for the purpose of processing my Single-Family Income Eligibility for Full-Incentive Energy Efficiency Services Form.
(Non-Electronic) If filling out the delineation by hand, please provide your original signature and date.

I understand that the information is subject to audit and investigation by the investor-owned utility or representative providing the program services.

Applicant Signature	Date
Contractor Signature	Date

Keep a copy of this form for your records.

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Multifamily Apartment Complex (five or more units)
Income Eligibility for Full-Incentive Energy Efficiency Services

This form is to verify that at least 75 percent of the units are rented by income-eligible customers. The Public Utility Commission of Texas has authorized energy efficiency programs to reduce the utility bills of income-eligible tenant households. Contractors participating in the programs receive higher incentive payments when at least 75 percent of the tenants qualify as income-eligible. **One form must be filled out for each qualifying multifamily apartment complex.**

The information provided below will be used solely for the purpose of determining household eligibility and will be kept confidential by the investor-owned utility contractor or other representative and by the Public Utility Commission of Texas and their contractor. It will not be sold or provided to any other party.

Name of Applicant (Property Owner or Agent)	Name of Property Owner	
Name of Multifamily Apartment Complex		Number of Units in Complex
Name of Management Company		Name of On-Site Property Manager
Complex Street Address		Suite Number
City	State TX	Zip Code
Property Owner or Agent's Phone Number with Area Code ( ) -	Fax Number with Area Code ( ) -	
Management Company's Phone Number with Area Code ( ) -	Fax Number with Area Code ( ) -	

☐ **Category 1A:** Eligible through other programs or services

The multifamily apartment complex qualifies in one or more of the programs listed below (☑ check all that apply, **digital or paper copy of proof of participation such as the land use restriction agreement required with this form**):

- ☐ Affordable Housing Disposition Program
- ☐ HOME Rental Housing Development
- ☐ Low-Income Housing Tax Credit Program
- ☐ Multifamily Bond Program
- ☐ Public Housing Authority (Texas Housing Association)
- ☐ Project-Based Section 8
- ☐ Rural Rental Section 515 (FMHA)
- ☐ Section 811 Project Rental Assistance Program
- ☐ Texas Housing Trust Fund
- ☐ Other income-qualifying housing program
  Program name: ______________________

Your signature is required on the last page of this form.

☐ **Category 1B:** Eligible through community action or social service agency
(**COMPLETED BY UTILITY, COMMUNITY ACTION, OR SOCIAL SERVICE AGENCY**)

I certify the named multifamily complex or 75 percent or more of tenants participate in one of the programs in Category 1A or other low-income program service (such as LIHEAP/CEAP and Weatherization Assistance), which our agency qualifies participation.

Agency Name	Contact Name	Contact Phone Number with Area Code ( ) -

☐ **Category 1C:** Eligible through geographic location
(**COMPLETED BY UTILITY OR THEIR REPRESENTATIVE OR PROVIDER**)

(☑ check box if applicable): Form is not required for geographical qualification as long as the relevant information is in the utility's tracking data (service address, geographic qualifier).

☐ Housing and Urban Development (HUD) Low-Income Housing-Qualified Census Tract or Block—GEO ID: ________________

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Multifamily Apartment Complex (five or more units)
Income Eligibility for Full-Incentive Energy Efficiency Services

☐ **Category 2:** Eligible through income verification
(DO NOT COMPLETE IF 1A, 1B, OR 1C COMPLETED ABOVE)

For an apartment complex to be eligible, at least 75 percent of the tenant household incomes before taxes are at or below 200 percent of the federal poverty guidelines.

STEP 1: Fill out the Apartment Complex Income Calculation Worksheet.
(Excel or hard copy must be included with this form)
*To accurately determine tenant **household income,** you may use the tenant rental application showing the number of individuals residing in the unit and the household income dated from within the past 18 months. If the rental application does not show the required information or the information is over 18 months old, then the tenant(s) must complete the **Single-Family Income Eligibility for Full-Incentive Energy Efficiency Services*** **form.** Supporting documentation for each unit must be available for utility audit.

STEP 2: Compare the tenant's total household income per week, month, or year to the amount shown in the table below for the number of persons residing in the unit.
If the total household income is equal to or less than the amount shown in the table, the unit is income-eligible for the full incentive. If the unit is not income-eligible, the unit is eligible for the residential incentive level.

200 Percent of Health and Human Services (HHS) Poverty Guidelines

Size of family unit	Annual income	Monthly income	Weekly income
1	$ 27,180	$ 2,265	$ 523
2	$ 36,620	$ 3,052	$ 704
3	$ 46,060	$ 3,838	$ 886
4	$ 55,500	$ 4,625	$ 1,068
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Each additional person, add:	$ 9,440	$787	$ 182

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Annual updates are posted on http://www.puc.texas.gov/industry/electric/forms/

STEP 3: Fill out the Apartment Complex Income Calculation Summary below.

Apartment Complex Income Calculation Summary

Apartment complex income calculation summary	Number of units
Number of income-eligible units	
Number of non-income-eligible units, including vacant units	
Total number of units	
Percentage of income-eligible units *(income-eligible units divided by the total number of units)*	

STEP 4: If "percentage of income-eligible units" is 75 percent or higher, please certify the eligibility of the apartment complex with your signature below.

(Electronic) By typing my name below, I certify the above statements to be true and correct to the best of my knowledge and that this information can be used for the purpose of processing my Multifamily Apartment Complex Income Eligibility for Full-Incentive Energy Efficiency Services Form.
(Non-Electronic) If filling out the delineation by hand, please provide your original signature and date.

I understand that the information is subject to audit and investigation by the investor-owned utility or representative providing the program services.

Applicant Signature (Property Owner or Agent)	Date
Contractor Signature	Date

Keep a copy of this form for your records.

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The Apartment Complex Income Calculation Worksheet is posted on Texas PUC Sharepoint ~~Texas PUC Sharepoint~~.