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Evaluation, Measurement, and Verification Report for Virginia Electric and Power Company (Dominion Energy)

CASE NO. PUR-2021-00247 (VIRGINIA)
DOCKET NO. E-22, SUB 645 (NORTH CAROLINA)

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Prepared by DNV Energy Insights USA Inc. (DNV)

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Appendix F
Technical Reference Manual (TRM) for Non-Residential Programs

Dominion Energy Virginia and North Carolina
Protocols to Track Demand-Side Management (DSM) Programs Resource Savings

Version 2022
Prepared by DNV Energy Insights USA Inc.

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1 NON-RESIDENTIAL LIGHTING SYSTEMS AND CONTROLS PROGRAM, DSM PHASE VII

The Non-Residential Lighting Systems and Controls Program is for DSM Phase VII. It has been offered in Virginia since 2019; it is not yet offered in North Carolina. The program provides incentives to non-residential customers who install new or retrofit existing lighting systems with more efficient lighting systems and/or install lighting sensors and controls.

Eligible measures defined under the Non-Residential Lighting Systems and Controls Program DSM Phase VII are shown in Table 1-1.

Table 1-1. Non-Residential Lighting Systems and Controls Program (DSM VII) measure list

End use	Measure	Manual section
Lighting	Lighting, fixtures, lamps, and delamping including T8s, T5s, LEDs, and CFLs	Section 1.1.1
	Occupancy sensors & controls	Section 1.1.2
	Occupancy sensors & controls, stairwell-integrated occupancy sensor	Section 1.1.3
	Reach-in unit occupancy sensor	Section 1.1.4

1.1 Lighting end use

1.1.1 Lighting fixtures, lamps, and delamping

1.1.1.1 Measure description

This measure realizes energy savings by installing reduced wattage lamp/ ballast systems that have higher lumens per watt than existing systems. The savings estimation method is applied to lighting that involves T8, T5, LED, or CFL lamps/ ballasts. The baseline is assumed to be a Bulged Reflector (BR) lamp of a standard BR30-type.

The measure also covers delamping of existing lighting systems. Delamping includes removal of one or more lamps in a fixture (e.g., removing two lamps out of a four-lamp fixture) or removal of the entire fixture itself that results in either a reduced or eliminated connected load. Similar to lamp and fixture retrofit calculations, changes in load due to delamping are tracked through the difference between baseline and installed wattages. The baseline will vary with pre-existing characteristics.

Gross coincident demand reduction for delamping measures is included in PJM EE Resource nominations when reflectors or tombstones are installed since these are defined as persistent.

This measure is offered through various programs as listed in Table 1-2 and uses the impacts estimation approach described in this section. There are two methodologies described for this measure:

- The retrofit/replace-on-burnout/exit signs/exterior methodology (applies to all programs).

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- The new construction methodology only applies to one program (shown in the table that follows).

Table 1-2. Programs that offer this measure

Program name	Methodology	Section
Non-Residential Lighting Systems and Controls Program, DSM Phase VII	Retrofit, replace-on-burnout, exit signs, exterior, and new construction	Section 1.1.1
Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Retrofit, replace-on-burnout, exit signs, and exterior	Section 8.3.1
Non-Residential Multifamily Program, DSM Phase VIII		Section 10.4.1
Non-Residential Agricultural Energy Efficiency Program, DSM Phase IX		Section 12.2.4

1.1.1.2 Impacts estimation approach

Each application of this measure uses its own impacts estimation approach as described in the sub-sections that follow.

Retrofit/replace-on-burnout/exit signs/exterior lighting

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \frac{(Qty_{base} \times watts_{base} - Qty_{ee} \times watts_{ee}) \times HOU \times WHF_e \times ISR}{1{,}000\, W/kW}$$

Per-measure, gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \frac{(Qty_{base} \times watts_{base} - Qty_{ee} \times watts_{ee}) \times CF_{summer} \times WHF_{d,summer} \times ISR}{1{,}000\, W/kW}$$

Per-measure, gross coincident winter peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \frac{(Qty_{base} \times watts_{base} - Qty_{ee} \times watts_{ee}) \times CF_{\ winter} \times WHF_{d,winter} \times ISR}{1{,}000\, W/kW}$$

New construction interior lighting

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \left(\frac{LPD_{base}}{LPD_{ee}} - 1\right) \times watts_{ee} \times Qty_{ee} \times HOU \times WHF_e \times ISR \times \frac{1\ kW}{1{,}000\ W}$$

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Per-measure, gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \left(\frac{LPD_{base}}{LPD_{ee}} - 1\right) \times watts_{ee} \times Qty_{ee} \times WHF_{d,summer} \times ISR \times CF_{summer} \times \frac{1\ kW}{1{,}000\ W}$$

Per-measure, gross coincident winter peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \left(\frac{LPD_{base}}{LPD_{ee}} - 1\right) \times watts_{ee} \times Qty_{ee} \times WHF_{d,winter} \times ISR \times CF_{winter} \times \frac{1\ kW}{1{,}000\ W}$$

Where:

ΔkWh	= per-measure gross annual electric energy savings
ΔkW_{summer}	= per-measure gross coincident summer peak demand reduction
ΔkW_{winter}	= per-measure gross coincident winter peak demand reduction
LPD_{base}	= baseline lighting power density
LPD_{ee}	= efficient lighting power density
Qty_{base}	= quantity of existing or baseline fixtures/lamps
Qty_{ee}	= quantity of installed energy-efficient (ee) fixtures/lamps
$watts_{base}$	= load of the existing or baseline fixture/lamp on a per unit basis
$watts_{ee}$	= load of installed energy-efficient (ee) fixture/lamps on a per unit basis
HOU	= annual operating hours of use for fixtures/lamps
WHF_e	= waste heat factor to account for annual cooling savings from efficient lighting
$WHF_{d,summer}$	= waste heat factor for summer peak demand to account for cooling savings from efficient lighting
$WHF_{d,winter}$	= waste heat factor for winter peak demand to account for heating penalty from efficient lighting
CF_{summer}	= summer coincidence factor
CF_{winter}	= winter coincidence factor
ISR	= in-service rate

1.1.1.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 1-3. Input values for lighting fixtures, lamps, and delamping savings calculations

Component	Type	Value	Unit	Source(s)
Qty_{base}	Variable	See customer application	-	Customer application
Qty_{ee}	Variable	See customer application	-	Customer application
$watts_{base}$	Variable	See customer application	watts	Customer application
$watts_{ee}$	Variable	See customer application	watts	Customer application
LPD_{base}	Variable	See Table 1-4	watt/sq.ft	2015 Virginia Energy Conservation Code/IECC 2015 Section C405.4.2, Table C405.4.2(1) and Maryland/Mid-Atlantic TRM v. 10, p. 229

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Component	Type	Value	Unit	Source(s)
		Default=Other building type	watts/sq.ft	Maryland/Mid-Atlantic TRM v.10, p. 217, per ENERGY STAR®[1]
LPD_{ee}	Variable	See customer application	watt/sq.ft	Customer application
CF_{summer}	Variable	For measures where the location is “Exit sign,” “Stairwell,” “Exterior light except garage,” or “Garage,” use Table 17-14 in . Treat “Exit sign” and “Stairwell” as “LED Exit Sign and ‘24/7’ lights.” Treat “Exterior light except garage” as “Outdoor LED and Roadway Lighting.” Treat “Garage” as “LED “Parking Garage - Parking garage.” For the Non-Residential Agricultural Energy Efficiency Program, DSM Phase IX and other programs have the location of “Interior light except exit light” and the use Table 17-15 in .	-	Maryland/Mid-Atlantic TRM v.10, pp. 215, 243, 255, and 272[2]
CF_{winter}	Variable		-	Maryland/Mid-Atlantic TRM v.10, pp. 215, 243, 255, and 272[3]
HOU	Variable		hours, annual	Maryland/Mid-Atlantic TRM v.10, pp. 215, 242, 254, 272, and 415-416
WHF_e	Variable		-	Maryland/Mid-Atlantic TRM v.10, pp. 419-420
$WHFd_{,summer}$	Variable		-	Maryland/Mid-Atlantic TRM v.10, pp. 419-420
$WHFd_{,winter}$	Variable		-	Maryland/Mid-Atlantic TRM v.10, pp. 419-420
ISR	Fixed	1.00	-	Maryland/Mid-Atlantic TRM v.10, p. 218[4]

Table 1-4. Interior lighting power allowances

Customer building type	LPD_{base}[5]
Education – Elementary and middle school	0.87
Education – High school	0.87
Education – College and university	0.87
Food Sales - Grocery	1.26
Food Sales – Convenience store	1.26
Food Sales – Gas station convenience store	1.26

[1] LED exit sign default values come from an ENERGY STAR® report: “Save Energy, Money and Prevent Pollution with Light-Emitting Diode (LED) Exit Signs” at LED Exit Signs Tech Sheet Final Version (energystar.gov) (accessed 03/20/2023).

[2] The LED measures were grouped with other lighting applications’ coincident factors based on their similar function or usage. LED downlights are assumed to be replacing CFL and T8 fixtures; LED or induction HE garage fixtures would be expected to replace PSMH in garage applications, and exterior LEDs replace exterior fixtures.

[3] The LED measures were grouped with other lighting applications’ coincident factors based on their similar function or usage. LED downlights are assumed to be replacing CFL and T8 fixtures; LED or induction HE garage fixtures would be expected to replace PSMH in garage applications, and exterior LEDs replace exterior fixtures.

[4] Maryland/Mid-Atlantic TRM v.9, p. 319 footnote 737 EmPOWER Maryland DRAFT Final Impact Evaluation Report Evaluation Year 4 (June 1, 2012 – May 31, 2013) Commercial & Industrial Prescriptive & Small Business Programs, Navigant, March 31, 2014.

[5] DNV mapped the building types with the building area types contained in IECC 2015 Section C405.4.2, Table C405.4.2(1).

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Customer building type	LPD_{base}[5]
Food Service – Full service	1.01
Food Service – Fast food	0.90
Health Care - Inpatient	1.05
Health Care - Outpatient	0.90
Lodging – (Hotel, motel, and dormitory)	0.87
Mercantile (Mall)	1.26
Mercantile (Retail, not mall)	1.26
Office – Small (<40,000 sq ft)	0.82
Office - Large (≥ 40,000 sq ft)	0.82
Other	1.17
Public assembly	1.01
Public order and safety (police and fire station)	0.87
Religious worship	1.00
Service – (beauty, auto repair workshop)	1.19
Warehouse and storage	0.66

1.1.1.4 Default savings

No default savings will be awarded for this measure if the proper values are not provided in the customer application.

1.1.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 1-5.

Table 1-5. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Agricultural Energy Efficiency Program, DSM Phase IX	10.65	years	Maryland/Mid-Atlantic TRM v.10, p. 219 and Wisconsin TRM 2022, p. 495[6]
VIII	Non-Residential Multifamily Program, DSM Phase VIII	8.40		Maryland/Mid-Atlantic TRM v.10, p. 219[7]
	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	10.10		Dominion Energy Non-Residential Lighting End-Use Baseline, Gross Impact, Net-to-Gross, and Persistence Study, DNV, 2023
VII	Non-Residential Lighting Systems and Controls Program, DSM Phase VII			

[6] Based on lifetime hours divided by annual operating hours for agriculture lighting (50,000 hours / 4,698 hours per year = 10.65 years)

[7] Based on lifetime hours divided by annual operating hours for multifamily common area lighting (50,000 hours / 5,950 hours per year = 8.40 years)

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1.1.1.6 Source(s)

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v.10, pp. 215–221, 241-243, 253-255, 271-272, 415-416, and 419-421, and the IECC 2015 Section C405.4.2.

1.1.1.7 Update summary

Updates made to this section are described in Table 1-6.

Table 1-6. Summary of update(s)

Version	Update type	Description
2022	EUL	Revised EUL
2021	Source	Updated page numbers / version of the Maryland/Mid-Atlantic TRM v.10
	Input table	Updated CF, HOU values
	Equation	Added coincident winter peak demand reduction equation
	New table	Effective Useful Life (EUL) by program
2020	None	No change
v10	-	Initial release

1.1.2 Occupancy sensors and daylight controls

1.1.2.1 Measure description

This measure defines the savings associated with installing at wall-, fixture-, or remote-mounted occupancy sensors that switch lights off or dim them after a brief delay when no occupants are detected, or daylight conditions are sufficient. The baseline condition is lighting that is controlled with a manual switch.

This measure is offered through different programs listed in Table 1-7 and uses the impacts estimation approach described in this section.

Table 1-7. Programs that offer this measure

Program name	Section
Non-Residential Lighting Systems and Controls Program, DSM Phase VII	Section 1.1.2
Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 8.3.2
Non-Residential Multifamily Program, DSM Phase VIII	Section 10.4.3

1.1.2.2 Impacts estimation approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh \quad = watts_{connected} \times \frac{1\ kW}{1{,}000\ W} \times\ HOU\ \times\ ESF_e\ \times\ ISR\ \times\ WHF_e$$

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Per-measure, gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = watts_{connected} \times \frac{1\ kW}{1{,}000\ W} \times ESF_d \times ISR \times WHF_{d,summer} \times CF_{summer}$$

Per-measure, gross coincident winter peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = watts_{connected} \times \frac{1\ kW}{1{,}000\ W} \times ESF_d \times ISR \times WHF_{d,winter} \times CF_{winter}$$

Where:

ΔkWh	= per-measure gross annual electric energy savings
ΔkW_{summer}	= per-measure gross coincident summer peak demand reduction
ΔkW_{winter}	= per-measure gross coincident winter peak demand reduction
$watts_{connected}$	= connected load on lighting sensor/control
HOU	= hours of use per year
ESF_e	= percentage of annual lighting energy saved by lighting control
ESF_d	= percentage of lighting demand saved by lighting control
WHF_e	= waste heat factor for energy to account for cooling savings from efficient lighting
$WHF_{d,summer}$	= waste heat factor for demand to account for cooling savings from efficient lighting
$WHF_{d,winter}$	= waste heat factor for demand to account for cooling savings from efficient lighting
CF_{summer}	= summer coincidence factor
CF_{winter}	= winter coincidence factor
ISR	= in-service rate represents the proportion of rebated measures installed

1.1.2.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 1-8. Input values for occupancy sensors and controls measure savings

Component	Type	Value	Unit	Source(s)
$watts_{connected}$	Variable	See customer application	watt	Customer application
HOU	Variable	See Table 17-15 in	hours/year	Maryland/Mid-Atlantic TRM v.10, p. 222
ESF_e	Fixed	0.28	-	Maryland/Mid-Atlantic TRM v.10, p. 222 and p. 225
ESF_d	Variable	Occupancy sensor = 0.14 Daylight control = 0.28	-	Maryland/Mid-Atlantic TRM v.10, p. 223 and p. 225
CF_{summer}	Variable	See Table 17-15 in	-	Maryland/Mid-Atlantic TRM v.10, p. 223
CF_{winter}	Variable	See Table 17-15 in	-	Maryland/Mid-Atlantic TRM v.10, p. 223
WHF_e	Variable	See Table 17-15 in	-	Maryland/Mid-Atlantic TRM v.10, pp. 419-421
		Default: 0.94		Assumes “Small Office” building type

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Component	Type	Value	Unit	Source(s)
$WHF_{d,summer}$	Variable	See Table 17-15 in	-	Maryland/Mid-Atlantic TRM v.10, pp. 419-421
		Default: 1.35		Assumes "Other" building type
$WHF_{d,winter}$	Variable	See Table 17-15 in	-	Maryland/Mid-Atlantic TRM v.10, pp. 419-421
		Default: 0.740		Assumes "Other" building type
ISR	Fixed	1.00	-	Maryland/Mid-Atlantic TRM v.10, p. 223

1.1.2.4 Default savings

No default savings will be awarded for this measure if the proper values are not provided in the customer application.

1.1.2.5 Effective Useful Life

The effective useful life of this measure is provided in Table 1-9.

Table 1-9. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
VIII	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	10.10	years	Dominion Energy Non-Residential Lighting End-Use Baseline, Gross Impact, Net-to-Gross, and Persistence Study, DNV, 2023
	Non-Residential Multifamily Program, DSM Phase VIII			
VII	Non-Residential Lighting Systems and Controls Program, DSM Phase VII			

1.1.2.6 Source(s)

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v.10, pp. 222-224, 225 – 227 and 419-421.

1.1.2.7 Update summary

Updates made to this section are described in Table 1-10.

Table 1-10. Summary of update(s)

Version	Update type	Description
2022	EUL	Revised EUL
2021	Source	Updated page numbers/version of the Maryland/Mid-Atlantic TRM v.10
	Inputs	Added daylight control inputs
	Equation	Added coincident winter peak demand reduction equation
	New table	Effective Useful Life (EUL) by program

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Version	Update type	Description
2020	None	No change
v10	-	Initial release

1.1.3 Occupancy sensors and controls – stairwell integrated and bi-level lighting

1.1.3.1 Measure description

This measure defines the savings associated with installing controls on existing fixtures or installation of luminaires with integrated bi-level control. This measure has multiple applications and can be used in stairwell lighting or agriculture facility.

For stairwell lighting applications, the bi-level control technology allows for continuous lighting that maintains the code-mandated minimum illumination levels in stairwells when unoccupied spaces while also providing higher light levels when occupied. The baseline condition is interior-space lighting that continues operation at high lighting levels, regardless of occupancy.

1.1.3.2 Impacts estimation approach

Per-measure, gross annual electric energy savings and coincident demand reduction are calculated according to the following equation:

$$\Delta kWh = \left[\frac{Qty_{base} \times watts_{base}}{1{,}000\ W/kW} - \left(\frac{Qty_{ee} \times watts_{ee}}{1{,}000\ W/kW} \times (1 - ESF)\right)\right] \times HOU$$

$$ESF = F_{low} \times \left(1 - \frac{watts_{ee,low}}{watts_{ee}}\right)$$

Per-measure, gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \left(\frac{Qty_{base} \times watts_{base} - Qty_{ee} \times watts_{ee}}{1{,}000\ W/kW}\right) \times CF_{summer}$$

Per-measure, gross coincident winter peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \left(\frac{Qty_{base} \times watts_{base} - Qty_{ee} \times watts_{ee}}{1{,}000\ W/kW}\right) \times CF_{winter}$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure gross coincident winter peak demand reduction

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Qty_{base} = quantity of baseline fixtures
Qty_{ee} = quantity of installed fixtures equipped with bi-level occupancy control
$watts_{base}$ = baseline wattage per fixture
$watts_{ee,low}$ = installed wattage per fixture at low-power output
$watts_{ee}$ = installed wattage per fixture at full-power output, if bi-level occupancy controls are installed on existing fixtures, $watts_{ee}$ = $watts_{base}$.
F_{low} = proportion of annual operating time that fixture operates at low power
ESF = energy savings factor
HOU = hours of use per year
CF_{summer} = summer peak coincidence factor
CF_{winter} = winter peak coincidence factor

1.1.3.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 1-11. Input values for occupancy sensors and controls-stairwell integrated measure

Component	Type	Value	Unit	Source(s)
Qty_{base}	Variable	See customer application	-	Customer application
Qty_{ee}	Variable	See customer application	-	Customer application
$watts_{base}$	Variable	See customer application	watts	Customer application
$watts_{ee,low}$	Variable	See customer application	watts	Customer application
$watts_{ee}$	Variable	See customer application	watts	Customer application
F_{low}	Fixed	0.73	-	New York TRM v9, p. 834
HOU	Fixed	8,760	hours, annual	New York TRM v9, p. 834
CF_{summer}	Fixed	1.00	-	New York TRM v9, p. 834
CF_{winter}	Fixed	1.00	-	New York TRM v9, p. 834[8]

1.1.3.4 Default savings

No default savings will be awarded for this measure if the proper values are not provided in the customer application.

1.1.3.5 Effective Useful Life

The effective useful life of this measure is provided in Table 1-12.

Table 1-12. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
VII	Non-Residential Lighting Systems and Controls Program, DSM Phase VII	10.10	years	Dominion Energy Non-Residential Lighting End-Use Baseline, Gross Impact, Net-to-Gross, and Persistence Study, DNV, 2023

[8] The source TRM doesn't differentiate between winter and summer peak periods. Therefore, the summer CF is also applied to winter peak periods.

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1.1.3.6 Source(s)

The primary source for this deemed savings approach is the New York TRM v9, pp. 832-836.

1.1.3.7 Update summary

Updates made to this section are described in Table 1-13.

Table 1-13. Summary of update(s)

Version	Update type	Description
2022	EUL	Revised EUL
	Inputs	Expanded inputs to accommodate the Non-Residential Agricultural Energy Efficiency Program, DSM Phase IX
	References	Updated source TRM and reference page number
2021	None	No change
	Equation	Added coincident winter peak demand reduction equation
	New table	Effective Useful Life (EUL) by program
2020	Equation	Modified the ΔkWh savings equation to incorporate the ESF and associated equation. This makes the calculation clearer and aligns with the reference TRM but does not change the result.
v10	-	Initial release

1.1.4 Reach-in unit occupancy sensor

1.1.4.1 Measure description

This measure realizes energy savings by adding occupancy sensors to reach-in refrigerated case lighting. Occupancy sensors reduce energy usage by turning off lights when customers are not present. Savings and assumptions are based on the lighting load controlled by each occupancy sensor. The baseline condition is reach-in refrigerated case lighting that is controlled with a manual switch.

1.1.4.2 Impacts estimation approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = Qty_{sensor} \times watts_{connected} \times \frac{1\ kW}{1{,}000\ W} \times HOU \times ESF_e \times ISR \times WHF_e$$

Per-measure, gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = Qty_{sensor} \times watts_{connected} \times \frac{1\ kW}{1{,}000\ W} \times ESF_d \times ISR \times WHF_{d,summer} \times CF_{summer}$$

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Per-measure, gross coincident winter peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = Qty_{sensor} \times watts_{connected} \times \frac{1\ kW}{1{,}000\ W} \times ESF_d \times ISR \times WHF_{d,winter} \times CF_{winter}$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross summer peak coincident demand reduction
ΔkW_{winter} = per-measure gross winter peak coincident demand reduction
Qty_{sensor} = number of occupancy sensors installed
$watts_{connected}$ = connected lighting load controlled by occupancy sensor
ESF_e = percentage of annual lighting energy saved by lighting control
ESF_d = percentage of lighting demand saved by lighting control
WHF_e = waste heat factor for energy; represents the increased savings due to reduced waste heat from lights that must be rejected by the refrigeration equipment
$WHF_{d,summer}$ = waste heat factor for demand; represents the increased savings due to reduced waste heat from lights that must be rejected by the refrigeration equipment
$WHF_{d,winter}$ = waste heat factor for demand; represents the increased savings due to reduced waste heat from lights that must be rejected by the refrigeration equipment

HOU = hours of use per year
CF_{summer} = summer peak coincidence factor
CF_{winter} = winter peak coincidence factor
ISR = in-service rate is the percentage of rebated measures actually installed

1.1.4.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 1-14. Input values for reach-in unit occupancy sensors savings calculations

Component	Type	Value	Unit	Source(s)
watts	Variable	See customer application	watts	Customer application
		Default = 38		Same default as from LED case lighting measure watts for 5-foot lamp
$Qty_{sensors}$	Variable	See customer application	-	Customer application
ESF_e	Fixed	0.31	-	Efficiency Maine Commercial TRM 2019, Appendix D, Table 409, p. 173
ESF_d	Fixed	0.14	-	Maryland/Mid-Atlantic TRM v.10, p. 223
HOU	Variable	See Table 17-15 in	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 222

[9] Maine TRM refers to "US DOE, "Demonstration Assessment of Light-Emitting Diode (LED) Freezer Case Lighting." Refrigerated cases were metered for 12 days to determine savings from occupancy sensors. Assumes that refrigerated freezers and refrigerated coolers will see the same amount of savings from sensors. The nature of the savings is not explained. Showcase controls often keep a fixed number of lights on to reduce the "dark aisle" conditions. It is assumed that this value accounts for both reduction in operating hours and incremental reduction in power.

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Component	Type	Value	Unit	Source(s)
ISR	Fixed	1.00	-	Maryland/Mid-Atlantic TRM v.10, p. 222
WHFe	Variable	Low Temp (-35˚F - -1˚F): 1.52 Med Temp (0˚F - 30˚F): 1.52 High Temp (31˚F - 55˚F): 1.41	-	Maryland/Mid-Atlantic TRM v.10, p. 269
$WHF_{d,\ summer}$	Variable	Low Temp (-35˚F - -1˚F): 1.51 Med Temp (0˚F - 30˚F): 1.51 High Temp (31˚F - 55˚F): 1.40	-	Maryland/Mid-Atlantic TRM v.10, p. 270
$WHF_{d,\ winter}$	Variable	Low Temp (-35˚F - -1˚F): 1.51 Med Temp (0˚F - 30˚F): 1.51 High Temp (31˚F - 55˚F): 1.40	-	Maryland/Mid-Atlantic TRM v.10, p. 270[10]
CF_{summer}	Fixed	0.96	-	Maryland/Mid-Atlantic TRM v.10, p. 270[11]
CF_{winter}	Fixed	0.96	-	Maryland/Mid-Atlantic TRM v.10, p. 270[12]

1.1.4.4 Default savings

If the proper values are not supplied, a default savings may be applied using conservative input values.

The default per-measure gross annual electric energy savings will be assigned according to the following calculations:

$$\Delta kWh = Qty_{sensor} \times \frac{watts}{1{,}000\ W/kW} \times HOU \times ESF_e \times ISR \times WHF_e$$

$$= 1 \times \frac{38\ W}{1{,}000\ W/kW} \times 7{,}272\ hours \times 0.31 \times 1.00 \times 1.41$$

$$= 120.79\ kWh$$

The default per-measure gross summer peak coincident demand reduction will be assigned according to the following calculations:

[10] The source TRM doesn't differentiate between winter and summer WHFs. Therefore, the summer WHF is applied to the winter WHF.

[11] Value for "grocery" building type from Mid-Atlantic TRM v.9, p. 270 footnote 579 "EmPOWER Maryland DRAFT Final Impact Evaluation Report Evaluation Year 4 (June 1, 2012 – May 31, 2013) Commercial & Industrial Prescriptive & Small Business Programs, Navigant, March 31, 2014."

[12] The source TRM doesn't differentiate between winter and summer peak periods. Therefore, the summer CF is applied to the winter CF.

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$$\Delta kW_{summer} = Qty_{sensor} \times \frac{watts}{1{,}000\ W/kW} \times ESF_d \times ISR \times WHF_{d,summer} \times CF_{summer}$$

$$= 1 \times \frac{38\ W}{1{,}000\ W/kW} \times 0.14 \times 1.00 \times 1.40 \times 0.96$$

$$= 0.007\ kW$$

The default per-measure gross winter peak coincident demand reduction will be assigned according to the following calculations:

$$\Delta kW_{winter} = Qty_{sensor} \times \frac{watts}{1{,}000\ W/kW} \times ESF_d \times ISR \times WHF_{d,winter} \times CF_{winter}$$

$$= 1 \times \frac{38\ W}{1{,}000\ W/kW} \times 0.14 \times 1.00 \times 1.40 \times 0.96$$

$$= 0.007\ kW$$

1.1.4.5 Effective Useful Life

The effective useful life of this measure is provided in Table 1-15.

Table 1-15. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
VII	Non-Residential Lighting Systems and Controls Program, DSM Phase VII	10.10	years	Dominion Energy Non-Residential Lighting End-Use Baseline, Gross Impact, Net-to-Gross, and Persistence Study, DNV, 2023

1.1.4.6 Source(s)

The primary sources for this deemed savings approach are the Efficiency Maine TRM 2019, p. 173, and Maryland/Mid-Atlantic TRM v.10, pp. 222-224 and 269-270.

1.1.4.7 Update summary

Updates made to this section are described in Table 1-16.

Table 1-16. Summary of update(s)

Version	Update type	Description
2022	EUL	Revised EUL

Version	Update type	Description
2021	Source	Updated page numbers / version of the Maryland/Mid-Atlantic TRM v.10
	New table	Effective Useful Life (EUL) by program
	Equation	Added gross winter peak demand reduction equation
2020	None	No change
v10	-	Initial release

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2 NON-RESIDENTIAL HEATING AND COOLING EFFICIENCY PROGRAM, DSM PHASE VII

The Non-Residential Heating and Cooling Efficiency program is offered in Virginia beginning July 1, 2019 and approved in North Carolina on November 13, 2019. The program provides incentives to non-residential customers to implement new and upgrade existing HVAC equipment to more efficient HVAC technologies.

Many types of HVAC systems are eligible as shown in Table 2-1.

Table 2-1. Non-Residential Heating and Cooling Efficiency Program measure list (DSM VII)

End use	Measure	Manual section
HVAC	Unitary/split Air Conditioning (AC) & Heat Pump (HP) Systems	Section 2.1.1
	Variable Refrigerant Flow (VRF) & Mini-split Systems	Section 2.1.2
	Water- and air-cooled chillers	Section 2.1.3
	Variable frequency drive	Section 2.1.4
	Dual enthalpy air-side economizer	Section 2.1.5

The algorithms to calculate heating, cooling, and demand reduction for each of these measures are described in this section.

2.1 Heating, Ventilation, and Air-Conditioning (HVAC) end use

2.1.1 Unitary/split air conditioning (AC) & Heat Pump (HP) Systems VAC upgrade

2.1.1.1 Measure description

This measure relates to the installation of new high-efficiency unitary/split HVAC units and heat pumps in place of standard-efficiency unitary/split HVAC units. For the standard (baseline) efficiencies, refer to Table 17-8 and Table 17-9 in Sub-Appendix F2-III: Non-residential HVAC . The measure efficiencies are based on the installed unit's efficiency provided by the application. The measure savings include both heating and cooling electric energy savings.

This measure is offered through the various programs listed in Table 2-2 and uses the impacts estimation approach described in this section. (Not all programs offer all the listed HVAC equipment types.)

Table 2-2. Programs that offer this measure

Program name	Section
Non-Residential Heating and Cooling Efficiency Program, DSM Phase VII	Section 2.1.1
Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 8.2.4
Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII	Section 9.2.1
Non-Residential Multifamily Program, DSM Phase VIII	Section 10.3.1

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2.1.1.2 Impacts estimation approach

Algorithms and inputs to calculate heating, cooling savings, and demand reduction for unitary/split HVAC, package terminal AC, packaged terminal heat pump, variable refrigerant flow, and mini-split systems are provided below. Gross annual electric energy savings and gross coincident demand reduction are calculated according to the equations following this section.

