Measure category	Measure description	Point estimates	Deemed savings tables	Savings algorithm	Calculator	M&V	10.0 update
Refrigeration	Door heater controls	–	X	X	–	–	No revision
	ECM evaporator fan motors	–	–	X	–	–	Added *schools* as an eligible building type
	Electronic defrost controls	–	–	X	–	–	Added *schools* as an eligible building type
	Evaporator fan controls	–	–	X	–	–	Added *schools* as an eligible building type
	Night covers for open refrigerated display cases	–	X	X	–	–	No revision
	Solid and glass door reach-ins	–	–	X	–	–	Added citation for average product volumes
	Strip curtains for walk-in refrigerated storage	–	X	–	–	–	No revision
	Zero-energy doors for refrigerated cases	–	X	X	–	–	Added clarification for baseline condition
	Door gaskets for walk-in and reach-in coolers and freezers	–	X	X	–	–	No revision
	High speed doors for cold storage	–	X	X	–	–	No revision
Water heating	Central domestic hot water controls	–	X	X	–	–	No revision
	Showerhead temperature sensitive restrictor valves	–	–	X	–	–	No revision
	Tub spout and showerhead temperature sensitive restrictor valves	–	–	X	–	–	No revision

Measure category	Measure description	Point estimates	Deemed savings tables	Savings algorithm	Calculator	M&V	10.0 update
Miscellaneous	Vending machine controls	–	X	X	–	–	No revision
	Lodging guest room occupancy sensor controls	–	X	–	–	–	Changed Climate Zone 4 reference city from McAllen to Corpus Christi
	Pump-off controllers	–	X	X	–	–	No revision
	ENERGY STAR® pool pumps	–	X	X	–	–	Updated for ENERGY STAR Version 3.0 Specification; increased upper limit for pump horsepower to 5 to better reflect product availability
	Computer power management	–	X	X	–	–	No revision
	Premium efficiency motors	–	–	X	–	–	Added guidance for rounding down motor size in the baseline efficiency lookup table; incremented RUL table for code compliance
	ENERGY STAR® electric vehicle supply equipment	–	X	X	–	–	Added reference for ENERGY STAR version
	Variable frequency drives for water pumping	–	X	X	–	–	General text edits
	Steam trap repair and replacement	–	X	X	–	–	No revision
	Hydraulic gear lubricants	–	–	X	–	–	No revision
	Hydraulic oils	–	–	X	–	–	No revision
	Hand dryers	–	X	X	–	–	TRM v10.0 origin

2. NONRESIDENTIAL MEASURES

2.1 NONRESIDENTIAL: LIGHTING

2.1.1 Lamps and Fixtures Measure Overview

TRM Measure ID: NR-LT-LF

Market Sector: Commercial

Measure Category: Lighting

Applicable Building Types: All commercial, multifamily common areas

Fuels Affected: Electricity (interactive HVAC effects: electric/gas space heating)

Decision/Action Types: Retrofit, and new construction

Program Delivery Type: Prescriptive, custom, direct install

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

This section provides estimates of the energy and peak savings resulting from the installation of energy efficient lamps and/or ballasts. The installation can be the result of new construction or the replacement of existing lamps and/or ballasts. This TRM Measure ID covers the following lighting technologies:

- Linear fluorescent T5s; high performance or reduced watt T8s. Linear fluorescent measures may also involve delamping[1] with or without the use of reflectors.
- Fluorescent electrodeless induction lamps and fixtures
- Compact fluorescent lamp (CFL) screw-based lamps and hard-wired pin-based fixtures
- Pulse-start (PSMH) and ceramic metal halide (CMH) lamps; high-intensity discharge (HID) lamps
- Light emitting diode (LED) screw-based lamps; hard-wired LED fixtures.

Energy and demand savings are based on operating hours, coincident-load factors, and changes in pre-existing and post-installation lighting loads, as determined using an approved lighting Standard Fixture Wattage table[2], available for download from the Texas Efficiency website and in the Fixture Codes tab in the latest version of the Lighting Survey Form (LSF). The LSF is one example of a calculator that is used to determine energy and demand savings.

[1] Delamping energy savings are eligible if done in conjunction with T-8 lamp and electronic ballast retrofits.

[2] Maintained by EUMMOT/Frontier Energy: http://texasefficiency.com/index.php/regulatory-filings/lighting.

Pre- and post-retrofit lighting inventories are entered and used with the pre-loaded stipulated values and algorithms needed to calculate energy and demand savings. Components of the calculator include:

- Instructions and project information.
- Pre- and post-retrofit lighting inventories. A tab for exempt fixtures and a description of the exemptions is also present in the calculator.
- Fixture wattages and descriptions are defined in a Standard Fixture Wattage table.
- Factor tables that contain stipulated operating hours, coincidence factors, interactive HVAC factors, control adjustment factors, and new construction lighting power density factors.
- A summary tab displaying the final energy and demand calculations. The data from this tab is entered into the utility program tracking data as the claimed savings values.

Although the generic LSF calculator is publicly available on the Texas Energy Efficiency website, several utilities have their own versions.

Eligibility Criteria

This section describes the system information and certified wattage values that must be used to estimate energy and peak savings from lighting systems installed as part of the Texas utility energy efficiency programs. The fixture codes and the demand values listed in the Table of Standard Fixture Wattages are used to calculate energy and demand savings for lighting efficiency projects.

Existing lighting fixtures must be removed or demolished in place after retrofit to count towards reduced pre-install wattage. Existing lighting fixtures that remain operable after retrofit should be listed in both the pre- and post-retrofit lighting inventory.

In addition, LED and linear fluorescent T8s need to be qualified, as follows:

- High-performance (HP) and reduced-watt (RW) T8 linear fluorescent lamps need to be qualified by the Consortium for Energy Efficiency (CEE). Their respective ballasts need to be qualified by NEMA.[3] See the High-efficiency Condition section for additional details.
- LED lamps and fixtures must have their input power (wattage) and an L70 rated life (hours) verified through some combination of the following references: DesignLights Consortium® (DLC), ENERGY STAR®, or independent lab testing[4] (e.g., LM-79, LM-80, TM-21, ISTMT). Rated life for LED fixtures should be greater than or equal to 50,000

[3] While CEE stopped qualifying ballasts in January 2015, the NEMA Premium Electronic Ballast Program has continued to be maintained and is consistent with the prior CEE specifications for high performance lamps and ballasts, tested in accordance with ANSI C82 Standards.

[4] DLC test lab requirements: https://www.designlights.org/solid-state-lighting/qualification-requirements/testing-lab-requirements/.

hours, which can be demonstrated by compliance with DLC v3.0 or later[5] or through independent lab testing. Similarly, rated life for integrated LED lamps should be greater than or equal to 10,000 hours, which can be demonstrated by compliance with ENERGY STAR Version 2.1 Specification or later[6] or through independent lab testing for integrated-ballast LED lamps. These values represent the point at which the minimum L70 was raised to levels consistent with current deemed measure life assumptions.

- DLC- and ENERGY STAR-certified model numbers should closely align with the installed model number. However, small variances are allowed for portions of the model number that may refer to aspects of the fixture that do not affect energy performance (e.g., color temperature, fixture housing). This allowance is provided at the discretion of the state evaluator and reported model numbers should always default to the closest match available.
- DLC and ENERGY STAR specifications are periodically updated. Projects may report fixture wattage from older versions of product certifications according to the following certification date guidelines if a copy of the original certification is preserved.
    1. New construction: permit date
    2. Small business: date of customer acceptance or project proposal
    3. All other: installation date
- If a product is available in various length increments but is DLC-certified for a specific fixture length, the specified DLC power may be converted to a watts-per-square-foot value to be multiplied against the installed fixture length instead of reporting as a non-qualified fixture.
- Field adjustable light output: If a product is available with field-adjustable light output (or wattage setpoints) that can be adjusted by an installation contractor to utilize some or all LED nodes on the fixture, this will be noted in the Product Capabilities section of the DLC certification. DLC will typically specify the maximum input wattage. These fixtures should be reported based on the following scenarios:
    - If the fixture is installed at a reduced setpoint, it should be reported at the maximum input wattage in combination with the institutional tuning control code to claim energy savings associated with a central control lighting output based on tuning sensors. This control type is similar because it is not easily adjustable over time.

[5] Equivalent to the L70 rated life requirement for all categories as specified in DesignLights Consortium™ (DLC) Technical Requirements v3.0. https://www.designlights.org/solid-state-lighting/qualification-requirements/past-technical-requirements/version-3-0-released-june-23-2015/.

[6] Equivalent to the rated life requirement for all lamps as specified in the ENERGY STAR® Lamps Version 2.1 Specification . https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Lamps%20V2.1%20Final%20Specification.pdf.

- If the fixture is installed with additional controls (e.g., occupancy sensor, daylighting), then it should be reported at the maximum input wattage in combination with the multiple control code.
- If the fixture is installed without adjustment, it should be reported at the maximum input wattage with no control code.
- If the fixture is installed with no additional controls and the DLC certificate specifies a lower wattage setpoint, then it should be reported as the lower input wattage with no control code.
- For all cases, project documentation should include a screenshot of the DLC certificate and an example photo of the field-adjustable setpoint.

Exempt lighting for new construction. Some types of new construction lighting fixtures are exempt from inclusion in the interior lighting demand savings calculation, but they are still included in the total installed lighting power calculations for a project. Exempt fixtures are those that do not provide general/ambient/area lighting, have separate control devices, and are installed in one of the following applications:[7]

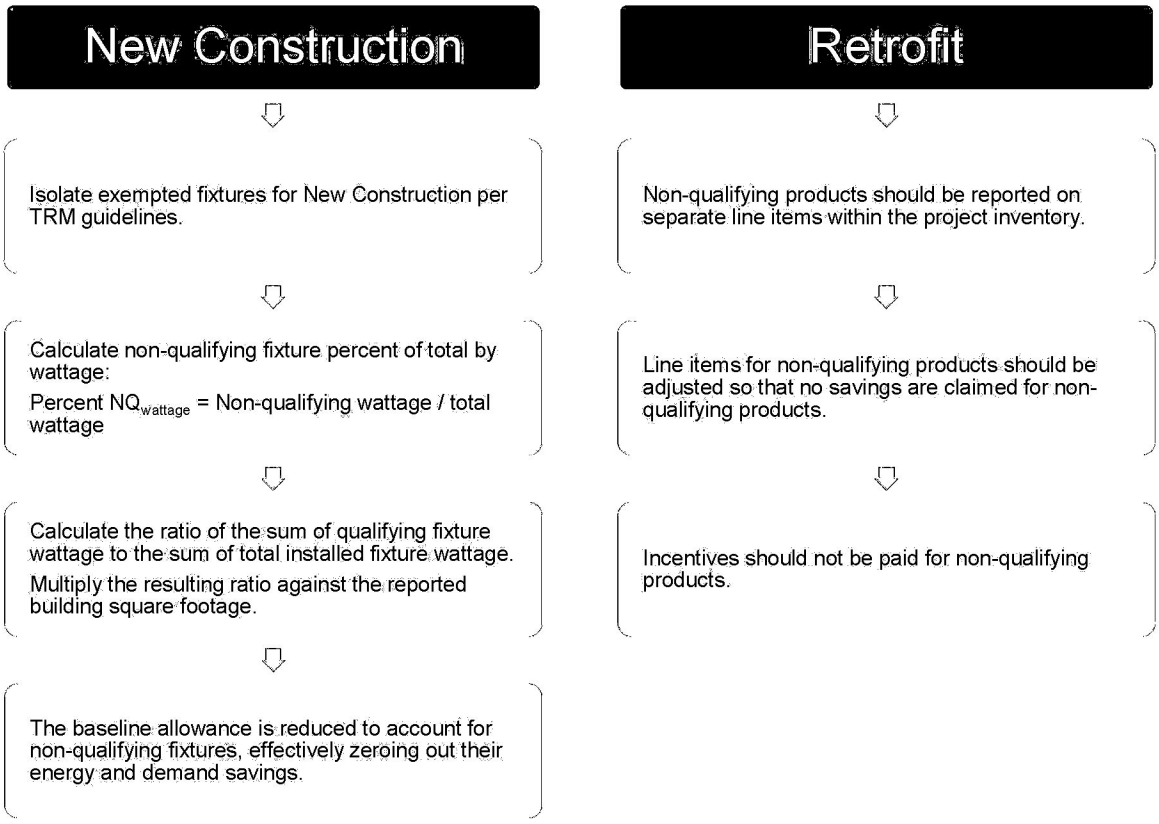
1. The connected power associated with the following lighting equipment is not included in calculating total connected lighting power
    1.1. Professional sports arena playing-field lighting
    1.2. Sleeping-unit lighting in hotels, motels, boarding houses, or similar buildings
    1.3. Emergency lighting automatically off during normal building operation
    1.4. Lighting in spaces specifically designed for use by occupants with special lighting needs including visual impairment and other medical and age-related issues
    1.5. Lighting in interior spaces that have been specifically designated as a registered interior historic landmark
    1.6. Casino gaming areas
    1.7. Mirror lighting in dressing rooms
2. Lighting equipment used for the following shall be exempt provided that it is in addition to general lighting and is controlled by an independent control device
    2.1. Task lighting for medical and dental purposes
    2.2. Display lighting for exhibits in galleries, museums, and monuments
3. Lighting for theatrical purposes, including performance, stage, film production, and video production
4. Lighting for photographic processes
5. Lighting integral to equipment or instrumentation and installed by the manufacturer

[7] IECC 2015, Section C405.4.1.

6. Task lighting for plant growth or maintenance
7. Advertising signage or directional signage
8. In restaurant building and areas, lighting for food warming or integral to food preparation equipment
9. Lighting equipment that is for sale
10. Lighting demonstration equipment in education facilities
11. Lighting approved because of safety or emergency considerations, inclusive of exit lights
12. Lighting integral to both open and glass-enclosed refrigerator and freezer cases
13. Lighting in retail display windows, provided the display area is enclosed by ceiling-height partitions
14. Furniture-mounted supplemental task lighting that is controlled by automatic shut off
15. Exit signs

Non-Qualifying LEDs. This section provides guidance to assess and calculate nonresidential lighting project savings that include non-qualifying LEDs. Figure 1 summarizes the recommended protocol for lighting system projects with non-qualifying LEDs when square footage cannot be isolated. Additional explanations and criteria for use follow.

Figure 1. Lamps & Fixtures—Non-Qualifying LED Process



Step 1: Qualify New Construction Projects. Calculate non-qualifying LED project percentage:

- Based as a percentage of demand (percent $NQ_{wattage}$ = wattage of non-qualifying fixtures / wattage of total fixtures)

Step 2: New Construction Projects Only. Non-qualifying fixtures that pass Step 1 would follow all instructions for excluded fixtures.

- List non-qualifying LEDs on separate lines (e.g., separate on lighting inventory worksheet of deemed savings calculator). Non-qualifying fixtures are identified by a unique fixture code.
- Adjust code allowable baseline wattage so that non-qualifying fixture wattage is not included as part of the lighting power density (LPD) code limit requirements. To do so, calculate the sum of the qualifying fixture wattage and the sum of the total installed fixture wattage. Take the ratio of qualifying fixture wattage to total fixture wattage and multiply the resulting ratio against the total treated square footage for space. The adjusted square footage is included as part of the overall LPD calculation and will decrease the total allowable baseline wattage for the project.

- **Fixture Isolation Method.** If non-qualifying fixtures are isolated to a section of the building whose square footage can be easily segmented from the total building square footage, the non-qualifying fixtures and affected square footage can be excluded from the lighting inventory. Excluded fixtures must be documented when using the fixture isolation method.

Step 3: Retrofit Projects. List non-qualifying LEDs on separate lines (e.g., separate on lighting inventory worksheet of deemed savings calculator).

- Include unique identifiers/markers for the non-qualifying LEDs within the inventory (e.g., fixture code, description, or another designator within the deemed savings tool).
- Adjust non-qualifying LED wattages, so their demand and energy savings are not included as part of the project savings. Demand and energy savings for non-qualifying LEDs shall result in zero-project savings.
- Adjust non-qualifying LED quantities so they are not included as part of the project incentive. Incentives shall not be paid on non-qualifying LEDs.
- Provide clear visibility for all changes within the savings calculation (e.g., deemed savings calculator), including changes to all input assumptions and calculation methodologies to implement the above procedure.
- All other savings procedures and requirements, as specified within the TRM for lighting measures apply to all fixtures of a lighting project.

Baseline Condition

The baseline condition or assumed baseline efficiency used in the savings calculations depends on the decision-type used for the measure. For new construction, the baseline will be based on a lighting power density (LPD) in watts per square foot by building type, as specified by the relevant energy code/standard applied to a specific project. For *retrofit* applications, the baseline efficiency would typically reflect the in-situ, pre-existing equipment, with the exception of linear fluorescent T12s and first-generation T8s, as explained below. Eligible baseline fixture types and wattages are specified in the Standard Fixture Wattages table.

Major renovation projects should use a new construction baseline (for the building type after the improvement) if either of the following conditions are met:

- Building type changes in combination with the renovation
- Renovation scope includes removing drywall and gutting existing building to the studs

Linear Fluorescent T12 Special Conditions

The US Energy Policy Act of 1992 (EPACT) set energy efficiency standards that preclude certain lamps and ballasts from being manufactured or imported into the US. The latest standards covering general service linear fluorescents went into full effect July 2014. Under this provision, almost all 4-foot and some 8-foot T12 lamps, as well as first-generation 4-foot, 700 series T8 lamps were prohibited from manufacture. Because all lighting equipment for Texas energy efficiency programs must be EPACT compliant, including existing or baseline equipment, adjustments were made to the T12 fixtures in the Standard Fixture Wattage table. Certain T12 lamp/ballast combinations which are non-EPACT compliant are assigned EPACT demand values.

As such, 4-foot and 8-foot T12s are no longer an approved baseline technology for Texas energy efficiency programs. 4-foot and 8-foot T12s are still eligible for lighting retrofit projects, but an assumed electronic T8 baseline will be used for estimating the energy and demand savings instead of the existing T12 equipment. T12 fixtures will remain in the Standard Fixture Wattage table, but the label for these records will be changed to "T12 (T8 baseline)" and the fixture wattage for these records will be adjusted to use the adjusted fixture wattages shown in Table 2.

Table 2. Lamps & Fixtures—Adjusted Baseline Wattages for T12 Equipment

T12 length	Lamp count	Revised lamp wattage	Revised system wattage
48-inch—std, HO, and VHO (4 feet)	1	32	31
	2	32	58
	3	32	85
	4	32	112
	6	32	170
	8	32	224
96-inch—std (8 feet) 60/75 W	1	59	69
	2	59	110
	3	59	179
	4	59	219
	6	59	330
	8	59	438*
96-inch HO and VHO (8 feet) 95/110 W	1	86	101
	2	86	160
	3	86	261
	4	86	319
	6	86	481
	8	86	638

T12 length	Lamp count	Revised lamp wattage	Revised system wattage
2-foot u-tube	1	32	32
	2	32	60
	3	32	89

*8 lamp fixture wattage approximated by doubling 4 lamp fixture wattage.

Key: HO = high output, VHO = very high output.

General Service Lamps

On May 8, 2022, the Department of Energy (DOE) issued two final rules relating to general service lamps (GSL):

- Energy Conservation Program: Definitions for General Service Lamps, effective July 8, 2022, which expanded the definition of a GSL.[8]
- Energy Conservation Program: Energy Conservation Standards for General Service Lamps, effective July 25, 2022, which shifted the baseline to 45 lumens/watt efficacy.[9]

The baseline is assumed to be the second-tier Energy Independence and Security Act of 2007 (EISA)-mandated efficiency for a GSL (see Table 3). The EISA regulations dictate that GSLs must comply with a 45 lumen/watt efficacy standard at time of sale beginning January 1, 2023. However, due to the DOE enforcement schedule, savings may be claimed against the first-tier EISA baseline through February 28, 2023, at the utility's discretion.[10]

Table 3. Lamps & Fixtures—EISA 2007 Baseline Adjustment for GSLs [11] [12]

Minimum lumens	Maximum lumens	Incandescent equivalent wattage	2nd Tier EISA 2007 baseline wattage
250	309	25	Exempt
310	749	40	12
750	1,049	60	20
1,050	1,489	75	28
1,490	2,600	100	45

[8] DOE Final Rule: Definitions for General Service Lamps. https://www.regulations.gov/document/EERE-2021-BT-STD-0012-0022.
[9] DOE Final Rule: Energy Conservation Standards for General Service Lamps. https://www.regulations.gov/document/EERE-2021-BT-STD-0005-0070.
[10] See PY2022 TRM 9.0 for methodology and baseline.
[11] Federal standard for General Service Incandescent Lamps (GSILs): https://www1.eere.energy.gov/buildings/appliance standards/standards.aspx?productid=20.
[12] If exempt, refer to incandescent equivalent wattage.

Minimum lumens	Maximum lumens	Incandescent equivalent wattage	2nd Tier EISA 2007 baseline wattage
2,601	3,300	150	66

High-Efficiency Condition

Eligible efficient fixture types and wattages are specified in the Standard Fixture Wattages table. In addition, some technologies such as LEDs must meet the additional requirements specified under Eligibility Criteria.

High-Efficiency/Performance Linear Fluorescent T8s

All 4-foot T8 post-retrofit technologies and new construction projects must use electronic ballasts manufactured after November 2014,[13] and high-performance T8 lamps that are on the T8 Replacement Lamp products list developed by the Consortium for Energy Efficiency (CEE) as published on its website.

If CEE does not have efficiency guidelines for a T8 system (such as for 8-foot, 3-foot, 2-foot, and U-bend T8 products), the product must have higher light output or reduced wattage than its standard equivalent product (minimum efficacy of 75 mean lumens per watt), while also providing a CRI (color rendering index) greater than 80, and an average rated life of 24,000 hours at three hours per start. In addition, 2-foot and 3-foot ballasts must also use electronic ballasts manufactured after November 2014.

Solar LEDs

Solar-powered LEDs are common in several commercial applications, primarily associated with pole-mounted fixtures. Solar lighting uses photovoltaic (PV) cells, which absorb solar energy to charge a battery and power the fixture. By default, solar fixtures should use an efficient wattage of 0. Because fixture performance relies on battery performance, the measure life for solar fixtures is capped at the expected battery life.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

This section describes the deemed savings methodology for both energy and demand savings for all lighting projects. Savings are calculated using separate methods for retrofit and new construction projects.

[13] Changes to the DOE Federal standards for electronic ballasts effective November 2014 met both the CEE performance specification and the NEMA Premium requirements, so CEE discontinued their specification and qualifying product lists. A legacy ballast list from January 2015 is still available.

Retrofit[14,15]

$$Energy\ Savings\ [kWh] = \left(kW_{pre} \times Hours_{pre} \times EAF_{pre} - kW_{installed} \times Hours_{installed}\right) \times HVAC_{energy}$$

Equation 1

$$Peak\ Demand\ Savings\ [kW] = \left(kW_{pre} \times CF_{pre} \times PAF_{pre} - kW_{installed} \times CF_{S/W}\right) \times HVAC_{demand}$$

Equation 2

New Construction

$$Energy\ Savings\ [kWh] = \left(\frac{LPD \times FloorArea}{1{,}000} - kW_{installed}\right) \times Hours \times HVAC_{energy}$$

Equation 3

$$Peak\ Demand\ Savings\ [kW] = \left(\frac{LPD \times FloorArea}{1{,}000} - kW_{installed}\right) \times CF_{S/W} \times HVAC_{demand}$$

Equation 4

Where:

kW_{pre} = *Total kW of existing measure(s) (Approved baseline fixture code wattage from deemed savings tool divided by 1,000 and multiplied by fixture/lamp quantity)*

$kW_{installed}$ = *Total kW of retrofit measure(s) (Verified installed fixture code wattage from deemed savings tool divided by 1,000 and multiplied by fixture/lamp quantity)* [16]

Note: wattage for installed LED fixtures may be rounded up or down to the nearest half watt; all other wattages should be rounded to the nearest watt.

LPD = *Acceptable lighting power density based on building type from efficiency codes from Table 4 (W/ft2)*

---

[14] For non-operating fixtures, the baseline demand may be adjusted by using values from the Standard Wattage Table. The number of non-operating fixtures will be limited to 10% of the total fixture count per facility.

[15] The energy and demand savings calculations should also account for lighting controls that are present on existing lighting systems. The EAF and PAF factors in the Lighting Controls measure section should be used for these calculations to adjust the deemed hours and coincidence factors on the pre-side of the equations. Savings for controls installed on new fixtures are accounted for in the Lighting Controls measure.

[16] Installed fixture wattage for fixtures defined by DLC as having "field-adjustable light output capability under the product features tab should be reported at the "default," or maximum lumen output, setting. These fixtures may also utilize the Institutional Tuning control type. Field adjustments should be tracked in project inventories and verified with lumen measurements conducted during field inspections.

Floor Area	=	*Floor area of the treated space where the lights were installed*
Hours	=	*Hours by building type from Table 9*
EAF	=	*Energy adjustment factor from Lighting Controls measure (set equal to 1 if no controls are installed on the existing fixture)*
$CF_{S/W}$	=	*Summer/winter seasonal peak coincidence factor by building type (see Table 10 or Table 11)*
PAF	=	*Power adjustment factor from Lighting Controls measure (set equal to 1 if no controls are installed on the existing fixture)*
$HVAC_{energy}$	=	*Energy interactive HVAC factor by building type*
$HVAC_{demand}$	=	*Demand interactive HVAC factor by building type*
ISR	=	*In-service rate, the percentage of incentivized units that are installed and in use (rather than removed, stored, or burnt out) to account for units incentivized but not operating = 1.0 unless otherwise specified for midstream/upstream applications (see Table 13)*

Each of the parameters in these equations, and the approach or their stipulated values, are discussed in detail below.

Lamp and Fixture Wattages (kW_{pre}, $kW_{installed}$)

Existing construction: standard fixture wattage table.[17] Another example of standard fixture wattage can be found in the Fixture Codes tab of the latest version of the LSF. This table is used to assign identification codes and demand values (watts) to common fixture types (e.g., fluorescent, incandescent, HID, LED) used in commercial applications. The table is subdivided into lamp types (e.g., linear fluorescent, compact fluorescent, mercury vapor) with each subdivision sorted by fixture code. Each record (or row) in the table contains a fixture code, serving as a unique identifier. A legend explains the rules behind the fixture codes.

Each record also includes a description of the fixture, the number of lamps, the number of ballasts if applicable, and the fixture wattage. The table wattage values for each fixture type are averages of various manufacturers' laboratory tests performed to ANSI test standards. By using standardized demand values for each fixture type, the Table simplifies the accounting procedures for lighting equipment retrofits. The table is updated periodically as new fixtures are added.

The fixture codes and the demand values listed in the watt/fixture column in the Table of Standard Fixture Wattages are used to calculate energy and demand savings for any lighting efficiency project.

[17] Maintained by EUMMOT/Frontier Energy: http://texasefficiency.com/index.php/regulatory-filings/lighting.

For implementers interested in adding new fixtures to EUMMOT's lighting table, a request should be submitted to Frontier. The request should include all information required to uniquely identify the fixture type and to fix its demand, as well as other contextual information needed for the table. If possible, the request should also be supported by manufacturer's ANSI test data. Frontier periodically releases updated versions of the LSF with new fixture codes.

New construction: lighting power density table. For new construction projects, the post-retrofit lighting wattages are determined as they are for the existing construction projects, from the Standard Fixture Wattage table. However, the baseline wattage is determined from the treated floor area and a lighting power density (LPD) value, which are the allowable watts per square foot of lit floor area as specified by the relevant energy code. The applicable baseline is the code that was in effect at the time of building permit issuance. The current Commercial code for the state of Texas is IECC 2015. These values for interior space types are presented in Table 4.

In Table 6, the climate zones used for exterior space types are:

- Climate Zone 1: Developed areas of national parks, state parks, forest lands, and rural areas
- Climate Zone 2: Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited night-time use, and residential mixed-use areas
- Climate Zone 3: All other areas
- Climate Zone 4: High-activity commercial districts in major metropolitan areas as designated by the local land-use planning authority.

Note: In most cases, the Climate Zone 1, 2, or 4 will be selected. Climate Zone 3 should only be selected if none of the others apply. The reported climate zone should match the code compliance report (COMcheck), if available.

Table 4. Lamps & Fixtures—New Construction LPDs for Interior Space Types by Building Type[18]

Facility type	Lighting power density (W/ft^2)	Facility type	Lighting power density (W/ft^2)
Automotive facility	0.80	Multifamily	0.51
Convention center	1.01	Museum	1.02
Courthouse	1.01	Office	0.82
Dining: bar/lounge/leisure	1.01	Parking garage	0.21
Dining: cafeteria/fast food	0.90	Penitentiary	0.81
Dining: family	0.95	Performing arts	1.39
Dormitory	0.57	Police stations	0.87
Exercise center	0.84	Post office	0.87
Fire station	0.67	Religious buildings	1.00

[18] IECC 2015 Table C405.4.2(1) and ANSI/ASHRAE/IESNA Standard 90.1-2013 Table 9.5.1.

Facility type	Lighting power density (W/ft^2)	Facility type	Lighting power density (W/ft^2)
Gymnasium	0.94	Retail	1.26
Health care/clinic	0.90	School/university	0.87
Hospital	1.05	Sports arena	0.91
Hotel/motel	0.87	Town hall	0.89
Library	1.19	Transportation	0.70
Manufacturing facility	1.17	Warehouse	0.66
Motion picture theater	0.76	Workshop	1.19

In addition to the interior building types specified in IECC 2015, the following LPDs have been established for agricultural greenhouses. Greenhouse types are defined as follows:

- High intensity sole-source greenhouse: All plant lighting is provided by ceiling-mounted high intensity artificial electric lighting.
- Supplemented greenhouse: Most plant lighting is provided by natural sunlight with supplemented artificial electric lighting used to extend daylight hours during winter seasons with short periods of sunlight or on inclement weather days when sunlight levels are suboptimal.
- Vertical farming: Plants are sacked along vertical shelving from floor to ceiling to increase grow area.

Table 5. Lamps & Fixtures—New Construction LPDs for Agricultural Greenhouses[19]

Facility type[20]	Lighting power density (W/ft^2)
Agricultural: high intensity sole-source greenhouse	52.16
Agricultural: supplemented greenhouse	10.92
Agricultural: vertical farming[21]	–

[19] "Energy Savings Potential of SSL in Agricultural Applications," US Department of Energy. June 2020. Table E-1. https://www.energy.gov/sites/prod/files/2020/07/f76/ssl-agriculture-jun2020.pdf.
[20] Weighted average of LPDs specified for LED, HPS/MH, and Fluorescent lighting type categories based on 2019 technology mix from Table E-1.
[21] Vertical farming was excluded due to 100% LED adoption in the 2019 technology mix from Table E-1.

The total exterior lighting power allowance for all exterior building applications is the sum of the base site allowance plus the individual allowances for areas that are to be illuminated and are permitted in Table 6.

Table 6. Lamps & Fixtures—New Construction LPDs for Exterior Space Types[22]

Facility type	Lighting power density (W/ft^2)			
	Climate Zone 1	Climate Zone 2	Climate Zone 3	Climate Zone 4
Base site allowance	500 W	600 W	750 W	1,300 W
Uncovered parking: Parking areas and drives	0.04	0.06	0.10	0.13
Building grounds: Walkways ≥ 10 ft. wide, plaza areas, and special feature areas	0.14	0.14	0.16	0.20
Building grounds: Stairways	0.75	1.00	1.00	1.00
Building grounds: Pedestrian tunnels	0.15	0.15	0.20	0.30
Building grounds: Landscaping (ASHRAE 90.1-2013 only)[23]	0.04	0.05	0.05	0.05
Building entrances and exits: Entry canopies	0.25	0.25	0.40	0.40
Building entrances, exits, and loading docks: Loading docks (ASHRAE 90.1-2013 specific)[24]	0.50	0.50	0.50	0.50
Sales canopies: Free-standing and attached	0.60	0.60	0.80	1.00
Outdoor sales: Open areas	0.25	0.25	0.50	0.70
Building facades[25]	–	0.075	0.113	0.150
Entrances and gatehouse inspection stations	0.75	0.75	0.75	0.75
Loading areas for emergency vehicles	0.50	0.50	0.50	0.50

[22] IECC 2015 Table C405.5.1(2) and ANSI/ASHRAE/IESNA Standard 90.1-2013 Table 9.4.2-2. Differences between the two standards are noted.

[23] In June 2016, the Texas Comptroller issued a state certification letter adopting ASHRAE 90.1-2013 as the energy code for state buildings while the Commercial building code remains IECC 2015. State-funded buildings are required to submit SECO compliance certificates as part of the NC/Renovation process. More details can be found at the Comptroller website: https://comptroller.texas.gov/programs/seco/code/state-funded.php. This space type is missing from the IECC 2015 LPD table, but the TRM authorizes the use of these LPDs for non-state-funded buildings.

[24] Ibid.

[25] ASHRAE 90.1-2013 reflects a higher baseline. The TRM specifies the higher, more conservative, baseline to allow the same LPD to apply to all buildings, regardless of whether they are state-funded.

The following default metal halide baseline wattage assumptions have been approved for exterior athletic fields and courts, which are not included in the above LPD table. These baseline wattages were derived based on a review of reported lumen range for available LED products and their reported equivalent metal halide (MH) wattage.

Table 7. Lamps & Fixtures—New Construction Baseline Wattages for Athletic Field/Court LEDs

Equivalent MH wattage	Number of lamps	LED rated lumen range
175	1	< 7,500
250	1	7,500-12,499
400	1	12,500-19,999
400	2	20,000-39,999
1,000	1	40,000-59,999
1,500	1	60,000-74,999
1,000	2	75,000-99,999
1,000	3	100,000-124,999
1,000	4	125,000-149,999
1,000	5	150,000-199,999
1,000	6 plus 1 additional lamp for every 50,000 lumens above 200,000 (rounded down)	> 200,000

Operating Hours (Hours) and Coincidence Factors (CFs)

Operating hours and peak demand coincidence factors are assigned by building type, as shown in Table 9 through Table 11. The building types used in this table are based on Commercial Buildings Energy Consumption Survey (CBECS)[26] building types but have been modified for Texas. Refer to Volume 1, Section 4 for a description of the Texas peak demand methodology. Winter peak coincidence factors are only specified for outdoor fixtures, including for the "Parking Garage" building type.

The operating hours and coincidence factors specified in this section have been calculated at the facility level and should be applied to the entire facility. Outdoor fixtures that are not associated with the typical building lighting schedule may be claimed separately. These can include parking lot, walkway, wall pack, or another lighting, while building-mounted lighting with an operating schedule that more closely approximates the interior lighting schedule typically should not be claimed separately.

[26] DOE-EIA Commercial Building Energy Consumption Survey.

Table 8. Lamps & Fixtures—Building Type Descriptions and Examples

Building type	Principal building activity	Definition	Detailed business type examples[27]
Agriculture	Dairy buildings	Buildings used to house dairy livestock and collect milk from dairy cows.	1) Dairy buildings
	Grow house	Buildings used to grow herbs, fruits, or vegetables under artificial lighting. Sole-source greenhouses rely on 100% artificial lighting, whereas supplemented greenhouses use both natural sunlight and artificial lighting.	1) 24-hour grow house 2) Non-24-hour sole-source greenhouse 3) Non-24-hour supplemented greenhouse
Data center	Data center	Buildings used to house computer systems and associated components.	1) Data center
Education	College/university	Buildings used for academic or technical classroom instruction, such as elementary, middle, or high schools, and classroom buildings on college or university campuses. Buildings on education campuses for which the main use is not classroom are included in the category relating to their use. For example, administration buildings are part of "Office," dormitories are "Lodging," and libraries are "Public Assembly."	1) College or university 2) Career or vocational training 3) Adult education
	Primary school		1) Elementary or middle school 2) Preschool or daycare
	Secondary school		1) High school 2) Religious education
Food sales	Convenience	Buildings used for retail or wholesale of food.	1) Gas station with a convenience store 2) Convenience store
	Supermarket		1) Grocery store or food market
Food service	Full-service restaurant	Buildings used for the preparation and	1) Restaurant or cafeteria

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

Building type	Principal building activity	Definition	Detailed business type examples[27]
	Quick-service restaurant	sale of food and beverages for consumption.	1) Fast food
Healthcare	Hospital	Buildings used as diagnostic and treatment facilities for inpatient care.	1) Hospital 2) Inpatient rehabilitation
	Outpatient healthcare	Buildings used as diagnostic and treatment facilities for outpatient care. Medical offices are included here if they use any type of diagnostic medical equipment (if they do not, they are categorized as an office building).	1) Medical office 2) Clinic or outpatient health care 3) Veterinarian
Multifamily	Common area	Buildings containing multifamily dwelling units, having multiple stories, and equipped with elevators.	1) Common area
Lodging	Large hotel	Buildings used to offer multiple accommodations for short-term or long-term residents.	1) Motel or inn 2) Hotel 3) Dormitory, fraternity, or sorority 4) Retirement home, nursing home, assisted living, or other residential care 5) Convent or monastery
	Nursing home		
	Small hotel/motel		

Building type	Principal building activity	Definition	Detailed business type examples[27]
Manufacturing	1 Shift (<70 hr/week)	Buildings used for manufacturing/industrial applications.	1) Apparel 2) Beverage, food, and tobacco products 3) Chemicals 4) Computer and electronic products 5) Appliances and components 6) Fabricated metal products 7) Furniture 8) Leather and allied products 9) Machinery 10) Nonmetallic mineral products 11) Paper 12) Petroleum and coal products 13) Plastics and rubber products 14) Primary metals 15) Printing and related support 16) Textile mills 17) Transportation equipment 18) Wood products
	2 Shift (70-120 hr/week)		
	3 Shift (>120 hr/week)		
Mercantile	Stand-alone retail	Buildings used for the sale and display of goods other than food.	1) Retail store 2) Beer, wine, or liquor store 3) Rental center 4) Dealership or showroom for vehicles or boats 5) Studio or gallery
	Strip mall/enclosed mall	Shopping malls comprised of multiple connected establishments.	1) Strip shopping center 2) Enclosed malls

Building type	Principal building activity	Definition	Detailed business type examples[27]
Office	Large office	Buildings used for general office space, professional office, or administrative offices. Medical offices are included here if they do not use any type of diagnostic medical equipment (if they do, they are categorized as an outpatient health care building).	1) Administrative or professional office 2) Government office 3) Mixed-use office 4) Bank or other financial institution 5) Medical office 6) Sales office 7) Contractor's office (e.g., construction, plumbing, HVAC) 8) Non-profit or social services 9) Research and development 10) City hall or city center 11) Religious office 12) Call center
	Medium office		
	Small office		
Parking	Parking garage	Buildings used for parking applications.	No sub-categories collected.

Building type	Principal building activity	Definition	Detailed business type examples[27]
Public assembly	Public assembly	Buildings in which people gather for social or recreational activities, whether in private or non-private meeting halls.	1) Social or meeting (e.g., community center, lodge, meeting hall, convention center, senior center) 2) Recreation (e.g., gymnasium, health club, bowling alley, ice rink, field house, indoor racquet sports) 3) Entertainment or culture (e.g., museum, theater, cinema, sports arena, casino, night club) 4) Library 5) Funeral home 6) Student activities center 7) Armory 8) Exhibition hall 9) Broadcasting studio 10) Transportation terminal
Public order and safety	Jail and prison	Government establishments engaged in justice, public order, and safety.	1) Correctional institutions 2) Prison administration and operation
	Other		1) Police protection 2) Legal counsel and prosecution 3) Fire protection 4) Public order and safety, not elsewhere classified
Religious worship	Religious worship	Buildings in which people gather for religious activities (such as chapels, churches, mosques, synagogues, and temples).	No sub-categories collected.

Building type	Principal building activity	Definition	Detailed business type examples[27]
Service	Service	Buildings in which some type of service is provided, other than food service or retail sales of goods.	1) Vehicle service or vehicle repair shop 2) Vehicle storage/maintenance 3) Repair shop 4) Dry cleaner or laundromat 5) Post office or postal center 6) Car wash 7) Gas station with no convenience store 8) Photo processing shop 9) Beauty parlor or barber shop 10) Tanning salon 11) Copy center or printing shop 12) Kennel
Warehouse	Warehouse	Buildings used to store goods, manufactured products, merchandise, raw materials, or personal belongings (such as self-storage).	1) Refrigerated warehouse 2) Non-refrigerated warehouse 3) Distribution or shipping center
Other	Other	For building types not explicitly listed.	Values used for other are the most conservative values from the explicitly listed building types.

Table 9. Lamps & Fixtures—Operating Hours by Building Type

Building type	Operating hours
Agriculture: Long-day lighting[28]	6,209
Agriculture: Non-24-hour sole-source greenhouse [29]	5,479
Agriculture: Non-24-hour supplemented greenhouse[30]	2,000
Data center	4,008
Education: K-12 with summer session, college, university, vocational, and day care	3,577
Education: K-12 with partial summer session[31]	3,177
Education: K-12 without summer session	2,777
Food Sales: Non-24-hour supermarket or convenience store	4,706
Food service: Full-service restaurant	4,368
Food service: Quick-service restaurant	6,188
Food service: 24-hour restaurant	7,311
Health care: Inpatient	5,730
Health care: Outpatient	3,386
Health care: Resident care and nursing home	4,271
Lodging: Hotel/motel/dorm, common area	6,630
Lodging: Hotel/motel/dorm, room	3,055
Manufacturing: 1 Shift (<70 hr/week)	2,786
Manufacturing: 2 Shift (70-120 hr/week)	5,188
Manufacturing: 3 Shift (>120 hr/week)	6,414
Mercantile: Non-24-hour stand-alone retail	3,668
Mercantile: Enclosed mall	4,813
Mercantile: Strip center and non-enclosed mall	3,965
Mercantile/food sales: 24-hour stand-alone retail, supermarket, or convenience store	6,900
Multifamily: Common area	4,772
Office	3,737

[28] Daily operating hours are 17 hours/day based on assumptions from the Minnesota and Wisconsin TRMs and market research indicating average 16–18 hours of daily operation. Annual operating hours are derived by multiplying 17 hours/day by 365.25 days/year.

[29] Daily operating hours are 15 hours/day based on market research indicating 14-16 hours of daily operation. Annual operating hours are derived by multiplying 15 hours/day by 365.25 days/year.

[30] "Energy Savings Potential of SSL in Agricultural Applications," US Department of Energy. June 2020. Table E-1. https://www.energy.gov/sites/prod/files/2020/07/f76/ssl-agriculture-jun2020.pdf.

[31] Assuming a partial summer session in June with no summer session in July.

Building type	Operating hours
Outdoor: Athletic field and court[32]	767
Outdoor: Billboard[33]	3,470
Outdoor: Dusk-to-dawn[34]	4,161
Outdoor: Less than dusk-to-dawn[35]	1,998
Parking garage	7,884
Public assembly	2,638
Public order and safety: Jail and prison	7,264
Public order and safety: Other	3,472
Religious worship	1,824
Service: Excluding food	3,406
Warehouse: Non-refrigerated	3,501
Warehouse: Refrigerated	3,798
Other	2,638

Table 10. Lamps & Fixtures—Summer Peak Coincidence Factors by Building Type[36]

Building type	Summer peak CF				
	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Agriculture: Long-day lighting	1.00	1.00	1.00	1.00	1.00
Agriculture: Non-24-hour sole-source greenhouse	1.00	1.00	1.00	1.00	1.00
Agriculture: Non-24-hour supplemented greenhouse[37]	–	–	–	–	–
Data center	0.85	0.85	0.85	0.85	0.85

[32] "2015 US Lighting Market Characterization," US Department of Energy. November 2017. Value derived by multiplying average daily operating hours from Table 2-30 by 365.25 hours/year.
[33] Ibid.
[34] This space type refers to fixtures controlled either by photocells or by timers operating on a dusk-to-dawn schedule. Calculated based on average dark hours for Amarillo (northernmost) and Corpus Christi (southernmost) climate zones from sunrise to sunset excluding ½ of civil twilight period. https://www.timeanddate.com/sun/. Note: pending update to US Naval Observatory annual data once website maintenance has completed. https://aa.usno.navy.mil/data/RS_OneYear.
[35] This space type refers to fixtures controlled by timers operating on a less than dusk-to-dawn schedule.
[36] Building operating schedules are adapted from COMNET Appendix C – Schedules (Rev. 3). https://comnet.org/appendix-c-schedules. Updated 7/25/2016.
[37] Assuming no peak coincidence because these fixtures are often operated exclusively during off-peak hours (ranging from 10 PM to 6 AM). This time range is not coincident with either the Texas summer or winter peak periods.