Cooling energy savings:

For heat pumps, and AC units <65,000 Btu/h, per-measure, gross annual electric cooling energy savings are calculated according to the following equation:

$$\Delta kWh_{cool} = Size_{cool} \times \left[\frac{1}{SEER_{base}} - \frac{1}{SEER_{ee}}\right] \times EFLH_{cool} \times \frac{1\ kBtuh}{1{,}000\ Btuh}$$

For heat pumps and AC units ≥65,000 Btu/h, per-measure, gross annual electric cooling energy savings are calculated according to the following equation:

$$\Delta kWh_{cool} = Size_{cool} \times \left[\frac{1}{IEER_{base}} - \frac{1}{IEER_{ee}}\right] \times EFLH_{cool} \times \frac{1\ kBtuh}{1{,}000\ Btuh}$$

For package terminal AC and HP units of all sizes, per-measure, gross annual electric cooling energy savings are calculated according to the following equation:

$$\Delta kWh_{cool} = Size_{cool} \times \left[\frac{1}{EER_{base}} - \frac{1}{EER_{ee}}\right] \times EFLH_{cool} \times \frac{1\ kBtuh}{1{,}000\ Btuh}$$

Heating energy savings:

For heat pumps <65,000 Btu/h, per-measure gross annual electric heating energy savings are calculated according to the following equation:

$$\Delta kWh_{heat} = Size_{heat} \times \left[\frac{1}{HSPF_{base}} - \frac{1}{HSPF_{ee}}\right] \times EFLH_{heat} \times \frac{1\ kBtuh}{1{,}000\ Btuh}$$

For heat pumps ≥65,000 Btu/h, and water-source heat pumps of all sizes, and package terminal HP units of all sizes, per-measure gross annual electric heating energy savings are calculated according to the following equation:

$$\Delta kWh_{heat} = Size_{heat} \times \left[\frac{1}{COP_{base}} - \frac{1}{COP_{ee}}\right] \times EFLH_{heat} \times \frac{1\ kBtuh}{1{,}000\ Btuh}$$

Heating and cooling energy savings are added to calculate the per-measure, gross annual electric energy savings as shown:

$$\Delta kWh = \Delta kWh_{cool} + \Delta kWh_{heat}$$

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The per-measure, gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = Size_{cool} \times \left[\frac{1}{EER_{base}} - \frac{1}{EER_{ee}}\right] \times CF_{summer} \times \frac{1\ kBtuh}{1{,}000\ Btuh}$$

The per-measure, gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \frac{\Delta kWh_{heat}}{EFLH_{heat}} \times CF_{winter}$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkWh_{cool} = per-measure gross annual electric cooling energy savings
ΔkWh_{heat} = per-measure gross annual electric heating energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure gross coincident winter peak demand reduction
ΔkW_{winter} = per-measure gross summer peak coincident demand reduction
$Size_{cool}$ = equipment cooling capacity of installed unit
$Size_{heat}$ = equipment heating capacity of installed unit
$SEER_{base}$ = seasonal energy efficiency ratio (SEER) of the existing or baseline air conditioning equipment. It is used for heat pumps and AC units that are smaller than 65,000 Btu/h.
$SEER_{ee}$ = seasonal energy efficiency ratio (SEER) of the installed air conditioning equipment. It is used for heat pumps and AC units that are smaller than 65,000 Btu/h.
$IEER_{base}$ = integrated energy efficiency ratio (IEER) of the existing or baseline air conditioning equipment. IEER is a weighted average of a unit's efficiency at four load points: 100%, 75%, 50%, and 25% of full cooling capacity. It is used for heat pumps and AC units that are 65,000 Btu/h or larger.
$IEER_{ee}$ = integrated energy efficiency ratio (IEER) of the installed air conditioning equipment. IEER is a weighted average of a unit's efficiency at four load points: 100%, 75%, 50%, and 25% of full cooling capacity. It is used for heat pumps and AC units that are 65,000 Btu/h or larger.
$EFLH_{cool}$ = equivalent full-load cooling hours
$EFLH_{heat}$ = equivalent full-load heating hours
EER_{base} = energy efficiency ratio (EER) of existing or baseline air conditioning equipment. EER is used to analyze demand performance of heat pumps and AC units.
EER_{ee} = energy efficiency ratio (EER) of installed air conditioning equipment. EER is used to analyze performance of heat pumps and AC units.
$HSPF_{base}$ = heating seasonal performance factor (HSPF) of existing or baseline heat pump. HSPF is used in heating savings for air source heat pumps.
$HSPF_{ee}$ = heating seasonal performance factor (HSPF) of installed heat pump. HSPF is used in heating savings for air source heat pumps.
COP_{base} = coefficient of performance (COP) of existing or baseline heating equipment. Ground source heat pumps use COP to determine heating savings.
COP_{ee} = coefficient of performance (COP) of installed heating equipment. Ground source heat pumps use COP to determine heating savings.
CF_{summer} = summer coincidence factor
CF_{winter} = winter coincidence factor

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For ground-source heat pumps, the baseline efficiency is assumed to be that of an air-source heat pump.[13] See Equation 1 and Equation 2 in Sub-Appendix F2-VI: General to convert between tons and Btu/h or kBtu/h, or vice versa.

In the event of a missing efficiency metric from an application, the equations provided in Sub-Appendix F2-VI: General may be used to estimate the missing efficiency using another application-provided efficiency metric.

2.1.1.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 2-3. Input values for Non-residential HVAC equipment

Component	Type	Value	Units	Source(s)
$Size_{cool}$	Variable	See customer application	Btu/h	Customer application
$Size_{heat}$	Variable	See customer application[14] Default = $Size_{cool}$	Btu/h	Customer application
$EFLH_{heat}$	Variable	See Table 17-5 in Sub-Appendix F2-II: Non-residential HVAC	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 423
$EFLH_{cool}$	Variable	See Table 17-4 in Sub-Appendix F2-II: Non-residential HVAC	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 422
HSPF/SEER/ IEER/EER/ COP_{base}	Variable	See Table 17-8 and Table 17-9 in Sub-Appendix F2-III: Non-residential HVAC . If required efficiency value is not available, refer to Sub-Appendix F2-VI: General to convert the available efficiency value to the required efficiency value.	kBtu/kW-hour (except COP is dimension-less)	ASHRAE 90.1 2013, Table 6.8.1-1
HSPF/SEER/ IEER/EER/COP_{ee}	Variable	See customer application If required efficiency value is not available, refer to Sub-Appendix F2-VI: General to convert the available efficiency value to the required efficiency value.	kBtu/kW-hour (except COP is dimension-less)	Customer application
CF_{summer}	Variable	Where baseline and installed system capacities differ, use installed system capacity to assign CF. Otherwise, use baseline system capacity to assign CF: < 135 kBtu/h = 0.588 ≥ 135 kBtu/h = 0.874	-	Maryland/Mid-Atlantic TRM v.10, p. 291
CF_{winter}	Variable	Where baseline and installed system capacities differ, use installed system	-	Maryland/Mid-Atlantic TRM v.10, p. 291[15]

[13] Although ASHRAE values reflect the Building Code minimum, savings are calculated using the efficiencies provided in Sub-Appendix F2-III: Non-residential HVAC . This is due to the Mid-Atlantic TRM 2020 assumption that the baseline technology—for residential ground source heat pump applications—is an air-cooled heat pump. (There is no corresponding commercial measure in the Mid-Atlantic TRM 2020.)

[14] When customer-provided heating system size is <80% or >156% of customer-provided cooling system size, a default value will be used, instead. In such instances, it is assumed that the heating system size was incorrectly documented. The acceptable range is based on a review of the AHRI database across numerous manufacturers and heat pump types.

[15] The source TRM does not provide a winter CF. Therefore, the summer CF is applied to the winter CF.

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Component	Type	Value	Units	Source(s)
		capacity to assign CF. Otherwise, use baseline system capacity to assign CF: < 135 kBtu/h = 0.588 ≥ 135 kBtu/h = 0.874		

2.1.1.4 Default savings

No default savings will be awarded for this measure if the proper values are not provided in the customer application.

2.1.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 2-4.

Table 2-4. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
VIII	Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII	15.00	years	Maryland/Mid-Atlantic TRM v.10, p. 291
	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII			
	Non-Residential Multifamily Program, DSM Phase VIII			
VII	Non-Residential Heating and Cooling Efficiency Program, DSM Phase VII	15.00	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

2.1.1.6 Source(s)

The primary sources for this deemed savings approach are the ENERGY STAR® Air Source Heat Pump Calculator (2002 EPA), Maryland/Mid-Atlantic TRM v.10, pp. 283-291 and 422-423, and ASHRAE 90.1 2013.

2.1.1.7 Update summary

Updates made to this section are described in Table 2-5.

Table 2-5. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the Maryland/Mid-Atlantic TRM v.10.
	Equation	Added Electric Base Board heating savings equations. Added coincident winter peak demand reduction equation.
	New table	Effective Useful Life (EUL) by program

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Version	Update type	Description
2020	Equation	Added size condition of <65,000 Btu/h and ≥65,000 Btu/h for determining which equation to use for ground-source heat pumps. Previously all ground-source heat pumps used equations with IEER and COP.
v10	Source	Updated page numbers / version of the Mid-Atlantic TRM v.9.
	Input variable	Update to weather stations in North Carolina resulted in revised EFLHs for weather-sensitive measures. Baseline efficiency levels were revised per update to ASHRAE 2013 in VA and NC.

2.1.2 Variable Refrigerant Flow Systems and mini-split systems

2.1.2.1 Measure description

This measure relates to installation of new high-efficiency variable refrigerant flow (VRF) and new mini-split systems in place of standard-efficiency air conditioners or heat pumps. For baseline VRF air conditioner and heat pump efficiencies refer to Table 17-10 in Sub-Appendix F2-III: Non-residential HVAC . The measure efficiency is based on the installed unit's efficiency. The measure-approved savings applies only to the air cooled VRF AC, and air cooled VRF HP. Water source or ground source units are not included.

This measure is offered through different programs listed in Table 2-6 and uses the impacts estimation approach described in this section.

Table 2-6. Programs that contain this measure

Program name	Section
Non-Residential Heating and Cooling Efficiency Program, DSM Phase VII	Section 2.1.2
Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII	Section 9.2.2

2.1.2.2 Impacts estimation approach

Algorithms and inputs to calculate heating, cooling, and gross coincident savings for variable refrigerant flow (VRF) systems and mini split systems are provided in this section. Gross annual electric energy savings and gross coincident demand reduction are calculated according to the equations following this section.

Cooling energy savings:

For VRF systems and mini-split systems <65,000 Btu/h, per-measure, gross annual electric cooling energy savings are calculated according to the following equation:

$$\Delta kWh_{cool} = Size_{cool} \times \left[\frac{1}{SEER_{base}} - \frac{1}{SEER_{ee}}\right] \times EFLH_{cool} \times \frac{1\ kBtuh}{1{,}000\ Btuh}$$

For VRF systems ≥65,000 Btu/h, per-measure gross annual electric cooling energy savings are calculated according to the following equation:

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$$\Delta kWh_{cool} = Size_{cool} \times \left[\frac{1}{IEER_{base}} - \frac{1}{IEER_{ee}}\right] \times EFLH_{cool} \times \frac{1\ kBtuh}{1{,}000\ Btuh}$$

Heating energy savings:

For VRF and mini-split heat pump systems <65,000 Btu/h, per-measure gross annual electric heating energy savings are calculated according to the following equation:

$$\Delta kWh_{heat} = Size_{heat} \times \left[\frac{1}{HSPF_{base}} - \frac{1}{HSPF_{ee}}\right] \times EFLH_{heat} \times \frac{1\ kBtuh}{1{,}000\ Btuh}$$

For VRF and mini-split heat pump systems ≥65,000 Btu/h, per-measure gross annual electric heating energy savings are calculated according to the following equation:

$$\Delta kWh_{heat}\quad pe = Size_{heat} \times \left[\frac{1}{COP_{base}} - \frac{1}{COP_{ee}}\right] \times EFLH_{heat} \times \frac{1\ kW}{3{,}412\ Btuh}$$

Heating and cooling energy savings are added to calculate the per-measure gross annual electric energy savings:

$$\Delta kWh = \Delta kWh_{cool} + \Delta kWh_{heat}$$

The per-measure, gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = Size_{cool} \times \left[\frac{1}{EER_{base}} - \frac{1}{EER_{ee}}\right] \times CF_{summer} \times \frac{1\ kBtuh}{1{,}000\ Btuh}$$

The per-measure, gross coincident winter peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \frac{\Delta kWh_{heat}}{EFLH_{heat}} \times CF_{winter}$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkWh_{cool} = per-measure gross annual electric cooling energy savings for mini split heat pump systems
ΔkWh_{heat} = per-measure gross annual electric heating energy savings for mini split heat pump systems
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure gross coincident winter peak demand reduction
$Size_{cool}$ = equipment cooling capacity of installed unit
$Size_{heat}$ = equipment heating capacity of installed unit
$SEER_{base}$ = seasonal energy efficiency ratio (SEER) of the existing or baseline equipment. SEER is used for units that are smaller than 65,000 Btu/h.
$SEER_{ee}$ = seasonal energy efficiency ratio (SEER) of the installed equipment. SEER is used for units that are smaller than 65,000 Btu/h.
$IEER_{base}$ = integrated energy efficiency ratio (IEER) of existing or baseline equipment. IEER is a weighted average of a unit's efficiency at four load points: 100%, 75%, 50%, and 25% of full

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cooling capacity. It is used for heat pumps and AC units that are 65,000 Btu/h or larger.

$IEER_{ee}$ = integrated energy efficiency ratio (IEER) of installed equipment. IEER is a weighted average of a unit's efficiency at four load points: 100%, 75%, 50%, and 25% of full cooling capacity. It is used for heat pumps and AC units that are 65,000 Btu/h or larger.
$EFLH_{cool}$ = equivalent full load cooling hours
$EFLH_{heat}$ = equivalent full load heating hours
EER_{base} = energy efficiency ratio (EER) of existing or baseline equipment
EER_{ee} = energy efficiency ratio (EER) of installed equipment
$HSPF_{base}$ = heating seasonal performance factor (HSPF) of existing or baseline system
$HSPF_{ee}$ = heating seasonal performance factor (HSPF) of installed equipment
COP_{base} = coefficient of performance (COP) of existing or baseline heating equipment
COP_{ee} = coefficient of performance (COP) of installed heating equipment
CF_{summer} = summer coincidence factor
CF_{winter} = winter coincidence factor

To convert between EER, SEER, and IEER, see equations in Sub-Appendix F2-VI: General .

2.1.2.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 2-7. Input values for VRF systems and mini-split systems

Component	Type	Value	Units	Source(s)
$Size_{cool}$	Variable	See customer application	Btu/h	Customer application
$Size_{heat}$	Variable	See customer application[16] Default = $Size_{cool}$	Btu/h	Customer application
$EFLH_{heat}$	Variable	See Table 17-5 in Sub-Appendix F2-II: Non-residential HVAC	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 423
$EFLH_{cool}$	Variable	See Table 17-4 in Sub-Appendix F2-II: Non-residential HVAC	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 422
HSPF/SEER/ EER/COP/ $IEER_{base}$	Variable	See Table 17-10 in Sub-Appendix F2-III: Non-residential HVAC If required efficiency value is not available, refer to Sub-Appendix F2-VI: General to convert the available efficiency value to the required efficiency value.	kBtu/kW-hour (except COP is dimension-less)	ASHRAE 90.1 2013, Table 68.1-1
HSPF/SEER/ EER/COP/ $IEER_{ee}$	Variable	See customer application[17] If required efficiency value is not available, refer to Sub-Appendix F2-VI: General to convert the available efficiency value to the required efficiency value.	kBtu/kW-hour (except COP is dimension-less)	Customer application
CF_{summer}	Fixed	Where baseline and install system capacity vary, use install system capacity to assign CF. Otherwise, use baseline system capacity to assign CF. < 135 kBtu/h = 0.588 ≥ 135 kBtu/h = 0.874	-	Maryland/Mid-Atlantic TRM v.10, p. 295

[16] When customer-provided heating system size is <80% or >156% of customer-provided cooling system size, a default value will be used, instead. In such instances, it is assumed that the heating system size was incorrectly documented. The acceptable range is based on a review of the AHRI database across numerous manufacturers and heat pump types.

[17] When missing an efficiency value, use the general equations to convert in Sub-Appendix F2-VI: General equations to convert to the appropriate value.

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Component	Type	Value	Units	Source(s)
CF_{winter}	Variable	Where baseline and installed system capacities differ, use installed system capacity to assign CF. Otherwise, use baseline system capacity to assign CF: < 135 kBtu/h = 0.588 ≥ 135 kBtu/h = 0.874	-	Maryland/Mid-Atlantic TRM v.10, p. 295[18]

2.1.2.4 Default savings

No default savings will be awarded for this measure if the proper values are not provided in the customer application.

2.1.2.5 Effective Useful Life

The effective useful life of this measure is provided in Table 2-8.

Table 2-8. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
VIII	Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII	18.00	years	Maryland/Mid-Atlantic TRM v.10, p. 295
VII	Non-Residential Heating and Cooling Efficiency Program, DSM Phase VII	15.00		Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

2.1.2.6 Source(s)

The primary sources for this deemed savings approach are the Maryland/Mid-Atlantic TRM v.10, pp. 292-295 and 422-423, and ASHRAE 90.1-2013.

2.1.2.7 Update summary

Updates made to this section are described in Table 2-9.

Table 2-9. Summary of update(s)

Version	Update type	Description
2022	Measure life	Updated Effective Useful Life (EUL) for the Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII
2021	Source	Updated page numbers / version of the Maryland/Mid-Atlantic TRM
	Equation	Added coincident winter peak demand reduction equation
	New table	Effective Useful Life (EUL) by program

[18] The source TRM does not provide a winter CF. Therefore, the summer CF is applied to the winter CF.

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Version	Update type	Description
2020	Equation	Added size condition of <65,000 Btu/h and ≥65,000 Btu/h for determining which equation to use for ground-source heat pumps. Previously all ground-source heat pumps used equations with IEER and COP.
V10	Source	Updated page numbers / version of the Maryland/Mid-Atlantic TRM
	Input variable	Update to weather stations in North Carolina resulted in revised EFLHs for weather-sensitive measures Baseline efficiency levels were revised per update to ASHRAE 2013 in VA and NC

2.1.3 Electric chillers

2.1.3.1 Measure description

This measure relates to the installation of a new high-efficiency electric water chilling package (either water- or air-cooled types) in place of a standard-efficiency electric water chilling package. For the baseline chiller efficiencies, refer to Table 17-11 of Sub-Appendix F2-III: Non-residential HVAC for the 2013 ASHRAE-90.1 specified minimum efficiencies. The installed chiller efficiency is taken from the customer application.

This measure is offered through different programs listed in Table 2-10 and uses the impacts estimation approach described in this section.

Table 2-10. Programs that offer this measure

Program name	Section
Non-Residential Heating and Cooling Efficiency Program, DSM Phase VII	Section 2.1.3
Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII	Section 9.2.3

2.1.3.2 Impacts estimation approach

Water-cooled chillers

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = Size_{ee} \times \left[\frac{kW}{ton_{base,IPLV}} - \frac{kW}{ton_{ee,IPLV}}\right] \times EFLH_{cool}$$

Per-measure, gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = Size_{ee} \times \left[\frac{kW}{ton_{base,full\ load}} - \frac{kW}{ton_{ee,full\ load}}\right] \times CF_{summer}$$

This measure does not have gross coincident winter peak demand reduction.

Air-cooled chillers

Per-measure, gross annual electric energy savings are calculated according to the following equation:

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$$\Delta kWh = Size_{ee} \times \left[\frac{12\,kBtuh/ton}{EER_{base,IPLV}} - \frac{12\,kBtuh/ton}{EER_{ee,IPLV}}\right] \times EFLH_{cool}$$

Per-measure, gross coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = Size_{ee} \times \left[\frac{12\,kBtuh/ton}{EER_{base,full\,load}} - \frac{12\,kBtuh/ton}{EER_{ee,full\,load}}\right] \times CF_{summer}$$

This measure does not provide gross coincident winter peak demand reduction.

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident demand reduction
$Size_{ee}$ = cooling capacity of the installed chiller system
$EER_{base,IPLV}$, $kW/ton_{base,IPLV}$ = chiller system baseline efficiency at integrated part load value (IPLV), in kW/ton (for $kW/ton_{base,IPLV}$) assigned based on installed system capacity
$EER_{ee,IPLV}$, $kW/ton_{ee,IPLV}$ = chiller system installed efficiency at integrated part load value (IPLV)
$EFLH_{cool}$ = equivalent full load hours of cooling
$EER_{base,full\ load}$, $kW/ton_{base,full\ load}$ = chiller system baseline efficiency at full load
$EER_{ee,full\ load}$, $kW/ton_{ee,full\ load}$ = chiller system installed efficiency at full load
CF_{summer} = summer peak coincidence factor

2.1.3.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 2-11. Input values for Non-residential electric chillers

Component	Type	Value	Unit	Source(s)
$Size_{ee}$	Variable	See customer application	ton, cooling capacity	Customer application
$kW/ton_{base,full-load}$	Variable	See Table 17-11 of Sub-Appendix F2-III: Non-residential HVAC	kW/ton	ASHRAE 90.1 2013, Table 6.8.1-3
$kW/ton_{base,IPLV}$	Variable	See Table 17-11 of Sub-Appendix F2-III: Non-residential HVAC	kW/ton	ASHRAE 90.1 2013, Table 6.8.1-3
$kW/ton_{ee,full-load}$	Variable	See customer application[19]	kW/ton	Customer application
$kW/ton_{ee,IPLV}$	Variable	See customer application[19]	kW/ton	Customer application
$EER_{base,\ full\ load}$	Variable	See customer application[20]	kBtu/kW	Customer Application
		Default: See Table 17-11 of Sub-Appendix F2-III: Non-residential HVAC		ASHRAE 90.1-2013, Table 6.8.1-3
$EER_{base,\ IPLV}$	Variable	See customer application[20]	kBtu/kW	Customer Application
		Default: See Table 17-11 Sub-Appendix F2-III: Non-residential HVAC		ASHRAE 90.1-2013, Table 6.8.1-3

[19] When missing either the IPLV or the full load value, use the general equations to convert in Sub-Appendix F2-VI: General equations to convert to the appropriate value.

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Component	Type	Value	Unit	Source(s)
$EER_{ee, full\ load}$	Variable	See customer application[20]	kBtu/kW	Customer application
$EER_{ee, IPLV}$	Variable	See customer application[20]	kBtu/kW	Customer application
$EFLH_{cool}$	Variable	See Table 17-4 in Sub-Appendix F2-II: Non-residential HVAC	hours, annual	Maryland/Mid-Atlantic TRM v.10, adjusted for ten locations in VA and NC, based on TMY3 cooling degree days data.
CF_{summer}	Fixed	0.923	-	Maryland/Mid-Atlantic TRM v.10, p. 304

Note that some jurisdictions, such as New Jersey, provide a fixed estimate of full-load cooling hours, while others provide several estimates of cooling hours based on factors such as facility type, chiller type, chiller efficiency, or weather region. This TRM follows a similar approach as used in Mid Atlantic TRM in that the full load cooling hours of chillers are assigned by building type. As per Table 17-11 of Sub-Appendix F2-III: Non-residential HVAC , the water chilling efficiency requirement from ASHRAE 90.1-2010, presents two paths of compliance for water-cooled chillers. Path A is intended for those project sites where the chiller application is primarily operating at full-load conditions during its annual operating period. Path B is intended for those project sites where the chiller application is primarily operating at part-load conditions during its annual operating period. Compliance with the code-specified minimum efficiency can be achieved by meeting the requirement of either Path A or Path B. However, both full-load and IPLV levels must be met to fulfill the requirements of Path A or Path B.

For applications in the Virginia and North Carolina regions, chillers are expected to operate primarily at full-load conditions for a significant portion of their operating period. Therefore, the Path A efficiency is used for the baseline.

2.1.3.4 Default savings

No default savings will be awarded for this measure if the proper values are not provided in the customer application.

2.1.3.5 Effective Useful Life

The effective useful life of this measure is provided in Table 2-12.

Table 2-12. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
VIII	Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII	23.00	years	Maryland/Mid-Atlantic v.10, p. 304
VII	Non-Residential Heating and Cooling Efficiency Program, DSM Phase VII	15.00	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

[20] When missing either the IPLV or the full load value, use the general equations to convert in Sub-Appendix F2-VI: General equations to convert to the appropriate value.

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2.1.3.6 Source(s)

The primary sources for this deemed savings approach are the Maryland/Mid-Atlantic TRM v.10, pp. 302-305 and 422 and ASHRAE 90.1-2013, Table 6.8.1-3 - Water Chilling Packages - Efficiency Requirements.

2.1.3.7 Update summary

Updates made to this section are described in Table 2-13.

Table 2-13. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the Maryland/Mid-Atlantic TRM
	New table	Effective Useful Life (EUL) by program
2020	None	No change
v10	Source	Updated page numbers / version of the Maryland/Mid-Atlantic TRM
	Input variable	Update to weather stations in North Carolina resulted in revised EFLHs for weather-sensitive measures Baseline efficiency levels were revised per update to ASHRAE 2013 in VA and NC

2.1.4 HVAC Variable Frequency Drives

2.1.4.1 Measure description

This measure defines savings that result from installing a variable frequency drive (VFD) control on a HVAC motor with application to supply fans, return fans, exhaust fans, cooling tower fans, chilled water pumps, condenser water pumps, and hot water pumps. The HVAC application must also have a variable load and proper controls in place: feedback control loops to fan/pump motors and variable air volume (VAV) boxes on air-handlers.

The algorithms and inputs to calculate energy and demand reduction for VFDs are provided below. The baseline equipment fan/pump type should be determined from the program application, if available. Otherwise, the minimum savings factors will be applied. For all known types, the energy savings calculations will include the following baseline applications:

HVAC Fans

Airfoil / Backward-Inclined (AF / BI) Fan

Airfoil / Backward-Inclined w/Inlet Guide Vanes (AF / BI IGV) Fan

Forward Curved (FC) Fan

Forward Curved w/Inlet Guide Vanes (FC IGV) Fan

Unknown (Default)

HVAC Pumps

Chilled Water Pump (CHW Pump)

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Condenser Water Pump (CW Pump)

Hot Water Pump (HW Pump)

Unknown (Default)

This measure is offered through the programs listed in Table 2-14. TheNon-Residential Heating and Cooling Efficiency Program, DSM Phase VII uses the impacts estimation approach described In this section. However, the savings methodology is different for the Non-Residential Small Business Improvement Enhanced Program, described in section 8.2.7.

Table 2-14. Programs that Offer this Measure

Program name	Section
Non-Residential Heating and Cooling Efficiency Program, DSM Phase VII	Section 2.1.4
Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 8.2.7

2.1.4.2 Impacts estimation approach

Per-measure, gross annual electric energy savings are calculated according to the following equations:

HVAC Fans:

$$\Delta kWh_{fan} = \frac{hp\ x\ 0.746\ x\ LF}{\eta} \times HOU \times \Delta LR$$

$$\Delta LR = \sum_{0\%}^{100\%} FF \times (PLR_{base} - PLR_{ee})$$

HVAC Pumps:

$$\Delta kWh_{pump} = \frac{hp\ x\ 0.746\ x\ LF}{\eta} \times HOU \times ESF$$

Per-measure, gross coincident summer peak demand reduction is calculated according to the following equation:

HVAC Fans:

$$\Delta kW_{fan,summer} = \frac{hp\ x\ 0.746\ x\ LF}{\eta} \times \left(PLR_{base,peak} - PLR_{ee,peak}\right) = 0$$

HVAC Pumps:

$$\Delta kW_{pump,summer} = \frac{hp\ x\ 0.746\ x\ LF}{\eta} \times CF_{summer} \times DSF$$

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Per-measure, gross coincident winter peak demand reduction is calculated according to the following equation:

HVAC Fans:

$$\Delta kW_{fan,winter} = \frac{hp\ x\ 0.746\ x\ LF}{\eta} \times \left(PLR_{base,peak} - PLR_{ee,peak}\right) = 0$$

HVAC Pumps:

$$\Delta kW_{pump,winter} = \frac{hp\ x\ 0.746\ x\ LF}{\eta} \times\ CF_{winter} \times\ DSF$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure gross coincident winter peak demand reduction
hp = motor horsepower
LF = motor load factor (%) at fan design airflow rate or pump design flowrate
η = NEMA-rated efficiency of motor
HOU = annual operating hours for fan motor based on building type
ΔLR = change in load ratio due to differences in part-load ratios
FF = flow fraction, percentage of run-time spent within a given range of flows
PLR_{base} = baseline part-load ratio
PLR_{ee} = efficient part-load ratio
$PLR_{base,\ peak}$ = summer peak baseline part-load ratio
$PLR_{ee,\ peak}$ = summer peak efficient part-load ratio
ESF = energy savings factor
DSF = demand savings factor
CF_{summer} = summer peak coincidence factor
CF_{winter} = winter peak coincidence factor

2.1.4.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 2-15. Input values for non-residential variable frequency drives

Component	Type	Value	Unit	Source(s)
hp	Variable	See customer application	horsepower	Customer application
LF	Variable	See customer application	-	Customer application
		Default: 0.65	-	Maryland/Mid-Atlantic TRM v.10, p. 297
η	Variable	See customer application	-	Customer application
		For default see Table 2-16. Baseline motor efficiency		NEMA Standards Publication Condensed MG 1-2007
FF	Fixed	0.524 per Table 2-17	-	Maryland/Mid-Atlantic TRM v.10, p. 297
PLR_{base}	Variable	See customer application	-	Customer application
		Default = 0.53 per Table 2-19. forward-curved fan with outlet dampers at FF=0.524		Maryland/Mid-Atlantic TRM v.10, p. 298

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Component	Type	Value	Unit	Source(s)
PLR$_{base, peak}$	Fixed	1.00	-	DNV engineering judgement
PLR$_{ee}$	Variable	See customer application	-	Customer application
		Default: 0.30[21] per Table 2-19. for VFD with duct Static Pressure Controls at FF=0.524		Maryland/Mid-Atlantic TRM v.10, p. 299
PLR$_{ee, peak}$	Fixed	1.00	-	DNV engineering judgement
ESF	Variable	See Table 2-20	-	Maryland/Mid-Atlantic TRM v.10, p. 301
DSF	Variable	See Table 2-20	-	Maryland/Mid-Atlantic TRM v.10, p. 301
HOU	Variable	See Table 17-6 in Sub-Appendix F2-II: Non-residential HVAC	hours, annual	Maryland/Mid-Atlantic TRM v.10, pp. 299-301
CF$_{summer}$	Fixed	0.55 for pump applications	-	Maryland/Mid-Atlantic TRM v.10, p. 299
CF$_{winter}$	Fixed	0.78 for pump applications	-	Dominion Energy 2012 Commercial HVAC VSD Study[22]

Table 2-16 provides the baseline motor efficiencies that are consistent with the minimum federal accepted motor efficiencies provided by the National Electrical Manufacturers Association (NEMA).[23]

Table 2-16. Baseline motor efficiency[24]

Horsepower (hp)	η		Horsepower (hp)	η
1	0.855		**60**	0.950
1.5	0.865		**75**	0.954
2	0.865		**100**	0.954
3	0.895		**125**	0.954
5	0.895		**150**	0.958
7.5	0.917		**200**	0.962
10	0.917		**250**	0.962
15	0.924		**300**	0.962
20	0.930		**350**	0.962
25	0.936		**400**	0.962
30	0.936		**450**	0.962
40	0.941		**500**	0.962
50	0.945			

21 Corresponds to the approximate PLR for ‘VFD with Duct Static Pressure Controls’ from Table 2-18. at the average FF of 52.4% from Table 2-17.
22 The source TRM does not provide a winter CF. Therefore, the results from Dominion Energy’s 2012 Commercial VSD Loadshape study to calculate winter CF.
23 Refer to NEMA Standards Publication “Condensed MG 1-2011 - Information Guide for General Purpose Industrial AC Small and Medium Squirrel-Cage Induction Motor Standards” and Table 52 ‘Full-Load Efficiencies for 60 Hz NEMA Premium Efficiency Electric Motors Rated 600 Volts or Less (Random Wound)’ in said standard.
24 NEMA Standards Publication Condensed MG 1-2011 - Information Guide for General Purpose Industrial AC Small and Medium Squirrel-Cage Induction Motor Standards. Assumed Totally Enclosed Fan-Cooled (TEFC), Premiums Efficiency, 1800 RPM (4 Pole).

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Table 2-17 provides the assumed proportion of time that fans operate within ten ranges of airflow rates, relative to the design airflow rate (cfm).

Table 2-17. Default fan duty cycle

Airflow range (% of design cfm)	Airflow Fraction (FF), percent of time in flow range	Average flow range (% of design cfm)
0% - 10%	0.0%	52.4%
10% - 20%	1.0%	
20% - 30%	5.5%	
30% - 40%	15.5%	
40% - 50%	22.0%	
50% - 60%	25.0%	
60% - 70%	19.0%	
70% - 80%	8.5%	
80% - 90%	3.0%	
90% - 100%	0.5%	

Table 2-18. provides the part-load ratios (PLRs) that vary with fan control types and air flow range.

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Table 2-18. Part load ratios by control type, fan type, and flow range

Control type	Fan type(s)	Airflow range (percent of design cfm)									
		0% - 10%	10% - 20%	20% - 30%	30% - 40%	40% - 50%	50% - 60%	60% - 70%	70% - 80%	80% - 90%	90% - 100%
No control or bypass damper	All	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Discharge dampers	All	0.46	0.55	0.63	0.70	0.77	0.83	0.88	0.93	0.97	1.00
Outlet damper	BI, AF	0.53	0.53	0.57	0.64	0.72	0.80	0.89	0.96	1.02	1.05
Inlet damper box	All	0.56	0.60	0.62	0.64	0.66	0.69	0.74	0.81	0.92	1.07
Inlet guide vane	BI, AF	0.53	0.56	0.57	0.59	0.60	0.62	0.67	0.74	0.85	1.00
Inlet vane dampers	All	0.38	0.40	0.42	0.44	0.48	0.53	0.60	0.70	0.83	0.99
Outlet damper	FC	0.22	0.26	0.30	0.37	0.45	0.54	0.65	0.77	0.91	1.06
Eddy current drives	All	0.17	0.20	0.25	0.32	0.41	0.51	0.63	0.76	0.90	1.04
Inlet guide vane	FC	0.21	0.22	0.23	0.26	0.31	0.39	0.49	0.63	0.81	1.04
VFD with duct static pressure controls	All	0.09	0.10	0.11	0.15	0.20	0.29	0.41	0.57	0.76	1.01
VFD with low/no duct static pressure controls (<1" w.g.)	All	0.05	0.06	0.09	0.12	0.18	0.27	0.39	0.55	0.75	1.00

Fan types include: Bi=Backward Inclined fan; AF=Airfoil Fan; and FC=Forward-Curved fan.