Building type	Summer peak CF				
	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Education: K-12 with summer session, college, university, vocational, and day care	0.90	0.90	0.90	0.90	0.90
Education: K-12 with partial summer session[38]	0.42	0.39	0.90	0.90	0.57
Education: K-12 without summer session	0.39	0.39	0.90	0.87	0.40
Food sales: Non-24-hour supermarket or convenience Store	0.90	0.90	0.90	0.90	0.90
Food service: Full-service restaurant	0.90	0.90	0.90	0.90	0.90
Food service: Quick-service restaurant	0.90	0.90	0.90	0.90	0.90
Food service: 24-hour restaurant	0.90	0.90	0.90	0.90	0.90
Health care: Inpatient	0.80	0.83	0.81	0.80	0.90
Health care: Outpatient	0.70	0.75	0.72	0.71	0.90
Health care: Resident care and nursing home	0.70	0.75	0.72	0.71	0.90
Lodging: Hotel/motel/dorm, common area	0.90	0.90	0.90	0.90	0.90
Lodging: Hotel/motel/dorm, room	0.30	0.30	0.30	0.30	0.30
Mercantile: Non-24-hour retail excluding mall and strip	0.90	0.90	0.90	0.90	0.90
Mercantile: Enclosed mall	0.90	0.90	0.90	0.90	0.90
Mercantile: Strip center and non-enclosed mall	0.90	0.90	0.90	0.90	0.90
Mercantile/food sales: 24-hour stand-alone retail, supermarket, or convenience store	0.90	0.90	0.90	0.90	0.90
Manufacturing: 1 Shift (<70 hr/week)	0.83	0.84	0.83	0.85	0.85
Manufacturing: 2 Shift (70-120 hr/week)	0.85	0.85	0.85	0.85	0.85
Manufacturing: 3 Shift (>120 hr/week)	0.85	0.85	0.85	0.85	0.85

[38] Assuming a partial summer session in June with no summer session in July.

Building type	Summer peak CF				
	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Multifamily: Common area	0.90	0.90	0.90	0.90	0.90
Office	0.87	0.88	0.86	0.90	0.90
Outdoor: Athletic field and court	–	–	–	–	–
Outdoor: Billboard	–	–	–	–	–
Outdoor: Dusk-to-dawn	–	–	–	–	–
Outdoor: Less than dusk-to-dawn	–	–	–	–	–
Parking garage	1.00	1.00	1.00	1.00	1.00
Public assembly	0.65	0.65	0.65	0.65	0.65
Public order and safety: Jail and prison	0.90	0.90	0.90	0.90	0.90
Public order and safety: Other	0.70	0.75	0.72	0.71	0.90
Religious worship	0.65	0.65	0.65	0.65	0.65
Service: Excluding food	0.90	0.90	0.90	0.90	0.90
Warehouse: Non-refrigerated	0.79	0.81	0.79	0.80	0.85
Warehouse: Refrigerated	0.79	0.81	0.79	0.80	0.85
Other	0.65	0.65	0.65	0.65	0.65

Table 11. Lamps & Fixtures—Winter Peak Coincidence Factors by Building Type[39]

Space type	Winter peak CF				
	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Outdoor: Athletic field and court	0.26	0.27	0.24	0.29	0.38
Outdoor: Billboards	0.59	0.62	0.53	0.65	0.87
Outdoor: Dusk-to-dawn[40]	0.67	0.71	0.61	0.75	1.00
Outdoor: Less than dusk-to-dawn[41]	0.67	0.71	0.61	0.75	1.00
Parking garage	1.00	1.00	1.00	1.00	1.00

[39] Operating schedules are based on sunrise/sunset times for each climate-zone reference city, adjusted for compliance with IESNA-DG-13-96 and IESNA-DG-13-98 recommendations.
[40] This space type refers to fixtures controlled either by photocells or by timers operating on a dusk-to-dawn schedule.
[41] This space type refers to fixtures controlled by timers operating on a less than dusk-to-dawn schedule.

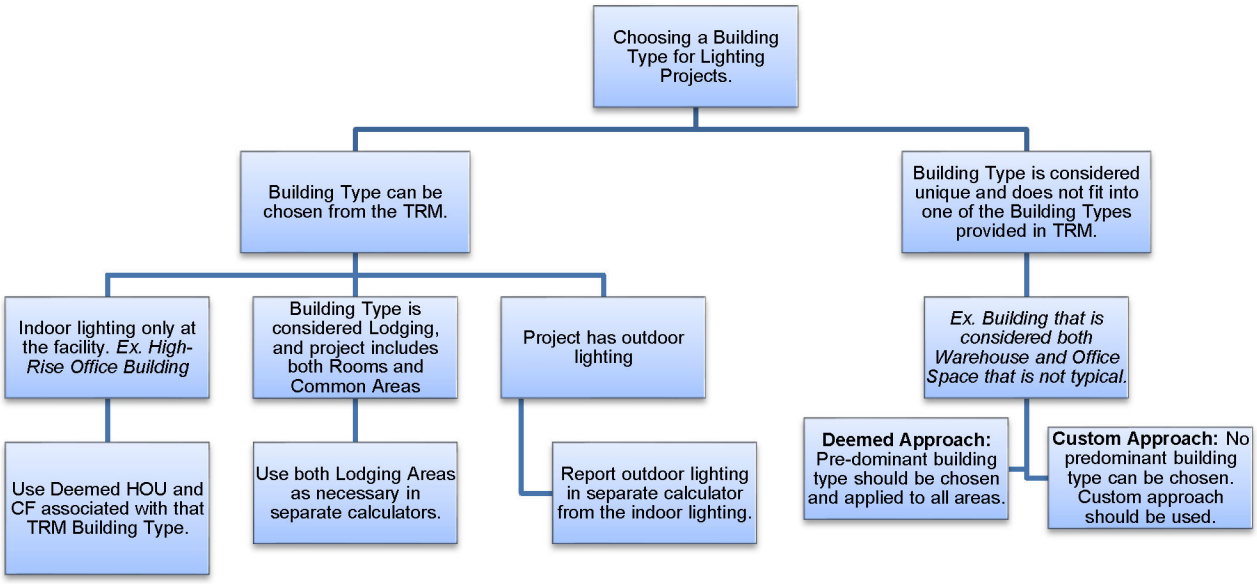
Building Type Selection

This section provides additional guidance on Recommendation #1b in the 2013 Statewide Annual Portfolio Evaluation Report.[42]

The deemed lighting hours of use (HOU) and peak summer coincidence factors (CF) for utilities to use in calculating savings associated with lighting are broken down by building type and use. If the building type changes in combination with the retrofit, the selected building type should be consistent with the space condition after improvement. These values are provided in Table 9 through Table 11. For the majority of the building types listed in this table, the HOU and CFs were created based on weighted averages of lighting usage across all activity areas of the building.[43] Therefore, the deemed HOU and CFs are representative of an entire building type, across all activity areas that are in a "typical" building for this type.

The following flow chart, Figure 2, has been provided to assist utilities in understanding how they can use the deemed methods to calculate lighting savings based on HOU and CF provided in the TRM. Additionally, it provides guidance on how to treat lodging facilities and outdoor lighting projects as well as unique building types.

Figure 2. Lamps & Fixtures—Building Type Decision-Making



Lodging sites. Lodging facilities (Hotel/Motel/Dormitories) have been identified in the TRM by *Common* and *Rooms*, both with different HOU and CF. As two different values have been provided for these areas, it is acceptable for the utilities to use either or both building types for a single project.

[42] *Annual Statewide Portfolio Report for Program Year 2013 – Volume I*. Prepared for the Public Utility Commission of Texas. October 6, 2014.
[43] More information on how these values were created can be found in PUCT Docket #39146.

Exterior lighting. Projects involving outdoor lighting should be claimed in a separate calculator or separate inventory within the same calculator. The exception to this is walkway lighting that is more consistent with building operation. In this application, the utilities should use the primary building type as their HOU and CFs have been rolled up into the overall building type calculations (e.g., walkway lighting between two buildings that operates during business hours).

Combination building types. In situations where multiple TRM building types seem plausible, or a predominant TRM building type is unclear, the utilities have two choices:

- **Deemed approach.** The deemed approach is a simplified method where utilities should choose a TRM building type based on the "best fit" for the facility. For interior spaces, this is determined by the largest interior area for the potential building types. Although, if that is not best fit, the utilities will use their best judgment to make this decision and provide sufficient, defensible documentation for their decision.

  The *manufacturing* building type is specified with 1-, 2-, and 3-shift options:

  - Shift 1: Typical operation of 9.5-11.5 hours per day and 4-6 days per week (<70 hours per week)
  - Shift 2: Typical operation of 18-20 hours per day and 5-6 days per week (70–120 hours per week)
  - Shift 3: Typical operation of 24 hours per day and 5-6 days per week (>120 hours per week)

  The following building type combinations are pre-authorized exceptions to this rule. For these combinations, individual fixtures can be reported as either specified building type based on location. All other interior space combinations should reference a single deemed building type unless authorized by the evaluator.

  - Office: Warehouse (refrigerated or non-refrigerated)
  - Office: Manufacturing (any shift number)
  - Manufacturing (buildings with different shift designations by area)
  - Inpatient healthcare: Outpatient healthcare
  - Lodging, common areas: Lodging, rooms

  The *other* building type can be used for business types that are not explicitly listed. The hours and CF values used for other are the most conservative from the explicitly listed building types (with the exception of the CF values specified for "Education: K-12 without Summer Session" and "Lodging: Hotel/Motel/Dorm, Common Areas", which are associated with very specific operating schedules that experience low coincidence with the summer peak period). When the Other building type is used, a description of the actual building type, the primary business activity, the business hours, and the lighting schedule must be collected for the project site and stored in the utility tracking data system.

"Outdoor Dusk-to-Dawn" applies to outdoor fixtures controlled by a photocell or timer with dusk-to-dawn operation throughout the entire year. Outdoor fixtures controlled by timers with less than dusk-to-dawn operation (excluding athletic fields and courts) may be claimed separately using the "Outdoor Less than Dusk-to-Dawn" building type or using a custom timer schedule.

Exterior spaces may reference multiple outdoor building types differentiated based on typical operating schedules (Outdoor Dusk-to-Dawn, Less than Dusk-to-Dawn, Athletic, or Billboard).

- **Custom approach.** In more unique situations, utilities should consider projects "custom" where (1) the deemed building types in the TRM may not represent the project's facility type, (2) the facility may represent multiple TRM building types without a clear predominant building type, or (3) the use of a predominant building type may be too conservative in the estimate of savings. The deemed methods only apply to specific scenarios and cannot be developed for all unique situations. Utilities should provide sufficient, defensible documentation for their HOU and CF values used in their savings calculations that the EM&V team can review.

Interactive HVAC Factors (HVAC Energy, Demand)

Basic lighting savings are adjusted to account for the lighting system interaction with HVAC systems in conditioned or refrigerated spaces. A reduced lighting load reduces the internal heat gain to the building, which reduces the air conditioning/cooling load while increasing the heating load. Currently, the TRM only considers additional cooling savings, and the heating penalty or increase in usage is ignored.

As Table 12 shows, four conditioned space types are used for the Texas programs: single air-conditioned space type, two options for commercial refrigeration, and refrigerated warehouses: medium and low temperature. Utility procedures state that if the actual application falls between these values, the higher temperature value should be used. The final space type is unconditioned (or more explicitly uncooled as the focus is on cooling). In the lighting calculators, these values are typically assigned at the line-item level based on the conditioning type for the space in which the fixtures are located.

Table 12. Lamps & Fixtures—Deemed Energy and Demand Interactive HVAC Factors[44]

Space conditioning type	Energy interactive HVAC factor	Demand interactive HVAC factor
Refrigerated air	1.05	1.10
Evaporative cooling[45]	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

[44] PUCT Docket 39146. Table 7 (page 17) and Table 12 (page 24).

[45] 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.

Upstream/Midstream Lighting

This section provides guidance on calculating and allocating savings at the sector-level for upstream/midstream lighting programs.

An increased number of utilities are offering or planning to offer upstream and/or midstream lighting programs in Texas. It is important that savings are calculated and reported consistently across utilities and in agreement with industry-standard practice and the Energy Efficiency Rule 16 TAC § 25.181.

Upstream/Midstream Program Assumptions

For upstream/midstream program delivery, use the following AOH and CF assumptions specified by lamp type. Assumed AOH and CF values have been weighted based on building type survey data from 2012 CBECS[46] and 2014 MECS[47] as well as lamp density and lamp type distribution survey data from the DOE 2015 US Lighting Market Characterization (LMC)[48].

All general service, decorative, and reflector lamps with an equivalent wattage of 100 W or lower distributed though upstream or midstream programs should calculate savings using a combination of residential and non-residential savings methodologies with 95 percent of savings allocated to the residential sector and the remaining 5 percent of savings allocated to the commercial sector.[49] While only summer demand savings are specified for the commercial sector, winter demand savings are allowed for the portion of savings allocated to the residential sector.

Table 13. Lamps & Fixtures—Upstream/Midstream Input Assumptions by Lamp Type[50]

Lamp type	AOH	Coincidence factors[51]					ISR
		Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso	
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

[46] 2012 Commercial Building Energy Consumption Survey (CBECS). https://www.eia.gov/consumption/commercial/. 2018 version not available until mid-2020.
[47] 2014 Manufacturing Energy Consumption Survey (MECS). https://www.eia.gov/consumption/manufacturing/.
[48] 2015 US Lighting Market Characterization, Department of Energy. November 2017. https://www.energy.gov/sites/prod/files/2017/12/f46/lmc2015_nov17.pdf.
[49] Weighting assumptions based on statewide evaluator review of LED purchasing behavior for similar program designs.
[50] 2012 CBECS and 2014 MECS.
[51] Outdoor coincidence factors are specified for winter peak. All other values reference summer peak.

Outdoor	4,161	0.67	0.71	0.61	0.75	1.00	1.00

Additionally, baseline wattage for ENERGY STAR-qualified products is assumed to be equal to the equivalent wattage from the ENERGY STAR certification. Baseline wattage assumptions for DLC- and third-party-qualified products should be determined based on product technical specifications and/or delivered light output (lumens) and detailed in the program qualified product listing.

Deemed Energy and Demand Savings Tables

This section is not applicable as these calculations are entirely dependent on site-specific parameters related to lighting system operation.

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) values are defined for the following lamp/fixture types.[52] A separate new construction EUL has been established due to account for the whole-building baseline.

- Halogen lamps: 1.5 years
- High-intensity discharge lamps: 15 years
- Integrated-ballast CCFL lamps: 4.5 years
- Integrated-ballast CFL lamps: 2.5 years
- Integral LED lamps: 9 years[53]
- LED fixtures: 15 years
- LED corn cob lamps: 15 years
- LED tubes: 15 years
- Solar LEDs[54]: 10 years
- Modular CFL and CCFL fixtures: 15 years
- T8 and T5 linear fluorescents: 15 years

[52] PUCT Docket 36779.
[53] PUCT Docket 38023.
[54] The typical solar battery life is approximately 5–15 years. A typical product warranty for a solar LED fixture is 10 years. This deemed EUL aligns with the average product life expectancy and typical warranty period.

- New construction interior fixtures/controls[55]: 14 years
- New construction exterior fixtures[56]: 15 years

Program Tracking Data and Evaluation Requirements

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

- Decision/action type: retrofit or new construction
- Building or space type
- Optional: building or space funding source (state or private)
- **For new construction only:** light power density factor
- **For new construction only:** interior and/or exterior space square footage
- **For new construction only:** if applicable, verify if SECO compliance certification forms were filed[57]
- Conditioned space type: cooling equipment type, refrigerated space temperature range, heating fuel type, percent heated/cooled for NC Only (specified per control)
- Baseline fixture configuration
- Baseline lamp wattage
- Baseline ballast type
- Baseline lighting controls
- Baseline counts of operating fixtures
- Baseline counts of inoperable fixtures
- Post-retrofit manufacturer and model number[58]
- Post-retrofit fixture configuration
- Post-retrofit lamp wattage[59]

[55] Based on review of new construction EULs claimed by Oncor and CenterPoint during the PY 2019 and 2020 weighted by energy savings.
[56] Ibid.
[57] State-funded buildings are required to submit SECO compliance forms as part of the NC/renovation process. Buildings that submit SECO compliance forms are considered state-funded and must meet the provisions of ASHRAE 90.1-2013 rather than IECC 2015. Previous tables in this section present the alternative compliance values where they are encountered in the codes.
[58] See Eligibility Criteria section for additional information and exceptions related to reporting post-retrofit model number.
[59] See Eligibility Criteria section for additional information and exceptions related to reporting post-retrofit fixture wattage.

- Post-retrofit lamp specifications sheets: Post retrofit lamp product qualification information from DLC, ENERGY STAR®, or independent lab testing
- Post-retrofit ballast type
- Post-retrofit lighting controls
- Post-retrofit counts of operating fixtures
- **For field adjustable light output fixtures only:** isolate these fixtures by setting type and location within reported project inventories and track field adjustment settings
- **For field adjustable light output fixtures only:** post-retrofit lumen readings for inspection sample
- Equipment operating hours
- Lighting measure group (from Measure Life groupings)
- **For retrofit only:** Proof of purchase: invoice showing model number; a photo of the model number on product packaging and installed fixture; OR an evaluator pre-approved inspection approach
- **For new construction only:** Proof of purchase: invoice showing model number; a photo of the model number on product packaging and installed fixture; as-built design drawings; lighting specifications package that provides detailed make and model information on installed lighting; OR an evaluator pre-approved inspection approach
- **For upstream/midstream only:** Qualified product list mapping efficient lighting products to baseline wattage assumptions

Lighting Measure Groups to be Used for Measure Summary Reports

The lighting measure groups, as defined in the Measure Life and Lifetime Savings list above, must be used for reporting summarized savings of lighting measures. Higher-level groupings of lighting technologies, such as "Non-LED" lighting, will not provide enough resolution for evaluation and cost-effectiveness analysis.

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 36779—Describes EUL
- PUCT Docket 39146—Describes deemed values for energy and demand savings
- PUCT Docket 38023—Describes LED installation and efficiency standards for nonresidential LED products

Relevant Standards and Reference Sources

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

Document Revision History

Table 14. Lamps & Fixtures—Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. *Measure Life section*: Added additional energy efficiency measures for consistency with the EUMMOT maintained list. *Calculator and Tools section*: Eliminated description of calculator output comparisons. *Tracking Data Requirements section:* Added lighting category requirements for measure summary reports.
v3.0	04/10/2015	TRM v3.0 update. Revised to eliminate T12 lamps as a valid baseline. *Measure Description section:* General clean-up of technology descriptions. *Program Tracking Data section:* Minor changes and clarifications.
v3.1	11/05/2015	TRM v3.1 update. *Revised to eliminate* T12 lamps as a valid baseline and eliminate the Oncor winter peak demand value to use the statewide average in all service territories. *Eligibility Criteria:* Adding sources for LED lamp and fixture eligibility.
v3.1	03/23/2016	TRM v3.1 March revision. Updated *Linear Fluorescent T12 Special Conditions* baseline table to include HO and VHO lamps. Updated criteria for miscellaneous length (e.g., 2-ft, 3-ft) T8s. Added footnote to explain how to account for non-rebated fixture lighting controls in savings calculations. Clarified some tracking data requirements.
v4.0	10/10/2016	TRM v4.0 update. Added LPD values and tracking data requirements for exterior space type climate zones used in Codes and Standards.
v5.0	10/2017	TRM v5.0 update. Added two new building types (i.e., Data Centers, 24-Hr Restaurants), and updated the Manufacturing building type to separate 1, 2 and 3 shift operations. Updated sources and references. Completed code updates where applicable (IECC 2015 and ASHRAE 90.1-2013). Note that Texas adopted IECC 2015 for commercial, industrial, and residential buildings taller than three stories and ASHRAE 90.1-2013 for state-funded buildings.
v6.0	10/2018	TRM v6.0 update. Updated eligibility criteria to broaden the qualification paths for LED fixtures. Added rounding opt-in for LED wattages. Clarifications added for building type definitions, including the addition of an “Other” category for buildings that do not fit into the list of pre-defined building types. Updated peak coincident factors for the PDPF methodology outlined in Volume 1.
v7.0	10/2019	TRM v7.0 update. Merged relevant Volume 5 Implementation Guidance into the measure. Changed non-qualified lighting thresholds and accounting procedures for new construction projects. Added guidance for EISA baselines. Added Base Site Allowance for exterior new construction projects. Added equivalent metal halide guidance for exterior athletic fields and courts. Added new building types (Agriculture, Outdoor: Billboards, Education K-12 with partial summer session, Facility-Wide 24-Hour Lighting). Revised Outdoor: Athletic Field and Court factors. Added Midstream lighting guidance, assumptions, and calculations. Program tracking requirements updated.