Table 2-19 displays the average part-load ratios calculated using the flow fractions from Table 2-17, and the part-load values across flow ranges from Table 2-18.

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Table 2-19. Average Baseline Part Load Ratios (PLRs) by control type, and fan type

Case	Control type	Fan type(s)	Weighted average PLR
Baseline	Outlet damper	Airfoil (AF) or Backward Inclined (BI)	0.78
		Forward Curved (FC) or Unknown	0.53
	Discharge damper	All	0.81
	Inlet damper box	All	0.70
	Inlet guide vane	Airfoil (AF) or Backward Inclined (BI)	0.64
		Forward Curved (FC) or Unknown	0.40
	Inlet vane damper	All	0.54
	Eddy current drive	All	0.50
	No control or bypass damper	All	1.00
Efficient	VFD with duct static pressure controls	All	0.30
	VFD with low/no duct static pressure controls (<1" w.g.)	All	0.28

Table 2-20. Energy and demand savings factors by application

VFD Applications[25]	ESF	DSF
Chilled Water Pump	0.633	0.460
Hot Water Pump	0.652	0.000
Unknown/Other Pump (Average)[26]	0.643	0.230

2.1.4.4 Default savings

No default savings will be awarded for this measure if the proper values are not provided in the customer application.

2.1.4.5 Effective Useful Life

The effective useful life of this measure is provided in Table 2-21.

Table 2-21. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
VII	Non-Residential Heating and Cooling Efficiency Program, DSM Phase VII	15.00	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

[25] Mid-Atlantic TRM 2020, p. 301.

[26] Assigned for pumps not specifically in this table, such as condenser water pump.

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2.1.4.6 Source(s)

The primary sources for this deemed savings approach Maryland/Mid-Atlantic TRM v.10, pp. 296-301.

2.1.4.7 Update summary

Updates made to this section are described in Table 2-22.

Table 2-22. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the Maryland/Mid-Atlantic TRM
	New table	Effective Useful Life (EUL) by program
	Equation	Added gross winter peak demand reduction equation
2020	None	Added efficient cases of control strategies to clarify assumptions. No change to resulting savings.
v10	Source	Updated page numbers / version of the Maryland/Mid-Atlantic TRM

2.1.5 Dual enthalpy air-side economizers

2.1.5.1 Measure description

Non-Residential Heating and Cooling Efficiency Program

This measure involves the installation of a dual-enthalpy economizer to provide free cooling during the appropriate ambient conditions. Dual-enthalpy economizers are used to control a ventilation system's outside-air intake in order to reduce a facility's total cooling load. The economizer operation controls the outside air and return air flow rates by monitoring the outside air temperature (sensible heat) and humidity (latent heat) and provides free cooling in place of mechanical cooling. This reduces the load on the mechanical cooling system and lowers the operating hours. This measure applies only to retrofits or newly-installed cooling units with a factory-installed "dual-enthalpy" economizer controller. The baseline condition is the existing HVAC system without economizer. The efficient condition is the HVAC system with functioning dual enthalpy economizer control(s).

Non-Residential Small Business Improvement Enhanced Program

In addition to the measure scope description in Non-Residential Heating and Cooling Efficiency Program above, this program also includes repair of existing dual-enthalpy economizer. This measure is offered through the programs listed in Table 2-23 and uses the impacts estimation approach described in this section.

Table 2-23. Programs that offer this measure

Program name	Section
Non-Residential Heating and Cooling Efficiency Program, DSM Phase VII	Section 2.1.5
Non-Residential Office Program, DSM Phase VII	Section 7.3.7
Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 8.2.5

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2.1.5.2 Impacts estimation approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = Size_{cool} \times ESF$$

Per-measure, gross summer and winter coincident demand reduction is assumed to be zero because an economizer will typically not operate during the peak period.[27] Hence,

$$\Delta kW_{summer} = \Delta kW_{winter} = 0$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross summer peak coincident demand reduction
ΔkW_{winter} = per-measure gross winter peak coincident demand reduction
$Size_{cool}$ = HVAC system cooling capacity
ESF = annual energy savings factor for the installation of dual enthalpy economizer control

2.1.5.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 2-24. Input values for economizer repair savings calculations

Component	Type	Value	Unit	Source(s)
$Size_{cool}$	Variable	See customer application	tons	Customer application
ESF	Variable	See Table 2-25	kWh/ton	Maryland/Mid-Atlantic TRM v.10, p. 314

[27] Maryland/Mid-Atlantic TRM v.10, p. 313.

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Table 2-25. Economizer energy savings factors by building type[28]

Building type	Energy savings factors (kWh/ton)										
	Baltimore, MD	Richmond, VA	Norfolk, VA	Roanoke, VA	Sterling, VA	Arlington, VA	Charlottes-ville, VA	Farmville, VA	Fredericksburg, VA	Elizabeth City, NC	Rocky Mount, NC
Education:[29] college and university, high school, – elementary and middle school	39	46	51	35	35	48	34	41	43	56	43
Food sales:[30] grocery,[31] convenience store, gas station convenience store	57	67	75	51	51	70	50	59	63	82	63
Food service:[32] full service, fast food[33]	29	34	38	26	26	36	26	30	32	41	32
	29	34	38	26	26	36	26	30	32	41	32
	37	43	49	33	33	46	33	39	41	53	41
Mercantile (retail, not mall)[34]	57	67	75	51	51	70	50	59	63	82	63
Mercantile (mall)	57	67	75	51	51	70	50	59	63	82	63

[28] Maryland/Mid-Atlantic TRM v.10, p. 314 lists savings factor for installation of dual enthalpy economizer. Mid Atlantic TRM does not have savings factor for VA or NC, therefore Baltimore, MD savings factors are scaled to determine those for Richmond, VA and Rocky Mount-Wilson/Elizabeth City, NC values using the CDD provided in Sub-Appendix F2-I: Cooling and heating degree days and . For example, VA and NC values are calculated from Baltimore, MD savings factors and degree days (DD-65°F = CDD) using TMY3 data.

[29] All education building types in the STEP Manual were mapped to savings factors for the "Primary School" building type listed in the Maryland/Mid-Atlantic TRM v.10, p. 314.

[30] All food sales, and service (beauty, auto repair workshop) building types in the STEP Manual were mapped to savings factors for the "Small Retail" building type listed in the Maryland/Mid-Atlantic TRM v.10, p. 314.

[31] Food-sales-grocery and mercantile (mall) building types in the STEP Manual were mapped to the "Big Box Retail" building type listed in the Maryland/Mid-Atlantic TRM v.10, p. 314.

[32] All general food service and food service-full service building types in the STEP Manual were mapped to savings factors for the "Full Service Restaurant" building type listed in the Maryland/Mid-Atlantic TRM v.10, p. 314.

[33] Food service – fast food building types in the STEP Manual were mapped to savings factors for the "Fast Food" building type in the Maryland/Mid-Atlantic TRM v.10, p. 314.

[34] Mercantile (retail, not mall) building types in the STEP Manual were mapped to savings factors for the "Small Retail" building type in the Maryland/Mid-Atlantic TRM v.10, p. 314.

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Building type	Energy savings factors (kWh/ton)										
	Baltimore, MD	Richmond, VA	Norfolk, VA	Roanoke, VA	Sterling, VA	Arlington, VA	Charlottes-ville, VA	Farmville, VA	Fredericksburg, VA	Elizabeth City, NC	Rocky Mount, NC
Office: Small (<40,000 sq. ft.)[35] and Large (≥ 40,000 sq. ft.)	57	67	75	51	51	70	50	59	63	82	63
Public assembly	25	29	33	23	22	31	22	26	28	36	28
Religious worship	6	7	8	5	5	7	5	6	7	9	7
Other[36]: lodging (hotel, motel and dormitory), health care (outpatient, inpatient) public order and safety (police and fire station)	57	67	75	51	51	70	50	59	63	82	63
Service (beauty, auto repair workshop)	57	67	75	51	51	70	50	59	63	82	63
Warehouse and storage	2	2	3	2	2	2	2	2	2	3	2

[35] Office – small (< 40,000 sqft) and office – large (>= 40,000 sqft) building types in the STEP Manual were mapped to savings factors for the "Small Office" building types in the Maryland/Mid-Atlantic TRM v.10, p. 314.

[36] Other, lodging – (hotel, motel and dormitory), health care-outpatient, healthcare-inpatient, public order and safety (police and fire station) building types in the STEP Manual were mapped to the "Other" building type in the Maryland/Mid-Atlantic TRM v.10, p. 314.

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2.1.5.4 Default savings

If the proper values are not supplied, a default savings may be applied using conservative input values. Default hours of use will be taken from the above chart if the building type is available.

The default gross coincident demand reduction is zero.

2.1.5.5 Effective Useful Life

The effective useful life of this measure is provided in Table 2-26.

Table 2-26. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Building Optimization Program, DSM Phase IX	10.00	years	Mid-Atlantic TRM 2020, p. 313
VIII	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII			
VII	Non-Residential Heating and Cooling Efficiency Program, DSM Phase VII	15.00	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)
VII	Non-Residential Office Program, DSM Phase VII	7.00		

2.1.5.6 Source(s)

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v.10, pp. 313-314.

2.1.5.7 Update summary

Updates made to this section are described in Table 2-27.

Table 2-27. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the Maryland/Mid-Atlantic TRM
	Input variable	Expanded weather stations
	New table	Effective Useful Life (EUL) by program
	Equation	Added gross winter peak demand reduction equation
2020	None	No change
v10	Source	Updated page numbers / version of the Maryland/Mid-Atlantic TRM
	Input variable	Updated weather stations in North Carolina

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3 NON-RESIDENTIAL WINDOW FILM PROGRAM, DSM PHASE VII

The Non-Residential Window Film Program provides incentives to non-residential customers to install reflective window film on existing windows in order to reduce the solar heat gain through the affected windows. The program has been offered in Virginia beginning August 1, 2014 and in North Carolina beginning January 1, 2015.

3.1 Building envelope end use

3.1.1 Window film

3.1.1.1 Measure description

This measure applies to window film installed on existing windows to reduce the solar heat gain through the affected window. Because the window film reduces solar heat gain, cooling loads are often reduced leading to mechanical cooling savings. For the same reason, heating load may also increase leading to mechanical heating penalties.

Windows facing any orientation are eligible. The film must be SHGC equal to or less than 0.5.[37]

This measure applies to window film installed on the exterior side of existing non-residential single pane or double pane windows. Savings are calculated per square foot of north, south, east, and west facing windows.

This measure is offered through different programs listed in Table 3-1 and uses the impacts estimation approach described in this section.

Table 3-1. Programs that offer this measure

Program name	Section
Non-Residential Window Film Program, DSM Phase VII	Section 3.1.1
Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 8.1.1

3.1.1.2 Impacts estimation approach

The window film installation measure savings calculations utilize savings factors developed using OpenStudio™ and EnergyPlus™ software simulations of prototypical building models. The prototype building models were sourced from the DOE Commercial Reference Buildings within OpenStudio. Two building types, the public assembly and public safety and health buildings, were developed by DNV, as these building types were not included in the DOE Commercial Reference Buildings. The prototype models were modified for various heating equipment types. All models were based on building energy code and ASHRAE climate zone 4A.

Savings factors are calculated as the difference in simulated energy consumption between the baseline models and the efficient models. An efficient model is created for windows facing each orientation. This is done by changing the window properties to the efficient case in a given orientation, to isolate the effects of installing window film on each orientation, on the building energy consumption. DNV modeled an array of different building types, to represent the

37 DSM Phase VII Non-Residential Window Film Program design assumptions.

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varying types of customers who may participate in this program. DNV encountered three modeling scenarios, related to where windows are installed on the prototypical baseline models:

There are prototype models where there are windows on all four walls. In these cases, the efficient models are run with window film applied to each individual window orientation, to isolate its impact on energy consumption.

In some of the prototype models there are windows only on one orientation. In these cases, the model was rotated by 90 degrees for each orientation in the efficient model, to isolate the effects of the window film installation on that orientation.

Some prototype models did not have windows in the North orientation. In these cases, savings are set to zero as the savings are relatively small compared to the other orientations and the quantity of windows in these building types with north facing windows will likely be relatively small.

Table 3-2 provides building descriptions and the HVAC heating type assumptions depending on the heating fuel type.

Table 3-2. DOE and DNV building type descriptions

Building type	Total floor area (sq. ft.)	No. Floors	Gas heating HVAC system	Electric heating HVAC system	Note
Quick service restaurant	2,500	1	Packaged AC w/ gas furnace	Packaged HP	No north-facing windows; north facing savings factors were not estimated
Full service restaurant	5,500	1	Packaged AC w/ gas furnace	Packaged HP	No north-facing windows; north facing savings factors were not estimated
Hospital	241,351	5	CHW/HW plant w/ VAV & HW reheat	PTHP & DOAS w/ HW coils	
Outpatient healthcare	40,946	3	Packaged VAV w/ HW & electric reheat	Packaged VAV w/ electric reheat	
Large hotel	122,120	6	CHW/HW plant w/ 4-pipe FC	PTHP & Packaged HPs	
Small office	5,500	1	Packaged AC w/ gas furnace	Packaged HP	
Large office	498,588	12	CHW/HW plant w/ VAV & HW reheat	WSHP	
Primary school	73,960	1	Packaged VAV w/ HW reheat	Packaged VAV w/ electric reheat	
Secondary school	210,887	2	CHW/HW plant w/ VAV & HW reheat	WSHP	
Stand-alone retail	24,962	1	Packaged AC w/ gas furnace	Packaged HP	Original model has only east-facing windows. Models were rotated to estimate savings for all cardinal directions

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Building type	Total floor area (sq. ft.)	No. Floors	Gas heating HVAC system	Electric heating HVAC system	Note
Strip mall	22,500	1	Packaged AC w/ gas furnace	Packaged HP	Original model has only east-facing windows. Models were rotated to estimate savings for all cardinal directions
Public assembly	28,024	2	Packaged AC w/ HW coils	Packaged HP	Developed by DNV
Public order and safety	8,734	2	Packaged AC w/ HW reheat	Packaged HP	Developed by DNV
Quick service restaurant	2,500	1	Packaged AC w/ gas furnace	Packaged HP	No north-facing windows; north facing savings factors were not estimated
Full service restaurant	5,500	1	Packaged AC w/ gas furnace	Packaged HP	No north-facing windows; north facing savings factors were not estimated
Hospital	241,351	5	CHW/HW plant w/ VAV & HW reheat	PTHP & DOAS w/ HW coils	
Outpatient healthcare	40,946	3	Packaged VAV w/ HW & electric reheat	Packaged VAV w/ electric reheat	
Large hotel	122,120	6	CHW/HW plant w/ 4-pipe FC	PTHP & Packaged HPs	

Models are run for various locations throughout Dominion Energy's service territory using typical meteorological year 3 (TMY3) data—and modification of a few key window parameters.[38] The assumed values for key parameters affected by addition of window film to single and double pane windows are provided in Table 3-3.

Table 3-3. Key building energy modelling parameters

Window variable	Window type	Baseline value	Source(s)[39]	Efficient value	Source(s)[39]
U-Factor	Single pane	1.23	DEER (1978-2001)	1.23	DEER (1978-2001)
	Double pane	0.77	DEER (1993-2001)	0.77	DEER (1993-2001)
SHGC	Single pane	0.82	DEER (1978-2001)	0.40	Program requirement
	Double pane	0.61	DEER (1993-2001)	0.40	Program requirement

The savings factors are listed per square foot of reflective window film area for each building type and window orientation Table 17-25 to Table 17-34 Table 17-33. Savings factors differ based on the number of panes within

38 See Sub-Appendix I: Cooling and Heating Degree Days and Hours for a description of the weather stations selected for this document.

39 Building vintage ranges defined in DEER, http://www.deeresources.com

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affected windows (single or double) and the heating fuel type of the building (electric or non-electric). Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh \quad = SqFt_{orientation} \times ESF_{orientation}$$

Per-measure, gross coincident summer and winter peak demand reduction is negligible for this measure

Where:

ΔkWh = per-measure gross annual electric energy savings
$SqFt_{orientation}$ = area of window film for each window orientation of a retrofitted building
$ESF_{orientation}$ = annual energy savings factor

3.1.1.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 3-4. Input values for solar window film

Component	Type	Value	Unit	Source(s)
$SqFt_{orientation}$	Variable	See customer application	sq.ft.	Customer application
$ESF_{orientation}$	Variable	See Table 17-25 to Table 17-34 in Sub-Appendix F2-V: Non-residential window film energy saving factors 17.8	kWh/sq.ft.	DOE 2.2 energy modeling software

3.1.1.4 Default savings

No default savings will be awarded for this measure if the proper values are not provided in the customer application.

3.1.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 3-5.

Table 3-5. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
VIII	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	10.00	years	New York TRM 2019 v.7, p. 770[40]
VII	Non-Residential Window Film Program, DSM Phase VII	10.00		Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

[40] California DEER 2014, GlazDaylt-WinFilm

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3.1.1.6 Source(s)

The deemed savings for this measure are determined by using prototypical building energy models defined by California's 2008 Database for Energy Efficient Resources (DEER)[41] and modified to represent program-specific window characteristics for ten cities across Dominion Energy's service territory in Virginia and North Carolina (eight locations in Virginia and two in North Carolina).

3.1.1.7 Update summary

Updates made to this section are described in Table 3-6.

Table 3-6. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	New table	Effective Useful Life (EUL) by program
	Input variable	Updated per-square-foot savings using new building models and revised weather stations
2020	None	No change
v10	Input variable	Updated per-square-foot savings for buildings in North Carolina based on revised weather stations

[41] https://cedars.sound-data.com/

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4 NON-RESIDENTIAL PRESCRIPTIVE PROGRAM, DSM PHASE VI

Dominion's Non-Residential Prescriptive Program provides qualifying business owners incentives to use pursue one or more of the qualified energy efficiency measures through a local, participating contractor in Dominion's contractor network. To qualify for this program, the customer must be responsible for the electric bill and must be the owner of the facility or reasonably able to secure permission to complete the measures. All program measures are summarized in Table 4-1.

Table 4-1. Non-residential prescriptive program measure list

End use	Measure	Manual section
Cooking	Commercial convection oven	Section 4.1.1
	Commercial combination oven	Section 4.1.2
	Commercial fryer	Section 4.1.3
	Commercial griddle	Section 4.1.4
	Commercial hot food holding cabinet	Section 4.1.5
	Commercial steam cooker	Section 4.1.6
	Variable speed drives on kitchen fan	Section 4.1.7
HVAC	Duct testing & sealing	Section 4.2.1
	Unitary/split AC/HP tune-up	Section 4.2.2
Appliance or Plug Load	Smart strip	Section 4.3.1
	Vending machine miser	Section 4.3.2
Refrigeration	Door closer	Section 4.4.1
	Door gasket	Section 4.4.2
	Commercial freezers and refrigerators – solid door	Section 4.4.3
	Commercial ice maker	Section 4.4.4
	Evaporator fan ECM retrofit	Section 4.4.5
	Evaporator fan control	Section 4.4.6
	Floating head pressure control	Section 4.4.7
	Low/no-sweat door film	Section 4.4.8
	Refrigeration night cover	Section 4.4.9
	Refrigerator coil cleaning	Section 4.4.10
	Suction pipe insulation (cooler & freezer)	Section 4.4.11
	Strip curtain (cooler & freezer)	Section 4.4.12

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4.1 Cooking end use

4.1.1 Commercial convection oven

4.1.1.1 Measure description

This measure involves the installation of an ENERGY STAR® qualified commercial convection oven. Commercial convection ovens that are ENERGY STAR certified have higher heavy load cooking efficiencies and lower idle energy rates making them more efficient than standard models.

The baseline equipment is assumed to be a standard-efficiency convection oven with a heavy-load efficiency of 65% for full-size electric ovens (i.e., a convection oven that can accommodate full-size sheet pans measuring 18 x 26 x 1-inch) and 68% for half-size electric ovens (i.e., a convection oven that can accommodate half-size sheet pans measuring 18 x 13 x 1-inch).

This measure is offered through different programs listed in Table 4-2 and uses the impacts estimation approach described in this section.

Table 4-2. Programs that offer this measure

Program name	Section
Non-Residential Prescriptive Program, DSM Phase VI	Section 4.1.1
Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII	Section 9.1.2
Non-Residential Prescriptive Enhanced Program, DSM Phase IX	Section 16.1.1

4.1.1.2 Impacts estimation approach

The baseline annual electric energy consumption is calculated as follows:

$$kWh_{base} = \left[lb_{daily} \times \frac{E_{conv}}{\eta_{base}} + kW_{base,idle} \times \left(Hours_{daily} - \frac{lb_{daily}}{PC_{base}}\right)\right] \times Days$$

The efficient annual electric energy consumption is calculated as follows:

$$kWh_{ee} = \left[lb_{daily} \times \frac{E_{conv}}{\eta_{ee}} + kW_{ee,idle} \times \left(Hours_{daily} - \frac{lb_{daily}}{PC_{ee}}\right)\right] \times Days$$

Per-measure, gross annual electric energy savings are calculated using the following equations:

$$\Delta kWh = kWh_{base} - kWh_{ee}$$

Per-measure, gross coincident summer peak demand reduction is calculated using the following equation:

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$$\Delta kW_{summer} = \frac{\Delta kWh}{(Hours_{daily} \times Days)} \times CF_{summer}$$

Per-measure, gross coincident winter peak demand reduction is calculated using the following equation:

$$\Delta kW_{winter} = \frac{\Delta kWh}{(Hours_{daily} \times Days)} \times CF_{winter}$$

where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per- measure gross coincident summer peak demand reduction
ΔkW_{winter} = per- measure gross coincident winter peak demand reduction
$hours_{daily}$ = average daily operating hours
$E_{conv.}$ = ASTM Energy to Food; the amount of energy absorbed by food during convection cooking
lb_{daily} = pounds of food cooked per day
days = annual days of operation
η_{base} = baseline equipment cooking energy efficiency
η_{ee} = efficient equipment cooking energy efficiency
$kW_{base,idle}$ = baseline equipment idle energy rate
$kW_{ee,idle}$ = efficient equipment idle energy rate
PC_{base} = baseline equipment production capacity
PC_{ee} = efficient equipment production capacity
CF_{summer} = summer peak coincidence factor
CF_{winter} = winter peak coincidence factor

4.1.1.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 4-3. Input parameters for convection oven

Component	Type	Value	Units	Source(s)
$Hours_{daily}$	Variable	See customer application	hours, daily	Customer application
		For defaults see Table 17-17 in Sub-Appendix F2-V: Non-residential commercial kitchen inputs		Maryland/Mid-Atlantic TRM v.10, p. 383
Days	Variable	See customer application	days, annual	Customer application
		For defaults see Table 17-17 in Sub-Appendix F2-V: Non-residential commercial kitchen inputs		Maryland/Mid-Atlantic TRM v.10, p. 383
lb_{daily}	Variable	See customer application	lb, daily	Customer application
		Default: 100		Maryland/Mid-Atlantic TRM v.10, p. 383
E_{conv}	Fixed	0.0732	kWh/lb	Maryland/Mid-Atlantic TRM v.10, p. 383

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Component	Type	Value	Units	Source(s)
PC_{base}	Variable	Half Size: 45 Full Size: 90	lb/hour	Maryland/Mid-Atlantic TRM v.10, p. 383
η_{base}	Variable	Half Size: 0.68 Full Size: 0.65	-	Maryland/Mid-Atlantic TRM v.10, p. 383
$kW_{base,idle}$	Variable	Half Size:1.03 Full Size: 2.00	kW	Maryland/Mid-Atlantic TRM v.10, p. 383
$kW_{ee,idle}$	Variable	Half Size: 1.00 Full Size: 1.60	kW	Maryland/Mid-Atlantic TRM v.10, p. 382
PC_{ee}	Variable	Half Size: 50 Full Size: 90	lb/hour	Maryland/Mid-Atlantic TRM v.10, p. 383
η_{ee}	Variable	Half Size: 0.71 Full Size: 0.71	-	Maryland/Mid-Atlantic TRM v.10, p. 383
CF_{summer}	Fixed	1.0	-	Maryland/Mid-Atlantic TRM v.10, p. 384[42]
CF_{winter}	Fixed	1.0	-	Maryland/Mid-Atlantic TRM v.10, p. 384[42]

4.1.1.4 Default savings

If the proper values are not supplied, a default savings may be applied using conservative input values. The default per-measure gross annual electric energy savings for a half size convection oven will be assigned as follows:

$$kWh_{base} = \left[lb_{daily} \times \frac{E_{conv}}{\eta_{base}} + kW_{base,idle} \times \left(Hours_{daily} - \frac{lb_{daily}}{PC_{base}}\right)\right] \times\ Days$$

$$= \left[100\ lb\ \times \frac{0.0732\ kW/lb}{0.68} + 1.03\ kW \times \left(13.1\ hr - \frac{100\ \ lb/day}{45\ \ lb/hr}\right)\right] \times\ 307\ days$$

$$= 6{,}744.43\ kWh$$

$$kWh_{ee} = \left[lb_{daily} \times \frac{E_{conv}}{\eta_{ee}} + kW_{ee,idle} \times \left(Hours_{daily} - \frac{lb_{daily}}{PC_{ee}}\right)\right] \times\ Days$$

$$= \left[100\ lb\ \times \frac{0.0732\ kW/lb}{0.71} + 1.00\ kW \times \left(13.1\ hr - \frac{100\ \ lb/day}{50\ \ lb/hr}\right)\right] \times\ 307\ days$$

$$= 6{,}572.83\ kWh$$

$$\Delta kWh = kWh_{base} -\ kWh_{ee}$$

[42] No specific study of commercial kitchen equipment coincident peak demand savings is available. In the absence of this information, a simple average demand value is used: Annual energy savings divided by the total annual hours of operation and the coincidence factor is 1.0.

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$$= 6{,}744\ kWh - 6{,}572\ kWh$$

$$= 171.60\ kWh$$

Per-measure, default gross coincident summer peak demand reduction is calculated using the following calculation:

$$\Delta kW_{summer} = \frac{\Delta kWh}{(Hours_{daily} \times Days)} \times CF_{summer}$$

$$= \frac{172\ kWh}{(13.1\ hr \times 307\ day)} \times 1.0$$

$$= 0.043\ kW$$

Per-measure, default gross coincident winter peak demand reduction is calculated using the following calculation:

$$\Delta kW_{winter} = \frac{\Delta kWh}{(Hours_{daily} \times Days)} \times CF_{winter}$$

$$= \frac{172\ kWh}{(13.1\ hr \times 307\ day)} \times 1.0$$

$$= 0.043\ kW$$

4.1.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 4-4.

Table 4-4. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	12.00	years	Maryland/Mid-Atlantic TRM v.10, p. 385
VIII	Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII			
VI	Non-Residential Prescriptive Program, DSM Phase VI	6.30	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

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4.1.1.6 Source(s)

The primary sources for this deemed savings approach is the Maryland/Mid-Atlantic TRM v.10, pp. 382-385.

4.1.1.7 Update summary

Updates made to this section are described in Table 4-5.

Table 4-5. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the Mid-Atlantic TRM
	Input variable	Updated $Hour_{daily}$ and Days values and default customer building type
	Equation	Added equation for coincident winter peak demand reduction
	New table	Effective Useful Life (EUL) by program
2020	None	No change
v10	Source	Updated page numbers / version of the Mid-Atlantic TRM
	Input variable	Clarified default assumption values

4.1.2 Commercial combination oven

4.1.2.1 Measure description

This measure involves the installation of an ENERGY STAR® qualified combination oven. A combination oven is a convection oven that includes the added capability to inject steam into the oven cavity and typically offers at least three distinct cooking modes. This measure applies to time of sale opportunities. The baseline equipment is assumed to be a typical standard-efficiency electric combination oven.

This measure is offered through different programs listed in Table 4-6 and uses the impacts estimation approach described in this section.

Table 4-6. Programs that offer this measure

Program name	Section
Non-Residential Prescriptive Program, DSM Phase VI	Section 4.1.2
Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII	Section 9.1.1
Non-Residential Prescriptive Enhanced Program, DSM Phase IXNon-Residential Prescriptive Enhanced Program, DSM Phase IX	Section 16.1.2

4.1.2.2 Impacts estimation approach

The baseline annual electric energy consumption is calculated as follows:

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$$kWh_{base,conv} = \left[lb_{daily} \times \frac{E_{conv}}{\eta_{base,conv}} + kW_{base,conv,idle} \times \left(Hours_{daily} - \frac{lb_{daily}}{PC_{base,conv}}\right)\right] \times (1 - PCT_{steam}) \times Day$$

$$kWh_{base,steam} = \left[lb_{daily} \times \frac{E_{steam}}{\eta_{base,steam}} + kW_{base,steam,idle} \times \left(Hours_{daily} - \frac{lb_{daily}}{PC_{base,steam}}\right)\right] \times PCT_{steam} \times Days$$

$$kWh_{base} = kWh_{base,conv} + kWh_{base,steam}$$

The efficient annual electric energy consumption is calculated as follows:

$$kWh_{ee,conv} = \left[lb_{daily} \times \frac{E_{conv}}{\eta_{ee,conv}} + kW_{ee,conv,idle} \times \left(Hours_{daily} - \frac{lb_{daily}}{PC_{ee,conv}}\right)\right] \times (1 - PCT_{steam}) \times Days$$

$$kWh_{ee,steam} = \left[lb_{daily} \times \frac{E_{steam}}{\eta_{ee,steam}} + kW_{ee,steam,idle} \times \left(Hours_{daily} - \frac{lb_{daily}}{PC_{ee,steam}}\right)\right] \times PCT_{steam} \times Days$$

$$kWh_{ee} = kWh_{ee,conv} + kWh_{ee,steam}$$

Per-measure, gross annual electric energy savings are calculated using the following equation:

$$\Delta kWh = kWh_{base} - kWh_{ee}$$

Per-measure, gross coincident summer peak demand reduction is calculated using the following equation:

$$kW_{summer} = \frac{\Delta kWh}{(Hours_{daily} \times Days)} \times CF_{summer}$$

Per-measure, gross coincident winter peak demand reduction is calculated using the following equation:

$$kW_{winter} = \frac{\Delta kWh}{(Hours_{daily} \times Days)} \times CF_{winter}$$

Per-measure, gross annual water savings are calculated according to the following equation:

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$$\Delta Water = (Water_{base} - Water_{ee}) \times Hours_{daily} \times PCT_{steam} \times Days$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure gross coincident winter peak demand reduction
kWh_{base} = annual energy usage of the baseline equipment
kWh_{ee} = annual energy usage of the efficient equipment
$kWh_{base,conv}$ = baseline annual cooking energy consumption in convection mode
$kWh_{base,steam}$ = baseline annual steam energy consumption in steam mode
$kW_{base,conv,idle}$ = baseline idle energy rate in convection mode
$kW_{base,steam,idle}$ = baseline idle energy rate in steam mode
$kWh_{ee,conv}$ = efficient annual cooking energy consumption in convection mode
$kWh_{ee,steam}$ = efficient annual steam energy consumption in steam mode
$kW_{ee,conv,idle}$ = efficient idle energy rate in convection mode
$kW_{ee,steam,idle}$ = efficient idle energy rate in steam mode
$\Delta Water$ = per-measure gross annual water savings
$Hours_{daily}$ = average daily operating hours
$Days$ = annual days of operation
lb_{daily} = pounds of food cooked per day
E_{conv} = ASTM Energy to Food, the amount of energy absorbed by the food during convection mode cooking, per pound of food
E_{steam} = ASTM Energy to Food, the amount of energy absorbed by the food during steam cooking mode, per pound of food
$\eta_{base,conv}$ = baseline equipment cooking energy efficiency in convection mode
$\eta_{base,steam}$ = baseline equipment cooking energy efficiency in steam mode
$\eta_{ee,conv}$ = efficient equipment cooking energy efficiency in convection mode
$\eta_{ee,steam}$ = efficient equipment cooking energy efficiency in steam mode
PCT_{steam} = percent of food cooked in steam cooking mode
$PC_{base,conv}$ = baseline equipment production capacity in convection mode
$PC_{ee,conv}$ = efficient equipment production capacity in convection mode
$PC_{base,steam}$ = baseline equipment production capacity in steam mode
$PC_{ee,steam}$ = efficient equipment production capacity in steam mode
$Water_{base}$ = average water consumption rate of baseline combination ovens
$Water_{ee}$ = average water consumption rate of efficient combination ovens
CF_{summer} = summer peak coincidence factor
CF_{winter} = winter peak coincidence factor

4.1.2.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 4-7. Input parameters for commercial electric combination ovens

Component	Type	Value	Units	Source(s)
$Hours_{daily}$	Variable	See customer application	hours, daily	Customer application
		For defaults see Table 17-17 in Sub-Appendix F2-V: Non-		Maryland/Mid-Atlantic TRM v.10, p. 387

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Component	Type	Value	Units	Source(s)
		residential commercial kitchen inputs		
Days	Variable	See customer application	days, annual	Customer application
		For defaults see Table 17-17 in Sub-Appendix F2-V: Non-residential commercial kitchen inputs		Maryland/Mid-Atlantic TRM v.10, p. 387
lb_{daily}	Variable	See customer application	pounds, daily	Customer application
		Default: 200		Maryland/Mid-Atlantic TRM v.10, p. 387
PCT_{steam}	Variable	See customer application	-	Customer application
		Default: 0.50		Maryland/Mid-Atlantic TRM v.10, p. 387
PCT_{conv}	Variable	See customer application	-	Maryland/Mid-Atlantic TRM v.10, p. 387
		Default: 0.50		
E_{conv}	Fixed	0.0732	kWh/lb	Maryland/Mid-Atlantic TRM v.10, p. 387
E_{steam}	Fixed	0.0308	kWh/lb	Maryland/Mid-Atlantic TRM v.10, p. 387
$PC_{base,conv}$	Variable	<15 pans: 79 ≥15 pans: 166	lb/hr	Maryland/Mid-Atlantic TRM v.10, p. 387
$PC_{base,steam}$	Variable	<15 pans: 126 ≥15 pans: 295	lb/hr	Maryland/Mid-Atlantic TRM v.10, p. 387
$\eta_{base,conv}$	Fixed	0.72	-	Maryland/Mid-Atlantic TRM v.10, p. 387
$\eta_{base,steam}$	Fixed	0.49	-	Maryland/Mid-Atlantic TRM v.10, p. 387
$kW_{base,conv,idle}$	Variable	<15 pans: 1.320 ≥15 pans: 2.280	kW	Maryland/Mid-Atlantic TRM v.10, p. 387
$kW_{base,steam,idle}$	Variable	<15 pans: 5.260 ≥15 pans: 8.710	kW	Maryland/Mid-Atlantic TRM v.10, p. 387
$kW_{ee,conv,idle}$[43]	Variable	<15 pans: 1.299 ≥15 pans: 2.099	kW	Maryland/Mid-Atlantic TRM v.10, p. 387
$kW_{ee,steam,idle}$[44]	Variable	<15 pans: 1.970 ≥15 pans: 3.300	kW	Maryland/Mid-Atlantic TRM v.10, p. 387
$PC_{ee,conv}$	Variable	<15 pans: 119 ≥15 pans: 201	lb/hr	Maryland/Mid-Atlantic TRM v.10, p. 387
$PC_{ee,steam}$	Variable	<15 pans: 177 ≥15 pans: 349	lb/hr	Maryland/Mid-Atlantic TRM v.10, p. 387
$\eta_{ee,conv}$	Fixed	0.76	-	Maryland/Mid-Atlantic TRM v.10, p. 387
$\eta_{ee,steam}$	Fixed	0.55	-	Maryland/Mid-Atlantic TRM v.10, p. 387
$Water_{base}$	Fixed	40.0	gal/ hr	Ohio TRM 2010, p. 260[45]

43 Maryland/Mid-Atlantic TRM v.10 provided an equation for calculating this value based on number of pans, as follows: =0.080 x Number of pans + 0.4989. To establish fixed kW values for efficient equipment, DNV reviewed the list of qualifying ENERGY STAR electric combination ovens and determined the mode for the number of pans: 10 pans is the mode for units having <15 pans (11 of 27 models or 41%); and 20 pans is the mode of capacity for units having ≥15 pans (5 of 7 models or 70%). These modes were used to calculate the kW values for <15 pans and ≥15 pans, respectively.

44 Maryland/Mid-Atlantic TRM v.10 provided an equation for calculating this value based on number of pans, as follows: = 0.133 x Number of pans + 0.64. To establish fixed kW values for efficient equipment, the list of qualifying ENERGY STAR electric combination ovens was reviewed to determine t the mode for the number of pans: 10 pans is the mode for units having <15 pans (11 of 27 models or 41%); and 20 pans is the mode of capacity for units having ≥15 pans (5 of 7 models or 70%). These modes were used to calculate the kW values for <15 pans and ≥15 pans, respectively.

45 Ohio TRM Revised Edition, 2013. Food Service Technology Center (FSTC), based on assumption that baseline ovens use water at an average rate of 40 gal/hr while the efficient models use water at an average rate of 20 gal/hr.

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Component	Type	Value	Units	Source(s)
$Water_{ee}$	Fixed	20.0	gal/ hr	Ohio TRM 2010, p. 260[46]
CF_{summer}	Fixed	1.0	-	Maryland/Mid-Atlantic TRM v.10, p. 387[47]
CF_{winter}	Fixed	1.0	-	Maryland/Mid-Atlantic TRM v.10, p. 387[47]

4.1.2.4 Default savings

If the proper values are not supplied, a default savings may be applied using conservative input values. The default efficient annual electric energy consumption will be as follows for <15 pans:

$$kWh_{base,conv} = \left[lb_{daily} \times \frac{E_{conv}}{\eta_{base}} + kW_{base,conv,idle} \times \left(Hours_{daily} - \frac{lb_{daily}}{PC_{base,conv}}\right)\right] \times (1 - PCT_{steam}) \times Days$$

$$= \left[200\ lb \times \frac{0.0732\ \ kWh/lb}{0.72} + 1.320\ kW \times \left(13.1\ hr - \frac{200\ lb}{79\ \ lb/hr}\right)\right] \times (1 - 0.50) \times 307\ days$$

$$= 5{,}262.53\ kWh$$

$$kWh_{base,steam} = \left[lb_{daily} \times \frac{E_{steam}}{\eta_{base}} + kW_{base,steam,idle} \times \left(Hours_{daily} - \frac{lb_{daily}}{PC_{base,steam}}\right)\right] \times PCT_{steam} \times Days$$

$$= \left[200\ lb \times \frac{0.0308\ \ kWh/lb}{0.49} + 5.260\ kW \times \left(13.1\ hr - \frac{200\ lb}{126\ \ lb/hr}\right)\right] \times 0.50 \times 307\ days$$

$$= 11{,}225.18\ kWh$$

46 Ibid

47 No specific study of commercial kitchen equipment coincident peak demand savings is available. In the absence of this information, a simple average demand value is used: Annual energy savings divided by the total annual hours of operation and the coincidence factor is 1.0.

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$$kWh_{base} = kWh_{base,conv} + kWh_{base,steam}$$

$$= 5{,}263\ kWh + 11{,}225\ kWh$$

$$= 16{,}487.71\ kWh$$

The efficient annual electric energy consumption is calculated as follows:

$$kWh_{ee,conv} = \left[lb_{daily} \times \frac{E_{conv}}{\eta_{ee,conv}} + kW_{ee,conv,idle} \times \left(Hours_{daily} - \frac{lb_{daily}}{PC_{ee,conv}}\right)\right] \times (1 - PCT_{steam}) \times Days$$

$$= \left[200\ lb \times \frac{0.0732\ kWh/lb}{0.76} + 1.299\ kW \times \left(13.1\ hr - \frac{200\ lb}{119\ lb/hr}\right)\right] \times (1 - 0.50) \times 307\ days$$

$$= 5{,}233.87\ kWh$$

$$tankWh_{ee,steam} = \left[lb_{daily} \times \frac{E_{steam}}{\eta_{ee,steam}} + kW_{ee,steam,idle} \times \left(Hours_{daily} - \frac{lb_{daily}}{PC_{ee,steam}}\right)\right] \times PCT_{steam} \times Days$$

$$= \left[200\ lb \times \frac{0.0308\ kWh/lb}{0.55} + 1.970\ kW \times \left(13.1\ hr - \frac{200\ lb}{177\ lb/hr}\right)\right] \times 0.50 \times 307\ days$$

$$= 5{,}338.89\ kWh$$

$$kWh_{ee} = kWh_{ee,conv} + kWh_{ee,steam}$$

$$= 5{,}234\ kWh + 5{,}339\ kWh$$

$$= 10{,}572.75\ kWh$$

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Per-measure, gross annual electric energy savings are calculated using the following equation:

$$\Delta kWh = kWh_{base} - kWh_{ee}$$

$$= 16{,}488\ kWh - 10{,}573\ kWh$$

$$= 5{,}914.96\ kWh$$

Per- measure, gross coincident summer peak demand reduction is calculated using the following equation:

$$\Delta kW_{summer} = \frac{\Delta kWh}{Hours_{daily} \times Days} \times CF_{summer}$$

$$= \frac{5{,}915\ kWh}{13.1\ hr \times 307\ days} \times 1.0$$

$$= 1.47\ kW$$

Per- measure, gross coincident winter peak demand reduction is calculated using the following equation:

$$\Delta kW_{winter} = \frac{\Delta kWh}{Hours_{daily} \times Days} \times CF_{winter}$$

$$= \frac{5{,}915\ kWh}{13.1\ hr \times 307\ days} \times 1.0$$

$$= 1.47\ kW$$

Per- measure, gross annual water savings are calculated according to the following equation.

$$\Delta Water = (Water_{base} - Water_{ee}) \times Hours_{daily} \times PCT_{steam} \times Days$$

$$= (40 - 20) gal/hr \times 13.1\ hr \times 0.5 \times 307 days$$

$$= 40{,}217 \text{ gallons}$$

4.1.2.5 Effective Useful Life

The effective useful life of this measure is provided in Table 4-8.

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Table 4-8. Effective Useful Life for Lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	12.00	years	Maryland/Mid-Atlantic TRM v.10, p. 389
VIII	Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII			
VI	Non-Residential Prescriptive Program, DSM Phase VI	6.30	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

4.1.2.6 Source(s)

The primary sources for this deemed savings approach is the Maryland/Mid-Atlantic TRM v.10, p. 383 and pp. 386-389.

4.1.2.7 Update summary

Updates made to this section are described in Table 4-9.

Table 4-9. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the Mid-Atlantic TRM
	Input variable	Updated $Hour_{daily}$ and Days values based on the customer building type Added $Water_{base}$ and $Water_{ee}$ constants for water savings calculation
	Equation	Added equation for coincident winter peak demand reduction Added gross annual water savings equation
	Default savings	Added default gross annual water savings value
	New table	Effective Useful Life (EUL) by program
2020	None	No change
v10	Source	Updated page numbers / version of the Mid-Atlantic TRM
	Equation	Added Qty to savings equations
	Input variable	Updated $Hours_{daily}$, Days, $kW_{ee,conv,idle}$, and $kW_{ee,steam,idle}$ value

4.1.3 Commercial fryer

4.1.3.1 Measure description

This measure involves the installation of an ENERGY STAR® qualified electric commercial fryer. Commercial fryers with the ENERGY STAR® designation offer shorter cook times and higher production rates through advanced burner

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and heat exchanger designs. Further, fry-pot insulation reduces standby losses resulting in a lower idle energy rate. This measure applies to both standard-size and large-vat fryers.

The baseline equipment is assumed to be a standard-efficiency electric fryer with a heavy load efficiency of 75% for standard sized equipment and 70% for large vat equipment.[48]

This measure is offered through different programs listed in Table 4-10 and uses the impacts estimation approach described in this section.

Table 4-10. Programs that offer this measure

Program name	Section
Non-Residential Prescriptive Program, DSM Phase VI	Section 4.1.3
Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII	Section 9.1.4
Non-Residential Prescriptive Enhanced Program, DSM Phase IX	Section 16.1.3

4.1.3.2 Impacts estimation approach

The baseline per-measure gross annual electric energy usage is calculated using the following equation:

$$kWh_{base} = \left[lb_{daily} \times \frac{E_{fry}}{\eta_{base}} + kW_{base,idle} \times \left(Hours_{daily} - \frac{lb_{daily}}{PC_{base}}\right)\right] \times Days$$

Similarly, the efficient per-measure gross annual electric energy usage is calculated using the following equation:

$$kWh_{ee} = \left[lb_{daily} \times \frac{E_{fry}}{\eta_{ee}} + kW_{ee,idle} \times \left(Hours_{daily} - \frac{lb_{daily}}{PC_{ee}}\right)\right] \times Days$$

Per-measure, gross annual energy savings are calculated using the following equation:

$$\Delta kWh = kWh_{base} - kWh_{ee}$$

Per-measure, gross coincident summer peak demand reduction is calculated using the following equation:

$$\Delta kW_{summer} = \frac{\Delta kWh}{(Hours_{daily} \times Days)} \times CF_{summer}$$

Per-measure, gross coincident winter peak demand reduction is calculated using the following equation:

$$\Delta kW_{winter} = \frac{\Delta kWh}{(Hours_{daily} \times Days)} \times CF_{winter}$$

[48] Standard fryers measure 12-18 in. wide and have a shortening capacity of 25-65 lb; large fryers measure 18-24-in. wide and have a shortening capacity greater than 50 lb.

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Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure gross coincident winter peak demand reduction
kWh_{base} = per-measure annual energy usage of the baseline equipment
kWh_{ee} = per-measure annual energy usage of the efficient equipment
$hours_{daily}$ = average daily operating hours
E_{fry} = ASTM Energy to Food ratio, the amount of energy absorbed by each pound of food during frying
lb_{daily} = pounds of food cooked per day
$days$ = annual days of operation
η_{base} = baseline equipment cooking energy efficiency
η_{eff} = efficient equipment cooking energy efficiency
$kW_{base,idle}$ = baseline equipment idle energy rate
$kW_{ee,idle}$ = efficient equipment idle energy rate
PC_{base} = baseline equipment production capacity
PC_{ee} = efficient equipment production capacity
CF_{summer} = summer peak coincidence factor
CF_{winter} = winter peak coincidence factor

4.1.3.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 4-11. Input parameters for electric commercial fryer measure

Component	Type	Value	Units	Source(s)
$Hours_{daily}$	Variable	See customer application	hours, daily	Customer application
		Default: Standard fryer: 16 Large-vat fryer: 12		Maryland/Mid-Atlantic TRM v.10, p. 371
E_{fry}	Fixed	0.167	kWh/lb	Maryland/Mid-Atlantic TRM v.10, p. 371
lb_{daily}	Variable	See customer application	lb, daily	Customer application
		Default: 150		Maryland/Mid-Atlantic TRM v.10, p. 371
Days	Variable	See customer application	days, annual	Customer application
		Default: 365		Maryland/Mid-Atlantic TRM v.10, p. 371
η_{base}	Variable	Standard fryer: 0.75 Large-vat fryer: 0.70	-	Maryland/Mid-Atlantic TRM v.10, p. 371
$kW_{base,idle}$	Variable	Standard fryer: 1.05 Large-vat fryer: 1.35	kW	Maryland/Mid-Atlantic TRM v.10, p. 371
PC_{base}	Variable	Standard fryer: 65 Large-vat fryer: 100	lb/hr	Maryland/Mid-Atlantic TRM v.10, p. 371
η_{ee}	Variable	Standard fryer: 0.83 Large-vat fryer: 0.80	-	Maryland/Mid-Atlantic TRM v.10, p. 371
$kW_{ee,idle}$	Variable	Standard fryer: 0.80 Large-vat fryer: 1.10	kW	Maryland/Mid-Atlantic TRM v.10, p. 371
PC_{ee}	Variable	Standard fryer: 70 Large-vat fryer: 110	lb/hr	Maryland/Mid-Atlantic TRM v.10, p. 371

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Component	Type	Value	Units	Source(s)
CF_{summer}	Fixed	1.0	-	Maryland/Mid-Atlantic TRM v.10, p. 371[49]
CF_{winter}	Fixed	1.0	-	Maryland/Mid-Atlantic TRM v.10, p. 371[49]

4.1.3.4 Default savings

If the proper values are not supplied, a default savings may be applied using conservative input values. The default per-measure gross annual electric energy savings will be assigned according to the following calculation (assuming for a standard fryer):

$$kWh_{base} = \left[lb_{daily} \times \frac{E_{fry}}{\eta_{base}} + kW_{base,idle} \times \left(Hours_{daily} - \frac{lb_{daily}}{PC_{base}}\right)\right] \times Days$$

$$= \left[150\ lb \times \frac{0.167\ kW/lb}{0.75} + 1.05\ kW \times \left(16\ hr - \frac{150\ lb/day}{65\ lb/hr}\right)\right] \times 365\ days$$

$$= 17{,}438.58\ kWh$$

$$kWh_{ee} = \left[lb_{daily} \times \frac{E_{fry}}{\eta_{ee}} + kW_{ee,idle} \times \left(Hours_{daily} - \frac{lb_{daily}}{PC_{base}}\right)\right] \times Days$$

$$= \left[150\ lb \times \frac{0.167\ kW/lb}{0.83} + 0.80\ kW \times \left(16\ hr - \frac{150\ lb/day}{70\ lb/hr}\right)\right] \times 365\ days$$

$$= 15{,}062.25\ kWh$$

$$\Delta kWh = kWh_{base} - kWh_{ee}$$

$$= 17{,}439\ kWh - 15{,}062\ kWh$$

$$= 2{,}376.33\ kWh$$

[49] No specific study of commercial kitchen equipment coincident peak demand savings is available. In the absence of this information, a simple average demand value is used: Annual energy savings divided by the total annual hours of operation and the coincidence factor is 1.0.

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The default per-measure gross coincident summer peak demand reduction is calculated using the following calculation:

$$\Delta kW_{summer} = \frac{\Delta kWh}{(Hours_{daily} \times Days)} \times CF_{summer}$$

$$= \frac{2{,}376.33\ kWh}{(16\ hr \times 365\ days)} \times 1.0$$

$$= 0.407\ kW$$

The default per-measure gross coincident winter peak demand reduction is calculated using the following calculation:

$$\Delta kW_{winter} = \frac{\Delta kWh}{(Hours_{daily} \times Days)} \times CF_{winter}$$

$$= \frac{2{,}376.33\ kWh}{(16\ hr \times 365\ days)} \times 1.0$$

$$= 0.407\ kW$$

4.1.3.5 Effective Useful Life

The effective useful life of this measure is provided in Table 4-12.

Table 4-12. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	12.00	years	Maryland/Mid-Atlantic TRM v.10, p. 372
VIII	Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII			
VI	Non-Residential Prescriptive Program, DSM Phase VI	6.30	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

4.1.3.6 Source(s)

The primary sources for this deemed savings approach is the Maryland/Mid-Atlantic TRM v.10, pp. 370-372.

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4.1.3.7 Update summary

Updates made to this section are described in Table 4-13.

Table 4-13. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the Mid-Atlantic TRM
	Equation	Added equation for coincident winter peak demand reduction
	New table	Effective Useful Life (EUL) by program
2020	None	No change
v10	Source	Updated page numbers / version of the Mid-Atlantic TRM

4.1.4 Commercial griddle

4.1.4.1 Measure description

This measure involves the installation of an ENERGY STAR® qualified commercial griddle. ENERGY STAR® qualified commercial griddles have higher cooking energy efficiency and lower idle energy rates than standard equipment. The result is more energy being absorbed by the food compared with the total energy use, and less wasted energy when the griddle is in standby mode. This measure applies to only 10-sq.ft. commercial griddles due to Dominion Energy program requirements.

The baseline equipment is assumed to be a standard-efficiency electric griddle with a cooking-energy efficiency of 65%.

This measure is offered through different programs listed in Table 4-14 and uses the impacts estimation approach described in this section.

Table 4-14. Programs that offer this measure

Program name	Section
Non-Residential Prescriptive Program, DSM Phase VI	Section 4.1.4
Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII	Section 9.1.3
Non-Residential Prescriptive Enhanced Program, DSM Phase IX	Section 16.1.4

4.1.4.2 Impacts estimation approach

Per-measure, gross annual electric energy savings are calculated using the following equations:

$$\Delta kWh \quad = kWh_{base} - kWh_{ee}$$

where,

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$$kWh_{base} = \left[lb_{daily} \times \frac{E_{griddle}}{\eta_{base}} + kW_{base,idle} \times SqFt \times \left(Hours_{daily} - \frac{lb_{daily}}{PC_{base} \times SqFt}\right)\right] \times Days$$

and

$$kWh_{ee} = \left[lb_{daily} \times \frac{E_{griddle}}{\eta_{ee}} + kW_{ee,idle} \times SqFt \times \left(Hours_{daily} - \frac{lb_{daily}}{PC_{ee} \times SqFt}\right)\right] \times Days$$

Per-measure, gross coincident summer peak demand reduction is calculated using the following equation:

$$\Delta kW_{summer} = \frac{\Delta kWh}{(Hours_{daily} \times Days)} \times CF_{summer}$$

Per-measure, gross coincident winter peak demand reduction is calculated using the following equation:

$$\Delta kW_{winter} = \frac{\Delta kWh}{(Hours_{daily} \times Days)} \times CF_{winter}$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure gross coincident winter peak demand reduction
kWh_{base} = per-measure annual energy usage of the baseline equipment
kWh_{ee} = per-measure annual energy usage of the efficient equipment
SqFt = surface area of griddle
$Hours_{daily}$ = average daily operating hours
$E_{griddle}$ = ASTM Energy to Food ratio, the amount of energy absorbed by each pound of food during griddling
lb_{daily} = pounds of food cooked per day
Days = annual days of operation
η_{base} = baseline equipment cooking energy efficiency
η_{ee} = efficient equipment cooking energy efficiency
$kW_{base,idle}$ = baseline equipment idle energy rate
$kW_{ee,idle}$ = efficient equipment idle energy rate
PC_{base} = baseline equipment production capacity
PC_{ee} = efficient equipment production capacity
CF_{summer} = summer peak coincidence factor
CF_{winter} = winter peak coincidence factor

4.1.4.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

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Table 4-15. Input parameters for commercial griddle measure

Component	Type	Value	Units	Source(s)
lb_{daily}	Variable	See customer application	lb, daily	Customer application
		Default: 100		Maryland/Mid-Atlantic TRM v.10, p. 380
SqFt	Variable	See customer application	sq.ft	Customer application
$Hours_{daily}$	Variable	See customer application	hours, daily	Customer application
		For defaults see Table 17-17 in Sub-Appendix F2-V: Non-residential commercial kitchen inputs		Maryland/Mid-Atlantic TRM v.10, p. 380[50], for default the Dominion Energy 2020 Commercial Energy Survey Appendix B, p.3 weighted average of building types is used
Days	Variable	See customer application	days, annual	Customer application
		For defaults see Table 17-17 in Sub-Appendix F2-V: Non-residential commercial kitchen inputs		Maryland/Mid-Atlantic TRM v.10, p. 38050, for default the Dominion Energy 2020 Commercial Energy Survey Appendix B, p.3 weighted average of building types is used
$E_{griddle}$	Fixed	0.139	kWh/lb	Maryland/Mid-Atlantic TRM v.10, p. 380
PC_{base}	Fixed	5.83	lb/hr/sq.ft	Maryland/Mid-Atlantic TRM v.10, p. 380
η_{base}	Fixed	0.65	-	Maryland/Mid-Atlantic TRM v.10, p. 380
$kW_{base,idle}$	Fixed	0.40	kW/sq.ft	Maryland/Mid-Atlantic TRM v.10, p. 380
$kW_{ee,idle}$	Fixed	0.32	kW/sq.ft	Maryland/Mid-Atlantic TRM v.10, p. 380
PC_{ee}	Fixed	6.67	lb/hr/sq.ft	Maryland/Mid-Atlantic TRM v.10, p. 380
η_{ee}	Fixed	0.70	-	Maryland/Mid-Atlantic TRM v.10, p. 380
CF_{summer}	Fixed	1.0	-	Maryland/Mid-Atlantic TRM v.10, p. 380[51]
CF_{winter}	Fixed	1.0	-	Maryland/Mid-Atlantic TRM v.10, p. 380[51]

4.1.4.4 Default savings

There are no default savings for this measure. Applicant will need to provide the surface area of the griddle in square feet, for savings to be calculated. Default values are provided for most other input parameters.

4.1.4.5 Effective Useful Life

The Effective Useful Life of this measure is provided in Table 4-16.

[50] Maryland/Mid-Atlantic TRM v. 10 uses customer application values for hours and days with a default provided. For consistency with commercial convection oven the same hours and days are used for his measure.

[51] No specific study of commercial kitchen equipment coincident peak demand savings is available. In the absence of this information, a simple average demand value is used: Annual energy savings divided by the total annual hours of operation and the coincidence factor is 1.0.

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Table 4-16. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	12.00	years	Maryland/Mid-Atlantic TRM v.10, p. 379
VIII	Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII			
VI	Non-Residential Prescriptive Program, DSM Phase VI	6.30	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

4.1.4.6 Source(s)

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v.10, pp. 379-381.

4.1.4.7 Update summary

Updates made to this section are described in Table 4-17.

Table 4-17. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the Mid-Atlantic TRM
	Equation	Added equation for coincident winter peak demand reduction
	New table	Effective Useful Life (EUL) by program
2020	None	No change
v10	Source	Updated page numbers / version of the Mid-Atlantic TRM

4.1.5 Commercial hot food holding cabinet

4.1.5.1 Measure description

This measure involves installing an ENERGY STAR® qualified commercial hot food holding cabinet. The installed equipment will incorporate better insulation, reducing heat loss, and may also offer additional energy saving devices such as magnetic door gaskets, auto-door closures, or Dutch doors. The insulation of the cabinet also offers better temperature uniformity within the cabinet from top to bottom. This means that qualified hot food holding cabinets are more efficient at maintaining food temperature while using less energy.

The baseline equipment is assumed to be a standard-efficiency hot food holding cabinet.

This measure is offered through different programs listed in Table 4-18 and uses the impacts estimation approach described in this section.

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Table 4-18. Programs that offer this measure

Program name	Section
Non-Residential Prescriptive Program, DSM Phase VI	Section 4.1.5
Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII	Section 9.1.6
Non-Residential Prescriptive Enhanced Program, DSM Phase IX	Section 16.1.5

4.1.5.2 Impacts estimation approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \frac{(watts_{base,idle} - watts_{ee,idle})}{1{,}000\ W/kW} \times Hours_{daily} \times Days$$

Per-measure, gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \frac{(watts_{base,idle} - watts_{ee,idle})}{1{,}000\ W/kW} \times CF_{summer}$$

Per-measure, gross coincident winter peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \frac{(watts_{base,idle} - watts_{ee,idle})}{1{,}000\ W/kW} \times CF_{winter}$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure gross coincident winter peak demand reduction
$watts_{base,idle}$ = idle energy rate of the baseline equipment
$watts_{ee,idle}$ = idle energy rate of the efficient equipment
1,000 = conversion factor for W to kW
$Hours_{daily}$ = average daily operating hours
Days = annual days of operation
CF_{summer} = summer peak coincidence factor
CF_{winter} = winter peak coincidence factor

4.1.5.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

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Table 4-19. Input parameters for hot food holding cabinet

Component	Type	Value	Units	Source(s)
watts$_{base,idle}$	Variable	40 x Vol[52]	watts	Maryland/Mid-Atlantic TRM v.10, p. 377
watts$_{ee,idle}$	Variable	Vol < 13: 21.5 x Vol + 0.0 13 ≤ Vol < 28: 2.0 x Vol + 254.0 Vol ≥ 28: 3.8 x Vol + 203.5	watts	Maryland/Mid-Atlantic TRM v.10, p. 377
Days	Variable	See customer application	days, annual	Customer application
		For defaults see Table 17-17 in Sub-Appendix F2-V: Non-residential commercial kitchen inputs		Maryland/Mid-Atlantic TRM v.10, p. 380[53], for default the Dominion Energy 2020 Commercial Energy Survey Appendix B, p.3 weighted average of building types is used
Hours$_{daily}$	Variable	See customer application	hours, daily	Customer application
		For defaults see Table 17-17 in Sub-Appendix F2-V: Non-residential commercial kitchen inputs		Maryland/Mid-Atlantic TRM v.10, p. 380[53], for default the Dominion Energy 2020 Commercial Energy Survey Appendix B, p.3 weighted average of building types is used
CF$_{summer}$	Fixed	1.0	-	Maryland/Mid-Atlantic TRM v.10, p. 377[54]
CF$_{winter}$	Fixed	1.0	-	Maryland/Mid-Atlantic TRM v.10, p. 377[54]

4.1.5.4 Default savings

There are no default savings for this measure. Applicant will need to provide the baseline and efficient idle wattage or the volume of the holding cabinet for savings to be calculated.

4.1.5.5 Effective Useful Life

The effective useful life of this measure is provided in Table 4-20.

Table 4-20. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	12.00	years	Maryland/Mid-Atlantic TRM v.10, p. 378
VIII	Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII			

52 Vol = the internal volume of the holding cabinet (ft^3) = volume of installed unit

53 Maryland/Mid-Atlantic TRM v. 10 uses customer application values for hours and days with a default provided. For consistency with commercial convection oven the same hours and days for this measure.

54 No specific study of commercial kitchen equipment coincident peak demand savings is available. In the absence of this information, a simple average demand value is used: Annual energy savings divided by the total annual hours of operation and the coincidence factor is 1.0.

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DSM Phase	Program name	Value	Units	Source(s)
VI	Non-Residential Prescriptive Program, DSM Phase VI	6.30	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

4.1.5.6 Source(s)

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v.10, pp. 377-378.

4.1.5.7 Update summary

Updates made to this section are described in Table 4-21.

Table 4-21. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the Mid-Atlantic TRM
	Equation	Added equation for coincident winter peak demand reduction
	New table	Effective Useful Life (EUL) by program
2020	None	No change
v10	Source	Updated page numbers / version of the Mid-Atlantic TRM

4.1.6 Commercial steam cooker

4.1.6.1 Measure description

This measure involves an ENERGY STAR® qualified commercial steam cookers. Energy efficient steam cookers that have earned the ENERGY STAR® label offer shorter cook times, higher production rates, and reduced heat loss due to better insulation and a more efficient steam-delivery system.

The baseline condition assumes a standard-efficiency, electric boiler-style steam cooker.

This measure is offered through different programs listed in Table 4-22 and uses the impacts estimation approach described in this section.