TRM version	Date	Description of change
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits. Updated EUL for new construction projects to apply to whole project. Updated dusk-to-dawn operating hours. Minor formula corrections. Updated DLC references to refer to v3.0 or later rather than explicit versions. Removed 10% nonqualified fixture threshold. Established lumens/watt assumptions for new construction baselines.
v9.0	10/2021	TRM v9.0 update. General reference checks and text edits. Added guidance for certification of incremented length products. Added upstream clarification. Combined greater and less than 100 W GSLs and reflectors for upstream/midstream. Adjusted upstream/midstream residential vs. commercial split and ISRs. Updated upstream/midstream outdoor hours of use. Added guidance for LED model number, performance characteristics certification, and dates of certification. Changed LSF references to fixture wattage table.
v10.0	10/2022	TRM v10.0 update. Corrected DLC version requirements omitted from final TRM v8.0. Added guidance for field adjustable lights. Addressed savings path for solar fixtures. Added guidance for new construction exterior lighting zone selection. Added guidance for building type selection. Clarified midstream outdoor coincident factor is winter peak.

2.1.2 Lighting Controls Measure Overview

TRM Measure ID: NR-LT-LC

Market Sector: Commercial

Measure Category: Lighting

Applicable Building Types: All commercial, multifamily common areas

Fuels Affected: Electricity (interactive HVAC effects: electric/gas space heating)

Decision/Action Types: Retrofit, new construction

Program Delivery Type: Prescriptive, custom, direct install

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure promotes the installation of lighting controls in both new construction and retrofit applications. For retrofit applications, lighting controls are typically installed where there is no control other than a manual switch (wall or circuit panel). For new construction lighting systems, controls would be added where they are not already required by existing energy or building codes. Promoted technologies include occupancy sensors and daylight dimming controls. Energy and peak demand savings are calculated for these technologies with an energy adjustment factor (EAF) for kWh and a power adjustment factor (PAF) for kW.

Eligibility Criteria

Measures installed through utility programs must be one of the occupancy sensor, daylighting, and tuning controls that are described in Table 15. Savings may be claimed for control types that exceed the minimum code-required controls, mainly occupancy sensors for interior spaces.

For new construction applications, lighting systems are required to be installed with controls.[60] For the areas of a building where occupancy sensor control is required, time switch controls may be substituted for occupancy sensor controls.

Exceptions: Lighting controls are not required in the following:

- Areas designated as security or emergency areas that are required to be continuously lighted
- Interior exit stairways, interior exit ramps, and exit passageways
- Emergency egress lighting that is normally off

[60] IECC 2015, Section C405.

Occupant sensor controls shall be installed to control lights in the following space types; lighting controls savings are not allowed for these space types:

- Classrooms/lecture/training rooms
- Conference/meeting/multipurpose rooms
- Copy/print rooms
- Lounges
- Employee lunch and break rooms
- Private offices
- Restrooms
- Storage rooms
- Janitorial closets
- Locker rooms
- Other spaces 300 square feet or less that are enclosed by floor-to-ceiling height partitions
- Warehouses

Field adjustable light output: If a product is available with field-adjustable light output (or wattage setpoints) that can be adjusted by an installation contractor to utilize some or all LED nodes on the fixture, this will be noted in the Product Capabilities section of the DLC certification. DLC will typically specify the maximum input wattage. These fixtures should be reported based on the following scenarios:

- If the fixture is installed at a reduced setpoint, it should be reported at the maximum input wattage in combination with the Institutional Tuning control code to claim energy savings associated with a central control lighting output based on tuning sensors. This control type is similar because it is not easily adjustable over time.
- If the fixture is installed with additional controls (e.g., occupancy sensor, daylighting), then it should be reported at the maximum input wattage in combination with the multiple control code.
- If the fixture is installed without adjustment, it should be reported at the maximum input wattage with no control code.
- If the fixture is installed with no additional controls and the DLC certificate specifies a lower wattage setpoint, then it should be reported as the lower input wattage with no control code.
- For all cases, project documentation should include a screenshot of the DLC certificate and an example photo of the field-adjustable setpoint.

Baseline Condition

The baseline condition assumes no existing or code required (for new construction) automatic lighting controls are installed on the existing lighting fixtures (i.e., they are only manually switched).

For control types that exceed the minimum required control types (usually occupancy sensors or time switch controls), savings can be claimed with the minimum required controls as the baseline efficiency. In these cases, the applicable baseline energy and power adjustment factors (EAF, PAF) are specified for occupancy sensors in Table 16.

For new construction projects, the baseline should be occupancy sensors in most cases unless a specific exception is allowed by code.[61]

High-Efficiency Condition

The energy-efficient condition is properly installed (not bypassed or overridden) and calibrated lighting controls that control overhead lighting in a facility based on occupancy, daylighting, or tuning sensors.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

The equations for lighting controls are similar to those used for lighting lamps and fixtures, with the addition of the EAF and PAF multipliers, as shown below. Additionally, the pre/post kW difference is replaced by a single kW value (the total fixture wattage controlled by the device).

$$Energy\ Savings\ [kWh] = kW_{controlled} \times EAF \times Hours \times HVAC_{energy}$$

Equation 5

$$Summer\ Peak\ Demand\ Savings\ [kW] = kW_{controlled} \times \mathrm{PAF} \times CF_S \times HVAC_{demand}$$

Equation 6

Where:

$kW_{controlled}$	=	*Total kW of controlled fixtures (Fixture wattage from Standard wattage table multiplied by quantity of fixtures)*
Hours	=	*Hours by building type from Table 9*
EAF	=	*Lighting control Energy Adjustment Factor (see Table 16)*
PAF	=	*Lighting control Power Adjustment Factor (see Table 16)*
CF_S	=	*Summer peak coincidence factor by building type (see Table 10)*

[61] Per IECC 2015, C405.2 lighting controls are mandatory.

$HVAC_{energy}$ = *Energy Interactive HVAC factor by building type (see Table 12)*

$HVAC_{demand}$ = *Demand Interactive HVAC factor by building type (see Table 12)*

See Section 2.1.1 of this volume for a full explanation of the non-control variables and their corresponding values. The lighting controls EAFs and PAFs for different building types are presented in Table 16. The EAF and PAF represent the reduction in energy and demand usage. For example, a factor of 0.24 would equate to 24 percent energy and demand savings. The same values from the referenced LBNL study are used for both EAF and PAF factors due to the lack of published data for demand factors.

Table 15. Lighting Controls—Control Definitions

Control type	Description
None	No control
Occupancy	Adjusting light levels according to the presence of occupants • Wall- or ceiling-mounted occupancy sensors • Integrated fixture occupancy sensors • Time clocks • Energy management systems
Daylighting (indoor)	Adjusting light levels automatically in response to the presence of natural light • Photosensors
Outdoor	Outdoor on/off photosensor/time clock controls; no savings attributed because already required by code
Personal tuning	Adjusting individual light levels by occupants according to their personal preference; applies to private offices, workstation-specific lighting in open-plan offices, and classrooms • Dimmers • Wireless ON/OFF switches • Personal computer-based controls • Pre-set scene selection
Institutional tuning	Adjustment of light levels through commissioning or provision of switches or controls for areas or groups of occupants • Dimmable ballasts • ON/OFF or dimmer switches for non-personal tuning
Multiple types	Any combination of the types described above

Table 16. Lighting Controls—Energy and Power Adjustment Factors[62]

Control type	Sub-category	Control codes	EAF	PAF
None	–	None	0.00	0.00
Occupancy	–	OS	0.24	0.24

[62] Williams, Alison, Atkinson, Barbara, Barbesi, Karina, and Rubinstein, Francis, "A Meta-Analysis of Energy Savings from Lighting Controls in Commercial Buildings". Lawrence Berkeley National Laboratory. September 2011. Table 6, p. 14. Weighted average by number of "reviewed" and "non-reviewed" papers.

Control type	Sub-category	Control codes	EAF	PAF
Daylighting (indoor)	Continuous dimming	DL-Cont	0.28	0.28
	Multiple-step dimming	DL-Step		
	ON/OFF	DL-ON/OFF		
Outdoor[63]	–	Outdoor	0.00	0.00
Personal tuning	–	PT	0.31	0.31
Institutional tuning	–	IT	0.36	0.36
Multiple/combined types	Various combinations	Multiple[64]	0.47	0.47

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

Lighting controls savings for interior new construction projects should be claimed at the project level (combined fixture and controls savings) using a 14-year estimated useful life (EUL).[65] Lighting controls savings are not eligible for exterior new construction applications.

For retrofit applications, the EUL for lighting controls is provided by the 2007 GDS Associates Report.[66]

- Occupancy Sensor: 10 years

[63] No control savings are allowed for outdoor controls because they are already required by code. ASHRAE 90.1-1989, Section 6.4.2.8 specifies that exterior lighting not intended for 24-hour continuous use shall be automatically switched by timer, photocell, or a combination of timer and photocell. This is consistent with current specifications in ASHRAE 90.1-2010, Section 9.4.1.3, which specifies that lighting for all exterior applications shall have automatic controls capable of turning off exterior lighting when sufficient daylight is available or when the lighting is not required during nighttime hours.

[64] For multiple control types, specify the installed control types by combining the control codes for the individual control types. Savings factor based on: "Energy Savings from Networked Lighting Control (NLC) Systems", Prepared by Energy Solutions for DesignLights Consortium. September 21, 2017. https://www.designlights.org/resources/reports/report-energy-savings-from-networked-lighting-control-nlc-systems/.

[65] Based on review of new construction EULs claimed by Oncor and CenterPoint during the PY 2019 and 2020 weighted by energy savings.

[66] GDS Associates. Measure Life Report—Residential and Commercial/Industrial Lighting and HVAC Measures. Prepared for the New England State Program Working Group (SPWG). June 2007. This report only specifies an EUL for Occupancy Sensors and Photocells, so it is assumed that the same EUL was applied to time clocks. http://library.cee1.org/content/measure-life-report-residential-and-Commercialindustrial-lighting-and-hvac-measures.

- Daylighting Control: 10 years
- Time Clock: 10 years
- Tuning Control: 10 years
- New Construction Interior Fixtures/Controls[67]: 14 years

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:

- Building type
- Decision/action type: retrofit or new construction
- Conditioned space type: cooling equipment type, refrigerated space temperature range (specified per control)
- Location of controlled lighting: interior or exterior (specified per control)
- Baseline and installed lighting control type code[68]
- Lighting control mount type: wall, ceiling, integrated fixture, etc.
- Lighting control specification sheets
- Controlled fixture lamp type
- Controlled fixture wattage.
- **For retrofit only:** Proof of purchase: invoice showing model number; a photo of the model number on product packaging and installed fixture; OR an evaluator pre-approved inspection approach
- **For new construction only:** Proof of purchase: invoice showing model number; a photo of the model number on product packaging and installed fixture; as-built design drawings; lighting specifications package that provides detailed make and model information on installed lighting; OR an evaluator pre-approved inspection approach

[67] Based on review of new construction EULs claimed by Oncor and CenterPoint during the PY 2019 and 2020 weighted by energy savings.

[68] For a control type that combines multiple features (e.g., occupancy + daylighting), specify the installed control types by combining the control codes for the individual control types.

References and Efficiency Standards

Petitions and Rulings

- "A Meta-Analysis of Energy Savings from Lighting Controls in Commercial Buildings." Williams, Alison, Atkinson, Barbara, Barbesi, Karina, and Rubinstein, Francis, Lawrence Berkeley National Laboratory (LBNL). September 2011. Table 6, p. 14. Weighted average by the number of "reviewed" and "non-reviewed" papers.
- PUCT Docket 40668—Describes deemed values to be used in energy and demand savings calculations.
- PUCT Docket 36779—Describes EUL.

Relevant Standards and Reference Sources

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

Document Revision History

Table 17. Lighting Controls—Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. No revision.
v2.1	01/30/2015	TRM v2.1 update. Corrections to Equation 5 and Equation 6 to accurately reflect the energy and power adjustment factors and to reflect savings based on connected load rather than a delta load. Consolidation of algorithms for retrofit and new construction projects.
v3.0	04/10/2015	TRM v3.0 update. Update EAF and PAF factors with values from a more current and comprehensive controls study. Update equations to use a "controlled lighting watts" approach for both retrofit and new construction. Updated Program Tracking parameters for consistency with other Lighting measures and added interior/exterior location.
v4.0	10/10/2016	TRM v4.0 update. No revision.
v5.0	10/2017	TRM v5.0 update. Completed source and code updates where applicable (IECC 2015 and ASHRAE 90.1-2013). Note that Texas adopted IECC 2015 for commercial, industrial, and residential buildings taller than three stories and ASHRAE 90.1-2013 for state-funded buildings.
v6.0	10/2018	TRM v6.0 update. Revised multiple/combined control types EAF and PAF.
v7.0	10/2019	TRM v7.0 update. Program tracking requirements updated.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits.
v9.0	10/2021	TRM v9.0 update. Added eligibility criteria for new construction applications.

TRM version	Date	Description of change
v10.0	10/2022	TRM v10.0 update. Added guidance for field adjustable lights. Clarified baseline controls for new construction projects.

2.1.3 Exterior Photocell and Time Clock Repair Measure Overview

TRM Measure ID: NR-LT-PR

Market Sector: Commercial

Measure Category: Lighting

Applicable Building Types: All commercial

Fuels Affected: Electricity

Decision/Action Types: Retrofit

Program Delivery Type: Prescriptive, custom, direct install

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure is for the repair of a photocell or time clock on an existing exterior light fixture. A photocell is designed to switch exterior light fixtures off during daylight hours. If broken, these fixtures may remain on as much as 8,760 hours per year.

Eligibility Criteria

This measure is only applicable to exterior retrofit applications where an existing photocell or time clock is not functioning as designed. New construction applications are not eligible.

The fixture must be manually controlled except for the photocell/time clock and may not be installed in combination with any supplemental controls.

Baseline Condition

The baseline condition is an exterior light fixture controlled by a photocell or time clock that is not functioning, allowing the fixture to operate continuously.

High-Efficiency Condition

The high-efficiency condition is a light fixture installed in combination with a functioning (repaired or new) photocell or time clock control.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

This section describes the deemed savings methodology for both energy and demand savings for all lighting projects. Savings are calculated using separate methods for retrofit and new construction projects.

$$Energy\ Savings\ [kWh] = kW_{fixture} \times (8{,}760 - AOH)$$

Equation 7

$$Peak\ Demand\ Savings\ [kW] = kW_{fixture} \times \left(1 - CF_{S/W}\right)$$

Equation 8

Where:

$kW_{fixture}$ = *Total kW of controlled fixture (approved baseline fixture code wattage from deemed savings tool divided by 1,000 and multiplied by fixture/lamp quantity)*[69]

AOH = *Hours by outdoor application (see Table 18)*

$CF_{S/W}$ = *Seasonal peak coincidence factor by outdoor application and climate zone (see Table 19)*

Table 18. Exterior Photocell Repair—Annual Operating Hours by Outdoor Application

Building type	AOH
Outdoor: Athletic field and court[70]	767
Outdoor: Billboard[71]	3,470
Outdoor: Dusk-to-dawn[72]	4,161
Outdoor: Less than dusk-to-dawn[73]	1,998

[69] Look up approved fixture wattage from the Standard Fixture Wattage Table. http://texasefficiency.com/index.php/regulatory-filings/lighting.

[70] "2015 US Lighting Market Characterization," US Department of Energy. November 2017. Value derived by multiplying average daily operating hours from Table 2-30 by 365.25 hours per year.

[71] Ibid.

[72] This space type refers to fixtures controlled either by photocells or by timers operating on a dusk-to-dawn schedule. Calculated based on average dark hours for Amarillo (northernmost) and Corpus Christi (southernmost) climate zones from sunrise to sunset excluding one-half of civil twilight period. https://www.timeanddate.com/sun/. Note: pending update to US Naval Observatory annual data once website maintenance has completed. https://aa.usno.navy.mil/data/RS_OneYear.

[73] This space type refers to fixtures controlled by timers operating on a less than dusk-to-dawn schedule.

Table 19. Exterior Photocell Repair—Winter Peak Coincidence Factors by Outdoor Application[74,75]

Building type	Summer peak CF	Winter peak CF				
	All climate zones	Climate Zone 1: Amarillo	Climate Zone 2: Dallas	Climate Zone 3: Houston	Climate Zone 4: Corpus Christi	Climate Zone 5: El Paso
Outdoor: Athletic field and court[76]	0.00	0.26	0.27	0.24	0.29	0.38
Outdoor: Billboard[77]	0.00	0.59	0.62	0.53	0.65	0.87
Outdoor: Dusk-to-dawn[78]	0.00	0.67	0.71	0.61	0.75	1.00
Outdoor: Less than dusk-to-dawn[79]	0.00	0.67	0.71	0.61	0.75	1.00

Deemed Energy and Demand Savings Tables

This section is not applicable as these calculations are entirely dependent on site-specific parameters related to lighting system operation.

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 1 year for photocell repair based on the estimated remaining life of an exterior lamp operating 8,760 hours per year.[80] This value is further capped at 1 year based on the expectation that the photocell would be repaired in absence of utility program intervention beyond this point.

[74] Operating schedules are based on sunrise/sunset times for each climate-zone reference city, adjusted for compliance with IESNA-DG-13-96 and IESNA-DG-13-98 recommendations.
[75] Summer coincidence factor is set to zero for all exterior lighting applications.
[76] "2015 US Lighting Market Characterization," US Department of Energy. November 2017. Value derived by multiplying average daily operating hours from Table 2-30 by 365.25 hours per year.
[77] Ibid.
[78] This space type refers to fixtures controlled either by photocells or by timers operating on a dusk-to-dawn schedule. Calculated based on average dark hours for Amarillo (northernmost) and Corpus Christi (southernmost) climate zones from sunrise to sunset excluding one-half of civil twilight period. https://www.timeanddate.com/sun/. Note: pending update to US Naval Observatory annual data once website maintenance has completed. https://aa.usno.navy.mil/data/RS_OneYear.
[79] This space type refers to fixtures controlled by timers operating on a less than dusk-to-dawn schedule.
[80] Metal halide rated life expected between 6,000–15,000 hours. 10,500–hour midpoint divided by 8,760 hours yields 1.2 years.

Program Tracking Data and Evaluation Requirements

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

- Climate zone
- Outdoor application
- Controlled fixture quantity
- Controlled fixture/lamp type
- Controlled fixture/lamp wattage
- Existing control type (photocell, time clock)
- Control intervention (repair, replacement)
- New control manufacturer and model number (replacement only)
- Photo of controlled light fixture nameplate, model number, or wattage stamp
- Photo demonstrating that fixture is operating during daytime hours
- Copy of project invoice detailing affected fixture quantity and control intervention
    - New photocell/time clock model number (replacement only)

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Reference Sources

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

Document Revision History

Table 20. Exterior Photocell Repair—Revision History

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

2.1.4 LED Traffic Signals Measure Overview

TRM Measure ID: NR-LT-TS

Market Sector: Commercial

Measure Category: Lighting

Applicable Building Types: Outdoor

Fuels Affected: Electricity

Decision/Action Type(s): Retrofit

Program Delivery Type(s): Prescriptive, custom, direct install

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure is for the installation of light emitting diode (LED) traffic signals (typically available in red, yellow, green, and pedestrian formats) at traffic lights serving any intersection, in retrofit applications.

Eligibility Criteria

New construction applications are not eligible for this measure, as incandescent traffic signals are not compliant with the current federal standard[81], effective January 1, 2006.

Baseline Condition

For all retrofit applications, the baseline is a fixture with incandescent lamps.

High-Efficiency Condition

Due to the increased federal standard for traffic signals, the ENERGY STAR® Traffic Signal specification was suspended effective May 1, 2007. ENERGY STAR chose to suspend the specification rather than revise it due to minimal additional savings that would result from a revised specification. Because the ENERGY STAR specification no longer exists, the efficiency standard is an equivalent LED fixture for the same application. The equivalent LED fixture must be compliant with the current federal standard except for yellow "ball" or "arrow" fixtures where there is no federal standard.

[81] Current federal standards for traffic and pedestrian signals can be found at the DOE website at: https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=12.

Table 21. LED Traffic Signals—Federal Standard Maximum Wattages[82] and Nominal Wattages[83]

Module type	Maximum wattage	Nominal wattage
12" red ball	17	11
8" red ball	13	8
12" red arrow	12	9
12" green ball	15	15
8" green ball	12	12
12" green arrow	11	11
Combination walking man/hand	16	13
Walking man	12	9
Orange hand	16	13

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

This section describes the deemed savings methodology for both energy and demand savings for all LED traffic signal projects.

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

Equation 9

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

Equation 10

Where:

kW_{pre}	=	*Total kW of existing measure (fixture wattage multiplied by quantity)*
$kW_{installed}$	=	*Total kW of retrofit measure (fixture wattage multiplied by quantity)*
Hours	=	*Annual operating hours from Table 22*
CF_S	=	*Summer peak coincidence factor from Table 22*

[82] Maximum wattage is the wattage at which power consumed by the module after being operated for 60 minutes while mounted in a temperature testing chamber so that the lensed portion of the module is outside the chamber, all portions of the module behind the lens are within the chamber at a temperature of 74°C, and the air temperature in front of the lens is maintained at a minimum of 49°C.

[83] Nominal wattage is defined as power consumed by the module when it is operated within a chamber at a temperature of 25°C after the signal has been operated for 60 minutes.

Table 22. LED Traffic Signals—Savings Calculation Input Assumptions[84]

Fixture type	Incandescent wattage	LED wattage	AOH	CF_S[85]
8” red ball	86	8	4,746	0.54
8” green ball		10	3,751	0.43
8” yellow ball		13	263	0.03
12” red ball	149	11	4,746	0.54
12” green ball		12	3,751	0.43
12” yellow ball		10	263	0.03
8” red arrow	69	8	6,570	0.75
8” green arrow		8	1,825	0.21
8” yellow arrow	128	10	263	0.03
12” red arrow		7.5	7,771	0.89
12” green arrow		10	726	0.08
12” yellow arrow		10	263	0.03
Large (16”x18”) pedestrian signal	149	9	8,642	0.99
Small (12”x12”) pedestrian signal	107	9	8,642	0.99

Deemed Energy and Demand Savings Tables

Table 23. LED Traffic Signals—Energy and Peak Demand Savings per Fixture

Fixture type	kWh savings	kW savings
8” red ball	370	0.042
8” green ball	285	0.033
8” yellow ball	19	0.002
12” red ball	655	0.075
12” green ball	514	0.059
12” yellow ball	37	0.004
8” red arrow	401	0.046
8” green arrow	111	0.013
8” yellow arrow	31	0.004
12” red arrow	936	0.107
12” green arrow	86	0.010
12” yellow arrow	31	0.004
Large (16”x18”) pedestrian signal	1,210	0.138
Small (12”x12”) pedestrian signal	847	0.097

Claimed Peak Demand Savings

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

Measure Life and Lifetime Savings

According to the Northwest Power and Conservation Council Regional Technical Forum, the EUL is 5 to 6 years depending on the installed fixture type, as shown in the following table.