Table 4-22. Programs that offer this measure

Program name	Section
Non-Residential Prescriptive Program, DSM Phase VI	Section 4.1.6
Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII	Section 9.1.5
Non-Residential Prescriptive Enhanced Program, DSM Phase IX	Section 16.1.6

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4.1.6.2 Savings estimation

Per-measure, gross annual electric energy savings are calculated using the following equations:

$$kWh_{base,steam} = lb_{daily} \times \frac{E_{steam}}{\eta_{base}} \times Days$$

$$kWh_{base,idle} = \left[(1 - PCT_{steam}) \times kW_{base,idle} + PCT_{steam} \times PC_{base} \times Qty_{pans} \times \frac{E_{steam}}{\eta_{base}}\right] \times \left(Hours_{daily} - \frac{lb_{daily}}{Qty_{pans} \times PC_{base}}\right) \times Days$$

$$kWh_{base} = kWh_{base,steam} + kWh_{base,idle}$$

$$kWh_{ee,steam} = lb_{daily} \times \frac{E_{steam}}{\eta_{ee}} \times Days$$

$$kWh_{ee,idle} = \left[(1 - PCT_{steam}) \times kW_{ee,idle} + PCT_{steam} \times PC_{ee} \times Qty_{pans} \times \frac{E_{steam}}{\eta_{ee}}\right] \times \left(Hours_{daily} - \frac{lb_{daily}}{Qty_{pans} \times PC_{ee}}\right) \times Days$$

$$kWh_{ee} = kWh_{ee,steam} + kWh_{ee,idle}$$

$$\Delta kWh = kWh_{base} - kWh_{ee}$$

Per-measure, gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \frac{\Delta kWh}{Hours_{daily} \times Days} \times CF_{summer}$$

Per-measure, gross coincident winter peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \frac{\Delta kWh}{Hours_{daily} \times Days} \times CF_{winter}$$

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Per-measure, gross annual water savings is calculated according to the following equation:

$$\Delta Water \quad = (GPH_{base} - GPH_{ee}) \times Hours_{daily} \times Days$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure gross coincident winter peak demand reduction
kWh_{base} = the annual energy usage of the baseline equipment
kWh_{ee} = the annual energy usage of the efficient equipment
$kWh_{base,steam}$ = baseline daily cooking energy consumption
$kWh_{base,idle}$ = baseline daily idle energy consumption
$\Delta Water$ = per-measure gross annual water savings
$Hours_{daily}$ = average daily operating hours
E_{steam} = ASTM Energy to Food (kWh/lb); the amount of energy absorbed by each pound of food during steaming
lb_{daily} = pounds of food cooked per day
$Days$ = annual days of operation
PCT_{steam} = percent of time in constant steam mode
Qty_{pans} = number of pans per unit
η_{base} = baseline equipment cooking energy efficiency
η_{ee} = efficient equipment cooking energy efficiency
$kW_{base,idle}$ = baseline equipment idle energy rate
$kW_{ee,idle}$ = efficient equipment idle energy rate
PC_{base} = baseline equipment production capacity
PC_{ee} = efficient equipment production capacity
GPH_{base} = water consumption rate of baseline equipment
GPH_{ee} = water consumption rate of efficient equipment
CF_{summer} = summer peak coincidence factor
CF_{winter} = winter peak coincidence factor

4.1.6.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 4-23. Input parameters for commercial steam cooker measure

Component	Type	Value	Units	Source(s)
$Hours_{daily}$	Variable	See customer application	hours, daily	Customer application
		For defaults see Table 17-17 in Sub-Appendix F2-V: Non-residential commercial kitchen inputs		Maryland/Mid-Atlantic TRM v.10, p. 380[55], for default the Dominion Energy 2020 Commercial Energy Survey Appendix B, p.3 weighted average of building types is used
Days	Variable	See customer application		Customer application

55 Maryland/Mid-Atlantic TRM v. 10 uses customer application values for hours and days with a default provided. For consistency with commercial convection oven the same hours and days for his measure.

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Component	Type	Value	Units	Source(s)
		For defaults see Table 17-17 in Sub-Appendix F2-V: Non-residential commercial kitchen inputs	days, annual	Maryland/Mid-Atlantic TRM v.10, p. 380[56], for default the Dominion Energy 2020 Commercial Energy Survey Appendix B, p.3 weighted average of building types is used
lb_{daily}	Variable	See customer application	lb, daily	Customer application
		Default: 100		Maryland/Mid-Atlantic TRM v.10, p. 374
Qty_{pans}	Variable	See customer application	pans	Customer application
		Default: 3[57]		Maryland/Mid-Atlantic TRM v.10, p. 374
E_{steam}	Fixed	0.0308	kWh/lb	Maryland/Mid-Atlantic TRM v.10, p. 374
PC_{base}	Fixed	23.3	lb/hr, per pan	Maryland/Mid-Atlantic TRM v.10, p. 375
η_{base}	Variable	Boilerless and Steam generator: 0.30 Boiler-based: 0.26	-	Maryland/Mid-Atlantic TRM v.10, p. 374
		Default = Boiler-based: 0.26		
$kW_{base,idle}$	Variable	Boilerless and Steam generator: 1.20 Boiler-based: 1.00	kW	Maryland/Mid-Atlantic TRM v.10, p. 375
		Default = Boiler-based: 1.00		
$kW_{ee,idle}$	Variable	3 pans: 0.40 4 pans: 0.53 5 pans: 0.67 6+ pans: 0.80	kW	Maryland/Mid-Atlantic TRM v.10, p. 375
		Default = 3 pans: 0.40		
PC_{ee}	Fixed	16.7	lb/hr, per pan	Maryland/Mid-Atlantic TRM v.10, p. 375
η_{ee}	Fixed	0.50	-	Maryland/Mid-Atlantic TRM v.10, p. 374
PCT_{steam}	Fixed	0.40	-	Maryland/Mid-Atlantic TRM v.10, p. 374
GPH_{base}	Variable	See Table 4-24	gal/hr	Maryland/Mid-Atlantic TRM v.10, p. 376
GPH_{ee}	Variable	See Table 4-24	gal/hr	Maryland/Mid-Atlantic TRM v.10, p. 376
CF_{summer}	Fixed	1.0	-	Maryland/Mid-Atlantic TRM v.10, p. 374[58]
CF_{winter}	Fixed	1.0	-	Maryland/Mid-Atlantic TRM v.10, p. 374[58]

[56] Maryland/Mid-Atlantic TRM v. 10 uses customer application values for hours and days with a default provided. For consistency with commercial convection oven the same hours and days for his measure.

[57] Assigned default of 3 pans based on the most conservative of the $kW_{ee,idle}$ options.

[58] No specific study of commercial kitchen equipment coincident peak demand savings is available. In the absence of this information, a simple average demand value is used: Annual energy savings divided by the total annual hours of operation and the coincidence factor is 1.0.

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Table 4-24. Water Consumption rate for the baseline and energy efficient equipment

Parameter	No. of Pans	Baseline model	Energy efficient model		
		All	Steam generator	Boiler based (default)	Boiler less
GPH	All	40	15	10	3

4.1.6.4 Default savings

If the proper values are not supplied, a default savings may be applied assuming boiler-based steam generation. The default per-measure, gross annual electric energy savings will be assigned according to the following equations:

$$kWh_{base,steam} = lb_{daily} \times \frac{E_{steam}}{\eta_{base}} \times Days$$

$$= 100\ lb \times \frac{0.0308\ kWh/lb}{0.26} \times 307\ days$$

$$= 3{,}636.77\ kWh$$

$$kWh_{base,idle} = \left[(1 - PCT_{steam}) \times kW_{base,idle} + PCT_{steam} \times PC_{base} \times Qty_{pans} \times \frac{E_{steam}}{\eta_{base}}\right] \times \left(Hours_{daily} - \frac{lb_{daily}}{Qty_{pans} \times PC_{base}}\right) \times Days$$

$$= \left[(1 - 0.40) \times 1.20\ kW + 0.40 \times 23.3\ \frac{lb}{hr} \times 3\ pans \times \frac{0.0308\ kWh/lb}{0.26}\right] \times \left(13.1\ hr - \frac{100\ lb}{3\ pans\ \times\ 23.3\ lb/hr}\right) \times 307\ days$$

$$= 14{,}445.31\ kWh$$

$$kWh_{ee,steam} = lb_{daily} \times \frac{E_{steam}}{\eta_{ee}} \times Days$$

$$= 100\ lb \times \frac{0.0308\ kWh/lb}{0.50} \times 307\ days$$

$$= 1{,}891.12\ kWh$$

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$$kWh_{ee,idle} = \left[(1 - PCT_{steam}) \times kW_{ee,idle} + PCT_{steam} \times PC_{ee} \times Qty_{pans} \times \frac{E_{steam}}{\eta_{ee}}\right] \times \left(Hours_{daily} - \frac{lb_{daily}}{Qty_{pans} \times PC_{ee}}\right) \times Days$$

$$= \left[(1 - 0.40) \times 0.4\ kW + 0.40 \times 16.7\ \frac{lb}{hr} \times 3\ pans \times \frac{0.0308\ kWh/lb}{0.50}\right] \times \left(13.1\ hr - \frac{100\ lb}{3\ pans \times 16.7\ lb/hr}\right) \times 307\ days$$

$$= 5{,}026.34\ kWh$$

$$\Delta kWh = kWh_{base,steam} + kWh_{base,idle} - \left(kWh_{ee,steam} + kWh_{ee,idle}\right)$$

$$= (3{,}636.77\ kWh + 14{,}445.31\ kWh) - (1{,}891.12\ kWh + 5{,}026.34\ kWh)$$

$$= 11{,}164.62\ kWh$$

Per-measure, gross coincident summer peak demand reduction is calculated using the following equation:

$$\Delta kW_{summer} = \frac{\Delta kWh}{Hours_{daily} \times Days} \times CF_{summer}$$

$$= \frac{11{,}164.62\ kWh}{(13.1\ hr/day \times 307\ days)} \times 1.0$$

$$= 2.77\ kW$$

Per-measure, gross coincident winter peak demand reduction is calculated using the following equation:

$$\Delta kW_{winter} = \frac{\Delta kWh}{Hours_{daily} \times Days} \times CF_{summer}$$

$$= \frac{11{,}164.62\ kWh}{(13.1\ hr/day \times 307\ days)} \times 1.0$$

$$= 2.77\ kW$$

Per-measure, gross annual water savings is calculated according to the following equation:

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$$\Delta Water = (GPH_{base} - GPG_{ee}) \times Hours_{daily} \times Days$$

$$= (40 - 10) \times 13.1 \times 307$$

$$= 120{,}651\ gallons$$

4.1.6.5 Effective Useful Life

The effective useful life of this measure is provided in Table 4-25.

Table 4-25. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	12.00	years	Maryland/Mid-Atlantic TRM v.10, p. 376
VIII	Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII			
VII	Non-Residential Prescriptive Program, DSM Phase VI	6.30	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

4.1.6.6 Source(s)

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v.10, pp. 373-376.

4.1.6.7 Update summary

Updates made to this section are described in Table 4-26.

Table 4-26. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the Mid-Atlantic TRM
	Equation	Added equation for coincident winter peak demand reduction Added gross annual water savings equation
	Input variable	Added GPH_{base} and GPH_{ee} variables for water savings calculation
	Default savings	Added default gross annual water savings value
	New table	Effective Useful Life (EUL) by program
2020	None	No change
v10	Source	Updated page numbers / version of the Mid-Atlantic TRM
	Input variable	Updated PC_{ee} value

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4.1.7 Variable speed drives on kitchen exhaust fan

4.1.7.1 Measure description

This measure involves installing variable speed drives at commercial kitchen exhaust fans so that the fan motor speed matches the demand. The baseline condition is the manual on/off switch and magnetic relay or motor starter for commercial kitchen hoods. The baseline assumes that the fan operates at full speed while in operation.

This measure involves retrofitting a variable-speed drive (VSD) controller at an existing kitchen exhaust fan with a make-up-air fan. The measure includes optical and temperature sensors to detect the level of cooking activity and modulate the speed of the exhaust-air fan accordingly. The optical and temperature sensor(s) are typically located either in the collar of or the inlet to the exhaust-fan hood. The kitchen hood exhaust fans are modulated automatically to vary the exhaust airflow rate and make-up (ventilation) air by adjusting the exhaust and make-up air fan speeds.

The total measure energy savings includes the energy savings resulted from fan power reduction during part load operation as well as a decrease in heating and cooling requirement of make-up air. The measure also provides cooling and heating savings for the make-up air if the existing kitchen system(s) supplies conditioned make-up air through a dedicated make-up air unit. If the supplied make-up air is not conditioned, no heating and cooling savings are provided. Furthermore, the measure does not approve heating savings from gas-fired make-up-air units.

This measure is meant for the kitchen hood exhaust flow control only. The exhaust system from kitchen dishwashers is not included in this measure.

This measure is offered through different programs listed in Table 4-27 and uses the Impacts Estimation Approach described in this section.

Table 4-27. Programs that offer variable speed drives on kitchen exhaust fan

Program name	Section
Non-Residential Prescriptive Program, DSM Phase VI	Section 4.1.7
Non-Residential Prescriptive Enhanced Program, DSM Phase IX	Section 16.1.7

4.1.7.2 Impacts Estimation Approach

Per-measure, gross annual electric energy savings for the exhaust fan are calculated according to the following equation:

$$\Delta kWh_{EF} = hp_{EF} \times LF_{EF} \times \frac{0.746}{\eta_{EF}} \times HOU \times \Delta Power_{EF}$$

If the make-up air is conditioned, then the cooling and heating savings are calculated according to the following equations:

$$\Delta kWh_{cool} = SqFt_{Kitchen} \times \frac{cfm}{SqFt} \times OF_{EF} \times \Delta cfm_{EF} \times CDD \times \frac{24 \times 1.08}{3{,}412 \times COP_{MUA_{cool}}}$$

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$$\Delta kWh_{heat} = SqFt_{Kitchen} \times \frac{cfm}{SqFt} \times OF_{EF} \times \Delta cfm_{EF} \times HDD \times \frac{24 \times 1.08}{3{,}412 \times COP_{MUA_{heat}}}$$

If make-up air is not conditioned, then the cooling and heating savings equal zero.

$$\Delta kWh_{cool} = \Delta kWh_{heat} = 0$$

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \Delta kWh_{EF} + \Delta kWh_{cool} + \Delta kWh_{heat}$$

There are no gross coincident summer and winter peak demand reduction:

$$\Delta kW_{summer} = 0\ kW$$

$$\Delta kW_{winter} = 0\ kW$$

Where:

ΔkWh_{EF}	= per-measure gross annual electric energy savings for the exhaust fan
ΔkWh_{cool}	= per-measure gross annual electric energy savings for cooling the make-up air
ΔkWh_{heat}	= per-measure gross annual electric energy savings for heating the make-up air
ΔkWh	= per-measure gross annual electric energy savings
ΔkW_{summer}	= per-measure gross coincident summer peak demand reduction
ΔkW_{winter}	= per-measure gross coincident winter peak demand reduction
hp_{EF}	= total motor horsepower of exhaust fan(s)
LF_{EF}	= load factor of exhaust fan motor(s)
η_{EF}	= efficiency of exhaust fan motor(s)
HOU	= annual run hours of use of exhaust fan(s)
$\Delta Power_{EF}$	= proportional exhaust fan power reduction due to VFD
$SqFt_{Kitchen}$	= floor area of kitchen
$\frac{cfm}{SqFt}$	= exhaust airflow rate per square foot of kitchen floor area
OF_{EF}	= oversize ratio of exhaust fan system
Δcfm_{EF}	= proportional exhaust fan airflow reduction due to VFD
CDD	= cooling degree days
$COP_{MUA_{cool}}$	= coefficient of performance of cooling component of make-up air system
HDD	= heating degree days
$COP_{MUA_{heat}}$	= coefficient of performance of heating component for make-up air system
0.746	= conversion factor for horsepower to kilowatt
3,412	= conversion factor for Btu/h to kilowatt-hour
24	= conversion factor for day to hour
1.08	= sensible heat factor for air, Btuh/cfm/°F

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4.1.7.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 4-28. Input parameters for VSD on kitchen fan(s)

Component	Type	Value	Units	Source(s)
hp_{EF}	Variable	See customer application	hp	Customer application
LF_{EF}	Fixed	90%	-	New Jersey Clean Energy Program Protocols to Measure Resource Savings: Revisions to FY2020 Protocols, p. 117
η_{EF}	Variable	See customer application	-	Customer application
		Default: See Table 2-16. Baseline motor efficiency based on hp_{EF}		See Table 2-16. Baseline motor efficiency in Section 2.1.4
HOU	Variable	See customer application	hours, annual	Customer application
		Default: See Table 4-29		New Jersey Clean Energy Program Protocols to Measure Resource Savings: Revisions to FY2020 Protocols, p. 118
$\Delta Power_{EF}$	Variable	See Table 4-29	-	New Jersey Clean Energy Program Protocols to Measure Resource Savings: Revisions to FY2020 Protocols, p. 118
$SqFt_{Kitchen}$	Variable	See customer application	sq.ft	Customer application
$\frac{cfm}{SqFt}$	Fixed	0.7	cfm/sq.ft	ASHRAE 62.1-2013, Table 6.5 – for Kitchen -Commercial
OF_{EF}	Fixed	1.4	-	New Jersey Clean Energy Program Protocols to Measure Resource Savings: Revisions to FY2020 Protocols, p. 117
Δcfm_{EF}	Variable	See Table 4-29	-	New Jersey Clean Energy Program Protocols to Measure Resource Savings: Revisions to FY2020 Protocols, p. 118
CDD	Variable	See Sub-Appendix F2-I: Cooling and heating degree days and	Cooling Degree Days	
HDD	Variable	See Sub-Appendix F2-I: Cooling and heating degree days and	Heating Degree Days	
$COP_{MUA_{cool}}$	Variable	See customer application	-	Customer application
		Default: 3.0		New Jersey Clean Energy Program Protocols to Measure Resource Savings 2020, p. 117
$COP_{MUA_{heat}}$	Variable	See customer application	-	Customer application
		Default: 3.0		New Jersey Clean Energy Program Protocols to Measure Resource Savings 2020, p. 117

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Table 4-29. Annual hours of use, power, and airflow reductions due to VSD[59]

Facility type	Annual Hours of Use (hours)	Proportion of power reduction ($\Delta Power_{EF}$)	Proportion of airflow reduction (Δcfm_{EF})
Campus	5,250	0.568	0.295
Lodging	8,736	0.618	0.330
Restaurant	5,824	0.552	0.295
Supermarket	5,824	0.597	0.320
Other	5,250	0.584	0.310

4.1.7.4 Default savings

If the proper input variables are not supplied, no default savings will be given.

4.1.7.5 Effective Useful Life

The effective useful life of this measure is provided in Table 4-30.

Table 4-30. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	15.00	years	New Jersey Clean Energy Program Protocols to Measure Resource Savings*:* Revisions to FY2020 Protocols, p. 128
VI	Non-Residential Prescriptive Program, DSM Phase VI	6.30		Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

4.1.7.6 Source(s)

The primary source for this deemed savings approach include the New Jersey Clean Energy Program Protocols to Measure Resource Savings 2020, pp. 116-119.

4.1.7.7 Update Summary

Updates made to this section are described in Table 4-31.

Table 4-31. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the New Jersey Clean Energy Program Protocols to Measure Resource Savings
	Equation	Removed peak coincident demand reduction equation as the source TRM does not attribute peak savings to this measure.
	New Table	Effective Useful Life (EUL) by program
2020	None	No change

[59] New Jersey Clean Energy Program Protocols to Measure Resource Savings: Revisions to FY2019 Protocols, pg. 106

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Version	Update type	Description
v10	Source	Updated page numbers / version of the New Jersey Clean Energy Program Protocols to Measure Resource Savings
	Input Variable	Update to weather stations in North Carolina resulted in revised CDDs/HDDs for weather-sensitive measures

4.2 Heating, Ventilation, and Air-Conditioning (HVAC) end use

4.2.1 Duct testing and sealing

4.2.1.1 Measure description

This measure provides building owners incentives to use Dominion-approved, duct-sealing contractors to reduce conditioned-air leakage to unconditioned spaces by the following steps:

1. Test non-residential duct systems for air leakage.
2. Seal the ducts using an aerosol-based product.
3. Test the sealed duct systems for air leakage to confirm that sealing the ducts reduced the air-leakage rate.

Eligible ductwork is connected to a unitary HVAC system or a heat pump and occurs within an unconditioned plenum space or between an insulated, finished ceiling and a roof surface. Based on DNV's judgment, this measure is applicable to ductwork at unitary and chiller-cooled systems.

This measure is offered through different programs listed in Table 4-32 and uses the impacts estimation approach described in this section.

Table 4-32. Programs that offer this measure

Program name	Section
Non-Residential Prescriptive Program, DSM Phase VI	Section 4.2.1
Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 8.2.1
Non-Residential Multifamily Program, DSM Phase VIII	Section 10.3.3
Non-Residential Prescriptive Enhanced Program, DSM Phase IX	Section 16.3.2

4.2.1.2 Impacts Estimation Approach

For all system types, per-measure gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh \quad = \Delta kWh_{cool} + \Delta kWh_{heat}$$

Duct testing and sealing on unitary systems, air source heat pumps, and AC units

Per-measure, gross annual electric cooling and heating energy savings are calculated according to the following equations.

For unitary-system heat pumps and AC units of $Size_{cool}$ < 65,000 Btu/h:

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$$\Delta kWh_{cool} = Size_{cool} \times \frac{12\frac{kBtuh}{ton}}{SEER} \times EFLH_{cool} \times \left(1 - \frac{\bar{n}_{dist,base}}{\bar{n}_{dist,ee}}\right)_{cool}$$

For unitary-system heat pumps of $Size_{heat}$ < 65,000 Btu/h:

$$\Delta kWh_{heat} = Size_{heat} \times \frac{1}{HSPF} \times EFLH_{heat} \times \left(1 - \frac{\bar{n}_{dist,base}}{\bar{n}_{dist,ee}}\right)_{heat}$$

For unitary-system heat pumps and AC units of $Size_{cool}$ ≥ 65,000 Btu/h,:

$$\Delta kWh_{cool} = Size_{cool} \times \frac{12\frac{kBtuh}{ton}}{IEER} \times EFLH_{cool} \times \left(1 - \frac{\bar{n}_{dist,base}}{\bar{n}_{dist,ee}}\right)_{cool}$$

For unitary-system heat pumps of $Size_{heat}$ ≥ 65,000 Btu/h:

$$\Delta kWh_{heat} = Size_{heat} \times \frac{1}{COP \times 3.412\frac{Btuh}{W}} \times EFLH_{heat} \times \left(1 - \frac{\bar{n}_{dist,base}}{\bar{n}_{dist,ee}}\right)_{heat}$$

Per-measure, gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = Size_{cool} \times \frac{12\frac{kBtuh}{ton}}{EER} \times \left(1 - \frac{n_{dist,pk,base}}{n_{dist,pk,ee}}\right) \times CF_{summer}$$

Per-measure, gross coincident winter peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = Size_{heat} \times \frac{1}{EER} \times \left(1 - \frac{n_{dist,pk,base}}{n_{dist,pk,ee}}\right) \times CF_{winter}$$

Duct testing and sealing on chiller systems

Water-cooled chiller systems, cooling savings:

$$\Delta kWh_{cool} = Size_{cool} \times \frac{kW}{ton_{IPLV}} \times EFLH_{cool} \times \left(1 - \frac{\bar{n}_{dist,base}}{\bar{n}_{dist,ee}}\right)_{cool}$$

Air-cooled chiller systems, cooling savings:

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$$\Delta kWh_{cool} = Size_{cool} \times \frac{12\frac{kBtuh}{ton}}{EER_{IPLV}} \times EFLH_{cool} \times \left(1 - \frac{\bar{n}_{dist,base}}{\bar{n}_{dist,ee}}\right)_{cool}$$

Chiller systems with non-electric heating fuel will not have heating savings. For chiller systems with electric heating, savings are calculated as follows:

Chiller system with electric heating system < 65,000 Btu/h:

$$\Delta kWh_{heat} = Size_{heat} \times \frac{1}{HSPF} \times FLH_{heat} \times \left(1 - \frac{\bar{n}_{dist,base}}{\bar{n}_{dist,ee}}\right)_{heat}$$

Chiller system with electric heating system ≥ 65,000 Btu/h:

$$\Delta kWh_{heat} = Size_{heat} \times \frac{1}{COP \times 3.412\frac{Btuh}{W}} \times EFLH_{heat} \times \left(1 - \frac{\bar{n}_{dist,base}}{\bar{n}_{dist,ee}}\right)_{heat}$$

The per-measure gross coincident summer peak demand reduction is calculated according to the following equations:

Duct testing and sealing on water-cooled chiller systems:

$$\Delta kW_{summer} = Size_{cool} \times \frac{kW}{ton_{full\ load}} \times \left(1 - \frac{\bar{n}_{dist,peak,base}}{\bar{n}_{dist,peak,ee}}\right) \times CF_{summer}$$

Duct testing and sealing on air-cooled chiller systems:

$$\Delta kW_{summer} = Size_{cool} \times \frac{12\frac{kBtuh}{ton}}{EER_{full\ load}} \times \left(1 - \frac{\bar{n}_{dist,peak,base}}{\bar{n}_{dist,peak,ee}}\right) \times CF_{summer}$$

Chiller systems with non-electric heating fuel will not have gross coincident winter peak demand reductions. For chiller systems with electric heating, savings are calculated as follows:

Air-cooled or water-cooled chiller system with electric resistance < 65,000 Btu/h:

$$\Delta kW_{winter} = Size_{heat} \times \frac{1}{HSPF} \times \left(1 - \frac{\bar{n}_{dist,base}}{\bar{n}_{dist,ee}}\right)_{heat} \times CF_{winter}$$

Air-cooled or water-cooled chiller system with electric resistance ≥ 65,000 Btu/h:

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$$\Delta kW_{winter} = Size_{heat} \times \frac{1}{COP \times 3.412 \frac{Btuh}{W}} \times \left(1 - \frac{\bar{n}_{dist,base}}{\bar{n}_{dist,ee}}\right)_{heat} \times CF_{winter}$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure summer peak gross coincident demand reduction
ΔkW_{winter} = per-measure winter peak gross coincident demand reduction
$Size_{cool}$ = system cooling capacity in tons, based on nameplate data
$Size_{heat}$ = system heating capacity in kBtu/h, based on nameplate data
SEER = seasonal energy efficiency ratio (SEER). It is used for heat pumps and AC units that are smaller than 65,000 Btu/h.
IEER = integrated energy efficiency ratio (IEER) of a unit's efficiency at four load points: 100%, 75%, 50%, and 25% of full cooling capacity. It is used for heat pumps and AC units that are 65,000 Btu/h or larger.
HSPF = heating seasonal performance factor (HSPF) of existing heat pump. HSPF is used in heating savings for air-source heat pumps.
COP = coefficient of performance (heating)
$\bar{n}_{dist,base,cool}$ = duct system average seasonal efficiency of baseline (pre-sealing) cooling system
$\bar{n}_{dist,base,heat}$ = duct system average seasonal efficiency of baseline (pre-sealing) heating system
$\bar{n}_{dist,ee,cool}$ = duct system average seasonal efficiency of efficient (post-sealing) cooling system
$\bar{n}_{dist,ee,heat}$ = duct system average seasonal efficiency of efficient (post-sealing) heating system
$n_{dist,peak,base}$ = duct system efficiency of baseline system, under peak conditions (equal to $\bar{n}_{dist,base,cool}$)
$n_{dist,peak,ee}$ = duct system efficiency of efficient system, under peak conditions (equal to $\bar{n}_{dist,ee,cool}$)
$EER_{full\text{-}load}$ = energy efficiency ratio (EER) of air-cooled chillers at full-load conditions.
EER_{IPLV} = energy efficiency ratio (EER) of air-cooled chillers at integrated part load value (IPLV).
$\frac{kW}{ton}_{IPLV}$ = energy efficiency of water-cooled chiller system at integrated part load value (IPLV)
$\frac{kW}{ton}_{full\ load}$ = energy efficiency of water-cooled chiller system at full load
$EFLH_{cool}$ = cooling equivalent full load hours (EFLH)
$EFLH_{heat}$ = heating equivalent full load hours (EFLH)
CF_{summer} = summer peak coincidence factor
CF_{winter} = winter peak coincidence factor
TRF = Thermal regain factor

In the event of a missing efficiency metric from an application, the equations provided in Sub-Appendix F2-VI: General may be used to estimate the missing efficiency using another application-provided efficiency metric.

4.2.1.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 4-33. Input values for duct sealing savings calculations

Component	Type	Value	Unit	Source(s)
$Size_{cool}$	Variable	See customer application	tons of cooling capacity (per unit)	Customer application

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Component	Type	Value	Unit	Source(s)
$Size_{heat}$	Variable	See customer application[60]	kBtu/h (per unit)	Customer application
		Default = $Size_{cool}$ x 12 kBtu/ton		
SEER/IEER/EER/COP/HSPF	Variable	See customer application[61]	Btu/W-hr (COP is dimension-less)	Customer application
		Default: See Table 17-8 and Table 17-9 in Sub-Appendix F2-III: Non-residential HVAC based on equipment type		ASHRAE 90.1-2013
$kW/ton_{full\ load}$	Variable	See customer application	kW/ton	Customer application
		Default: see Table 17-11 in Sub-Appendix F2-III: Non-residential HVAC based on equipment type		ASHRAE 90.1-2013
kW/ton_{IPLV}	Variable	See customer application	kW/ton	Customer application
		Default: see Table 17-11 in Sub-Appendix F2-III: Non-residential HVAC based on equipment type		ASHRAE 90.1-2013
$EER_{full\ load}$	Variable	See customer application[61]	Btu/W-h	Customer application
		Default: see Table 17-11 in Sub-Appendix F2-III: Non-residential HVAC based on equipment type		ASHRAE 90.1-2013
EER_{IPLV}	Variable	See customer application[61]	kBtu/kW-h	Customer application
		Default: see Cooling efficiencies of water chilling packages Table 17-11 in Sub-Appendix F2-III: Non-residential HVAC based on equipment type		ASHRAE 90.1-2013
$\bar{n}_{dist,base,cool}$	Variable	See customer application along with Table 4-34 and Table 4-35	percent	Customer application
		Default: No insulation, 30% leakage.		New York TRM 2018, p. 242
$\bar{n}_{dist,base,heat}$	Variable	See customer application along with Table 4-34 and Table 4-35	percent	Customer application
		Default: No insulation, 30% leakage		New York TRM 2018, p. 242
$\bar{n}_{dist,ee,cool}$	Variable	See customer application along with Table 4-34 and Table 4-35	percent	Customer application
		Default: No insulation, 15% leakage		New York TRM 2018, p. 242
$\bar{n}_{dist,ee,heat}$	Variable	See customer application along with Table 4-34 and Table 4-35	percent	Customer application
		Default: No insulation, 15% leakage		New York TRM 2018, p. 242
$n_{dist,peak,base}$	Variable	See customer application along with Table 4-34 and Table 4-35	percent	Customer application
		Default: No insulation, 30% leakage		New York TRM 2018, p. 242
$n_{dist,peak,ee}$	Variable	See customer application along with Table 4-34 and Table 4-35	percent	Customer application

60 When customer-provided heating system size is <80% or >156% of customer-provided cooling system size, a default value will be used, instead. In such instances, it is assumed that the heating system size was incorrectly documented. The acceptable range is based on a review of the AHRI database across numerous manufacturers and heat pump types.

61 The customer provided efficiency values are reviewed for reasonability. If the efficiency value is outside acceptable bounds the applicable default value is applied. The bounds were determined from a review of the AHRI database. Bounds are as follows: 9.90 < SEER < 46.2, 7.92 < EER < 22.11, 8.10 < IEER < 34.82, 8.82 < CEER < 16.50, 5.85 < HSPF < 15.07, 2.70 < COP < 15.01.

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Component	Type	Value	Unit	Source(s)
		Default: No insulation, 15% leakage		New York TRM 2018, p. 242
$EFLH_{heat}$	Variable	See Table 17-5 in Sub-Appendix F2-II: Non-residential HVAC	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 423
$EFLH_{cool}$	Variable	See Table 17-4 in Sub-Appendix F2-II: Non-residential HVAC	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 422
CF_{summer}	Variable	Where baseline and installed system capacities differ, use installed system capacity to assign CF. Otherwise, use baseline system capacity to assign CF: < 135 kBtu/h = 0.588 ≥ 135 kBtu/h = 0.874	-	Maryland/Mid-Atlantic TRM v.10, p. 291[62]
CF_{winter}		Where baseline and installed system capacities differ, use installed system capacity to assign CF. Otherwise, use baseline system capacity to assign CF: < 135 kBtu/h = 0.588 ≥ 135 kBtu/h = 0.874	-	Maryland/Mid-Atlantic TRM v.10, p. 291[63]

The New York TRM provides values for duct system efficiency for uninsulated ducts and ducts with R-6 insulation for four building types: assembly buildings, fast-food restaurants, full-service restaurant, and small retail. The average column in Table 4-34 is a simple average of the four building types. The values for R-2, R-4 and R-8 insulation have been calculated by scaling the results using an engineering relationship of the effectiveness of increasing R-values (non-linear).

The manual provides efficiencies for only five leakage-rate bins: 8%, 15%, 20%, 25%, and 30%. In preparation for receiving duct leakage percentages that do not match these specific values, DNV used a linear regression to model duct system efficiency as a function of leakage proportion. The coefficients from this model were used to compute duct system efficiency for any leakage value between 0% and 50%.

62 The New York TRM 2018 provides a CF with no specific source as a placeholder. Therefore, the same CFs are applied as used for other HVAC measure using the Maryland/Mid-Atlantic TRM v.10.

63 The Maryland/Mid-Atlantic TRM v.10 does not provide a winter CF. Therefore, the summer CF is applied to the winter CF.

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Table 4-34. Duct system efficiency by broad building type categories[64]

Duct total leakage	Duct system R-Value	Assembly		Fast food restaurant		Full service restaurant		Small retail		Average	
		Heating	Cooling	Heating	Cooling	Heating	Cooling	Heating	Cooling	Heating	Cooling
8%	Uninsulated	0.857	0.922	0.766	0.866	0.797	0.854	0.614	0.838	0.759	0.870
15%	Uninsulated	0.829	0.908	0.734	0.853	0.765	0.845	0.581	0.827	0.727	0.858
20%	Uninsulated	0.810	0.897	0.714	0.844	0.743	0.837	0.559	0.818	0.707	0.849
25%	Uninsulated	0.793	0.886	0.693	0.834	0.721	0.829	0.538	0.809	0.686	0.840
30%	Uninsulated	0.776	0.873	0.675	0.823	0.701	0.820	0.520	0.799	0.668	0.829
8%	R-2	0.877	0.954	0.821	0.906	0.845	0.904	0.691	0.885	0.808	0.912
15%	R-2	0.846	0.938	0.780	0.889	0.807	0.893	0.648	0.871	0.770	0.898
20%	R-2	0.826	0.926	0.754	0.878	0.781	0.884	0.619	0.861	0.745	0.887
25%	R-2	0.807	0.913	0.729	0.865	0.755	0.874	0.593	0.850	0.721	0.875
30%	R-2	0.789	0.899	0.707	0.852	0.732	0.864	0.570	0.839	0.699	0.863
8%	R-4	0.886	0.970	0.848	0.925	0.869	0.929	0.729	0.908	0.833	0.933
15%	R-4	0.855	0.952	0.802	0.907	0.827	0.917	0.681	0.893	0.791	0.917
20%	R-4	0.833	0.940	0.774	0.894	0.799	0.908	0.649	0.883	0.764	0.906
25%	R-4	0.814	0.926	0.747	0.881	0.772	0.897	0.621	0.871	0.738	0.893
30%	R-4	0.795	0.911	0.723	0.867	0.748	0.885	0.594	0.859	0.715	0.881
8%	R-6	0.896	0.986	0.875	0.945	0.893	0.954	0.767	0.931	0.858	0.954
15%	R-6	0.863	0.967	0.825	0.925	0.848	0.941	0.714	0.915	0.813	0.937
20%	R-6	0.841	0.954	0.794	0.911	0.818	0.931	0.679	0.904	0.783	0.925
25%	R-6	0.821	0.939	0.765	0.896	0.789	0.919	0.648	0.891	0.756	0.911
30%	R-6	0.801	0.924	0.739	0.881	0.763	0.907	0.619	0.879	0.731	0.898
8%	R-8	0.901	0.994	0.889	0.955	0.905	0.967	0.786	0.943	0.870	0.965
15%	R-8	0.867	0.974	0.836	0.934	0.858	0.953	0.731	0.926	0.823	0.947
20%	R-8	0.845	0.961	0.804	0.919	0.827	0.943	0.694	0.915	0.793	0.935
25%	R-8	0.825	0.946	0.774	0.904	0.798	0.930	0.662	0.901	0.764	0.920
30%	R-8	0.804	0.930	0.747	0.888	0.771	0.918	0.631	0.889	0.738	0.906

64 NY TRM 2019, Appendix H. Distribution Efficiencies, pp. 681–686. New York City values are used for heating and cooling efficiencies for different building types. This table represent more R-Values and total duct leakage (%) than the reference table and for those cases, regression analysis was performed to obtain the respective heating and cooling duct system efficiencies.

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Table 4-35. Duct system efficiency mapping to building type[65]

Building type	Associated duct system efficiency building type
Education **Education – College and university** **Education – High school** **Education – Elementary and middle school** **Health Care – inpatient** **Health Care – outpatient** **Lodging – (hotel, motel, and dormitory)** **Office – Small (< 40,000 sq ft)** **Office – Large (≥ 40,000 sq ft)** **Other** **Warehouse and storage**	Average
Food sales **Food sales – Gas station convenience store** **Food sales – Convenience store** **Food sales – Grocery** **Mercantile (retail, not mall)** **Mercantile (mall)** **Service (Beauty, auto repair workshop)**	Small retail
Food service **Food service – Fast food** **Food service – Other**	Fast food restaurant
Food service – Restaurant **Food service – Full service**	Full service restaurant
Public assembly **Public order and safety (police and fire station)** **Religious worship**	Assembly building

4.2.1.4 Default savings

If the proper values are not supplied, a default savings may be applied using conservative input values. Default hours of use will be taken from the above chart if the building type is available.

4.2.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 4-36.

Table 4-36. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	18.00	years	New York TRM 2019, p. 772
VIII	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII			
	Non-Residential Multifamily Program, DSM Phase VIII			

65 Where "Building Type" does not clearly map to "Associated Duct System Efficiency Building Type," "Associated Duct System Efficiency Building Type is assigned to most conservative type." Full building type list was consolidated to map directly to 2003 U.S. DOE CBECS building types. Full building type list from Maryland/Mid-Atlantic TRM. Original sources: Connecticut Program Savings Document for 2012 Program Year (September 2011), pp. 219-220. https://energizect.com/sites/default/files/documents/2012%20CT%20Program%20Savings%20Documentation%20FINAL.pdf, 2003 US DOE CBECS building type definitions.

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DSM Phase	Program name	Value	Units	Source(s)
VI	Non-Residential Prescriptive Program, DSM Phase VI	6.30	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

4.2.1.6 Source(s)

The primary sources for this deemed savings approach is the New York TRM 2018, pp. 241-244, New York TRM 2019, pp. 681-686, Maryland/Mid-Atlantic TRM v.10, pp. 422-423, and ASHRAE 90.1-2013.

4.2.1.7 Update summary

Updates made to this section are described in Table 4-37.

Table 4-37. Summary of update(s)

Version	Update type	Description
2022	Section	Moved from the Non-Residential Small Business Improvement Program, DSM Phase V Section as that program is no longer active.
2021	Source	Updated page numbers / version of the Maryland/Mid-Atlantic TRM
	New table	Effective Useful Life (EUL) by program
	Equation	Added gross winter peak demand reduction equation
2020	Equation	Added size condition of <65,000 Btu/h and ≥65,000 Btu/h for determining which equation to use for ground-source heat pumps. Previously all ground-source heat pumps used equations with IEER and COP efficiency metrics.
v10	Source	Updated page numbers / version of the New York TRM
	Input variable	Update to weather stations in North Carolina resulted in revised EFLHs for weather-sensitive measures Equipment efficiency levels were revised per update to ASHRAE 2013 in VA and NC
	Default savings	Default savings modified due to changes to Sub-Appendix F2-III: Non-residential HVAC

4.2.2 Unitary/split air conditioning, heat pump, and chiller tune-up

4.2.2.1 Measure description

This measure involves tuning up packaged air conditioning units, heat pump units (both air and ground source), and air- and water-cooled cooled chillers at small commercial and industrial sites. All HVAC applications other than space cooling and heating—such as process cooling—are ineligible for this measure.

For the Small Business Improvement Program, this measure is separated from the Refrigerant Charge Adjustment retrocommissioning measure. However, this measure is also offered by the Commercial Non-Residential Prescriptive Program in which case, the tune-up and the refrigerant charge adjustment steps are combined into a single measure.

This measure is offered through different programs listed in Table 4-38, and uses the impacts estimation approach described in this section.

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Table 4-38. Programs that offer this measure

Program name	Section
Non-Residential Prescriptive Program, DSM Phase VI	Section 4.2.2
Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 8.2.2
Non-Residential Multifamily Program, DSM Phase VIII	Section 10.3.2
Non-Residential Prescriptive Enhanced Program, DSM Phase IX	Section 16.3.1

4.2.2.2 Impacts Estimation Approach

Algorithms and inputs to calculate heating, cooling savings, and demand reduction for unitary/split HVAC and package terminal AC system tune-ups are provided below. Gross annual electric energy savings and gross coincident demand reduction are calculated according to the equations following this section.

Per-measure gross annual electric energy savings are calculated by combining the cooling and heating energy savings according to the following equation:

$$\Delta kWh = \Delta kWh_{cool} + \Delta kWh_{heat}$$

Cooling energy savings

For heat pumps and AC units <65,000 Btu/h, the per- measure gross annual electric cooling energy savings are calculated as follows:

$$\Delta kWh_{cool} = Size_{cool} \times \frac{12\ kBtuh/ton}{SEER} \times EFLH_{cool} \times TUF$$

For heat pumps and AC units ≥65,000 Btu/h, the per-measure gross annual electric cooling energy savings are calculated as follows:

$$\Delta kWh_{cool} = Size_{cool} \times \frac{12\ kBtuh/ton}{IEER} \times EFLH_{cool} \times TUF$$

For air- and water-cooled chillers:

$$\Delta kWh_{cool} = Size_{cool} \times IPLV \times EFLH_{cool} \times TUF$$

Heating energy savings

For heat pumps <65,000 Btu/h, the per-measure gross annual electric heating energy savings are calculated as follows:

$$\Delta kWh_{heat} = Size_{heat} \times \frac{1}{HSPF} \times EFLH_{heat} \times TUF$$

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For heat pumps ≥65,000 Btu/h the per-measure gross annual electric heating energy savings are calculated as follows:

$$\Delta kWh_{heat} = Size_{heat} \times \frac{1}{COP \times 3.412\ Btuh/W} \times EFLH_{heat} \times TUF$$

For AC units and air- and water-cooled chillers, there are no per-measure gross annual electric heating energy savings:

$$\Delta kWh_{heat} = 0$$

Per-measure gross coincident demand reduction is calculated according to the following equation for air-conditioning and heat pump systems and chillers:

$$\Delta kW_{summer} = Size_{cool} \times \frac{12\ kBtuh/ton}{EER} \times CF_{summer} \times TUF$$

Per-measure gross coincident demand reduction is calculated according to the following equation for air-conditioning and heat pump systems and chillers:

$$\Delta kW_{winter} = \frac{\Delta kWh_{heat}}{EFLH_{heat}} \times CF_{winter}$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross summer peak coincident demand reduction
ΔkW_{winter} = per-measure gross winter peak coincident demand reduction
ΔkWh_{cool} = per-measure gross annual electric cooling energy savings
ΔkWh_{heat} = per-measure gross annual electric heating energy savings
$Size_{cool}$ = tons of cooling capacity of equipment
$Size_{heat}$ = heating capacity of equipment, if applicable.
SEER = seasonal energy efficiency ratio (SEER) of the installed air conditioning equipment. It is used for heat pumps and AC units that are smaller than 65,000 Btu/h.
IEER = integrated energy efficiency ratio (IEER) of the existing or baseline air conditioning equipment. IEER is a weighted average of a unit's efficiency at four load points: 100%, 75%, 50%, and 25% of full cooling capacity. It is used for heat pumps and AC units that are 65,000 Btu/h or larger.
$EFLH_{cool}$ = equivalent full load cooling hours
$EFLH_{heat}$ = equivalent full load heating hours
IPLV = energy efficiency at integrated part load value (IPLV) of chillers. For air-cooled chillers, this is typically shown as EER_{IPLV}; for water-cooled chillers, this is typically shown as kW/ton_{IPLV}.
TUF = rate of energy efficiency improvement due to tune-up
EER = energy efficiency ratio of air-conditioning and heat pump systems and air- and water-cooled chillers at full load conditions.

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HSPF = heating seasonal performance factor (HSPF) of existing heat pump. HSPF is used in heating savings for air-source heat pumps.
COP = coefficient of performance of existing heating equipment. Ground source heat pumps use COP to determine heating savings.
CF_{summer} = summer coincidence factor
CF_{winter} = winter coincidence factor

4.2.2.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 4-39. Input variables for AC/HP/chiller tune-up measure

Component	Type	Value	Units	Source(s)
Sizecool	Variable	See customer application	tons of cooling capacity	Customer application
Sizeheat	Variable	See customer application[66]	kBtu/h	Customer application
		Default for HPs: 12 x Sizecool		
EFLHcool	Variable	Refer to Sub-Appendix F2-II: Non-residential HVAC ACs, HPs, & Chillers: Table 17-4	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 422
EFLHheat	Variable	Refer to Sub-Appendix F2-II: Non-residential HVAC HPs: Table 17-5	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 423
HSPF/SEER/IEER/ EER/COP	Variable	See customer application[67]	kBtu/kW-hour (except COP is dimensionless)	Customer application
		Refer to Sub-Appendix F2-III: Non-residential HVAC ACs & HPs: Table 17-9 Chillers: Table 17-11		ASHRAE 90.1-2013
IPLV	Variable	See customer application	Btu/W for air-cooled chillers; kW/ton for water-cooled chillers	Customer application
		Refer to Sub-Appendix F2-III: Non-residential HVAC Chillers: Table 17-11		ASHRAE 90.1-2013
RCA_Done[68]	Boolean	See customer application	True/False	Customer application
TUF	Variable	If RCA was not done: ACs: 0.023 HPs: 0.028 Chillers: 0.050 If RCA was also done (only for Commercial Non-residential prescriptive program): ACs: 0.050	-	Maryland/Mid-Atlantic TRM v.10, p. 316, California Impact Evaluation of 2013-14 Commercial Quality Maintenance Programs,[69] and Wisconsin Focus on

66 When customer-provided heating system size is <80% or >156% of customer-provided cooling system size, a default value will be used, instead. In such instances, it is assumed that the heating system size was incorrectly documented. The acceptable range is based on a review of the AHRI database across numerous manufacturers and heat pump types.

67 The customer provided efficiency values are reviewed for reasonability. If the efficiency value is outside acceptable bounds the applicable default value is applied. The bounds were determined from a review of the AHRI database. Bounds are as follows: 9.90 < SEER < 46.2, 7.92 < EER < 22.11, 8.10 < IEER < 34.82, 8.82 < CEER < 16.50, 5.85 < HSPF < 15.07, 2.70 < COP < 15.01.

68 RCA_Done is only relevant to the Non-Residential Prescriptive Program; it is neither collected nor used for the Small Business Improvement Program because Refrigerant Charge Adjustment is a separate measure.

69 California Public Utilities Commission (2016). Impact Evaluation of 2013-14 Commercial Quality Maintenance Programs (HVAC3), While these proportions were not provided in the report, DNV analyzed the same supporting data—though owned by the CPUC and not publicly available—used to produce the tables provided on pages BB-2 and BB-3 of Appendix BB of the report. Whereas the tables provided in Appendix BB were aggregated by program, DNV aggregated the raw data by HVAC-system type to determine appropriate TUF values. This analysis showed that for packaged air-conditioning systems, an average of 54.7% of the overall tune-up savings were attributable to the RCA treatment; for packaged heat pump systems, 44.7% of the overall tune-up savings were attributable to the RCA treatment.

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Component	Type	Value	Units	Source(s)
		HPs: 0.050 Chillers: 0.050		Energy 2020 TRM, pp. 957-959.
CF_{summer}	Variable	Use system capacity to assign CF: < 11.5 tons = 0.588 ≥ 11.5 tons = 0.874	-	Maryland/Mid-Atlantic TRM v.10, p. 316
CF_{winter}	Variable	Use system capacity to assign CF: < 11.5 tons = 0.588 ≥ 11.5 tons = 0.874	-	Maryland/Mid-Atlantic TRM v.10, p. 316[70]

4.2.2.4 Default savings

No default savings will be awarded for this measure if the proper values are not provided in the customer application.

4.2.2.5 Effective Useful Life

The effective useful life of this measure is provided in Table 4-40.

Table 4-40. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	5.00	years	Maryland/Mid-Atlantic TRM v.10, p. 316
VIII	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII			
	Non-Residential Multifamily Program, DSM Phase VIII			
VI	Non-Residential Prescriptive Program, DSM Phase VI	6.30	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

4.2.2.6 Source(s)

The primary sources for this deemed savings approach include the ASHRAE 90.1-2013, Maryland/Mid-Atlantic TRM v.10, pp. 315-316, pp. 422-423, the California Impact Evaluation of 2013-14 Commercial Quality Maintenance Programs and the Wisconsin Focus on Energy TRM 2020, pp. 957-959.

4.2.2.7 Update summary

Updates made to this section are described in Table 4-41.

Table 4-41. Summary of update(s)

Version	Update Type	Description
2022	None	No change

[70] The source TRM does not provide a winter CF. Therefore, the summer CF is applied to the winter CF.

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Version	Update Type	Description
2021	Source	Updated page numbers and versions of the Maryland/Mid-Atlantic TRM and Wisconsin TRM
	Equation	Added gross winter peak demand reduction equation
	New table	Effective Useful Life (EUL) by program
2020	Equation	Added size condition of <65,000 Btu/h and ≥65,000 Btu/h for determining which equation to use for ground-source heat pumps. Previously all ground-source heat pumps used equations with IEER and COP efficiency metrics.
v10	Source	Updated page numbers and versions of references to: Maryland/Mid-Atlantic TRM Wisconsin Focus on Energy TRM Clarified citation and footnote of CPUC's Impact Evaluation for 2013-14 (HVAC3)
	Input variable	For HPs at which RCA was not performed, revised Tune-up Factor (TUF) value from 0.027 to 0.028 Update to weather stations in North Carolina resulted in revised EFLHs for weather-sensitive measures Baseline efficiency levels were revised per update to ASHRAE 2013 in VA and NC

4.3 Appliance or Plug Load end use

4.3.1 Smart strip

4.3.1.1 Measure description

This measure realizes energy savings by installing a "smart-strip" plug outlet in place of a standard "power strip." Smart strip devices are designed to automatically turn-off connected loads when those devices are not in use, therefore minimizing energy losses caused by phantom loads.

The baseline condition is a standard "power strip." This strip is simply a "plug multiplier" that allows the user to plug in multiple devices using a single wall outlet. Additionally, the baseline unit has no ability to control power flow to the connected devices.

4.3.1.2 Impacts Estimation Approach

Per-measure, gross annual electric energy savings are assigned per unit as follows:[71]

$$\Delta kWh = 26.9\ kWh$$

Per-measure, gross coincident summer and winter peak demand reduction is assigned no reduction, as follows:

[71] Energy & Resource Solutions (ERS) 2013. Emerging Technologies Research Report; Advanced Power Strips for Office Environments prepared for the Regional Evaluation, Measurement, and Verification Forum facilitated by the Northeast Energy Efficiency Partnerships." Assumes savings consistent with the 20W threshold setting for the field research site demonstrating higher energy savings (of two available sites). ERS noted that the 20 W threshold may be unreliable due to possible inaccuracy of the threshold setting in currently available units. It is assumed that future technology improvements will reduce the significance of this issue. Further, savings from the site with higher average savings was adopted (26.9 kWh versus 4.7 kWh) acknowledging that investigations of APS savings in other jurisdictions have found significantly higher savings. For example, Northwest Power and Conservation Council, Regional Technical Forum. 2011. "Smart Power Strip Energy Savings Evaluation" found average savings of 145 kWh.

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$$\Delta kW_{summer} = 0\ kW$$

$$\Delta kW_{winter} = 0\ kW$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure gross coincident winter peak demand reduction

4.3.1.3 Effective Useful Life

The effective useful life of this measure is provided in Table 4-42.

Table 4-42. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
VI	Non-Residential Prescriptive Program, DSM Phase VI	6.30	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

4.3.1.4 Source(s)

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v.10, pp. 368-369.

4.3.1.5 Update summary

Updates made to this section are described in Table 4-43.

Table 4-43. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the Mid-Atlantic TRM
	New table	Effective Useful Life (EUL) by program
2020	Source	Updated page numbers / version of the Mid-Atlantic TRM
v10	Source	Updated page numbers / version of the Mid-Atlantic TRM

4.3.2 Vending machine miser

4.3.2.1 Measure description

This measure realizes energy savings by installing vending misers that control the vending machine lighting and refrigeration systems power consumption of distributed closed-door cases. Miser controls power down these systems during periods of inactivity while ensuring that the product stays cold. Qualifying machines include glass front

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refrigerated coolers, non-refrigerated snack vending machines, and refrigerated beverage vending machines, but this measure does not apply to ENERGY STAR® vending machines that have built-in internal controls or distributed open door cases.

This measure is offered through different programs listed in Table 4-49 and uses the impacts estimation approach described in this section.

Table 4-44. Programs that Offer this Measure

Program Name	Section
Non-Residential Prescriptive Program, DSM Phase VI	Section 4.3.2
Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 8.4.1

4.3.2.2 Impacts Estimation Approach

Per-measure gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = kW_{rated} \times HOU \times ESF$$

Per-measure, gross coincident summer peak demand reductions are calculated according to the following equation:

$$\Delta kW_{summer} = \frac{\Delta kWh}{HOU} \times CF_{summer}$$

Per-measure, gross coincident winter peak demand reductions are calculated according to the following equation:

$$\Delta kW_{winter} = \frac{\Delta kWh}{HOU} \times CF_{winter}$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure gross coincident winter peak demand reduction
kW_{rated} = rated kilowatts of connected equipment
HOU = annual hours of use
ESF = energy savings factor
CF_{summer} = summer coincidence factor
CF_{winter} = winter coincidence factor

4.3.2.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 4-45. Input values for vending miser savings calculations

Component	Type	Value	Unit	Source(s)
kW_{rated}	Variable	See customer application	kW	Customer application

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Component	Type	Value	Unit	Source(s)
		See Table 4-46		Massachusetts e-TRM 2019-2021, p. 595
ESF	Variable	See Table 4-46	-	Massachusetts e-TRM 2019-2021, p. 595
HOU	Fixed	8,760	hours, annual	Massachusetts e-TRM 2019-2021, p. 595
CF_{summer}	Fixed	1.0		Massachusetts e-TRM 2019-2021, p. 595[72]
CF_{winter}	Fixed	1.0		Wisconsin TRM 2019, p. 822[72]

Table 4-46. Vending miser rated kilowatts and energy savings factors[73]

Equipment Type	kW_{rated} (kW)	ESF
Refrigerated Beverage Vending Machine	0.400	0.46
Non-Refrigerated Snack Vending Machine (Default)	0.085	0.46
Glass Front Refrigerated Cooler	0.460	0.30

4.3.2.4 Default savings

If the proper values are not supplied, a default savings may be applied using conservative input values.

The default, per-measure gross annual electric energy savings will be applied according to the following calculation:

$$\Delta kWh = kW_{rated} \times HOU \times ESF$$

$$= 0.085\ kW \times 8{,}760\ hours \times 0.46$$

$$= 342.52\ kWh$$

The default, per-measure, gross coincident summer peak demand reduction will be applied according to the following calculation:

$$\Delta kW_{summer} = \frac{\Delta kWh}{HOU} \times CF_{summer}$$

$$= \frac{343\ kWh}{8{,}760\ hours} \times 1.0$$

72 The Massachusetts TRM does not provide summer or winter CFs. However, the equation for peak demand is kWh savings divided by annual hours implying a CF of 1.0.

73 Massachusetts TRM 2019-2021 Plan Version, p. 595-597; https://www.masssavedata.com/Public/TechnicalReferenceLibrary (accessed on April 18, 2012).

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$$= 0.039\ kW$$

The default, per-measure, gross coincident winter peak demand reduction will be applied according to the following calculation:

$$\Delta kW_{winter} = \frac{\Delta kWh}{HOU} \times CF_{winter}$$

$$= \frac{343\ kWh}{8{,}760\ hours} \times 1.0$$

$$= 0.039\ kW$$

4.3.2.5 Effective Useful Life

The effective useful life of this measure is provided in Table 4-47.

Table 4-47. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	5.00	years	Massachusetts e-TRM 2019-2021, p. 596
VI	Non-Residential Prescriptive Program, DSM Phase VI	6.30	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

4.3.2.6 Source(s)

The primary source for this deemed savings approach is the Massachusetts e-TRM 2019-2021, pp. 595-597.

4.3.2.7 Update Summary

Updates made to this section are described in Table 4-48.

Table 4-48. Summary of Update(s)

Version	Update Type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the Massachusetts TRM
	Equation	Added equation for coincident winter peak demand reduction
	New Table	Effective Useful Life (EUL) by program
2020	None	No change
v10	Source	Verified no changes to page numbers / version of the Massachusetts TRM

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4.4 Refrigeration end use

4.4.1 Door closer (cooler and freezer)

4.4.1.1 Measure description

This measure realizes energy savings by installing an auto-closer on main doors to walk-in coolers or freezers, or by installing an automatic, hydraulic-type door closer on glass-reach-in doors to coolers or freezers. This measure consists of installing a door closer where none existed before. Gross annual electric energy savings are gained when an auto-closer installation reduces the infiltration of warmer outside air into a cooler or freezer environment.

Savings assume that an auto-closer reduces warm air infiltration on average by 40% and the walk-in coolers and freezer doors have effective strip curtains.[74] To simulate the reduction, the main door open time is reduced by 40%. For walk-in coolers and freezers, savings are calculated with the assumption that strip curtains that are 100% effective are installed on the doorway.

This measure is offered through different programs listed in Table 4-49, and uses the impacts estimation approach described in this section.

Table 4-49. Programs that offer this measure

Program name	Section
Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 8.5.5
Non-Residential Prescriptive Enhanced Program, DSM Phase IX	Section 16.6.3

4.4.1.2 Impacts Estimation Approach

Per-measure, gross annual electric energy savings are assigned according to the refrigeration unit type and temperature setting:

Cooler doors:

$$\Delta kWh = \Delta kWh_{cooler}$$

Freezer doors:

$$\Delta kWh = \Delta kWh_{freezer}$$

Per-measure, gross coincident summer peak demand reduction is assigned according to the refrigeration unit type and temperature setting:

Cooler doors:

$$\Delta kW_{summer} = \Delta kW_{cooler}$$

[74] Tennessee Valley Authority TRM 2018, p. 127 -128. Original sources: California Database for Energy Efficiency Resources, www.deeresources.com (DEER 2008), and San Diego Gas & Electric work paper WPSDGENRRN0110 Rev 0, August 17, 2012, “Auto-Closers for Main Cooler of Freezer Doors.”

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Freezer doors:

$$\Delta kW_{summer} = \Delta kW_{freezer}$$

Per-measure, gross coincident winter peak demand reduction is assigned according to the refrigeration unit type and temperature setting:

Cooler doors:

$$\Delta kW_{winter} = \Delta kW_{cooler}$$

Freezer doors:

$$\Delta kW_{winter} = \Delta kW_{freezer}$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure gross coincident winter peak demand reduction
ΔkWh_{cooler} = annual electric energy savings for main cooler doors
ΔkW_{cooler} = coincident demand reduction for main cooler doors
$\Delta kWh_{freezer}$ = annual electric energy savings for main freezer doors
$\Delta kW_{freezer}$ = coincident demand reduction for main freezer doors

4.4.1.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 4-50. Door closer electric energy savings and gross coincident demand reduction (per closer)[75]

Refrigeration unit type	Location	Walk-in		Reach-in	
		ΔkWh	ΔkW[76]	ΔkWh	ΔkW[76]
Cooler (31°F to 55°F)	Richmond, VA	43.9	0.0050	102	0.0116
	Norfolk, VA	43.5	0.0050	101	0.0115
	Roanoke, VA	42.4	0.0048	98	0.0112
	Sterling, VA	42.3	0.0048	98	0.0112
	Arlington, VA	42.3	0.0048	98	0.0112
	Charlottesville, VA	42.7	0.0049	99	0.0113
	Farmville, VA	44.8	0.0051	104	0.0119
	Fredericksburg, VA	43.3	0.0049	101	0.0115
	Elizabeth City, NC	43.1	0.0049	100	0.0114
	Rocky Mount, NC	43.6	0.0050	101	0.0116
Freezer	Richmond, VA	172.7	0.0197	439	0.0501

75 Methodology from Tennessee Valley Authority TRM 2018, pp. 127-129, was used. Savings were revised using the TMY3 weather data for Dominion Energy service territory locations.

76 The source TRM calculates coincident kW as the kWh savings divided by 8,760 hours. This implies that the demand reduction is the same in all periods. This is the best information available. Therefore, the same coincident peak demand reduction for summer and winter periods.

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Refrigeration unit type	Location	Walk-in		Reach-in	
		ΔkWh	ΔkW[76]	ΔkWh	ΔkW[76]
(-35°F to 30 °F)	Norfolk, VA	170.2	0.0194	433	0.0494
	Roanoke, VA	165.8	0.0189	422	0.0481
	Sterling, VA	167.2	0.0191	425	0.0486
	Arlington, VA	167.2	0.0191	425	0.0486
	Charlottesville, VA	167.5	0.0191	426	0.0486
	Farmville, VA	176.4	0.0201	449	0.0512
	Fredericksburg, VA	171.8	0.0196	437	0.0499
	Elizabeth City, NC	168.4	0.0192	428	0.0489
	Rocky Mount, NC	171.4	0.0196	436	0.0498

4.4.1.4 Default savings

In the event of incomplete data, make the following conservative assumptions:

- If the door type is missing, assume it is a walk-in door type.
- If the refrigeration system type is missing, assume it is a high-temperature cooler.

4.4.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 4-51.

Table 4-51. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	8.00	years	Tennessee Valley Authority TRM 2018, p. 128
VIII	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII			

4.4.1.6 Source(s)

The primary source for this deemed savings approach is the Tennessee Valley Authority TRM 2018, pp. 127-129.

4.4.1.7 Update summary

Updates made to this section are described in Table 4-52.

Table 4-52. Summary of update(s)

Version	Update type	Description
2022	None	None change
2021	New table	Effective Useful Life (EUL) by program

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Version	Update type	Description
	Inputs	Added large office building type and expanded to 10 weather stations
	Equation	Added equation for coincident winter peak demand reduction
2020	None	No change
v10	Source	Updated page numbers / version of the Tennessee Valley Authority TRM
	Default savings	Default savings were adjusted due to change of weather stations in North Carolina (from Charlotte to Elizabeth City and Rocky Mount-Wilson)

4.4.2 Door gasket (cooler and freezer)

4.4.2.1 Measure description

This measure realizes energy savings by replacing worn-out gaskets with new gaskets on walk-in and reach-in refrigerator or freezer doors. By replacing the gasket, the air infiltration and cooling loads is reduced, saving energy.

This is a retrofit measure with the baseline condition being the worn-out gasket. The efficient case is a new gasket.

4.4.2.2 Impacts Estimation Approach[77]

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \frac{\Delta kWh}{ft} \times L$$

Per-measure, gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \frac{\Delta kW}{ft} \times L$$

Per-measure, gross coincident winter peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \frac{\Delta kW}{ft} \times L$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure gross coincident winter peak demand reduction
$\Delta kWh/ft$ = gross annual electric energy savings per linear foot
$\Delta kW/ft$ = gross coincident demand reduction per linear foot
L = length of gasket applied

[77] Electric energy and demand reduction for this measure are based on modeled results found in the Tennessee Valley Authority TRM 2018, which based its model assumptions and equations on 3 sources: the California Database for Energy Efficiency Resources, www.deeresources.com (DEER 2008), the 2009 Southern California Edison Company- WPSCNRRN0004.1 - Door Gaskets for Glass Doors of Walk-In Coolers work paper, and the 2009 Southern California Edison Company- WPSCNRRN0001.1 - Door Gaskets for Main Door of Walk-in Coolers and Freezers work paper.

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4.4.2.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 4-53. Input values for door gasket savings calculations

Component	Type	Value	Unit	Source(s)
ΔkWh/ft	Variable	See Table 4-54	kWh/ft	Tennessee Valley Authority TRM 2018, p. 123.
ΔkW/ft	Variable	See Table 4-54Table 4-54	kW/ft	Tennessee Valley Authority TRM 2018, p. 123.[78]
L	Variable	See customer application	feet	Customer application
		Default = 15		DNV engineering judgment

Table 4-54. Door gasket annual electric energy and coincident demand reductions [79]

Refrigeration type	ΔkWh/ ft	ΔkW/ft
Freezer (-35°F to 30°F)		
Walk-in Door	29.5	0.0036
Reach-in glass door	22.2	0.0025
Cooler (31°F to 55°F)		
Walk-in door	9.3	0.0011
Reach-in glass door	3.4	0.0004

4.4.2.4 Default savings

If the proper values are not supplied, a default savings may be applied using conservative input values assuming a reach-in, glass-door cooler.

The default per-measure, gross annual electric energy savings per unit cooler/freezer will be assigned according to the following calculation:

$$\Delta kWh = \frac{\Delta kWh}{ft} \times L$$

$$= 3.4 \frac{kWh}{ft} \times 15\, ft$$

[78] The source TRM calculates coincident kW as the kWh savings divided by 8,760 hours. This implies that the demand reduction is the same in all periods. This is the best information available. Therefore, the same coincident peak demand reduction for summer and winter periods.