Table 24. LED Traffic Signals—EULs by Fixture Type[86]

Fixture type	EUL (years)
8" and 12" red, green, and yellow ball	6
8" and 12" red, green, and yellow arrow	
Large (16"x18") pedestrian signal	5
Small (12"x12") pedestrian signal	

Program Tracking Data and Evaluation Requirements

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

- Decision/Action Type: retrofit or NC (NC not eligible)
- Fixture type
- Quantity of installed fixtures
- Proof of purchase: invoice showing model number; a photo of the model number on product packaging and installed fixture; OR an evaluator pre-approved inspection approach

References and Efficiency Standards

Petitions and Rulings

Not applicable.

---

[84] Northwest Power and Conservation Council: Regional Technical Forum. Commercial LED Traffic Signals measure workbook. Version 2.2 updated 6/29/2016. https://rtf.nwcouncil.org/deactivated-measures/.

[85] Traffic signals operate consistently during each hour of the year. Therefore, CFs are calculated by dividing the assumed AOH value by 8,760 hours/year.

[86] Northwest Power and Conservation Council: Regional Technical Forum. Commercial LED Traffic Signals measure workbook. Version 2.2 updated 6/29/2016. http://rtf.nwcouncil.org/measures/measure.asp?id=114&decisionid=37.

Relevant Standards and Reference Sources

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

Document Revision History

Table 25. LED Traffic Signals—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.
v9.0	10/2021	TRM v9.0 update. No revision.
v10.0	10/2022	TRM v10.0 update. General reference checks and text edits.

2.2 NONRESIDENTIAL: HVAC

2.2.1 Air Conditioner and Heat Pump Tune-Ups Measure Overview

TRM Measure ID: NR-HV-TU

Market Sector: Commercial

Measure Category: HVAC

Applicable Building Types: See Table 34 through Table 40

Fuels Affected: Electricity

Decision/Action Type(s): Retrofit

Program Delivery Type(s): Prescriptive

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Engineering algorithms and estimates

Measure Description

This measure applies to direct expansion central air conditioners (AC) and heat pumps (HP) of any configuration where all applicable actions from the checklist below are completed. An AC tune-up involves checking, cleaning, adjusting, and resetting the equipment to factory conditions to restore operating efficiencies, closer to as-new performance. This measure applies to all commercial applications.

For this measure, the service technician must complete the following tasks according to industry best practices. To properly assess and adjust the refrigerant charge level, the unit must be operating under significant (normal) cooling load conditions. Therefore, this measure may only be performed for energy savings reporting purposes when the outdoor ambient dry bulb temperature is above 75˚F and the indoor return air dry bulb temperature is above 70˚F.

Air Conditioner Inspection and Tune-up Checklist[87]

- Tighten all electrical connections, measure motor voltage and current
- Lubricate all moving parts, including motor and fan bearings
- Inspect and clean condensate drain
- Inspect controls of the system to ensure proper and safe operation; check startup/shutdown cycle of the equipment to assure the system starts, operates, and shuts off properly
- Clean evaporator and condenser coils

[87] Based on ENERGY STAR® HVAC Maintenance Checklist. www.energystar.gov/index.cfm?c=heat_cool.pr_maintenance.

- Clean indoor blower fan components
- Inspect and clean (or change) air filters; replacement preferred best practice
- Measure airflow via static pressure across the cooling coil and adjust to manufacturers specifications
- Check refrigerant level and adjust to manufacturer specifications
- Check capacitor functionality and capacitance; compare to OEM specifications

Eligibility Criteria

All commercial customers are eligible for this measure if they have direct expansion refrigerated air conditioning that has not been serviced in the last 5 years. This measure does not apply to chillers.

Baseline Condition

The baseline is a system with all or some of the following issues:

- Dirty condenser coil
- Dirty evaporator coil
- Dirty blower wheel
- Dirty filter
- Improper airflow
- Incorrect refrigerant charge

The baseline system efficiency should be calculated using the following formulas:

$$EER_{pre} = (1 - EL) \times EER_{post}$$

Equation 11

$$HSPF_{pre} = (1 - EL) \times HSPF_{post}$$

Equation 12

Where:

EER_{pre}	=	*Efficiency of the cooling equipment before tune-up [Btuh/W]*
EL	=	*Efficiency loss due to dirty coils, blower, filter, improper airflow, and/or incorrect refrigerant charge = 0.05*
EER_{post}	=	*Deemed cooling efficiency of the equipment after tune-up [Btuh/W] (see Table 26)*

$HSPF_{pre}$ = *Heating efficiency of the air source heat pump before tune-up [Btuh/W]*

$HSPF_{post}$ = *Deemed heating efficiency of air source heat pumps after tune-up [Btuh/W] (see Table 26)*

Table 26. AC/HP Tune-Ups—Default EER and HSPF per Size Category[88]

Size category (Btuh/hr)	AC only default EER	Heat pump default EER	Default HSPF
< 65,000	11.2	11.2	7.7
≥ 65,000 and < 135,000	10.1	9.9	10.9
≥ 135,000 and < 240,000	9.5	9.1	10.6
≥ 240,000 and < 760,000	9.3	8.8	10.6
≥ 760,000	9.0	8.8	10.6

High-Efficiency Condition

After the tune-up, the equipment must be clean with airflows and refrigerant charges adjusted as appropriate and set forth above. Additionally, refrigerant charge adjustments must be within ± 3 degrees of target sub-cooling for units with thermal expansion valves (TXV) and ± 5 degrees of target super heat for units with fixed orifices or capillary tubes.

The efficiency standard, or efficiency after the tune-up, is deemed to be the manufacturer specified energy efficiency ratio (EER) of the existing central air conditioner or heat pump, which has been determined using the following logic and standards. The useful life of an AC unit is 19 years. The useful life of a heat pump is 16 years. Therefore, it is conservatively thought that the majority of existing, functioning units were installed under the federal standard in place between January 23, 2006 and January 1, 2015 for units less than 65,000 Btuh, which set a baseline of 13 SEER and 7.7 HSPF[89], and prior to January 1, 2010 for units greater than 65,000 Btuh. A 13 SEER is equivalent to approximately 11.2 EER[90] using the conversion developed by Lawrence Berkeley Lab and US DOE: EER = -0.02 x $SEER^2$ + 1.12 x SEER. A 3.2 and 3.1 COP is equivalent to approximately 10.9 and 10.6 HSPF, respectively, using the conversion of HSPF = 3.412 x COP.

[88] Code specified EER and HSPF value from ASHRAE 90.1-2010 (efficiency value effective January 23, 2006 for units < 65,000 Btu/hr and prior to January 1, 2010 for units ≥ 65,000 Btu/hr). HSPF = COP x 3.412.

[89] Code specified HSPF from federal standard effective January 23, 2006, through January 1, 2015.

[90] Code specified 13 SEER from federal standard effective January 23, 2006, through January 1, 2015, converted to EER using EER = -0.02 x $SEER^2$ + 1.12 x SEER. National Renewable Energy Laboratory (NREL). "Building America House Simulation Protocols." U.S. Department of Energy. Revised October 2010. http://www.nrel.gov/docs/fy11osti/49246.pdf.

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Savings are based on an assumed efficiency loss factor of five percent due to dirty coils, dirty filters, improper airflow, and/or incorrect refrigerant charge.[91]

Heating energy savings are only applicable to heat pumps.

$$Total\ Energy\ Savings\ [kWh] = kWh_C + kWh_H$$

Equation 13

$$Cooling\ Energy\ Savings\ [kWh_C] = Cap_C \times \left(\frac{1}{EER_{pre}} - \frac{1}{EER_{post}}\right) \times EFLH_C \times \frac{1\ kW}{1{,}000\ W}$$

Equation 14

$$Heating\ Energy\ Savings\ [kWh_H] = Cap_H \times \left(\frac{1}{HSPF_{pre}} - \frac{1}{HSPF_{post}}\right) \times EFLH_H \times \frac{1\ kW}{1{,}000\ W}$$

Equation 15

Where:

Cap_C	=	*Rated cooling/heating capacity of the equipment based on model number [Btuh] (1 ton = 12,000 Btuh)*
$EFLH_{C/H}$	=	*Cooling/heating equivalent full-load hours for appropriate climate zone [hours]; see Table 36 through Table 40 in Section 2.2.2*

Demand Savings Algorithms

Summer and winter demand savings are determined by applying a coincidence factor for each season. Winter peak demand savings are only applicable to heat pumps.

$$Summer\ Peak\ Demand\ Savings\ [kW] = Cap_C \times \left(\frac{1}{EER_{pre}} - \frac{1}{EER_{post}}\right) \times DF_S \times \frac{1\ kW}{1{,}000\ W}$$

Equation 16

$$Winter\ Peak\ Demand\ Savings\ [kW] = Cap_H \times \left(\frac{1}{HSPF_{pre}} - \frac{1}{HSPF_{post}}\right) \times DF_W \times \frac{1\ kW}{1{,}000\ W}$$

Equation 17

[91] Energy Center of Wisconsin, May 2008; "Central Air-Conditioning in Wisconsin, A Compilation of Recent Field Research."

Where:

$DF_{S/W}$ = *Summer/winter seasonal peak demand factor; see Table 36 through Table 40 in Section 2.2.2*

Deemed Energy Savings Tables

There are no lookup tables available for this measure. See engineering algorithms in the previous section for calculating energy and demand savings.

Deemed Summer Demand Savings Tables

There are no lookup tables available for this measure. See engineering algorithms in the previous section for calculating energy and demand savings.

Deemed Winter Demand Savings Tables

There are no lookup tables available for this measure. See engineering algorithms in the previous section for calculating energy and demand savings.

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 a tune-up is 5 years.[92]

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:

- Manufacturer
- Model number
- Cooling capacity of the installed unit (tons)
- Climate zone or county of the site
- Type of unit

[92] GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. Prepared for The New England State Program Working Group; Page 1-3, Table 1.

- Air conditioner
- Air source heat pump

- Recommended
  - Serial number
  - Refrigerant type
  - Target superheat or subcooling
  - Post-tune-up superheat or subcooling
  - Amount of refrigerant added or removed
  - Static pressures before and after a tune-up
  - Return and supply dry bulb and wet bulb temperatures
  - Before and after tune-up pictures of components illustrating condition change due to cleanings (Note: pictures that include well-placed familiar objects like hand tools often provide a sense of scale and a reference for color/shading comparisons. Pictures of equipment nameplates are useful).

References and Efficiency Standards

Petitions and Rulings

Not applicable.

Relevant Standards and Efficiency Sources

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

Document Revision History

Table 27. AC/HP Tune-Ups—Revision History

TRM version	Date	Description of change
v4.0	10/10/2016	TRM v4.0 origin.
v5.0	10/2017	TRM v5.0 update. No revision.
v6.0	10/2018	TRM v6.0 update. No revision
v7.0	10/2019	TRM v7.0 update. No revision.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits.
v9.0	10/2021	TRM v9.0 update. Updated EUL reference.
v10.0	10/2022	TRM v10.0 update. No revision.

2.2.2 Split and Packaged Air Conditioners and Heat Pumps Measure Overview

TRM Measure ID: NR-HV-SP

Market Sector: Commercial

Measure Category: HVAC

Applicable Building Types: See Table 34 through Table 40

Fuels Affected: Electricity

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

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Energy modeling, engineering algorithms, and estimates

Measure Description

This section summarizes the deemed savings methodology for the installation of air-cooled split system and single packaged air conditioning (AC) and heat pump (HP) systems. This document covers assumptions made for baseline equipment efficiencies for early retirement (ER) based on the age of the replaced equipment and for replace-on-burnout (ROB) and new construction (NC) situations based on efficiency standards. Savings calculations incorporate the use of both full-load and part-load efficiency values. For ER, the actual age of the baseline system should be determined from the equipment nameplate or other physical documentation whenever possible. Default values are provided for when the actual age of the unit is unknown.

Applicable efficient measure types include:

- Packaged and split direct expansion (DX) ACs
- Packaged and split DX HPs

Note: HPs less than 5.4 tons without SEER2 ratings are extended a one-year sell through allowance for units manufactured prior to January 1, 2023, and should refer to the PY2021 TRM 9.0 methodology. HPs less than 5.4 tons with SEER2 ratings are expected to comply with the guidelines outlined in this measure.

Eligibility Criteria

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

- The existing and proposed cooling equipment is electric.
- The building falls into one of the categories listed in Table 36 through Table 40. Building type descriptions and examples are provided in Table 34 and Table 35.

- For ER projects: ER projects involve the replacement of a working system. Additionally, the ER approach cannot be used for projects involving a renovation where a major structural change or internal space remodel has occurred. A ROB approach should be used for these scenarios.
- If these conditions are not met, the deemed savings approach cannot be used, and the Simplified M&V Methodology or the Full M&V Methodology must be used.

Manufacturer datasheets for installed equipment or documentation of Air-Conditioning, Heating, and Refrigeration Institute (AHRI) or DOE CCMS certification must be provided.[93,94]

Baseline Condition

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

Early Retirement

Early Retirement (ER) systems involve the replacement of a working system, prior to natural burnout. The ER baseline cannot be used for projects involving a renovation where a major structural change or internal space remodel has occurred.

Two baseline condition efficiency values are required for an ER scenario, one for the ER (RUL) period and one for the ROB (EUL-RUL) period. For the ROB period, the baseline efficiency is the same as ROB/NC scenario. For the ER period, the baseline efficiency should be estimated using the values from

Table 28 through Table 32 according to the capacity, system type, and age (based on year manufactured) of the replaced system.[95] When the system age can be determined (e.g., from nameplate, building prints, equipment inventory list), the baseline efficiency levels provided in

Table 28 through Table 32 should be used. If individual system components were installed at different times, use the condenser age as a proxy for the entire system. When the system age is unknown, assume a default value equal to the EUL. This corresponds to an age of 15 years.[96] A default RUL may be used exclusively if applied consistently for all projects. Otherwise, the default should only be used when a project is reported and documented as having a nameplate that is illegible.

---

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

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

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

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

PUCT Docket 40885 provided baseline efficiencies for split and packaged systems replaced via ER.

ER baseline efficiency values represent the code-specified efficiency in effect at the time the system was installed. Prior to 2002, code-specified efficiencies from ASHRAE 90.1-1989 were in effect. Code-specified efficiencies increased in 2002, approximating the effective date of ASHRAE 90.1-1999, which went into effect on October 29, 2001. Code-specified efficiencies increased again in 2010 and 2018, coinciding with the IECC 2009 and IECC 2015 code increases. The baseline efficiency levels shown in

Table 28 through Table 32 are based on assumptions of the predominant heating types expected in the state. For air conditioners, baseline cooling efficiencies are displayed for a natural gas furnace heating section type. For HPs, baseline cooling efficiencies are displayed for electric resistance supplemental heating section type.

For units < 5.4 tons, EER, SEER, and HSPF values are converted to EER2, SEER2, and HSPF2 for consistency with the current federal standard. Unspecified EER2 are calculated by multiplying average EER/EER2 ratios, referencing EER2 values specified in the current federal standard for 12.2 and 11.7 EER. Unspecified SEER2 values are calculated by multiplying average SEER/SEER2 ratios, referencing SEER2 values specified for 14, 14.5, 15, and 16 SEER. Unspecified HSPF2 values are calculated by multiplying average HSPF/HSPF2 ratios, referencing HSPF2 values specified for 8.0 and 8.8 HSPF.

Refer to TRM 9.0 for exempted HPs < 5.4 tons referencing the previous federal standard. Units with a SEER2 rating are expected to comply with the guidelines outlined in this measure.

For 5.4+ ton units, baseline EER values shown from ASHRAE/IECC assume natural gas heating for the predominant heating section type expected for commercial facilities in Texas. For units installed from 2002 to present, 0.2 EER may be added for “Electric Resistance (or None)” heating types. For units installed before 2002 and 11.3+ tons, 0.2 EER may be added for no heating.

Table 28. DX HVAC—ER Baseline Full-Load Efficiency for ACs

Year installed (replaced system)	Split systems < 5.4 tons (EER2)	Package system < 5.4 tons (EER2)	All systems 5.4 to < 11.3 tons (EER)	All systems 11.3 to < 20 tons (EER)	All systems 20 to < 63.3 tons (EER)	All systems ≥ 63.3 tons (EER)
≤ 2005	7.8	7.5	10.1	9.5	9.3	9.0
2006–2009	10.1	10.1	10.1	9.5	9.3	9.0
2010–2017	10.1	10.1	11.0	10.8	9.8	9.5
≥ 2018	10.1	10.9	11.0	10.8	9.8	9.5

Table 29. DX HVAC—ER Baseline Part-Load Efficiency for ACs[97]

Year installed (replaced system)	Split systems < 5.4 tons (SEER2)	Package system < 5.4 tons (SEER2)	All systems 5.4 to < 11.3 tons (IEER)	All systems 11.3 to < 20 tons (IEER)	All systems 20 to < 63.3 tons (IEER)	All systems ≥ 63.3 tons (IEER)
≤ 2005	9.5	9.2	10.3	9.7	9.4	9.1
2006–2009	12.4	12.4	10.3	9.7	9.4	9.1
2010–2017	12.4	12.4	11.2	11.0	9.9	9.6
≥ 2018	12.4	13.4	12.6	12.2	11.4	11.0

Table 30. DX HVAC—ER Baseline Full-Load Cooling Efficiency for HPs

Year installed (replaced system)	Split systems < 5.4 tons (EER2)	Package system < 5.4 tons (EER2)	All systems 5.4 to < 11.3 tons (EER)	All systems 11.3 to < 20 tons (EER)	All systems 20 to < 63.3 tons (EER)	All systems ≥ 63.3 tons (EER)
≤ 2005	7.8	7.5	10.1	9.3	9.0	9.0
2006–2009	10.1	10.1	10.1	9.3	9.0	9.0
2010–2017	10.1	10.1	11.0	10.6	9.5	9.5
≥ 2018	10.9	10.9	11.0	10.6	9.5	9.5

[97] IEER values were not added to the Standard until 2010, so IEERs for prior years are approximated as EER + 0.2 for systems between 5.4 tons and less than 20 tons and as EER + 0.1 for systems greater than 20 tons based on the relationship of EER to IEER from the current federal standard.

Table 31. DX HVAC—ER Baseline Part-Load Cooling Efficiency for HPs[98]

Year installed (replaced system)	Split systems < 5.4 tons (SEER2)	Package system < 5.4 tons (SEER2)	All systems 5.4 to < 11.3 tons (IEER)	All systems 11.3 to < 20 tons (IEER)	All systems 20 to < 63.3 tons (IEER)	All systems ≥ 63.3 tons (IEER)
≤ 2005	9.5	9.2	10.3	9.5	9.1	9.1
2006–2009	12.4	12.4	10.3	9.5	9.1	9.1
2010–2017	12.4	12.4	11.2	10.7	9.6	9.6
≥ 2018	13.4	13.4	12.0	11.6	10.6	10.6

Table 32. DX HVAC—ER Baseline Heating Efficiency for HPs

Year installed (replaced system)	Split systems < 5.4 tons (HSPF2)	Package system < 5.4 tons (HSPF2)	All systems 5.4 to < 11.3 tons (COP)	All systems ≥ 11.3 tons (COP)
≤ 2005	5.7	5.6	3.2	3.1
2006–2009	6.5	6.5	3.2	3.1
2010–2017	6.5	6.5	3.3	3.2
≥ 2018	6.9	6.7	3.3	3.2

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

Baseline efficiency levels for package and split DX ACs and HPs are provided in Table 33. These baseline efficiency levels reflect the latest minimum efficiency requirements from the current federal standard, effective January 1, 2023, for units with a rated cooling capacity of less than 65,000 Btu/hour (5.4 tons) and IECC 2015 for units 5.4 tons and greater.

HPs < 5.4 tons are exempted from enforcement of the current federal standard based on a sell-through allowance for units manufactured before January 1, 2023. For units that do not have SEER2 ratings at the time of purchase but that have SEER2 ratings added to AHRI prior to evaluation, the previous SEER, EER, and HSPF baselines if project documentation can demonstrate that no SEER2 rating was available at the time of purchase. Appropriate documentation may include a copy of the AHRI certificate, manufacturer specification sheet, or other evaluator pre-approved documentation. These projects should reference the previous TRM 9.0 for applicable baseline efficiency values. This one-year exception will no longer apply starting with the implementation of the 2024 program year.

[98] IEER values were not added to the Standard until 2010, so IEERs for prior years are approximated as EER + 0.2 for systems between 5.4 tons and less than 20 tons and as EER + 0.1 for systems greater than 20 tons based on the relationship of EER to IEER from the current federal standard.

For ACs, baseline cooling efficiencies are displayed for a natural gas furnace heating section type. For HPs, baseline cooling efficiencies are displayed for electric resistance supplemental heating section type. For all other heating section types, or for no heating section type, the baseline efficiencies may need to be adjusted as specified by the footnotes in the tables.

Refer to TRM 9.0 for exempted HPs < 5.4 tons referencing the previous federal standard. Units with a SEER2 rating are expected to comply with the guidelines outlined in this measure.

Table 33. DX HVAC—NC/ROB Baseline Efficiency Levels[99]

System type	Capacity (tons)	Baseline efficiencies	Source[100]
Air conditioner	Split < 3.75	11.7 EER2 14.3 SEER2	DOE Standards
	Split ≥ 3.75	11.2 EER2 13.8 SEER2	
	Packaged < 5.4 tons	10.9 EER2[101] 13.4 SEER2	
	All < 5.4 tons rated at ≧ 15.2 SEER2	9.8 EER2[102]	
	5.4 to < 11.3	11.0 EER 12.6 IEER	IECC 2015
	11.3 to < 20	10.8 EER 12.2 IEER	
	20 to < 63.3	9.8 EER 11.4 IEER	
	≥ 63.3	9.5 EER 11.0 IEER	

[99] IECC 2015 Table C403.2.3(1) and C403.2.3(2).

[100] These baseline efficiency standards noted as "DOE Standards" are cited in the Code of Federal Regulations, 10 CFR 431.97. https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-431/subpart-F/subject-group-ECFR2640f6ad978e4e6/section-431.97

[101] Unspecified EER2 values are calculated by multiplying average EER/EER2 ratios, referencing EER2 values specified in the current federal standard for 12.2 and 11.7 EER.

[102] When installing any system with a part-load efficiency rating of 15.2 SEER2 or higher, the reduced 9.8 EER2 full-load efficiency baseline should be applied in lieu of the applicable value presented earlier in the table except where the specified baseline EER2 value is lower than 9.8 EER2.

System type	Capacity (tons)	Baseline efficiencies	Source[100]
Heat pump (cooling)[103]	Split < 5.4	11.7 EER2 14.3 SEER2	DOE Standards
	Packaged < 5.4	10.9 EER2[104] 13.4 SEER2	
	All < 5.4 tons rated at ≧ 15.2 SEER2	9.8 EER2[105]	
	5.4 to < 11.3	11.0 EER 12.0 IEER	IECC 2015
	11.3 to < 20	10.6 EER 11.6 IEER	
	≥ 20	9.5 EER 10.6 IEER	
Heat pump (heating)[106]	Split < 5.4	7.5 HSPF2	DOE Standards
	Packaged < 5.4	6.7 HSPF2	
	5.4 to < 11.25	3.3 COP	IECC 2015
	≥ 11.3	3.2 COP	

High-Efficiency Condition

Split and packaged systems must exceed the minimum efficiencies specified in Table 33. Split system efficiencies are driven primarily by the efficiency of the condenser unit. If the paired outdoor and indoor units are not listed on the AHRI certification listing and only provide DOE CCMS testing results, then the capacity and efficiency of the high-efficiency condition shall not exceed the average of the AHRI certification listing pairing for the matching condenser. The DOE CCMS listing provides documentation of the results that are on the AHRI certification listing and can be downloaded and filtered based on listing using a similar condenser and various indoor units.

[103] ASHRAE 90.1-2010 Table 6.8.1B. These systems larger than 5.4 tons, the minimum efficiency levels provided in this table are based on systems with heating type "No Heating or Electric Resistance Heating", excluding systems with "All Other Types of Heating".

[104] Unspecified EER2 values are calculated by multiplying average EER/EER2 ratios, referencing values specified in the current federal standard for 12.2 and 11.7 EER.

[105] When installing any system with a part-load efficiency rating of 15.2 SEER2 or higher, the reduced 9.8 EER2 full-load efficiency baseline should be applied in lieu of the applicable value presented earlier in the table except where the specified baseline EER2 value is lower than 9.8 EER2.

[106] Heat pump retrofits must also exceed the baseline efficiency levels for heating efficiencies.

For reference, both ENERGY STAR®[107] and the Consortium for Energy Efficiency (CEE)[108] offer suggested guidelines for high-efficiency equipment. Additional conditions for replace-on-burnout, ER and new construction are in the sections below.

New Construction and Replace-on-Burnout

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

Early Retirement

The high-efficiency retrofits must meet the following criteria:[109]

- For ER projects only, the installed equipment cooling capacity must be within 80 percent to 120 percent of the replaced electric cooling capacity. For scenarios involving the replacement of a combination of systems by an alternate combination of systems of varying capacities, ER savings can still be claimed if the overall pre- and post-capacities for the total combination of systems are within ± 20 percent. In these cases, a custom calculation should be performed to establish the following weighted savings factors to be applied over the ER portion of the savings calculation: manufacturer year, EUL, RUL, full and part-load baseline efficiency, demand factor, and EFLH. These factors should be weighted based on contribution to overall capacity.
- No additional measures are being installed that directly affect the operation of the cooling equipment (e.g., control sequences, cooling towers, and condensers).

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

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

Equation 18

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

Equation 19

$$Total\ Energy\ Savings\ [kWh] = kWh_C + kWh_H$$

Equation 20

[107] ENERGY STAR® Heating & Cooling, https://www.energystar.gov/products/heating_cooling.
[108] CEE Program Resources, http://www.cee1.org/content/cee-program-resources.
[109] From PUCT Docket #41070.

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

Equation 21

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

Equation 22

Where:

$Cap_{C/H,pre}$ = *For ER, rated equipment cooling/heating capacity of the existing equipment at AHRI-standard conditions; for ROB and NC, rated equipment cooling/heating capacity of the new equipment at AHRI-standard conditions [Btuh]; 1 ton = 12,000 Btuh*

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

Note: refer to PY2022 TRM 9.0 for exempted HPs < 5.4 tons referencing the previous federal standard. For HPs with a SEER2 rating and all other units < 5.4 tons, baseline and installed efficiencies should be specified as SEER2, EER2, or HSPF2.

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

$\eta_{installed,C}$ = *Rated cooling efficiency of the newly installed equipment (Must exceed ROB/NC baseline efficiency standards in Table 33) [Btuh/W]*

$\eta_{baseline,H}$ = *Heating efficiency of existing equipment (ER) or standard equipment (ROB/NC) [COP]*

$\eta_{installed,H}$ = *Rated heating efficiency of the newly installed equipment (Must exceed baseline efficiency standards in Table 33) [COP]*

Note: Use EER for kW savings calculations and SEER/IEER and COP for kWh savings calculations. The COP expressed for units ≥ 5.4 tons is a full-load COP. Heating efficiencies expressed as HSPF will be approximated as a seasonal COP and should be converted using the following equation:

$$COP = \frac{HSPF}{3.412}$$

Equation 23

$DF_{S/W}$ = *Summer/winter seasonal peak demand factor (see Table 36 through Table 40)*

$EFLH_{C/H}$ = *Cooling/heating equivalent full-load hours [hours] (see Table 36 through Table 40)*

Early Retirement Savings

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

System Type Conversion

Chiller to AC: Conversions from chiller-based systems to a packaged/split AC system are covered under this measure. See the reference tables in the HVAC Chillers measure for the savings.

AC to HP: Conversions from AC to HP are acceptable in commercial applications. Use CAP_H, $\eta_{baseline,H}$, DF_W, and $EFLH_H$ values for the new HP as a proxy for the baseline AC heating savings coefficients.

Deemed Energy and Demand Savings Tables

Deemed peak demand factor (DF) and equivalent full-load hour (EFLH) values are presented by building type and climate zone. A description of the building types that are used for HVAC systems is presented in Table 34 and Table 35. These building types are derived from the EIA CBECS study.[110]

The DF and EFLH values for packaged and split AC and HP units are presented in Table 36 through Table 40.

A description of the calculation method used to derive these values can be found in Docket No. 40885, Attachment B.

Combination building types. In situations where multiple TRM building types seem plausible or a predominant TRM building type is unclear, the utilities have two choices:

- **Deemed approach.** The deemed approach is a simplified method where utilities should choose a TRM building type based on the "best fit" for the facility. This is determined by the largest interior area for the potential building types. Although, if that is not best fit, the utilities will use their best judgment to make this decision and provide sufficient, defensible documentation for their decision.

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

The following building type combinations are pre-authorized exceptions to this rule. For these combinations, individual fixtures can be reported as either specified building type based on location. All other interior space combinations should reference a single deemed building type unless authorized by the evaluator.

- Office (any size): Warehouse
- Hospital: Outpatient healthcare

The *other* building type can be used for business types that are not explicitly listed. The DF and EFLH values used for *other* are the most conservative from the explicitly listed building types. When the *other* building type is used, a description of the actual building type, the primary business activity, the business hours, and the HVAC schedule must be collected for the project site and stored in the utility tracking data system.

For those combinations of technology, climate zone, and building type with no values, a project with that specific combination should use the *other* building type.

- **Custom approach.** In more unique situations, utilities should consider projects "custom" where (1) the deemed building types in the TRM may not represent the project's facility type, (2) the facility may represent multiple TRM building types without a clear predominant building type, or (3) the use of a predominant building type may be too conservative in the estimate of savings. The deemed methods only apply to specific scenarios and cannot be developed for all unique situations. Utilities should provide sufficient, defensible documentation for their EFLH and CF values used in their savings calculations that the EM&V team can review.

Table 34. DX HVAC—Building Type Descriptions and Examples

Building type	Principal building activity	Definition	Detailed business type examples[111]
Data center	Data center	Buildings used to house computer systems and associated components.	1) Data center
Education	College/university	Buildings used for academic or technical classroom instruction, such as elementary, middle, or high schools, and classroom buildings on college or university campuses. Buildings on education campuses for which the main use is not classroom are included in the category relating to their use. For example, administration buildings are part of "Office," dormitories are "Lodging," and libraries are "Public Assembly."	1) College or university 2) Career or vocational training 3) Adult education
	Primary school		1) Elementary or middle school 2) Preschool or daycare
	Secondary school		1) High school 2) Religious education

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

Building type	Principal building activity	Definition	Detailed business type examples[111]
Food sales	Convenience	Buildings used for retail or wholesale of food.	1) Gas station with a convenience store 2) Convenience store
	Supermarket		1) Grocery store or food market
Food service	Full-service restaurant	Buildings used for the preparation and sale of food and beverages for consumption.	1) Restaurant or cafeteria
	Quick-service restaurant		1) Fast food
Healthcare	Hospital	Buildings used as diagnostic and treatment facilities for inpatient care.	1) Hospital 2) Inpatient rehabilitation
	Outpatient healthcare	Buildings used as diagnostic and treatment facilities for outpatient care. Medical offices are included here if they use any type of diagnostic medical equipment (if they do not, they are categorized as an office building).	1) Medical office 2) Clinic or outpatient health care 3) Veterinarian
Large multifamily	Midrise apartment	Buildings containing multifamily dwelling units, having multiple stories, and equipped with elevators.	No sub-categories collected.
Lodging	Large hotel	Buildings used to offer multiple accommodations for short-term or long-term residents, including skilled nursing and other residential care buildings.	1) Motel or inn 2) Hotel 3) Dormitory, fraternity, or sorority 4) Retirement home, nursing home, assisted living, or other residential care 5) Convent or monastery
	Nursing home		
	Small hotel/motel		
Mercantile	Stand-alone retail	Buildings used for the sale and display of goods other than food.	1) Retail store 2) Beer, wine, or liquor store 3) Rental center 4) Dealership or showroom for vehicles or boats 5) Studio or gallery
	Strip mall	Shopping malls comprised of multiple connected establishments.	1) Strip shopping center 2) Enclosed malls

Building type	Principal building activity	Definition	Detailed business type examples[111]
Office	Large office	Buildings used for general office space, professional office, or administrative offices. Medical offices are included here if they do not use any type of diagnostic medical equipment (if they do, they are categorized as an outpatient health care building).	1) Administrative or professional office 2) Government office 3) Mixed-use office 4) Bank or other financial institution 5) Medical office 6) Sales office 7) Contractor's office (e.g., construction, plumbing, HVAC) 8) Non-profit or social services 9) Research and development 10) City hall or city center 11) Religious office 12) Call center
	Medium office		
	Small office		
Public assembly	Public assembly	Buildings in which people gather for social or recreational activities, whether in private or non-private meeting halls.	1) Social or meeting (e.g., community center, lodge, meeting hall, convention center, senior center) 2) Recreation (e.g., gymnasium, health club, bowling alley, ice rink, field house, indoor racquet sports) 3) Entertainment or culture (e.g., museum, theater, cinema, sports arena, casino, night club) 4) Library 5) Funeral home 6) Student activities center 7) Armory 8) Exhibition hall 9) Broadcasting studio 10) Transportation terminal
Religious worship	Religious worship	Buildings in which people gather for religious activities (such as chapels, churches, mosques, synagogues, and temples).	No sub-categories collected.

Building type	Principal building activity	Definition	Detailed business type examples[111]
Service	Service	Buildings in which some type of service is provided, other than food service or retail sales of goods.	1) Vehicle service or vehicle repair shop 2) Vehicle storage/maintenance 3) Repair shop 4) Dry cleaner or laundromat 5) Post office or postal center 6) Car wash 7) Gas station with no convenience store 8) Photo processing shop 9) Beauty parlor or barber shop 10) Tanning talon 11) Copy center or printing shop 12) Kennel
Warehouse	Warehouse	Buildings used to store goods, manufactured products, merchandise, raw materials, or personal belongings (such as self-storage).	1) Refrigerated warehouse 2) Non-refrigerated warehouse 3) Distribution or shipping center
Other	Other	For building types not explicitly listed.	Values used for other are the most conservative values from the explicitly listed building types.

Table 35. DX HVAC—Building Type Floor Area and Number of Floors[112]

Building type	Principal building activity	Average floor area (ft^2)	Average number of floors
Data center	Data center	Not specified	Not specified
Education	College/university	Not specified	Not specified
	Primary school	73,960	1
	Secondary school	210,887	2
Food sales	Convenience	Not specified	1
	Supermarket	45,000	1

[112] Building prototype information from DOE Commercial Reference Buildings, "Not specified" means that a building prototype is not defined for that building type. http://energy.gov/eere/buildings/Commercial-reference-buildings.

Building type	Principal building activity	Average floor area (ft^2)	Average number of floors
Food service	Full-service restaurant	5,500	1
	Quick-service restaurant	2,500	1
Healthcare	Hospital	241,351	5
	Outpatient healthcare	40,946	3
Large multifamily	Midrise apartment	33,740	4
Lodging	Large hotel	122,120	6
	Nursing home	Not specified	Not specified
	Small hotel/motel	43,200	4
Mercantile	Stand-alone retail	24,962	1
	Strip mall	22,500	1
Office	Large office	498,588	12
	Medium office	53,628	3
	Small office	5,500	1
Public assembly	Public assembly	Not specified	Not specified
Religious worship	Religious worship	Not specified	Not specified
Service	Service	Not specified	Not specified
Warehouse	Warehouse	52,045	1

Table 36. DX HVAC—DF and EFLH Values for Climate Zone 1: Amarillo

Building type	Principal building activity	Package and split DX					
		Air conditioner		Heat pump[113]			
		DF_S	$EFLH_C$	DF_S	$EFLH_C$	DF_W	$EFLH_H$
Data center	Data center	0.89	2,048	0.89	2,048	–	–
Education	College/university	0.69	787	0.69	787	–	–
	Primary school	0.64	740	0.64	740	0.43	701
	Secondary school	0.69	535	0.69	535	0.43	736
Food sales	Convenience	0.73	884	0.73	884	–	–
	Supermarket	0.29	219	0.29	219	–	–

[113] For heat pump projects without explicit heating factors, implementers may use the listed heating factors from the *other* building type for heating energy/demand savings.

Building type	Principal building activity	Package and split DX					
		Air conditioner		Heat pump[113]			
		DF_S	$EFLH_C$	DF_S	$EFLH_C$	DF_W	$EFLH_H$
Food service	Full-service restaurant	0.83	1,020	0.83	1,020	0.43	1,123
	24-hour full-service	0.81	1,093	0.81	1,093	0.43	1,346
	Quick-service restaurant	0.73	765	0.73	765	0.48	1,029
	24-hour quick-service	0.74	817	0.74	817	0.48	1,300
Healthcare	Hospital	0.72	2,185	0.72	2,185	–	–
	Outpatient healthcare	0.71	2,036	0.71	2,036	0.27	579
Large multifamily	Midrise apartment	0.68	674	0.68	674	–	–
Lodging	Large hotel	0.58	1,345	0.58	1,345	0.86	1,095
	Nursing home	0.68	685	0.68	685	–	–
	Small hotel/motel	0.57	1,554	0.57	1,554	0.36	475
Mercantile	Stand-alone retail	0.68	623	0.68	623	0.99	907
	24-hour stand-alone retail	0.80	820	0.80	820	0.43	1,277
	Strip mall	0.75	687	0.75	687	0.39	753
Office	Large office	0.90	2,058	0.90	2,058	–	–
	Medium office	0.64	925	0.64	925	0.72	576
	Small office	0.72	711	0.72	711	0.29	340
Public assembly	Public assembly	0.64	995	0.64	995	–	–
Religious worship	Religious worship	0.57	387	0.57	387	–	–
Service	Service	0.83	790	0.83	790	–	–
Warehouse	Warehouse	0.34	173	0.34	173	–	–
Other	Other	0.29	173	0.29	173	0.27	340

Table 37. DX HVAC—DF and EFLH Values for Climate Zone 2: Dallas

Building type	Principal building activity	Package and Split DX					
		Air Conditioner		Heat Pump[114]			
		DF_S	$EFLH_C$	DF_S	$EFLH_C$	DF_W	$EFLH_H$
Data center	Data center	1.08	3,401	1.08	3,401	–	–
Education	College/university	1.02	1,595	1.02	1,595	–	–
	Primary school	0.88	1,208	0.88	1,208	0.66	397
	Secondary school	1.02	1,084	1.02	1,084	0.59	489

[114] For heat pump projects without explicit heating factors, implementers may use the listed heating factors from the *other* building type for heating energy/demand savings.

Building type	Principal building activity	Package and Split DX					
		Air Conditioner		Heat Pump[114]			
		DF_S	$EFLH_C$	DF_S	$EFLH_C$	DF_W	$EFLH_H$
Food sales	Convenience	1.08	1,835	1.08	1,835	–	–
	Supermarket	0.58	615	0.58	615	–	–
Food service	Full-service restaurant	1.09	1,823	1.09	1,823	0.50	688
	24-hour full-service	1.09	2,061	1.09	2,061	0.49	873
	Quick-service restaurant	1.08	1,588	1.08	1,588	0.61	631
	24-hour quick-service	1.08	1,765	1.08	1,765	0.60	794
Healthcare	Hospital	0.92	3,097	0.92	3,097	–	–
	Outpatient healthcare	0.80	2,532	0.80	2,532	0.28	310
Large multifamily	Midrise apartment	1.04	1,709	1.04	1,709	–	–
Lodging	Large hotel	0.70	2,079	0.70	2,079	0.82	464
	Nursing home	1.04	1,736	1.04	1,736	–	–
	Small hotel/motel	0.55	2,281	0.55	2,281	0.42	249
Mercantile	Stand-alone retail	0.95	1,157	0.95	1,157	0.55	352
	24-hour stand-alone retail	1.01	1,539	1.01	1,539	0.57	632
	Strip mall	0.91	1,100	0.91	1,100	0.55	376
Office	Large office	1.03	2,379	1.03	2,379	–	–
	Medium office	0.76	1,236	0.76	1,236	0.66	262
	Small office	0.92	1,203	0.92	1,203	0.40	153
Public assembly	Public assembly	0.88	1,624	0.88	1,624	–	–
Religious worship	Religious worship	0.55	567	0.55	567	–	–
Service	Service	1.09	1,412	1.09	1,412	–	–
Warehouse	Warehouse	0.84	597	0.84	597	–	–
Other	Other	0.55	567	0.55	567	0.28	153

Table 38. DX HVAC—DF and EFLH Values for Climate Zone 3: Houston

Building type	Principal building activity	Package and split DX					
		Air conditioner		Heat pump[115]			
		DF_S	$EFLH_C$	DF_S	$EFLH_C$	DF_W	$EFLH_H$
Data center	Data center	1.05	4,022	1.05	4,022	–	–
Education	College/university	0.98	1,843	0.98	1,843	–	–
	Primary school	0.88	1,443	0.88	1,443	0.50	239
	Secondary school	0.98	1,253	0.98	1,253	0.54	293
Food sales	Convenience	1.03	2,142	1.03	2,142	–	–
	Supermarket	0.60	744	0.60	744	–	–
Food service	Full-service restaurant	1.05	2,135	1.05	2,135	0.44	429
	24-hour full-service	1.06	2,426	1.06	2,426	0.44	559
	Quick-service restaurant	1.03	1,853	1.03	1,853	0.51	372
	24-hour quick-service	1.05	2,059	1.05	2,059	0.50	483
Healthcare	Hospital	0.90	3,490	0.90	3,490	–	–
	Outpatient healthcare	0.80	2,844	0.80	2,844	0.29	196
Large multifamily	Midrise apartment	1.00	2,031	1.00	2,031	–	–
Lodging	Large hotel	0.70	2,531	0.70	2,531	0.33	250
	Nursing home	1.00	2,063	1.00	2,063	–	–
	Small hotel/motel	0.65	2,316	0.65	2,316	0.19	147
Mercantile	Stand-alone retail	0.95	1,399	0.95	1,399	0.43	204
	24-hour stand-alone retail	0.97	1,804	0.97	1,804	0.41	374
	Strip mall	0.92	1,330	0.92	1,330	0.42	218
Office	Large office	1.00	2,619	1.00	2,619	–	–
	Medium office	0.75	1,387	0.75	1,387	0.42	149
	Small office	0.88	1,338	0.88	1,338	0.28	69
Public assembly	Public assembly	0.88	1,940	0.88	1,940	–	–
Religious worship	Religious worship	0.65	576	0.65	576	–	–
Service	Service	1.05	1,653	1.05	1,653	–	–
Warehouse	Warehouse	0.84	633	0.84	633	–	–
Other	Other	0.60	576	0.60	576	0.19	69

[115] For heat pump projects without explicit heating factors, implementers may use the listed heating factors from the *other* building type for heating energy/demand savings.