[79] Tennessee Valley Authority 2018, p. 123 – 124, methodology was used. TMY3 weather data was applied for Richmond, VA and Charlotte, NC. The difference between these locations was less than 1%. Richmond values are applied for all locations across Dominion Energy service territory as the variance is negligible across locations..

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$$= 51.00\ kWh$$

The default per-measure, gross coincident summer peak demand savings per unit cooler/freezer will be assigned according to the following calculation:

$$\Delta kW_{summer} = \frac{\Delta kW}{ft} \times L$$

$$= 0.0004 \frac{kW}{ft} \times 15\ ft$$

$$= 0.006\ kW$$

The default per-measure, gross coincident winter peak demand savings per unit cooler/freezer will be assigned according to the following calculation:

$$\Delta kW_{winter} = \frac{\Delta kW}{ft} \times L$$

$$= 0.0004 \frac{kW}{ft} \times 15\ ft$$

$$= 0.006\ kW$$

4.4.2.5 Effective Useful Life

The effective useful life of this measure is provided in Table 4-55.

Table 4-55. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	4.00	years	Maryland/Mid-Atlantic TRM v10
VI	Non-Residential Prescriptive Program, DSM Phase VI	6.30		Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

4.4.2.6 Source(s)

The primary source for this deemed savings approach is the Tennessee Valley Authority TRM 2018, pp. 123-124.

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4.4.2.7 Update summary

Updates made to this section are described in Table 4-56.

Table 4-56. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	New Table	Effective Useful Life (EUL) by program
	Equation	Added equation for coincident winter peak demand reduction
2020	Source	No change
v10	Source	Updated page numbers / version of the Tennessee Valley Authority TRM

4.4.3 Commercial freezers and refrigerators

4.4.3.1 Measure description

This measure involves the installation of an ENERGY STAR® qualified commercial freezer or refrigerator. These models are designed for warm commercial kitchen environments with frequent door opening. Qualifying equipment utilize a variety of energy-efficient components such as ECM fan motors, hot gas anti-sweat heaters, or high-efficiency compressors. Qualifying equipment must not exceed the maximum daily kWh values determined by the volume, door type, and configuration specified by Version 4.0 specifications that went into effect March 2017.

This measure is offered through different programs listed in Table 4-57 and uses the impacts estimation approach described in this section.

Table 4-57. Programs that offer this measure

Program name	Section
Non-Residential Prescriptive Program, DSM Phase VI	Section 4.4.3
Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII	Section 9.3.1
Non-Residential Prescriptive Enhanced Program, DSM Phase IX	Section 16.6.1

4.4.3.2 Impacts Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = (kWh_{base} - kWh_{ee}) \times Days$$

Per-measure, gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \left(\frac{\Delta kWh}{EFLH}\right) \times CF_{summer}$$

Per-measure, gross coincident winter peak demand reduction is calculated according to the following equation:

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$$\Delta kW_{winter} = \left(\frac{\Delta kWh}{EFLH}\right) \times CF_{winter}$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure gross coincident winter peak demand reduction
kWh_{base} = daily energy consumption of the baseline equipment
kWh_{ee} = daily energy consumption of the efficient equipment
Days = days per year
EFLH = equivalent full load hours of equipment
CF_{summer} = summer peak coincidence factor
CF_{winter} = winter peak coincidence factor

4.4.3.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 4-58. Input parameters for commercial freezers and refrigerator measure

Component	Type	Value	Units	Source(s)
kWh_{base}	Variable	See Table 4-59	kWh	Federal Standards, Energy Efficiency Program for Certain Commercial and Industrial Equipment, title 10, sec. 431.66 (2013)[80]
kWh_{ee}	Variable	See Table 4-60	kWh	ENERGY STAR® Certified-commercial-refrigerators-and-freezers[81]
Days	Fixed	365	days, annual	Constant
EFLH	Fixed	5,858	hours, annual	Maryland/Mid-Atlantic TRM v.10, pp. 335 and 339[82]
CF_{summer}	Fixed	0.77	-	Maryland/Mid-Atlantic TRM v.10, pp. 335 and 339[83]
CF_{winter}	Fixed	0.77	-	Maryland/Mid-Atlantic TRM v.10, pp. 335 and 339[84]
Volume	Variable	See customer application	cubic feet	Customer application

80 The Maryland/Mid-Atlantic TRM v.10 references the federal standards, but the actual values used do not match. Since the baseline daily kWh is greater than required by code, it is assumed that they have been modified per program design.

81 Values are provided in ENERGY STAR Certified Commercial Refrigerators and Freezers List as the “Energy Use (Daily Energy Consumption)(kWh/day)” downloadable list can be found here: https://www.energystar.gov/productfinder/product/certified-commercial-refrigerators-and-freezers/results

82 Original source is cited as: Efficiency Vermont Technical Reference User Manual No. 2013-82.5, August 2013; Derived from Washington Electric Coop data by West Hill Energy Consultants.

83 Derived from Itron eShapes, using 8,760 hourly data by end use for Upstate New York. This was combined with full load hour assumptions used for efficiency measures to account for diversity of equipment usage within the peak period hours.

84 The Maryland/Mid-Atlantic TRM v.10 only provides summer peak CF. Without winter peak CF value available, the summer peak CF is applied.

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Table 4-59. Calculated baseline daily energy consumption from volume, V

Equipment type	Refrigerator energy, kWh	Freezer energy, kWh
Vertical Closed		
Solid Door	= 0.050 x V + 1.360	= 0.220 x V + 1.380
Transparent	= 0.100 x V + 0.860	= 0.290 x V + 2.950
Horizontal Closed		
Solid Door	= 0.050 x V + 0.910	= 0.060 x V + 1.120
Transparent	= 0.060 x V + 0.370	= 0.080 x V + 1.230

Table 4-60. Calculated efficient unit daily energy consumption from volume

Equipment type and volume (ft^3)	Refrigerator energy, kWh	Freezer energy, kWh
Vertical Closed		
Solid Door		
$V < 15$ ft^3	=0.022 x V + 0.970	=0.210 x V + 0.900
$15 \leq V < 30$ ft^3	=0.066 x V + 0.310	=0.120 x V + 2.248
$30 \leq V < 50$ ft^3	=0.040 x V + 1.090	=0.285 x V - 2.703
$V \geq 50$ ft^3	=0.024 x V + 1.890	=0.142 x V + 4.445
Transparent Door		
$V < 15$ ft^3	=0.095 x V + 0.445	=0.232 x V + 2.360
$15 \leq V < 30$ ft^3	=0.050 x V + 1.120	=0.232 x V + 2.360
$30 \leq V < 50$ ft^3	=0.076 x V + 0.340	=0.232 x V + 2.360
$V \geq 50$ ft^3	=0.105 x V - 1.111	=0.232 x V + 2.360
Horizontal Closed		
Solid or Transparent Door		
All Volumes	=0.050 x V + 0.280	=0.057 x V + 0.550

4.4.3.4 Default savings

This measure does not have default savings.

4.4.3.5 Effective Useful Life

The effective useful life of this measure is provided in Table 4-61.

Table 4-61. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	12.00	years	Mid-Atlantic TRM 2020, p. 335

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DSM Phase	Program name	Value	Units	Source(s)
VIII	Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII			
VI	Non-Residential Prescriptive Program, DSM Phase VI	6.30	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

4.4.3.6 Source(s)

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v.10, pp. 334–341.

4.4.3.7 Update summary

Updates made to this section are described in Table 4-62.

Table 4-62. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the Mid-Atlantic TRM
	Equation	Added equation for coincident winter peak demand reduction
	New table	Effective Useful Life (EUL) by program
2020	None	No change
v10	Source	Updated page numbers / version of the Mid-Atlantic TRM
	Input variable	Updated CF value

4.4.4 Commercial ice maker

4.4.4.1 Measure description

This measure involves high-efficiency ice makers meeting ENERGY STAR® or CEE Tier 2 ice maker requirements. The measure applies to batch type (also known as cube type) and continuous type (also known as flake or nugget type) equipment. The equipment includes ice-making head (without storage bin), self-contained, or remote-condensing units. ENERGY STAR® ice makers are limited to only air-cooled units while CEE Tier 2 standards address water-cooled units. The baseline for each type of ice maker is the corresponding Federal standard for the same technology.

This measure is offered through different programs listed in Table 4-65 and uses the impacts estimation approach described in this section.

Table 4-63. Programs that offer this measure

Program name	Section
Non-Residential Prescriptive Program, DSM Phase VI	Section 4.4.4

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Program name	Section
Non-Residential Prescriptive Enhanced Program, DSM Phase IX	Section 16.6.2

4.4.4.2 Impacts Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \left(\frac{kWh_{base} - kWh_{ee}}{100\ lb}\right) \times H_{rated} \times DC \times Days$$

Per-measure, gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \frac{\Delta kWh}{8{,}760\ hours} \times CF_{summer}$$

Per-measure, gross coincident winter peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \frac{\Delta kWh}{8{,}760\ hours} \times CF_{winter}$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure gross coincident winter peak demand reduction
kWh_{base} = energy consumption per 100 lb of ice produced by the baseline equipment
kWh_{ee} = energy consumption per 100 lb of ice produced by the new equipment
H_{rated} = manufacturer-rated daily harvest rate of equipment
DC = duty cycle of ice machine
Days = number of days per year
CF_{summer} = summer peak coincidence factor
CF_{winter} = winter peak coincidence factor

4.4.4.3 Input Variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 4-64. Input parameters for commercial ice maker

Component	Type	Value	Units	Source(s)
kWh_{base}	Variable	Batch-type: See Table 4-65 Continuous-type: See Table 4-66	kWh/ 100-lb of ice	Federal Standards 80 FR 4645[85]
kWh_{ee}	Variable	<u>CEE Tier 2 Water-cooled:</u> See Table 4-67	kWh/ 100-lb of ice	

[85] The standards are available here: https://www.regulations.gov/document?D=EERE-2010-BT-STD-0037-0137. Batch type ice maker efficiencies are on p. 5-4 and continuous type baseline efficiency levels are on p. 5-9.

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Component	Type	Value	Units	Source(s)
		Air-cooled: ENERGY STAR batch-type: See Table 4-68 ENERGY STAR continuous-type: See Table 4-69 If ice machine type is unknown and water cooled: Default = cube or nugget If ice machine is ENERGY STAR and water-cooled[88]: Default = CEE Tier 2 Water-cooled = cube or nugget		CEE Tier 2[86] and ENERGY STAR®[87] lists of qualifying equipment
H_{rated}	Variable	See customer application	pound, daily	Customer application
DC	Fixed	0.5	-	Arkansas TRM 2019 Volume 8.1 p. 498[89]
Days	Fixed	365	days, annual	Arkansas TRM 2019 Volume 8.1 p. 498
CF_{summer}	Fixed	1.0	-	Arkansas TRM 2019 Volume 8.1 p. 498[90]
CF_{winter}	Fixed	1.0	-	Arkansas TRM 2019 Volume 8.1 p. 498[90]

Table 4-65. Batch-type ice machine baseline efficiencies[91]

Ice machine type	Type of cooling	Harvest rate (lb/day)	kWh_{base} (kWh/100-lb ice)
Ice-making head	Water	< 300	6.880 – 0.00550 x H_{rated}
		≥ 300 and < 850	5.800 – 0.00191 x H_{rated}
		≥ 850 and < 1,500	4.420 – 0.00028 x H_{rated}
		≥ 1,500 and < 2,500	4.000
		≥ 2,500 and < 4,000	4.000
	Air	< 300	10.000 – 0.01233 x H_{rated}
		≥ 300 and < 800	7.055 – 0.00250 x H_{rated}
		≥ 800 and < 1,500	5.550 – 0.00063 x H_{rated}
		≥ 1,500 and < 4,000	4.610
Remote-condensing w/o remote compressor	Air	≥ 50 and < 1,000	7.970 – 0.00342 x H_{rated}
		≥ 1,000 and < 4,000	4.590
Remote-condensing w/ remote compressor	Air	< 942	7.970 – 0.00342 x H_{rated}
		≥ 942 and < 4,000	4.790

86 Currently qualifying ice makers meet CEE requirements effective 7/01/2011. Qualifying equipment is updated quarterly, available here: https://library.cee1.org/content/commercial-kitchens-ice-machines-qualifying-product-list.

87 Currently qualifying ice makers meet ENERGY STAR® Version 3.0 program requirements effective January 28, 2018. The list of qualifying equipment can be found here: https://www.energystar.gov/productfinder/product/certified-commercial-ice-machines/results.

88 ENERGY STAR does not include water-cooled ice makers. If both of these are indicated to be true on the application, it is assumed the equipment type is CEE Tier-2 water-cooled.

89 Per Arkansas TRM, this value was selected based on the most conservative value from a collection of sources including TRMs in Vermont, Pennsylvania, Ohio, Wisconsin, and Missouri.

90 Per Arkansas TRM, this value was selected based on building types and lighting CFs. There is limited information about the specific load profile of ice makers. No winter CF is provided so summer CF is used.

91 10 CFR Part 431 Subpart H, Automatic Commercial Ice Makers. 77 FR 1591. January 11, 2012. New minimum requirements effective January 28, 2018.

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Ice machine type	Type of cooling	Harvest rate (lb/day)	kWh_{base} (kWh/100-lb ice)
Self-contained	Water	< 200	9.500 – 0.00342 x H_{rated}
		≥ 200 and < 2,500	5.700
		≥ 2500 and < 4,000	5.700
	Air	< 110	14.790 – 0.04690 x H_{rated}
		≥ 110 and < 200	12.420 – 0.02533 x H_{rated}
		≥ 200 and < 4,000	7.350

Table 4-66. Continuous-type ice machine baseline efficiencies

Ice machine type	Type of cooling	Harvest rate (lb/day)	kWh_{base} (kWh/100-lb ice)
Ice-making head	Water	< 801	6.48 – 0.00267 x H_{rated}
		≥ 801 and < 2,500	4.34
		≥ 2,500 and < 4,000	4.34
	Air	< 310	9.19 – 0.00629 x H_{rated}
		≥ 310 and < 820	8.23 – 0.00320 x H_{rated}
		≥ 820 and < 4,000	5.61
Remote-condensing w/o remote compressor	Air	< 800	9.70 – 0.00580 x H_{rated}
		≥ 800 and < 4,000	5.06
Remote-condensing w/ remote compressor	Air	< 800	9.90 – 0.00580 x H_{rated}
		≥ 800 and < 4,000	5.26
Self-contained	Water	< 900	7.60 – 0.00302 x H_{rated}
		≥ 900 and < 2,500	4.88
		≥ 2,500 and < 4,000	4.88
	Air	< 200	14.22 – 0.03000 x H_{rated}
		≥ 200 and < 700	9.47 – 0.00624 x H_{rated}
		≥ 700 and < 4,000	5.10

Table 4-67. CEE Tier 2 ice machine qualifying efficiencies[92]

Ice type[93]	Type of cooling	Harvest rate (lb/day)	kWh_{ee} (kWh/100-lb ice)
Cube or nugget (default)	Water	< 175	10.6 – 0.0241 x H_{rated}
		≥ 175 and < 450	7.1 – 0.0062 x H_{rated}
		≥ 450 and < 1,000	4.7 – 0.0011 x H_{rated}
		≥ 1,000	3.7 – 0.0002 x H_{rated}

92 CEE Requirements don't differentiate between continuous or batch type ice machines, requirements are found here: https://library.cee1.org/system/files/library/4280/CEE_Ice_Machines_Spec_Final_Effective_01Jul2011_-_updated_July_7_2015.pdf

93 CEE Ice machine types are cube (self-contained), Nugget (ice-making head) and flake (ice-making head). The application determines if the equipment is self-contained or ice-making head. However, the application does not differentiate between flake or nugget ice making head. Flake ice machine types make up a low percent of the CEE Tier 2 models and typically used for specific applications. Therefore, cube or nugget ice machine type is used as the default for CEE Tier 2 water cooled ice makers.

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Ice type[93]	Type of cooling	Harvest rate (lb/day)	kWh_{ee} (kWh/100-lb ice)
Flake Type	Water	< 1,000	4.8 – 0.0017 x H_{rated}
		≥ 1,000	3.2

Table 4-68. Batch-type ENERGY STAR® ice machine qualifying efficiencies[94]

Ice machine type	Type of cooling	Harvest rate (lb/day)	kWh_{ee} (kWh/100-lb ice)
Ice-making head	Air	< 300	9.20 – 0.01134 x H_{rated}
		≥ 300 and < 800	6.49 – 0.0023 x H_{rated}
		≥ 800 and < 1,500	5.11 – 0.00058 x H_{rated}
		≥ 1,500 and ≤ 4,000	4.24
Remote-condensing (with and without remote compressor)	Air	< 988	7.17 – 0.00308 x H_{rated}
		≥ 988 and ≤ 4,000	4.13
Self-contained	Air	< 110	12.57 – 0.0399 x H_{rated}
		≥ 110 and < 200	10.56 – 0.0215 x H_{rated}
		≥ 200 and ≤ 4,000	6.25

Table 4-69. Continuous-type ENERGY STAR® ice machine qualifying efficiencies[95]

Ice machine type	Type of cooling	Harvest rate (lb/day)	kWh_{ee} (kWh/100-lb ice)
Ice-making head	Air	< 310	7.90 – 0.005409 x H_{rated}
		≥ 310 and < 820	7.08 – 0.002752 x H_{rated}
		≥ 820 and ≤ 4,000	4.82
Remote-condensing (with and without remote compressor)	Air	< 800	7.76 – 0.00464 x H_{rated}
		≥ 800 and ≤ 4,000	4.05
Self-contained	Air	< 200	12.37 – 0.0261 x H_{rated}
		≥ 200 and < 700	8.24 – 0.005429 x H_{rated}
		≥ 700 and ≤ 4,000	4.44

4.4.4.4 Default savings

If the proper values are not available, some values have defaults savings. However, there are no default savings for this measure as some values are needed to calculate savings.

4.4.4.5 Effective Useful Life

The effective useful life of this measure is provided in Table 4-70.

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[94] Currently qualifying ice makers meet ENERGY STAR® Version 3.0 program requirements effective January 28, 2018.: The current requirements are found here: https://www.energystar.gov/sites/default/files/Final%20V3.0%20ACIM%20Specification%205-17-17_1_0.pdf, https://www.energystar.gov/products/commercial_food_service_equipment/commercial_ice_makers/key_product_criteria

[95] Ibid

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Table 4-70. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	10.00	years	Arkansas TRM 2019 Volume 8.1 p. 497
VI	Non-Residential Prescriptive Program, DSM Phase VI	6.30		Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

4.4.4.6 Source(s)

The primary source for this deemed savings approach is the Arkansas TRM 2019 Version 8.1, pp. 495–498.

4.4.4.7 Update summary

Updates made to this section are described in Table 4-71.

Table 4-71. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the Arkansas TRM
	Equation	Added equation for coincident winter peak demand reduction
	New Table	Effective Useful Life (EUL) by program
2020	Source	Clarified which kWh_{ee} values to use for conflicts between CEE Tier 2, ENERGY STAR, for air-cooled and water-cooled units
		Clarified CEE Tier 2 ice machine types and assigned default to cube or nugget ice machine types (not collected by the current Non-Residential Prescriptive Program)
v10	Source	Updated page numbers of the Arkansas TRM
	Equation	Updated equation

4.4.5 Evaporator Fan Electronically Commutated Motor (ECM) Retrofit (Reach-in and walk-in coolers and freezers)

4.4.5.1 Measure description

The measure replaces the baseline shaded-pole (SP), evaporator-fan motors with electronically-commuted motors (ECMs). The baseline motors run 24 hour/day, seven day/week (24/7) and have no controls.

Evaporator fans circulate air in refrigerated spaces by drawing air across the evaporator coil and into the space. Fans are found in both reach-in and walk-in coolers and freezers. Energy and demand savings for this measure are achieved by reducing motor operating power. Additional savings come from refrigeration interactive effects. Because electronically-commutated motors (ECMs) are more efficient and use less power, they introduce less heat into the

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refrigerated space compared to the baseline motors and result in a reduction in cooling load on the refrigeration system.

This measure is offered through different programs listed in Table 4-72 and uses the impacts estimation approach described in this section.

Table 4-72. Programs that offer this measure

Program name	Section
Non-Residential Prescriptive Program, DSM Phase VI	Section 4.4.5
Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 8.5.3
Non-Residential Prescriptive Enhanced Program, DSM Phase IX	Section 16.6.5

4.4.5.2 Impacts Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \frac{(watts_{base} - watts_{ee})}{1{,}000\ W/kW} \times \%\ ON \times HOU \times WHF_e$$

Per-measure, gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \frac{(watts_{base} - watts_{ee})}{1{,}000\ W/kW} \times WHF_d \times CF_{summer}$$

Per-measure, gross coincident winter peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \frac{(watts_{base} - watts_{ee})}{1{,}000\ W/kW} \times WHF_d \times CF_{winter}$$

If the application shows that the rated wattage of existing/baseline evaporator fan motor, W_{base}, is less than rated wattage of electronically commutated evaporator fan motor, W_{ee}, then it is assumed that the baseline motor was replaced with a larger energy efficient motor. In such instances, the default values for these variables—provided in The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 4-73—are to be used.

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure gross coincident summer peak demand reduction
$watts_{base}$ = rated wattage of existing/baseline evaporator fan motor
$watts_{ee}$ = rated wattage of electronically commutated evaporator fan motor
%ON = duty cycle (effective run time) of controlled evaporator-fan motors
HOU = annual operating hours

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WHF_e = Waste Heat Factor for Energy; represents the increased savings due to reduced waste heat from motors that must be rejected by the refrigeration equipment
WHF_d = Waste Heat Factor for Demand; represents the increased savings due to reduced waste heat from motors that must be rejected by the refrigeration equipment
CF_{summer} = summer peak demand Coincidence Factor
CF_{winter} = winter peak demand Coincidence Factor

4.4.5.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 4-73. Input values for ECM evaporator savings calculations

Component	Type	Value	Unit	Source(s)
$watts_{base}$	Variable	See customer application	watts	Customer application
		Defaults: See Table 4-74		Wisconsin TRM 2020, p. 795
$watts_{ee}$	Variable	See customer application	watts	Customer application
		Defaults: See Table 4-74		Wisconsin TRM 2020, p. 795
%ON	Variable	Uncontrolled: 0.978 ON/OFF Control: 0.636 Multispeed Control/ Unknown (default): 0.692	-	Maryland/Mid-Atlantic TRM v.10, p. 349
HOU	Fixed	8,760	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 346
WHF_e	Variable	Low Temp (-35˚F - -1˚F): 1.76 Med Temp (0˚F - 30˚F): 1.76 High Temp (31˚F - 55˚F): 1.38	-	Maryland/Mid-Atlantic TRM v.10, p. 347
		Default: 1.38		
WHF_d	Variable	Low Temp (-35˚F - -1˚F): 1.76 Med Temp (0˚F - 30˚F): 1.76 High Temp (31˚F - 55˚F): 1.38	-	Maryland/Mid-Atlantic TRM v.10, p. 347
		Default: 1.38		
CF_{summer}	Fixed	0.978	-	Maryland/Mid-Atlantic TRM v.10, p. 349[96]
CF_{winter}	Fixed	0.978	-	Maryland/Mid-Atlantic TRM v.10, p. 349[97]

Table 4-74. Total deemed savings for ECM evaporator fan motor

system type	Motor size	$watts_{base}$	$watts_{ee}$	Source
Walk-In Cooler	<1/20 hp	79.38	26.64	Wisconsin TRM 2020, pp:795-796
Walk-In Cooler	1/20 - 1 hp	211.66	71.04	Wisconsin TRM 2020, pp:795-796

[96] Maryland/Mid-Atlantic TRM v.10, p. 347. Coincidence factors were developed by dividing the PJM Peak Savings for EF Motors and Controls from Table 47 by the product of the average ECM wattage per rated horsepower (0.758 kW/hp) and the Waste Heat Factor for Demand. Note: the CF was adjusted to 0.978 (percent on), for uncontrolled evaporator fan motors. The Mid-Atlantic TRM has a CF greater than one because it is calculated relative to the wattage of the post-retrofit ECM motor as opposed to the existing SP motor.

[97] Maryland/Mid-Atlantic TRM v.10, p. 347. Winter coincidence factors were not provided in source TRM. Similar to summer CF, the Note: the CF referenced load shape study does not provide winter peak reduction relative to the change in baseline and ECM power. Instead, the reduction is provided in terms of the ECM wattage. There isn't enough information provided to determine the winter CF. Therefore, the percentage on is used as an approximation.

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system type	Motor size	watts$_{base}$	watts$_{ee}$	Source
Walk-in Cooler or Unknown (default)	Unknown (default)[98]	151.19	50.74	Wisconsin TRM 2020, pp:795-796
Walk-In Freezer	<1/20 hp	90.70	30.44	Wisconsin TRM 2020, pp:795-796
Walk-In Freezer	1/20 - 1 hp	244.22	81.97	Wisconsin TRM 2020, pp:795-796
Walk-in Freezer	Unknown (default)[99]	188.95	63.42	Wisconsin TRM 2020, pp:795-796
Reach-In Cooler	<1/20 hp or 1/20 - 1 hp	31.00	12.00	Maryland/Mid-Atlantic TRM v.10, p. 346
Reach-In Freezer	<1/20 hp or 1/20 - 1 hp	31.00	12.00	Maryland/Mid-Atlantic TRM v.10, p. 346

4.4.5.4 Default savings

If the proper values are not supplied, a default savings may be applied using conservative input values. Accordingly, the default per-measure, gross annual electric energy savings will be assigned according to the following calculation:

$$\Delta kWh = \frac{(watts_{base} - watts_{ee})}{1{,}000\, W/kW} \times \%ON \times HOU \times WHF_e$$

$$= \frac{(151.19\, W - 50.74\, W)}{1{,}000\, W/kW} \times 0.692 \times 8{,}760\, hours \times 1.38$$

$$= 840.31\, kWh$$

The default per-measure, gross coincident summer peak demand reduction will be assigned according to the following calculation:

$$\Delta kW_{summer} = \frac{(watts_{base} - watts_{ee})}{1{,}000\, W/kW} \times WHF_d \times CF_{summer}$$

$$= \frac{(151.19\, W - 50.74\, W)}{1{,}000\, W/kW} \times 1.38 \times 0.978$$

$$= 0.136\, kW$$

The default per-measure, gross coincident winter peak demand reduction will be assigned according to the following calculation:

[98] Applied the Wisconsin TRM 2020 weighted average of all of the motors surveyed, 45.7% <1/20 hp and 54.3% 1/20 – 1 hp.
[99] Applied the Wisconsin TRM 2020 weighted average of all of the motors surveyed, 36.0% <1/20 hp and 64.0% 1/20 – 1 hp.

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$$\Delta kW_{winter} = \frac{(watts_{base} - watts_{ee})}{1{,}000\,W/kW} \times WHF_d \times CF_{winter}$$

$$= \frac{(151.19\,W - 50.74\,W)}{1{,}000\,W/kW} \times 1.38 \times 0.978$$

$$= 0.136\,kW$$

4.4.5.5 Effective Useful Life

The effective useful life of this measure is provided in Table 4-75.

Table 4-75. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	15.00	years	Maryland/Mid-Atlantic TRM v.10, p. 347
VIII	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII			
VI	Non-Residential Prescriptive Program, DSM Phase VI	6.30	years	Program design assumptions (weighted average of EULs across all measures offered by program and their planned uptake)

4.4.5.6 Source(s)

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v.10, pp. 346-347 and Wisconsin TRM 2020, pp. 394-397.

4.4.5.7 Update summary

Updates made to this section are described in Table 4-76.

Table 4-76. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the Mid-Atlantic TRM
	Input variable	• Updated values of $watts_{base}$, $watts_{ee}$ • Replaced DC_{evap} with %ON and updated values
	Default savings	Updated default savings value
	Equation	Added equation for coincident winter peak demand reduction
	New table	Effective Useful Life (EUL) by program
2020	None	No change

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Version	Update type	Description
v10	Input variable	Deleted a conversion factor, CW_{rated}, as it was not needed
	Source	Updated page numbers / version of the Mid-Atlantic TRM and Wisconsin TRM

4.4.6 Evaporator fan control (cooler and freezer)

4.4.6.1 Measure description

This measure realizes energy savings by installing evaporator controls for reach-in or walk-in coolers and freezers. Typically, evaporator fans run constantly (24 hours per day, 365 days per year) to provide cooling when the compressor is running, and to provide air circulation when the compressor is not running. This measure saves energy by cycling the fan off or reducing fan speed when the compressor is not running. This results in a reduction in fan energy usage and a reduction in the refrigeration load resulting from the reduction in heat given off by the fan.

This approach applies to reach-in or walk-in freezers and refrigerator units; it is not applicable to refrigerated warehouses or other industrial refrigeration applications.

This measure is offered through different programs listed in Table 4-77, and uses the impacts estimation approach described in this section.

Table 4-77. Programs that Offer this Measure

Program name	Section
Non-Residential Prescriptive Program, DSM Phase VI	Section 4.4.6
Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 8.5.4

4.4.6.2 Impacts Estimation Approach

Per-measure, gross annual electric energy savings are calculated using the following equation:

$$\Delta kWh \quad = hp \times \frac{kW}{hp} \times (\%On_{base} - \%On_{ee}) \times HOU \times WHF_e$$

Per-measure, gross coincident summer peak demand reduction is calculated using the following equation:

$$\Delta kW_{summer} \quad = hp \times \frac{kW}{hp} \times WHF_d \times CF_{summer}$$

Per-measure, gross coincident winter peak demand reduction is calculated using the following equation:

$$\Delta kW_{winter} \quad = hp \times \frac{kW}{hp} \times WHF_d \times CF_{winter}$$

Where:

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ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure gross coincident winter peak demand reduction
hp = rated hp of evaporator fan motors connected to control
kW/hp = evaporative fan connected load per rated horsepower
$\%On_{base}$ = duty cycle of the uncontrolled evaporator fan
$\%On_{ee}$ = duty cycle of the controlled evaporator fan
HOU = annual hours of use
WHF_e = waste heat factor (WHF) for energy; represents the increased savings due to reduced waste heat from motors that must be rejected by the refrigeration equipment
WHF_d = waste heat factor (WHF) for Demand; represents the increased savings due to reduced waste heat from motors that must be rejected by the refrigeration equipment
CF_{summer} = summer peak demand coincidence factor (CF)
CF_{winter} = winter peak demand coincidence factor (CF)

4.4.6.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 4-78. Input values for freezer and cooler evaporator fan controls saving calculations

Component	Type	Value	Unit	Source(s)
hp	Variable	See customer application	hp	Customer application
		Default: If system is walk-in: 1/15 hp If system is reach-in: 1/62 hp		Maryland/Mid-Atlantic TRM v.10, p. 348[100]
kW/hp	Variable	Single-speed: 2.088 kW/hp Multi-speed: 0.758 kW/hp	kW/hp	Maryland/Mid-Atlantic TRM v.10, p. 348
		Default: 0.758 kW/hp		
$\%On_{base}$	Fixed	0.978	-	Maryland/Mid-Atlantic TRM v.10, p. 348
$\%On_{ee}$	Variable	Single-speed (on/off controls): 0.636 Multi-speed: 0.692	-	Maryland/Mid-Atlantic TRM v.10, p. 349
		Default: 0.692		
HOU	Fixed	8,760	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 349
WHFe	Variable	Low Temp (-35˚F to -1˚F): 1.76 Med Temp (0˚F - 30˚F): 1.76 High Temp (31˚F - 55˚F): 1.38	-	Maryland/Mid-Atlantic TRM v.10, p.349
		Default: 1.38		
WHFd	Variable	Low Temp (-35˚F - -1˚F): 1.76 Med Temp (0˚F - 30˚F): 1.76 High Temp (31˚F - 55˚F): 1.38	-	Maryland/Mid-Atlantic TRM v.10, p. 349
		Default: 1.38		
CF_{summer}	Variable	Single-speed (on/off controls): 0.11 Multi-speed: 0.31	-	Maryland/Mid-Atlantic TRM v.10, p. 349[101]

100 Default value not provided in Mid-Atlantic TRM, however the original source is the Commercial Refrigeration Loadshape Project NEEP 2015, p. 5, finds that the average new ECM motor is rated at 1/15 hp. This majority of motors studied were installed in walk-in cases. Therefore, 1/15 hp or 50 W is the default for walk-in applications. Default size for reach-in cases is the smallest motor sizes identified in this study, 1/62 hp or 12 W

101 The Maryland/Mid-Atlantic TRM references the Commercial Refrigeration Loadshape Project NEEP 2015 for the summer CF. The CFs are calculated and separated out for single-speed and multispeed summer CFs.