Table 39. DX HVAC—DF and EFLH Values for (Climate Zone 4: Corpus Christi

Building type	Principal building activity	Package and split DX					
		Air conditioner		Heat pump[116]			
		DF_S	$EFLH_C$	DF_S	$EFLH_C$	DF_W	$EFLH_H$
Data center	Data center	0.97	4,499	0.97	4,499	–	–
Education	College/university	0.96	2,211	0.96	2,211	–	–
	Primary school	0.88	1,680	0.88	1,680	0.30	156
	Secondary school	0.96	1,503	0.96	1,503	0.35	196
Food sales	Convenience	0.94	2,510	0.94	2,510	–	–
	Supermarket	0.54	894	0.54	894	–	–
Food service	Full-service restaurant	0.98	2,530	0.98	2,530	0.35	292
	24-hour full-service	0.97	2,897	0.97	2,897	0.36	377
	Quick-service restaurant	0.94	2,172	0.94	2,172	0.34	232
	24-hour quick-service	0.93	2,440	0.93	2,440	0.34	296
Healthcare	Hospital	0.86	3,819	0.86	3,819	–	–
	Outpatient healthcare	0.78	3,092	0.78	3,092	0.08	122
Large multifamily	Midrise apartment	0.92	2,236	0.92	2,236	–	–
Lodging	Large hotel	0.65	2,981	0.65	2,981	0.21	131
	Nursing home	0.92	2,271	0.92	2,271	–	–
	Small hotel/motel	0.58	2,530	0.58	2,530	0.10	82
Mercantile	Stand-alone retail	0.84	1,582	0.84	1,582	0.22	131
	24-hour stand-alone retail	0.86	2,118	0.86	2,118	0.25	255
	Strip mall	0.82	1,510	0.82	1,510	0.21	141
Office	Large office	0.91	2,778	0.91	2,778	–	–
	Medium office	0.66	1,523	0.66	1,523	0.24	83
	Small office	0.80	1,504	0.80	1,504	0.14	39
Public assembly	Public assembly	0.88	2,259	0.88	2,259	–	–
Religious worship	Religious worship	0.58	629	0.58	629	–	–
Service	Service	0.98	1,959	0.98	1,959	–	–
Warehouse	Warehouse	0.73	665	0.73	665	–	–
Other	Other	0.54	629	0.54	629	0.08	39

[116] For heat pump projects without explicit heating factors, implementers may use the listed heating factors from the *other* building type for heating energy/demand savings.

Table 40. DX HVAC—DF and EFLH Values for Climate Zone 5: El Paso

Building type	Principal building activity	Package and split DX					
		Air conditioner		Heat pump[117]			
		DF_S	$EFLH_C$	DF_S	$EFLH_C$	DF_W	$EFLH_H$
Data center	Data center	0.88	2,547	0.88	2,547	–	–
Education	College/university	0.87	1,092	0.87	1,092	–	–
	Primary school	0.91	996	0.91	996	0.37	408
	Secondary school	0.87	742	0.87	742	0.43	431
Food sales	Convenience	0.76	1,251	0.76	1,251	–	–
	Supermarket	0.38	347	0.38	347	–	–
Food service	Full-service restaurant	0.76	1,276	0.76	1,276	0.28	613
	24-hour full-service	0.74	1,413	0.74	1,413	0.27	809
	Quick-service restaurant	0.76	1,082	0.76	1,082	0.26	522
	24-hour quick-service	0.77	1,171	0.77	1,171	0.26	697
Healthcare	Hospital	0.81	2,555	0.81	2,555	–	–
	Outpatient healthcare	0.81	2,377	0.81	2,377	0.04	320
Large multifamily	Midrise apartment	0.88	1,209	0.88	1,209	–	–
Lodging	Large hotel	0.63	1,701	0.63	1,701	0.21	440
	Nursing home	0.88	1,228	0.88	1,228	–	–
	Small hotel/motel	0.63	1,921	0.63	1,921	0.06	185
Mercantile	Stand-alone retail	0.80	904	0.80	904	0.26	384
	24-hour stand-alone retail	0.86	1,228	0.86	1,228	0.28	808
	Strip mall	0.83	931	0.83	931	0.27	448
Office	Large office	0.98	2,423	0.98	2,423	–	–
	Medium office	0.77	1,173	0.77	1,173	0.27	256
	Small office	0.84	1,037	0.84	1,037	0.15	146
Public assembly	Public assembly	0.91	1,339	0.91	1,339	–	–
Religious worship	Religious worship	0.63	478	0.63	478	–	–
Service	Service	0.76	988	0.76	988	–	–
Warehouse	Warehouse	0.75	324	0.75	324	–	–
Other	Other	0.38	324	0.38	324	0.04	146

[117] For heat pump projects without explicit heating factors, implementers may use the listed heating factors from the *other* building type for heating energy/demand savings.

Claimed Peak Demand Savings

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

Upstream/Midstream Delivery

For upstream/midstream program delivery, use the EFLH and DF assumptions outlined in Table 41. Assumed values have been weighted based on building-type survey data from 2012 CBECS[118] and 2014 MECS[119].

For upstream/midstream program designs where the building type is known, use the savings coefficients from Table 36 through Table 40. For program designs where the building type is unknown, you may use the savings coefficients from Table 41. However, calculations of savings in program implementation should not switch between savings coefficient methods over the implementation period.

Table 41. DX HVAC—Upstream/Midstream Input Assumptions[120]

Savings coefficient	Climate Zone 1	Climate Zone 2	Climate Zone 3	Climate Zone 4	Climate Zone 5
$EFLH_C$	1,062	1,543	1,752	1,947	1,338
$EFLH_H$	504	245	130	79	243
DF_S	0.68	0.92	0.91	0.84	0.84
DF_W	0.37	0.39	0.27	0.14	0.13

Measure Life and Lifetime Savings

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

Estimated Useful Life

The EUL for split and packaged ACs and HPs is 15 years.[121]

[118] 2012 Commercial Building Energy Consumption Survey (CBECS). https://www.eia.gov/consumption/commercial/. 2018 version not available until mid-2020.
[119] 2014 Manufacturing Energy Consumption Survey (MECS). https://www.eia.gov/consumption/manufacturing/.
[120] 2012 CBECS and 2014 MECS.
[121] The EUL of 15 years has been cited in several places - PUCT Docket No. 36779, DOE 77 FR 28928, 10 CFR Part 431, and in the DEER 2014 update.

Remaining Useful Life (RUL)

The RUL of replaced systems is provided according to system age in Table 42. If individual system components were installed at different times, use the condenser age as a proxy for the entire system. For ER units of unknown age, assume a default value equal to the EUL. This corresponds to a default RUL of 2.8 years. Default RUL may be used exclusively if applied consistently for all projects. Otherwise, the default should only be used when a project is reported and documented as having a nameplate that is illegible. Both the RUL and EUL are needed to estimate savings for ER projects for two distinct periods: The ER period (RUL) and the ROB period (EUL – RUL). The calculations for ER projects are extensive, and as such, are provided in Appendix A.

Table 42. DX HVAC—Remaining Useful Life Early Retirement Systems[122,123]

Age of replaced system (years)	Split/packaged AC/HP systems RUL (years)	Age of replaced system (years)	Split/packaged AC/HP systems RUL (years)
1	14.0	10	5.7
2	13.0	11	5.0
3	12.0	12	4.4
4	11.0	13	3.8
5	10.0	14	3.3
6	9.1	15	2.8
7	8.2	16	2.0
8	7.3	17	1.0
9	6.5	18[124]	0.0

Program Tracking Data and Evaluation Requirements

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

- Decision/action type: ER, ROB, NC, system type conversion
- Building type (except for upstream/midstream programs)
- Climate zone

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

[123] Current New Construction baseline matches the baseline for existing systems manufactured in 2018. Existing systems manufactured after 1/1/2018 are not eligible to use the early retirement baseline and should use the ROB baseline instead. These values are greyed out in the table and displayed for informational purposes only.

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

- Baseline number of units
- Baseline equipment type
- Baseline rated cooling and heating capacities
- **For ER only**: Baseline age and method of determination (e.g., nameplate, blueprints, customer reported, not available)
- **For ER only**: Photograph of retired unit nameplate demonstrating model number, serial number, and manufacturer if blueprints are not provided; if photograph of nameplate is unavailable or not legible, provide a photo and/or description documenting the reason why the nameplate photo was unobtainable (alternate forms of documentation can be approved at the evaluator's discretion)
- Installed number of units
- Installed equipment type
- Installed equipment rated cooling and heating capacities
- Installed cooling and heating efficiency ratings
- Installed manufacturer and model
- Installed unit AHRI/DOE CCMS certificate or reference number
    - For exempted HPs < 5.4 tons referencing the previous federal standard, a copy of the AHRI certificate or manufacturer specification sheet with date corresponding to time of application or purchase demonstrating that unit does not have a SEER2 efficiency rating is required.
- **For retrofit only:** Proof of purchase: invoice showing model number; a photo of the model number on product packaging or installed unit(s); OR an evaluator pre-approved inspection approach
- **For new construction only:** Proof of purchase: invoice showing model number; a photo of the model number on product packaging or installed unit(s); as-built design drawings; HVAC specifications package that provides detailed make and model information on installed unit(s); OR an evaluator pre-approved inspection approach
- **For Other building types only**: A description of the actual building type, the primary business activity, the business hours, and the HVAC schedule

References and Efficiency Standards

Petitions and Rulings

- PUCT Docket 36779—Provides EUL for HVAC equipment.
- PUCT Docket 40083—Provides incorporation of ER savings for existing commercial HVAC SOP designs and updates for baseline equipment efficiency levels for ROB and new construction projects involving package and split systems.

- PUCT Docket 40885—Provides a petition to revise deemed savings values for commercial HVAC replacement measures. Items covered by this petition include the following:
- Updated baseline efficiencies use for estimating deemed savings for commercial PTAC/PTHP's, room air conditioners, and chilled water systems.
- Approved estimates of RUL of working chilled water systems.
- Updated demand and energy coefficients for all commercial HVAC systems.
- Updated EUL of centrifugal chilled water systems installed in ROB or new construction projects.
- Provide a method for utilizing the ER concept developed in the petition in Docket No. 40083 for packaged and split DX systems and applied to chilled water systems when the age of the system being replaced cannot be ascertained.
- PUCT Docket 41070—Provides energy and demand savings coefficients for an additional climate zone, El Paso, Texas. Prior to this filing, savings for the Dallas-Fort Worth area were used for El Paso, but Dallas-Fort Worth has a colder winter, somewhat more moderate summer, more sunshine, and less precipitation than El Paso.
- PUCT Docket 43681—Updated the approach for calculating early replacement energy and demand savings using a Net Present Value (NPV) method. Documented in Appendix A

Relevant Standards and Reference Sources

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

Document Revision History

Table 43. DX HVAC—Revision History

TRM version	Date	Description of change
v1.0	11/25/2013	TRM v1.0 origin.
v2.0	04/18/2014	TRM v2.0 update. Modified ER savings calculations and added references to Appendix A, which details those calculations. Added heat pump minimum required heating efficiencies for reference. Revised baseline efficiency standards based on updates to federal standards.
v2.1	01/30/2015	TRM v2.1 update. Minor text updates and clarification of ER requirements.
v3.0	04/10/2015	TRM v3.0 update. Update of savings method to allow for part-load efficiency calculations. For heat pumps: Added heating efficiencies and split EFLH into cooling and heating components.
v3.1	11/05/2015	TRM v3.1 update. Update the building type definitions and descriptions. Added "Other" building type for when building type is not explicitly listed.

TRM version	Date	Description of change
v4.0	10/10/2016	TRM v4.0 update. Used modeling approach to update DF and EFLH for applicable building types and climate zones. Updated baseline efficiency values for split and packaged units less than 5.4 tons to be consistent with updated federal standards.
v5.0	10/2017	TRM v5.0 update. Updated baseline efficiency values for IECC 2015 and added 24-hour building load shapes. Updated RUL table based on DOE survival curves. Updated baseline efficiency tables to include "Electric Resistance (or None)" heating section type EER/IEER values. Modified baseline cooling efficiency tables for heat pumps to assume Electric Resistance supplemental; corrected an error on the 11.3 to 20 tons category for the EER to IEER conversion.
v6.0	10/2018	TRM v6.0 update. Revised ER criteria for systems with an overall capacity change. Added Data Center as a new building type. Created methodology for heat pump projects without explicitly building type modeling.
v7.0	10/2019	TRM v7.0 update. Program tracking requirements updated.
v8.0	10/2020	TRM v8.0 update. General reference checks and text edits. Clarified use of post capacity for ROB baselines. Verify M&V plan requirement for VRF and documentation requirements. Added unknown age defaults for ER.
v9.0	10/2021	TRM v9.0 update. General reference checks and text edits. Removed baseline efficiency splits between heating section types for air conditioners and defaulted to "All Other" efficiencies. Clarified approach for system types conversion to split/packaged AC systems. Updated EUL methodology. Incorporated building type weighted savings coefficients for upstream/midstream. Incremented RUL table for code compliance.
v10.0	10/2022	TRM v10.0 update. Added additional guidance for selection of building types for complex projects. Incremented RUL table for code compliance.

2.2.3 HVAC Chillers Measure Overview

TRM Measure ID: NR-HV-CH

Market Sector: Commercial

Measure Category: HVAC

Applicable Building Types: See Table 57 through Table 61.

Fuels Affected: Electricity

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

Program Delivery Type: Prescriptive

Deemed Savings Type: Deemed savings calculation

Savings Methodology: Energy modeling, engineering algorithms, and estimates

Measure Description

This document presents the deemed savings methodology for the installation of chillers. This document covers assumptions made for baseline equipment efficiencies for early retirement (ER) based on the age of the replaced equipment and replace-on-burnout (ROB) and new construction (NC) situations based on efficiency standards.

Savings calculations incorporate the use of both full-load and part-load efficiency values. For ER, the actual age of the baseline system should be determined from the equipment nameplate or other physical documentation, whenever possible. Default values are provided for when the actual age of the unit is unknown. Minimum efficiencies are defined in units of kW/ton, the ratio of input power in kW to the cooling capacity in tons, or EER, the ratio of cooling capacity in Btu/h to input power in Watts.

Two paths are currently available for chiller compliance through the IECC and ASHRAE rating standards. Path A requires higher efficiency ratings for full-load operation, with lower ratings for part-load efficiency, and is most applicable to units that are expected to operate at or near full-load conditions. Path B requires higher efficiency ratings for part-load operation, with lower ratings for full-load efficiency, and is most applicable to units that are expected to operate primarily at part-load conditions with variable frequency drives. Either Path can be used for compliance on any particular chiller, but the chiller must meet the minimum requirements for both full and part-load efficiency that are set forth in the following sections.

Applicable efficient measure types include:[125]

- Compressor types: centrifugal or positive-displacement (screw, scroll, or reciprocating)
- Condenser/heat rejection type: air-cooled or water-cooled system type conversions. Retrofits involving a change from a chiller-based system to a packaged/split system are also covered under this measure. If this type of retrofit is performed, reference the tables from the split/single packaged air conditioners and heat pumps measure.
- Chiller type conversions: from an air-cooled chiller system to a water-cooled chiller system is also addressed in this measure. An additional adjustment is made to the basic chiller savings to account for the auxiliary equipment associated with a water-cooled chiller.

Eligibility Criteria

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

- The existing and proposed cooling equipment is electric.
- The building falls into one of the categories listed in Table 57 through Table 61. Building type descriptions and examples are provided in Table 34 and Table 35.
- For early retirement projects: ER projects involve the replacement of a working system before natural burnout. Additionally, the ER approach cannot be used for projects involving a renovation where a major structural change or internal space remodel has occurred. A ROB approach should be used for these scenarios.
- For redundant chiller configurations, the installed chiller must not be exclusively sequenced as a standby chiller. As an example, for N+1 configurations where the redundant chiller is rotated, the deemed savings approach should only be used for N chillers, where N is the total number of chillers in the redundant chiller configuration minus one. Multiple chillers sequenced in a lead-lag or base-trim configuration are eligible to use the deemed savings.

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

Manufacturer datasheets for installed equipment or documentation of AHRI or DOE CCMS certification must be provided.[126, 127]

[125] Savings can also be claimed by a retrofit involving a change in equipment type (e.g., air-cooled packaged DX system to a water-cooled centrifugal chiller, or a split system air-cooled heat pump to an air-cooled non-centrifugal chiller). If this type of retrofit is performed, reference the tables from the following HVAC measure templates: HVAC-Chillers, Split System/Single Packaged Heat Pumps, and Air Conditioners

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

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

Baseline Condition

Early Retirement

Early retirement systems involve the replacement of a working system prior to natural burnout. The early retirement baseline cannot be used for projects involving a renovation where a major structural change or internal space remodel has occurred.

Two baseline condition efficiency values are required for an ER scenario, one for the ER (RUL) period and one for the ROB (EUL-RUL) period. For the ROB period, the baseline efficiency is the same as for a ROB/NC scenario. For the ER period, the baseline efficiency should be estimated using the values from Table 44 through Table 55 according to the capacity, chiller type, and age (based on year manufactured) of the replaced system.[128] When the chiller age can be determined (from a nameplate, building prints, equipment inventory list, etc.), the baseline efficiency levels provided in Table 44 through Table 55 should be used. When the system age is unknown, assume a default value equal to the EUL. This corresponds to 20 years for non-centrifugal chillers and 25 years for centrifugal chillers. A default RUL may be used exclusively if applied consistently for all projects. Otherwise, the default should only be used when a project is reported and documented as having a nameplate that is illegible.

ER baseline efficiency values represent the code-specified efficiency in effect at the time the chiller was installed. Prior to 2002, code-specified efficiencies from ASHRAE 90.1-1989 were in effect. Code-specified efficiencies increased in 2002, approximating the effective date of ASHRAE 90.1-1999, which went into effect on October 29, 2001. Code-specified efficiencies increased again in 2010 and 2018,[129] coinciding with the IECC 2009 and IECC 2015 code increases.

PUCT Docket 40885 provided baseline efficiencies for chillers replaced via early retirement programs and included a category for 1990-2001. However, the common practice for energy efficiency programs in Texas is to allow systems older than 1990 to use the same baseline efficiencies as those listed for 1990-2001. This practice is reflected in the baseline efficiency tables, by showing the Year Installed as ≤ 2001 rather than 1990-2001.

[128] The actual age should be determined from the nameplate, building prints, equipment inventory list, etc. and whenever possible the actual source used should be identified in the project documentation.
[129] IECC 2015 not enforced in Texas until program year 2018.

ER Baseline: Air-Cooled Chillers

Table 44. Chillers—Air-Cooled Path A ER Baseline Full-Load Efficiency[130]

Year installed (replaced system)	< 75 tons (EER)	≥ 75 to 150 tons (EER)	≥ 150 to 300 tons (EER)	≥ 300 to 600 tons (EER)	≥ 600 tons (EER)
≤ 2001	*9.212*	*9.212*	*8.530*	*8.530*	*8.530*
2002–2009	9.562	9.562	9.562	9.562	9.562
2010–2017	9.562	9.562	9.562	9.562	9.562
≥ 2018	10.100	10.100	10.100	10.100	10.100

Table 45. Chillers—Air-Cooled Path B ER Baseline Full-Load Efficiency[131]

Year installed (replaced system)	< 75 tons (EER)	≥ 75 to 150 tons (EER)	≥ 150 to 300 tons (EER)	≥ 300 to 600 tons (EER)	≥ 600 tons (EER)
≤ 2001	*9.212*	*9.212*	*8.530*	*8.530*	*8.530*
2002–2009	9.562	9.562	9.562	9.562	9.562
2010–2017	9.562	9.562	9.562	9.562	9.562
≥ 2018	9.700	9.700	9.700	9.700	9.700

Table 46. Chillers—Air-Cooled Path A ER Baseline Part-Load Efficiency (IPLV)[132]

Year installed (replaced system)	< 75 tons (EER)	≥ 75 to 150 tons (EER)	≥ 150 to 300 tons (EER)	≥ 300 to 600 tons (EER)	≥ 600 tons (EER)
≤ 2001	*9.554*	*9.554*	*8.530*	*8.530*	*8.530*
2002–2009	10.416	10.416	10.416	10.416	10.416
2010–2017	12.500	12.500	12.500	12.500	12.500
≥ 2018	13.700	13.700	14.000	14.000	14.000

Table 47. Chillers—Air-Cooled Path B ER Baseline Part-Load Efficiency (IPLV)[133]

Year installed (replaced system)	< 75 tons (EER)	≥ 75 to 150 tons (EER)	≥ 150 to 300 tons (EER)	≥ 300 to 600 tons (EER)	≥ 600 tons (EER)
≤ 2001	*9.554*	*9.554*	*8.530*	*8.530*	*8.530*
2002–2009	10.416	10.416	10.416	10.416	10.416
2010–2017	12.500	12.500	12.500	12.500	12.500
≥ 2018	15.800	15.800	16.100	16.100	16.100

[130] Code-specified efficiencies in effect prior to 2002 were given in COP and have been converted to EER using EER = COP x 3.412. Values in the "≤ 2001" row have been converted and are expressed in italics.
[131] Ibid.
[132] Ibid.
[133] Ibid.

ER Baseline: Centrifugal Water-Cooled Chillers

Table 48. Chillers—Water-Cooled Centrifugal Path A ER Baseline Full-Load Efficiency[134]

Year installed (replaced system)	< 75 tons (kW/ton)	≥ 75 to 150 tons (kW/ton)	≥ 150 to 300 tons (kW/ton)	≥ 300 to 400 tons (kW/ton)	≥ 400 to 600 tons (kW/ton)	≥ 600 tons (kW/ton)
≤ 2001	*0.925*	*0.925*	*0.837*	*0.748*	*0.748*	*0.748*
2002–2009	0.703	0.703	0.634	0.576	0.576	0.576
2010–2017	0.634	0.634	0.634	0.576	0.576	0.570
≥ 2018	0.610	0.610	0.610	0.560	0.560	0.560

Table 49. Chillers—Water-Cooled Centrifugal Path B ER Baseline Full-Load Efficiency[135]

Year installed (replaced system)	< 75 tons (kW/ton)	≥ 75 to 150 tons (kW/ton)	≥ 150 to 300 tons (kW/ton)	≥ 300 to 400 tons (kW/ton)	≥ 400 to 600 tons (kW/ton)	≥ 600 tons (kW/ton)
≤ 2001	*0.925*	*0.925*	*0.837*	*0.748*	*0.748*	*0.748*
2002–2009	0.703	0.703	0.634	0.576	0.576	0.576
2010–2017	0.639	0.639	0.639	0.600	0.600	0.590
≥ 2018	0.695	0.695	0.635	0.595	0.585	0.585

Table 50. Chillers—Water-Cooled Centrifugal Path A ER Baseline Part-Load Efficiency (IPLV)[136]

Year installed (replaced system)	< 75 tons (kW/ton)	≥ 75 to 150 tons (kW/ton)	≥ 150 to 300 tons (kW/ton)	≥ 300 to 400 tons (kW/ton)	≥ 400 to 600 tons (kW/ton)	≥ 600 tons (kW/ton)
≤ 2001	*0.902*	*0.902*	*0.781*	*0.733*	*0.733*	*0.733*
2002–2009	0.670	0.670	0.596	0.549	0.549	0.549
2010–2017	0.596	0.596	0.596	0.549	0.549	0.539
≥ 2018	0.550	0.550	0.550	0.520	0.500	0.500

[134] Ibid.
[135] Ibid.
[136] Ibid.

Table 51. Chillers—Water-Cooled Centrifugal Path B ER Baseline Part-Load Efficiency (IPLV)[137]

Year installed (replaced system)	< 75 tons (kW/ton)	≥ 75 to 150 tons (kW/ton)	≥ 150 to 300 tons (kW/ton)	≥ 300 to 400 tons (kW/ton)	≥ 400 to 600 tons (kW/ton)	≥ 600 tons (kW/ton)
≤ 2001	*0.902*	*0.902*	*0.781*	*0.733*	*0.733*	*0.733*
2002–2009	0.670	0.670	0.596	0.549	0.549	0.549
2010–2017	0.450	0.450	0.450	0.400	0.400	0.400
≥ 2018	0.440	0.440	0.400	0.390	0.380	0.380

ER Baseline: Positive-Displacement (Screw, Scroll, or Reciprocating) Water-Cooled Chillers

Table 52. Chillers—Water-Cooled Screw/Scroll/Recip. Path A ER Baseline Full-Load Efficiency[138]

Year installed (replaced system)	< 75 tons (kW/ton)	≥ 75 to <150 tons (kW/ton)	≥ 150 to <300 tons (kW/ton)	≥ 300 to <600 tons (kW/ton)	≥ 600 tons (kW/ton)
≤ 2001	*0.925*	*0.925*	*0.837*	*0.748*	*0.748*
2002–2009	0.790	0.790	0.718	0.639	0.639
2010–2017	0.780	0.775	0.680	0.620	0.620
≥ 2018	0.750	0.720	0.660	0.610	0.560

Table 53. Chillers—Water-Cooled Screw/Scroll/Recip. Path B ER Baseline Full-Load Efficiency[139]

Year installed (replaced system)	< 75 tons (kW/ton)	≥ 75 to <150 tons (kW/ton)	≥ 150 to <300 tons (kW/ton)	≥ 300 to <600 tons (kW/ton)	≥ 600 tons (kW/ton)
≤ 2001	*0.925*	*0.925*	*0.837*	*0.748*	*0.748*
2002–2009	0.790	0.790	0.718	0.639	0.639
2010–2017	0.800	0.790	0.718	0.639	0.639
≥ 2018	0.780	0.750	0.680	0.625	0.585

[137] Ibid.
[138] Ibid.
[139] Ibid.

Table 54. Chillers—Water-Cooled Screw/Scroll/Recip. Path A ER Baseline Part-Load Efficiency (IPLV)[140]

Year installed (replaced system)	< 75 tons (kW/ton)	≥ 75 to <150 tons (kW/ton)	≥ 150 to <300 tons (kW/ton)	≥ 300 to <600 tons (kW/ton)	≥ 600 tons (kW/ton)
≤ 2001	*0.902*	*0.902*	*0.781*	*0.733*	*0.733*
2002–2009	0.676	0.676	0.628	0.572	0.572
2010–2017	0.630	0.615	0.580	0.540	0.540
≥ 2018	0.600	0.560	0.540	0.520	0.500

Table 55. Chillers—Water-Cooled Screw/Scroll/Recip. Path B ER Baseline Part-Load Efficiency (IPLV)[141]

Year installed (replaced system)	< 75 tons (kW/ton)	≥ 75 to <150 tons (kW/ton)	≥ 150 to <300 tons (kW/ton)	≥ 300 to <600 tons (kW/ton)	≥ 600 tons (kW/ton)
≤ 2001	*0.902*	*0.902*	*0.781*	*0.733*	*0.733*
2002–2009	0.676	0.676	0.628	0.572	0.572
2010–2017	0.600	0.586	0.540	0.490	0.490
≥ 2018	0.500	0.490	0.440	0.410	0.380

Replace-on-Burnout and New Construction

New baseline efficiency levels for chillers are provided in Table 56, which includes both full load and integrated part load value (IPLV) ratings. The IPLV accounts for chiller efficiency at part-load operation for a given duty cycle. These baseline efficiency levels reference standard ASHRAE 90.1-2010. This standard contains two paths for compliance, Path A or Path B. According to ASHRAE 90.1-2007 Addenda M, Path A is intended for applications where significant operating time is expected at full-load conditions, while Path B is an alternative set of efficiency levels for chillers intended for applications where significant time is spent at part-load operation (such as with a VSD chiller). Path A chillers are eligible to claim savings using the full-load efficiency conditions in the energy and demand savings algorithms.[142] Path B chillers are eligible to claim savings using the Path B chiller part-load baseline efficiencies with the demand and energy coefficients defined in this measure.

[140] Ibid.
[141] Ibid.
[142] According to ASHRAE 90.1-2007 Addenda M, Path A is intended for applications where significant operating time is expected at full-load conditions, while Path B is an alternative set of efficiency levels for water-cooled chillers intended for applications where significant time is spent at part-load operation (such as with a VSD chiller).

Table 56. Chillers—NC/ROB Baseline Efficiencies[143]

System type (efficiency units)		Efficiency type	Capacity (tons)	Path A		Path B	
				Full-load	IPLV	Full-load	IPLV
Air-cooled chiller		EER	< 150	≥ 10.100	≥ 13.700	≥ 9.700	≥ 15.800
			≥ 150	≥ 10.100	≥ 14.000	≥ 9.700	≥ 16.100
Water-cooled chiller	Screw/ scroll/ recip.	kW/ton	< 75	≤ 0.750	≤ 0.600	≤ 0.780	≤ 0.500
			≥ 75 and < 150	≤ 0.720	≤ 0.560	≤ 0.750	≤ 0.490
			≥ 150 and < 300	≤ 0.660	≤ 0.540	≤ 0.680	≤ 0.440
			≥ 300 and < 600	≤ 0.610	≤ 0.520	≤ 0.625	≤ 0.410
			≥ 600	≤ 0.560	≤ 0.500	≤ 0.585	≤ 0.380
	Centrifugal		< 150	≤ 0.610	≤ 0.550	≤ 0.695	≤ 0.440
			≥ 150 and < 300	≤ 0.610	≤ 0.550	≤ 0.635	≤ 0.400
			≥ 300 and < 400	≤ 0.560	≤ 0.520	≤ 0.595	≤ 0.390
			≥ 400	≤ 0.560	≤ 0.500	≤ 0.585	≤ 0.380

High-Efficiency Condition

Chillers must exceed the minimum efficiencies specified in Table 56 for either Path A or Path B. For whichever path is used, the chiller must exceed the minimum baseline efficiency for both full-load and IPLV of that path to qualify. Additional conditions for replace-on-burnout, early retirement, and new construction are as follows:

New Construction and Replace-on-Burnout

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

Early Retirement

The high-efficiency retrofits must meet the following criteria:[144]

- For early retirement projects only, the installed equipment cooling capacity must be within 80 percent to 120 percent of the replaced electric cooling capacity. For scenarios involving the replacement of a combination of systems by an alternate combination of systems of varying capacities, early retirement savings can still be claimed if the overall pre- and post-capacities for the total combination of systems are within ± 20 percent. In these cases, a custom calculation should be performed to establish the following weighted savings factors to be applied over the early retirement portion of the savings calculation: manufacturer year, EUL, RUL, path A/B full and part-load baseline efficiency, demand factor, and EFLH. These factors should be weighted based on contribution to overall capacity.

[143] IECC 2015 Table C403.2.3(7).
[144] From PUCT Docket #41070.

- No additional measures are being installed that directly affect the operation of the cooling equipment (e.g., control sequences, cooling towers, and condensers).

Energy and Demand Savings Methodology

Savings Algorithms and Input Variables

Path A and B Air and Water-Cooled Chillers

$$Summer\ Peak\ Demand\ Savings\ [kW] = \left(Cap_{C,pre} \times \eta_{baseline} - Cap_{C,post} \times \eta_{installed}\right) \times DF_S$$

Equation 24

$$Energy\ Savings\ [kWh] = \left(Cap_{C,pre} \times \eta_{baseline} - Cap_{C,post} \times \eta_{installed}\right) \times EFLH_C$$

Equation 25

Where:

$Cap_{C,pre}$ = *For ER, rated equipment cooling capacity of the existing equipment at $AHRI_{standard}$ conditions; for ROB & NC, rated equipment cooling capacity of the new equipment at AHRI-standard conditions [tons]*

$Cap_{C,post}$ = *Rated equipment cooling capacity of the newly installed equipment at AHRI-standard conditions [tons]*

$\eta_{baseline}$ = *Efficiency of existing equipment (ER) or standard equipment (ROB/NC) [kW/ton] – default values, based on system type, are given in Table 44 through Table 56; for efficiencies given in EER instead of kW/ton, convert to kW/ton using Equation 26 [kW/ton]*

$\eta_{installed}$ = *Rated efficiency of the newly installed equipment – must exceed efficiency standards, shown in Table 56; for efficiencies given in EER instead of kW/ton, convert to kW/ton using Equation 26 [kW/ton]*

Note: Use full-load efficiency (kW/ton) for kW demand savings calculations and part-load efficiency (IPLV) for kWh energy savings calculations.

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

Equation 26

DF_S = *Summer peak demand factor (see Table 57 through Table 61)*

$EFLH_C$ = *Cooling equivalent full-load hours [hours] (see Table 57 through Table 61)*

Air- to Water-Cooled Replacement: Adjustments for Auxiliary Equipment[145]

The equipment efficiency for an air-cooled chiller includes condenser fans, but the equipment efficiency for a water-cooled chiller does not include the condenser water pump and cooling tower (auxiliary equipment). Therefore, when an air-cooled chiller is replaced with a water-cooled chiller, the savings must be reduced to account for the impact of the water-cooled system's additional equipment. This type of retrofit is only applicable for ER situations. The following equations are used:

$$kW_{adjust} = \left(HP_{CW\,pump} + HP_{CT\,fan}\right) \times \frac{0.746}{0.86} \times 0.80$$

Equation 27

$$kWh_{adjust} = kW \times 8{,}760$$

Equation 28

Where:

$HP_{CW\,pump}$	=	*Horsepower of the condenser water pump*
$HP_{CT\,fan}$	=	*Horsepower of the cooling tower fan*
0.746	=	*Conversion from HP to kW [kW/HP]*
0.86	=	*Assumed equipment efficiency*
0.80	=	*Assumed load factor*
8,760	=	*Annual run-time hours*

The energy and demand of the condenser water pump and cooling tower fans are subtracted from the final savings, to reach the net savings:

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

Equation 29

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

Equation 30

Early Retirement Savings

The first-year savings algorithms in the above equations are used for all HVAC projects, across NC, ROB, and ER projects. However, ER projects require weighted savings calculated over both the ER period and the ROB period, accounting for the EUL and the RUL. The final reported savings for ER projects are not actually a "first-year" savings, but an "average annual savings over the lifetime (EUL) of the measure." These savings calculations are explained in Appendix A.Table 57 through Table 61 present the demand and energy coefficients as well as the Part Load Factor. These HVAC coefficients vary by climate zone, building type, and equipment type. A description of the calculation method can be found in Docket No. 40885, Attachment B.

[145] This extra adjustment is noted in PUCT Docket No. 41070.

Deemed Energy and Demand Savings Tables

Deemed peak demand factor (DF) and equivalent full-load hour (EFLH) values are presented by building type and climate zone. A description of the building types that are used for HVAC systems is presented in Table 34 and Table 35. These building types are derived from the EIA CBECS study.[146]

Deemed peak demand factor (DF) and equivalent full-load hour (EFLH) values are presented by building type and climate zone for chillers in Table 57 through Table 61. These tables also include an "Other" building type, which can be used for business types that are not explicitly listed. The DF and EFLH values used for Other are the most conservative values from the explicitly listed building types. When Other building type is used, a description of the actual building type, the primary business activity, the business operating hours, and the HVAC schedule must be collected for the project site and stored in the utility tracking data system.

For those combinations of technology, climate zone, and building type where no values are present, a project with that specific combination cannot use the deemed approach. A description of the calculation method can be found in Docket No. 40885, Attachment B.

Table 57. Chillers—DF and EFLH for Climate Zone 1: Amarillo

Building type	Principal building activity	Chiller[147]			
		Air-cooled		Water-cooled	
		DF	$EFLH_c$	DF	$EFLH_c$
Data center	Data center	0.56	2,807	0.73	5,100
Education	College	0.87	1,115	0.68	1,243
	Primary school	0.44	576	0.53	971
	Secondary school	0.70	802	0.58	1,772
Healthcare	Hospital	0.70	2,006	0.65	2,711
Large multifamily	Midrise apartment	0.41	421	0.50	1,098
Lodging	Large hotel	0.58	1,283	0.59	1,553
	Nursing home	0.41	428	0.50	1,115
Mercantile	Stand-alone retail	0.52	489	0.54	719
	24-hour retail	0.67	681	0.62	974
Office	Large office	0.70	1,208	0.61	1,506
Public assembly	Public assembly	0.44	774	0.53	1,306

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

[147] Coefficient values are derived from the petitions filed in Docket 40885 and Docket 30331. Coefficients were updated with Docket 40885, but not all building types (herein "principal building activities," or PBAs) that were originally available in Docket 30331 were updated in Docket 40885. Coefficient values for those PBAs that were not updated in Docket 40885 remain valid.

Building type	Principal building activity	Chiller[147]			
		Air-cooled		Water-cooled	
		DF	$EFLH_c$	DF	$EFLH_c$
Religious worship	Religious worship	0.52	294	0.54	433
Other	Other	0.41	294	0.50	433

Table 58. Chillers—DF and EFLH for Climate Zone 2: Dallas

Building type	Principal building activity	Chiller[148]			
		Air-cooled		Water-cooled	
		DF	$EFLH_c$	DF	$EFLH_c$
Data center	Data center	0.54	2,791	0.77	4,906
Education	College	0.89	1,587	0.81	1,761
	Primary school	0.48	726	0.60	1,412
	Secondary school	0.84	1,170	0.54	2,234
Healthcare	Hospital	0.90	2,784	0.81	3,683
Large multifamily	Midrise apartment	0.68	1,060	0.66	2,053
Lodging	Large hotel	0.80	2,086	0.71	2,627
	Nursing home	0.68	1,077	0.66	2,085
Mercantile	Stand-alone retail	0.79	936	0.72	1,328
	24-hour retail	0.89	1,307	0.79	1,975
Office	Large office	0.92	1,711	0.70	2,062
Public assembly	Public assembly	0.48	976	0.60	1,898
Religious worship	Religious worship	0.79	563	0.72	799
Other	Other	0.48	563	0.54	799

Table 59. Chillers—DF and EFLH for Climate Zone 3: Houston

Building type	Principal building activity	Chiller[149]			
		Air-cooled		Water-cooled	
		DF	$EFLH_c$	DF	$EFLH_c$
Data center	Data center	0.53	2,824	0.76	5,075
Education	College	0.80	1,858	0.84	2,099
	Primary school	0.45	818	0.60	1,627
	Secondary school	0.77	1,306	0.55	2,404
Healthcare	Hospital	0.85	3,116	0.79	4,171
Large multifamily	Midrise apartment	0.65	1,295	0.66	2,467
Lodging	Large hotel	0.71	2,499	0.73	3,201
	Nursing home	0.65	1,315	0.66	2,506
Mercantile	Stand-alone retail	0.83	1,224	0.78	1,712
	24-hour retail	0.80	1,513	0.74	2,427
Office	Large office	0.92	1,820	0.71	2,312
Public assembly	Public assembly	0.45	1,100	0.60	2,188

[148] Ibid.
[149] Ibid.

Building type	Principal building activity	Chiller[149]			
		Air-cooled		Water-cooled	
		DF	$EFLH_c$	DF	$EFLH_c$
Religious worship	Religious worship	0.83	737	0.78	1,031
Other	Other	0.45	737	0.55	1,031

Table 60. Chillers—DF and EFLH for Climate Zone 4: Corpus Christi

Building type	Principal building activity	Chiller[150]			
		Air-cooled		Water-cooled	
		DF	$EFLH_c$	DF	$EFLH_c$
Data center	Data center	0.48	2,881	0.77	5,266
Education	College	0.80	2,340	0.87	2,583
	Primary school	0.45	937	0.61	1,845
	Secondary school	0.68	1,503	0.55	2,577
Healthcare	Hospital	0.79	3,455	0.82	4,637
Large multifamily	Midrise apartment	0.61	1,534	0.67	2,840
Lodging	Large hotel	0.74	2,908	0.73	3,713
	Nursing home	0.61	1,558	0.67	2,884
Mercantile	Stand-alone retail	0.75	1,394	0.76	1,953
	24-hour retail	0.70	1,725	0.73	2,768
Office	Large office	0.82	2,027	0.72	2,570
Public assembly	Public assembly	0.45	1,260	0.61	2,481
Religious worship	Religious worship	0.75	839	0.76	1,176
Other	Other	0.45	839	0.55	1,176

[150] Ibid.

Table 61. Chillers—DF and EFLH for Climate Zone 5: El Paso

Building type	Principal building activity	Chiller[151]			
		Air-cooled		Water-cooled	
		DF	$EFLH_c$	DF	$EFLH_c$
Data center	Data center	0.56	2,950	0.71	5,137
Education	College	0.93	1,278	0.96	1,458
	Primary school	0.61	751	0.53	1,113
	Secondary school	0.77	1,039	0.54	2,196
Healthcare	Hospital	0.71	2,355	0.59	2,992
Large multifamily	Midrise apartment	0.56	841	0.52	1,553
Lodging	Large hotel	0.63	1,815	0.58	2,038
	Nursing home	0.56	854	0.52	1,577
Mercantile	Stand-alone retail	0.64	722	0.55	948
	24-hour retail	0.61	884	0.60	1,371
Office	Large office	0.77	1,442	0.60	1,683
Public assembly	Public assembly	0.61	1,010	0.53	1,496
Religious worship	Religious worship	0.64	435	0.55	571
Other	Other	0.56	435	0.52	571

Claimed Peak Demand Savings

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

Upstream/Midstream Lighting

For upstream/midstream program delivery, use the EFLH and DF assumptions outlined in Table 59 and Table 60. Assumed values have been weighted based on building type survey data from 2012 CBECS[152] and 2014 MECS[153].

For upstream/midstream program designs where building type is known, use the savings coefficients from Table 57 through Table 61. For program designs where building type is unknown, you may use the savings coefficients from Table 62 and Table 63. However, calculations of savings in program implementation should not switch between savings coefficient methods over the implementation period.

[151] Ibid.
[152] 2012 Commercial Building Energy Consumption Survey (CBECS). https://www.eia.gov/consumption/commercial/. 2018 version not available until mid-2020.
[153] 2014 Manufacturing Energy Consumption Survey (MECS). https://www.eia.gov/consumption/manufacturing/.

Table 62. Chillers—Air-Cooled Upstream/Midstream Input Assumptions[154]

Savings coefficient	Climate Zone 1	Climate Zone 2	Climate Zone 3	Climate Zone 4	Climate Zone 5
$EFLH_c$	967	1,408	1,575	1,789	1,211
DF_s	0.62	0.80	0.78	0.72	0.71

Table 63. Chillers—Water-Cooled Upstream/Midstream Input Assumptions[155]

Savings coefficient	Climate Zone 1	Climate Zone 2	Climate Zone 3	Climate Zone 4	Climate Zone 5
$EFLH_C$	1,349	1,941	2,232	2,511	1,578
DF_S	0.58	0.68	0.70	0.70	0.59

Measure Life and Lifetime Savings

Estimated Useful Life (EUL)

The EUL of HVAC equipment is provided below:

- Screw/scroll/reciprocating chillers: 20 years[156]
- Centrifugal chillers: 25 years.[157]

Remaining Useful Life (RUL)

The RUL of replaced systems is provided according to system age in Table 64. For ER units of unknown age, a default value of 20 years for non-centrifugal chillers and 25 years for centrifugal chillers should be used (equal to the EUL). This corresponds to a default RUL of 3.6 years for non-centrifugal chillers and 5.4 years for centrifugal chillers. Default RUL may be used exclusively if applied consistently for all projects. Otherwise, the default should only be used when a project is reported and documented as having a nameplate that is illegible. Both the RUL and EUL are needed to estimate savings for early retirement projects for two distinct periods: The ER period (RUL) and the ROB period (EUL-RUL). The calculations for early retirement projects are extensive, and as such, are provided in Appendix A.

[154] 2012 CBECS and 2014 MECS.
[155] Ibid.
[156] PUCT Docket No. 36779. The original source was DEER 2008, but DEER 2014 provides the same value of 20 years for "High Efficiency Chillers". DEER does not differentiate between centrifugal and non-centrifugal chillers.
[157] PUCT Docket No. 40885, review of multiple studies looking at the lifetime of centrifugal chillers as detailed in petition workpapers.