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Component	Type	Value	Unit	Source(s)
CF_{winter}	Variable	Single-speed (on/off controls): 0.12 Multi-speed: 0.31	-	Maryland/Mid-Atlantic TRM v.10, p. 349[102]

4.4.6.4 Default savings

If the proper values are not supplied, a default savings may be applied using conservative input values.

The default per-measure, gross annual electric energy savings for a high-temperature walk-in and reach-in coolers with a multi-speed evaporator motor will be assigned according to the following calculation, respectively:

Walk-in

$$\Delta kWh = hp \times \frac{kW}{hp} \times (\%On_{base} - \%On_{ee}) \times HOU \times WHF_e$$

$$= \frac{1}{15} hp \times 0.758 \frac{kW}{hp} \times (0.978 - 0.692) \times 8{,}760\ hours \times 1.38$$

$$= 174.14\ kWh$$

Reach-in

$$\Delta kWh = hp \times \frac{kW}{hp} \times (\%On_{base} - \%On_{ee}) \times HOU \times WHF_e$$

$$= \frac{1}{62} hp \times 0.758 \frac{kW}{hp} \times (0.978 - 0.692) \times 8{,}760\ hours \times 1.38$$

$$= 42.27\ kWh$$

The corresponding default per-measure, gross coincident demand reduction for walk-in and reach-in coolers will be assigned according to the following calculation, respectively:

Walk-In

$$\Delta kW_{summer} = hp \times \frac{kW}{hp} \times WHF_d \times CF_{summer}$$

$$= \frac{1}{15} hp \times 0.758 \frac{kW}{hp} \times 1.38 \times 0.26$$

[102] The Maryland/Mid-Atlantic TRM does not provide a winter CF. The referenced Commercial Refrigeration Loadshape Project NEEP 2015 is used to calculate winter CF.

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$$= 0.018\, kW$$

$$\Delta kW_{winter} = hp \times \frac{kW}{hp} \times WHF_d \times CF_{winter}$$

$$= \frac{1}{15} hp \times 0.758 \frac{kW}{hp} \times 1.38 \times 0.26$$

$$= 0.018\, kW$$

Reach-in

$$\Delta kW_{summer} = hp \times \frac{kW}{hp} \times WHF_d \times CF_{summer}$$

$$= \frac{1}{62} hp \times 0.758 \frac{kW}{hp} \times 1.38 \times 0.26$$

$$= 0.004\, kW$$

$$\Delta kW_{winter} = hp \times \frac{kW}{hp} \times WHF_d \times CF_{winter}$$

$$= \frac{1}{62} hp \times 0.758 \frac{kW}{hp} \times 1.38 \times 0.26$$

$$= 0.004\, kW$$

4.4.6.5 Effective Useful Life

The effective useful life of this measure is provided in Table 4-79.

Table 4-79. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program name	Value	Units	Source(s)
VIII	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	10.00	years	Maryland/Mid-Atlantic TRM v.10, p. 349
VI	Non-Residential Prescriptive Program, DSM Phase VI	6.30	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

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4.4.6.6 Source(s)

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v.10, pp. 348-349.

4.4.6.7 Update summary

Updates made to this section are described in Table 4-80.

Table 4-80: Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the Mid-Atlantic TRM
	Input variable	Updated hp values
	Default calculation	Updated default calculation
	Equation	Added equation for coincident winter peak demand reduction
	New table	Effective Useful Life (EUL) by program
2020	None	No change
v10	Source	Updated page numbers / version of the Mid-Atlantic TRM
	Input variable	• Clarified kW/hp, WHF_e, and WHF_d default assumptions for values • Updated hp, $\%On_{base}$ and $\%On_{ee}$ values

4.4.7 Floating head pressure control

4.4.7.1 Measure description

This measure realizes energy savings by adjusting the head-pressure setpoint in response to different outdoor temperatures. Without controls, the head-pressure setpoint is based on the design conditions regardless of the actual condenser operating conditions. By installing the floating-head pressure controller, the head-pressure setpoint is adjusted based on outside-air temperature. When conditions allow, the compressor operates at a lower discharge-head pressure, resulting in compressor energy savings.

4.4.7.2 Impacts Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \frac{kWh}{hp} \times hp_{comp}$$

Per-measure, gross coincident summer peak and winter peak demand reduction is zero[103], as shown in the following equations:

[103] Gross coincident demand savings are zero since savings are realized during off-peak periods. No demand reduction is expected from this measure.

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$$\Delta kW_{summer} = 0$$

$$\Delta kW_{winter} = 0$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure gross coincident winter peak demand reduction
kWh/hp = floating head pressure control gross annual electric energy savings per compressor horsepower (hp)
hp_{comp} = compressor horsepower

4.4.7.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 4-81. Input values for floating head pressure control savings calculations

Component	Type	Value	Unit	Source(s)
kWh/hp	Variable	See Table 4-82	kWh/ horsepower/ year	Maine Commercial TRM v2020.4, p. 95
		Default = 509 (High Temperature, Scroll Compressor)		
hp_{comp}	Variable	See customer application.	horsepower	Customer application
		Default = 5		Vermont TRM 2015, p. 132[104]

Table 4-82. Floating-head pressure control gross annual electric energy savings (per horsepower)[105]

Compressor type	Electric savings (kWh/hp/year)		
	Low temperature (-35°F to -1°F) ($Temp_{ref}$ -20°F SST)	Medium temperature (0°F to 30°F) ($Temp_{ref}$ 20°F SST)	High temperature (31°F to 55°F) ($Temp_{ref}$ 45°F SST)
Standard Reciprocating	695	727	657
Discus	607	598	694
Scroll	669	599	509

4.4.7.4 Default savings

If the proper values are not supplied, a default savings may be applied using conservative input values.

The default gross annual electric energy savings will be assigned according to the following calculation:

[104] Vermont TRM 2015, p. 132. Assumes "5 HP compressor data used, based on average compressor size."
[105] Efficiency Maine Commercial TRM v2020.4, Table 16 – Floating Head Pressure Control kWh Savings per Horsepower, p. 95.

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$$\Delta kWh = \frac{kWh}{hp} \times hp_{comp}$$

$$= 509\ \frac{kWh}{hp} \times 5\ hp$$

$$= 2{,}545\ kWh$$

The default gross coincident summer peak demand reduction will be assigned according to the following calculation:

$$\Delta kW_{summer} = 0$$

The default gross coincident winter peak demand reduction will be assigned according to the following calculation:

$$\Delta kW_{winter} = 0$$

4.4.7.5 Effective Useful Life

The effective useful life of this measure is provided in Table 4-83.

Table 4-83. Effective useful life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
VI	Non-Residential Prescriptive Program, DSM Phase VI	6.30	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

4.4.7.6 Source(s)

The primary source for this deemed savings approach is the Maine Commercial TRM v2020, pp. 94-95. Additionally, the Vermont TRM 2015, p. 132, was used to estimate the default compressor size.

4.4.7.7 Update summary

Updates made to this section are described in Table 4-84.

Table 4-84. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page number / version of the Maine Commercial TRM
	New table	Effective Useful Life (EUL) by program
2020	None	No change
v10	Source	Updated page numbers / version of the Maine Commercial TRM

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4.4.8 Low/Anti-sweat door film

4.4.8.1 Measure description

This measure involves the installation of window film on the doors of refrigerated cooler and freezer cases. Anti-sweat film prevents condensation from forming and collecting on refrigerated case doors. This measure saves energy by allowing anti-sweat heaters to be deactivated permanently. Typically, anti-sweat door heaters (ASDH) are installed on the glass itself to raise the surface temperature and prevent condensation from collecting on the glass. However, the low/anti-sweat door film eliminates the need for these heaters.[106] Note that this measure does not affect frame heaters.

The savings methodology borrows from that of ASDH controls. The baseline condition for this measure is refrigerated case doors with operational ASDH, with or without controls. The measure case is door film with no ASDHs in use. Refrigerated case doors without ASDH are not allowed under this measure. Door size is assumed to be 12.5 sq.ft. based on program design assumptions.

This measure is offered through different programs listed in Table 4-85 and uses the impacts estimation approach described in this section.

Table 4-85. Programs that offer this measure

Program name	Section
Non-Residential Prescriptive Program, DSM Phase VI	Section 4.4.8
Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 16.6.6

4.4.8.2 Impacts Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = kW_{ASDH} \times DC \times HOU \times WHF_e$$

Per-measure, gross coincident summer peak demand reduction is assigned as follows:

$$\Delta kW_{summer} = kW_{ASDH} \times DC \times WHF_d \times CF_{summer}$$

Per-measure, gross coincident winter peak demand reduction is assigned as follows:

$$\Delta kW_{winter} = kW_{ASDH} \times DC \times WHF_d \times CF_{winter}$$

Where:

ΔkWh = per-measure, gross annual electric energy savings
ΔkW_{summer} = per-measure, gross coincident summer peak demand reduction

[106] In some cases, ASDHs may not be deactivated altogether, but their controls are modified to drastically lower the dew-point setpoint thereby reducing the duration of heater operation. In these cases, it is assumed that the duration of heater operation is negligible.

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ΔkW_{winter} = per-measure, gross coincident winter peak demand reduction
kW_{ASDH} = rated power of the existing ASDH
DC = duty cycle (effective run time) of the existing ASDH based on existing controls
HOU = annual operating hours
WHF_e = waste heat factor (WHF) represents the increased gross annual electric savings due to reduced heat from ASDH that must be rejected by the refrigeration equipment
WHF_d = waste heat factor (WHF) represents the increased gross coincident demand reduction due to reduced heat from ASDH that must be rejected by the refrigeration equipment
CF_{summer} = summer peak coincidence factor (CF)
CF_{winter} = winter peak coincidence factor (CF)

4.4.8.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 4-86. Input parameters for low/no-sweat door film

Component	Type	Value	Units	Source(s)
kW_{ASDH}	Variable	See customer application	kW	Customer application
		Default: 0.13		Maryland/Mid-Atlantic TRM v.10, p. 344[107]
DC	Variable	No controls: 0.907 On/Off controls: 0.589 Micropulse controls: 0.428	-	Maryland/Mid-Atlantic TRM v.10, p. 344
		Default: 0.428	-	Maryland/Mid-Atlantic TRM v.10, p. 345
HOU	Fixed	8,760	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 345
WHF_e	Variable	Low temp (-35˚F - -1˚F): 1.50 Med temp (0˚F - 30˚F): 1.50 High temp (31˚F - 55˚F): 1.25	-	Maryland/Mid-Atlantic TRM v.10, p. 345
		Default: 1.25		
WHF_d	Variable	Low temp (-35˚F - -1˚F): 1.50 Med temp (0˚F - 30˚F): 1.50 High temp (31˚F - 55˚F): 1.25	-	Maryland/Mid-Atlantic TRM v.10, p. 345
		Default: 1.25		
CF_{summer}	Variable	Freezer (Low/med temp) case: On/Off controls: 0.21 Micropulse: 0.30 No controls: 1.00	-	Maryland/Mid-Atlantic TRM v.10, pp. 345[108]. Without heater controls, uniform load throughout year is assumed.
		Default for freezer case: 0.21		
		Refrigerated (High temp) case: On/off controls: 0.25 Micropulse: 0.36 No controls: 1.00		
		Default for refrigerated case: 0.25		
CF_{winter}	Variable	Freezer (Low/med temp) case: On/off controls: 0.20 Micropulse: 0.29 No controls: 1.00		

107 Original source: Cadmus. 2015. Commercial Refrigeration Loadshape Project. Lexington, MA.

108 Coincidence factors developed by dividing the PJM Summer Peak Savings for ASDH Controls from Table 52 of the original source by the product of the average wattage of ASDH per connected door (0.13 kW) and the Waste Heat Factor for Demand.

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Component	Type	Value	Units	Source(s)
		Default for freezer case: 0.20		Maryland/Mid-Atlantic TRM v.10, pp. 345[109]. Without heater controls, uniform load throughout year is assumed.
		Refrigerated (High Temp) case: On/Off controls: 0.24 Micropulse: 0.35 No controls: 1.00		
		Default for refrigerated case: 0.24		

4.4.8.4 Default savings

When the application does not have information about the ASDH control type, it is assumed to have micropulse controls. When the temperature range and the case type are also unknown, the case is assumed to be a high-temperature, refrigerated case.

Accordingly, the default per-measure gross annual energy savings are as follows:

$$\Delta kWh = kW_{ASDH} \times DC \times HOU \times WHF_e$$

$$= 0.13\ kW \times 0.428 \times 8{,}760\ hours \times 1.25$$

$$= 609.26\ kWh$$

And the default per-measure, gross coincident summer peak demand reduction is:

$$\Delta kW_{summer} = kW_{ASDH} \times DC \times WHF_d \times CF_{summer}$$

$$= 0.13\ kW \times 0.428 \times 1.25 \times 0.25$$

$$= 0.017\ kW$$

And the default per-measure, gross coincident winter peak demand reduction is:

$$\Delta kW_{winter} = kW_{ASDH} \times DC \times WHF_d \times CF_{winter}$$

$$= 0.13\ kW \times 0.428 \times 1.25 \times 0.24$$

$$= 0.017\ kW$$

[109] Applied the same methodology that Maryland/Mid-Atlantic TRM v.10, pp. 345 uses for summer CF and applied to the winter peak values provided by Cadmus. 2015. Commercial Refrigeration Loadshape Project

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4.4.8.5 Effective Useful Life

The effective useful life of this measure is provided in Table 4-87.

Table 4-87. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	12.00	years	Maryland/Mid-Atlantic TRM v.10, p. 345
VI	Non-Residential Prescriptive Program, DSM Phase VI	6.30	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

4.4.8.6 Source(s)

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v.10, pp. 344–345. The method was adapted from the ASDH controls methodology.

4.4.8.7 Update summary

Updates made to this section are described in Table 4-88.

Table 4-88. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page number / version of the Mid-Atlantic TRM
	Equation	Added equation for coincident winter peak demand reduction
	New table	Effective Useful Life (EUL) by program
2020	None	No change
v10	Source	Updated page numbers / version of the Mid-Atlantic TRM
	Input variable	Clarified WHF_e and WHF_d default assumption values

4.4.9 Refrigeration night cover

4.4.9.1 Measure description

This measure realizes energy savings by installing a cover to minimize the energy losses associated with top open-case refrigeration units. Walk-in units are not included in this measure. The cover is used during hours which the business is closed. The baseline equipment is a refrigerated case without a night cover.

This measure is offered through different programs listed in Table 4-89 and uses the impacts estimation approach described in this section.

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Table 4-89. Programs that offer this measure

Program name	Section
Non-Residential Prescriptive Program, DSM Phase VI	Section 4.4.9
Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 8.5.2

4.4.9.2 Impacts Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \frac{load}{12{,}000\, Btuh/ton} \times \frac{3.516\, kW/ton}{COP} \times L \times ESF \times HOU$$

Per-measure, gross coincident summer and winter peak demand reduction is zero,[110] as shown in the following equations:

$$\Delta kW_{summer} = 0$$

$$\Delta kW_{winter} = 0$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident demand reduction
ΔkW_{winter} = per-measure gross coincident demand reduction
load = average refrigeration load per linear foot of refrigerated case without night covers deployed
L = linear feet of covered refrigerated case
COP = coefficient of performance of refrigerated case
ESF = energy savings factor; reflects the percentage reduction in refrigeration load due to the deployment of night covers
HOU = annual hours of use

4.4.9.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 4-90. Input values for refrigeration night cover savings calculations

Component	Type	Value	Unit	Source(s)
load	Fixed	See customer application	Btu/hour/ feet	Customer application
		Default = 1,500		Maryland/Mid-Atlantic TRM v.10, p. 342[111]
L	Variable	See customer application	feet	Customer application
		Default = 6		DNV judgment

[110] Mid-Atlantic TRM 2020, p. 343. Assumed that continuous covers are deployed at night; therefore, no demand savings occur during the peak period.

[111] Mid-Atlantic 2020, p. 342. Original source: Davis Energy Group, Analysis of Standard Options for Open Case Refrigerators and Freezers.

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Component	Type	Value	Unit	Source(s)
COP[112]	Fixed	2.20	-	Maryland/Mid-Atlantic TRM v.10, p. 342
ESF[113]	Fixed	0.09	-	Maryland/Mid-Atlantic TRM v.10, p. 342
HOU	Fixed	8,760	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 343

4.4.9.4 Default savings

If the proper values are not supplied, a default savings may be applied using conservative input values.

The default gross annual electric energy savings will be assigned according to the following calculation:

$$\Delta kWh = \frac{load}{12{,}000\ Btuh/ton} \times L \times \frac{3.516\, kW/ton}{COP} \times ESF \times HOU$$

$$= \frac{1{,}500\, Btuh/feet}{12{,}000\, Btuh/ton} \times \frac{3.516\, kW/ton}{2.2} \times\ 6\, feet\ \times\ 0.09\ \times\ 8{,}760\, hours$$

$$= 945.0\, kWh$$

The default gross coincident summer and winter peak demand reduction will be assigned as follows:

$$\Delta kW_{summer} = 0$$

$$\Delta kW_{winter} = 0$$

4.4.9.5 Effective Useful Life

The effective useful life of this measure is provided in Table 4-91.

Table 4-91. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
VIII	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	5.00	years	Maryland/Mid-Atlantic TRM v.10, p. 343
VI	Non-Residential Prescriptive Program, DSM Phase VI	6.30	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

[112] Kuiken et al, Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0, KEMA, March 22, 2010.

[113] Mid-Atlantic TRM 2020, p. 342. Original source: Effects of the Low Emissivity Shields on Performance and Power Use of a Refrigerated Display Case, Southern California Edison, August 8, 1997. Characterization assumes covers are deployed for six hours per day.

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4.4.9.6 Source(s)

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v10, pp. 342-343.

4.4.9.7 Update summary

Updates made to this section are described in Table 4-92.

Table 4-92. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the Maryland/Mid-Atlantic TRM v10
	New table	Effective Useful Life (EUL) by program
2020	None	No change
v10	Source	Updated page numbers / version of the Mid-Atlantic TRM
	Default savings	Corrected mistaken default annual energy savings

4.4.10 Refrigeration coil cleaning

4.4.10.1 Measure description

This measure realizes energy savings by cleaning the condenser coils on reach-in and walk-in coolers and freezers. Eligible units will have 25% fouling or greater based on visual inspection. This measure may only receive energy savings and demand reduction when combined with the floating head pressure measure.

This measure is offered through different programs listed in Table 4-93 and uses the impacts estimation approach described in this section.

Table 4-93. Programs that offer this measure

Program name	Section
Non-Residential Prescriptive Program, DSM Phase VI	Section 4.4.10
Non-Residential Prescriptive Enhanced Program, DSM Phase IX	Section 16.6.7

4.4.10.2 Impacts Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \frac{load}{12{,}000\, Btuh/ton} \times \frac{3.156\, kW/ton}{COP} \times HOU \times ESF$$

Per-measure, gross coincident summer peak demand reduction is calculated according to the following equation:

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$$\Delta kW_{summer} = \frac{load}{12{,}000\ Btuh/ton} \times \frac{3.156\, kW/ton}{COP} \times DRF_{summer}$$

Per-measure, gross coincident winter peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \frac{load}{12{,}000\ Btuh/ton} \times \frac{3.156\, kW/ton}{COP} \times DRF_{winter}$$

Where:

ΔkWh = per-measure gross annual energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction
load = total capacity of condensers (BTU per hour)
COP = coefficient of performance of refrigeration equipment
ESF = savings factor attributable to coil cleaning for annual energy
DRF_{summer} = savings factor attributable to coil cleaning for summer peak demand reduction
DRF_{winter} = savings factor attributable to coil cleaning for winter peak demand reduction
HOU = annual hours of use

4.4.10.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 4-94. Input values for refrigeration coil cleaning savings calculations

Component	Type	Value	Unit	Source(s)
load	Variable	See customer application	Btu/h	Customer application
COP	Variable	Low Temp (-35°F – -1°F): 1.30 Med Temp (0°F – 30°F): 1.30 High Temp (31°F – 55°F): 2.51	-	Pennsylvania TRM V3, 2019, p. 155
HOU	Variable	Low Temp (-35°F - -1°F): 6,370 Med Temp (0°F - 30°F): 6,370 High Temp (31°F - 55°F): 6,173	hours, annual	Calculated duty cycle using weather factor, defrost factor, and capacity factor[114]
ESF	Fixed	0.048	-	Qureshi and Zubair (2011)[115]
DRF_{summer}	Fixed	0.022	-	Qureshi and Zubair (2011)[116]
DRF_{winter}	Fixed	0.022	-	Qureshi and Zubair (2011)[117]

4.4.10.4 Default savings

If the proper values are not supplied, no default savings will be awarded for this measure.

[114] The duty cycle is calculated using the same method as is used by TVA 2016 TRM for refrigeration measures. For coolers, a defrost factor of 0.995, a capacity factor of 0.87, and a weather factor of 0.84 is assumed. For freezers, a defrost factor of 0.90, a capacity factor of 0.87, and a weather factor of 0.90 is assumed.

[115] Qureshi B.A. and Zubair S.M., “Performance degradation of a vapor compression refrigeration system under fouled conditions.” International Journal of Refrigeration 24 (2011), p. 1016 – 1027. Figure 2-(a). Assumes a weighting of refrigerant types of 80% R-134 and 20% R-404.

[116] Ibid.

[117] The source study for this measure does not provide a winter DRF. Therefore, the summer DRF is applied.

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4.4.10.5 Effective Useful Life

The effective useful life of this measure is provided in Table 4-95.

Table 4-95. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	15.00	years	Pennsylvania TRM V3, 2019, p. 154
VI	Non-Residential Prescriptive Program, DSM Phase VI	6.30	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

4.4.10.6 Source(s)

The primary sources for this deemed savings approach are the Pennsylvania TRM V3, 2019, p.155 and the technical paper titled, "Performance degradation of a vapor compression refrigeration system under fouled conditions.

4.4.10.7 Update summary

Updates made to this section are described in Table 4-96.

Table 4-96. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the Pennsylvania TRM
	Input value	Updated COP value
	Equation	Added equation for coincident winter peak demand reduction
	New table	Effective Useful Life (EUL) by program
2020	None	No Change
V10	None	No Change

4.4.11 Suction pipe insulation (cooler and freezer)

4.4.11.1 Measure description

This measure realizes energy savings by installing insulation on existing bare suction lines (lines that run from evaporator to compressor) that are located outside of the refrigerated space.

4.4.11.2 Impacts Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

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$$\Delta kWh = \frac{\Delta kWh}{ft} \times L$$

Per-measure, gross coincident summer and winter peak demand reduction are calculated according to the following equation:

$$\Delta kW_{summer} = \frac{\Delta kW}{ft} \times L$$

$$\Delta kW_{winter} = \frac{\Delta kW}{ft} \times L$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident demand reduction
ΔkW_{winter} = per-measure gross coincident demand reduction
ΔkWh/ft = gross annual electric energy savings per linear foot
ΔkW/ft = gross coincident demand reduction per linear foot
L = length of insulation applied in linear feet

4.4.11.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 4-97. Input values for suction pipe insulation savings calculations

Component	Type	Value	Unit	Source(s)
ΔkWh/ft	Variable	See Table 4-98	kWh/feet	Pennsylvania TRM V3, 2019, p. 178
ΔkW/ft	Variable	See Table 4-98	kW/feet	Pennsylvania TRM V3 2019, p. 178[118]
L	Variable	See customer application	feet	Customer application
		Default = 1		Per unit savings

Table 4-98. Suction pipe insulation annual electric energy savings and coincident demand reduction[119]

Refrigeration type	ΔkWh/year·ft	ΔkW/ft
Low temperature (-35°F - -1°F)	85.5	0.016
Medium temperature (0°F - 30°F)	85.5	0.016
High temperature (31°F - 55°F)	24.8	0.005

118 The source TRM only provides summer peak demand reduction. Therefore, the summer CF is applied to the winter CF.
119 Pennsylvania TRM V3 2019, p. 178, original source: Southern California Edison Company, “Insulation of Bare Refrigeration Suction Lines”, Work Paper WPSCNRRN0003.

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4.4.11.4 Default savings

If the proper values are not supplied, a default savings value may be applied using conservative input values.

The default per-measure, gross annual electric energy savings will be assigned according to the following calculation:

$$\Delta kWh = \frac{\Delta kWh/year}{ft} \times L$$

$$= 24.8\, kWh/ft \times 1\, foot$$

$$= 24.8\, kWh$$

The default per-measure, gross coincident demand reduction will be assigned according to the following calculation:

$$\Delta kW_{summer} = \frac{\Delta kW}{ft} \times L$$

$$= 0.005\, kW/ft \times 1ft$$

$$= 0.005\, kW$$

$$\Delta kW_{winter} = \frac{\Delta kW}{ft} \times L$$

$$= 0.005\, kW/ft \times 1ft$$

$$= 0.005\, kW$$

4.4.11.5 Effective Useful Life

The effective useful life of this measure is provided in Table 4-99.

Table 4-99. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
VI	Non-Residential Prescriptive Program, DSM Phase VI	6.30	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

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4.4.11.6 Source(s)

The primary source for this deemed savings approach is the Pennsylvania TRM V3 2019, pp. 177–178.

4.4.11.7 Update summary

Updates made to this section are described in Table 4-100.

Table 4-100. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	• Updated page numbers / version of the Pennsylvania TRM • Updated footnote
	Input values	Update annual electric energy savings per linear foot (ΔkWh/ft) and coincident demand reduction per linear foot (ΔkW/ft)
	Equation	Added equation for coincident winter peak demand reduction
	New table	Effective Useful Life (EUL) by program
2020	None	No change
v10	Source	Updated footnote

4.4.12 Strip curtain (cooler and freezer)

4.4.12.1 Measure description

The measure realizes energy savings by installing strip curtains on walk-in coolers and freezers. Strip curtains reduce the refrigeration load by minimizing infiltration of non-refrigerated air into the refrigerated space of walk-in coolers or freezers. Strip curtains are assumed to be operational only during building operating hours. When buildings are not operational, coolers and freezers doors will be closed.

This measure is offered through different programs listed in Table 4-101 and uses the impacts estimation approach described in this section.

Table 4-101. Programs that offer this measure

Program name	Section
Non-Residential Prescriptive Program, DSM Phase VI	Section 4.4.12
Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 8.5.7
Non-Residential Prescriptive Enhanced Program, DSM Phase IX	Section 16.6.8

4.4.12.2 Impacts Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh \quad = kWh/ft^2 \times Area$$

Per-measure, gross coincident summer peak demand reductions are calculated according to the following equation:

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$$\Delta kW_{summer} = \frac{\Delta kWh}{HOU} \times CF_{summer}$$

Per-measure, gross coincident winter peak demand reductions are calculated according to the following equation:

$$\Delta kW_{winter} = \frac{\Delta kWh}{HOU} \times CF_{winter}$$

Where:

ΔkWh	= per-measure gross annual electric energy
ΔkW_{summer}	= per-measure gross coincident summer peak demand reduction
ΔkW_{winter}	= per-measure gross coincident winter peak demand reduction
kWh/ft^2	= average annual kilowatt hour savings per square foot of infiltration barrier
Area	= area of doorway where strip curtains are installed
CF_{summer}	= summer coincidence factor
CF_{winter}	= winter coincidence factor

4.4.12.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 4-102. Input values for strip curtain savings calculations

Component	Type	Value	Unit	Source(s)
ΔkWh/sq.ft	Variable	See Table 4-103	kWh/sq.ft	Pennsylvania TRM V3, 2019, p. 167
		Default = 19		Assume convenience store, Cooler
Area	Variable	See Table 4-104	sq.ft	Pennsylvania TRM V3, 2019, p. 168
		Default = 21		Assume convenience store
HOU	Fixed	8,760	hours, annual	Wisconsin TRM 2019, p. 822
CF_{summer}	Fixed	1.0	-	Wisconsin TRM 2019, p. 822[120]
CF_{summer}	Fixed	1.0	-	Wisconsin TRM 2019, p. 822[120]

Table 4-103. Strip curtain gross annual electric energy savings (per sq.ft.)

Type		Annual Electric Energy Savings per Square Foot (ΔkWh/sq.ft)
Grocery	Cooler	123
	Freezer	535
Convenience Store	Cooler	19
	Freezer	31

[120] The Wisconsin TRM 2019 does not provide summer or winter CFs. However, the equation for peak demand is kWh savings divided by annual hours implying a CF of 1.0.

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Type		Annual Electric Energy Savings per Square Foot (ΔkWh/sq.ft)
Restaurant	Cooler	24
	Freezer	129
Refrigerator	Cooler	410

Table 4-104. Doorway area assumptions (sq.ft.)

Type		Doorway Area (sq.ft)
Grocery	Cooler	21
	Freezer	21
Convenience Store	Cooler	21
	Freezer	21
Restaurant	Cooler	21
	Freezer	21
Refrigerator	Cooler	120

4.4.12.4 Default savings

The default per-measure, gross annual electric energy savings will be assigned—assuming the strip curtains were installed at a cooler within a convenience store for the baseline conditions—according to the following calculation:

$$\Delta kWh = kWh/ft^2 \times Area$$

$$= 19\ kWh/ft^2 \times 21\ ft^2$$

$$= 399\ kWh$$

The default per-measure, gross coincident summer peak demand reduction will be assigned according to the following calculation:

$$\Delta kW_{summer} = \frac{\Delta kWh}{HOU} \times CF_{summer}$$

$$= \frac{231\ kWh}{8{,}760\ hours} \times 1.0$$

$$= 0.026\ kW$$

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The default per-measure, gross coincident winter peak demand reduction will be assigned according to the following calculation:

$$\Delta kW_{winter} = \frac{\Delta kWh}{HOU} \times CF_{winter}$$

$$= \frac{231\ kWh}{8{,}760\ hours} \times 1.0$$

$$= 0.026\ kW$$

4.4.12.5 Effective Useful Life

The effective useful life of this measure is provided in Table 4-105.

Table 4-105. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	4.00	years	Wisconsin TRM 2020, p. 821
VIII	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII			
VI	Non-Residential Prescriptive Program, DSM Phase VI	6.30	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

4.4.12.6 Source(s)

The primary source for this deemed savings approach is the Pennsylvania TRM V3, 2019, pp. 166-168 and Wisconsin TRM 2020, p. 822.

4.4.12.7 Update summary

Updates made to this section are described in Table 4-106.

Table 4-106. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the Pennsylvania TRM and Wisconsin TRM
	Input value	Updated Area and ΔkWh/sq.ft
	Equation	Added equation for coincident winter peak demand reduction
	Default savings	Updated default savings

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Version	Update type	Description
	New table	Effective Useful Life (EUL) by program
2020	None	No change
v10	Source	Updated page numbers / version of the Pennsylvania TRM
	Equation	Updated equations

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5 NON-RESIDENTIAL DISTRIBUTED GENERATION PROGRAM, DSM PHASE II

The Non-Residential Distributed Generation (NRDG) Program is designed to reduce peak demand for the Company. During a Distributed Generation Program dispatch event, large non-residential customers are incentivized to transfer their electrical demand from the grid to a distributed on-site resource. A third-party contractor installs, monitors, and operates the distributed equipment controls.

Participants and the implementation contractor are notified 30 minutes in advance of an NRDG dispatch event by e-mail or telephone. The number of dispatched sites, and the beginning and ending event-hours varies by event. The program operates 12 months a year, but annual event-hours are limited per the terms of the program.

5.1.1.1 Measure description

The impacts from the non-residential DG program are calculated by measuring the amount of aggregate and site-level kW generated by a distributed resource. The most important performance indicator is the program realization rate. The methodology for calculating the realization rate is presented below. A customer is compliant with the terms of the program if their average event-based generated kW, calculated monthly, is at least 95% of enrolled and committed kW.

5.1.1.2 Impacts Estimation Approach

At the site and interval level, the ex-post impact is defined as the measured kW generated by the distributed resource. Dispatched generation is the amount of electricity requested by the company during a non-residential DG event. The sources of dispatched generation and enrolled dispatchable supply can be found in The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 5-1.

5.1.1.3 Realization rate

The program realization rate for a given dispatch event (j) is the sum of measured generation (kW) from called participants (i) for the interval divided by the sum of dispatched generation for called participants.

$$Realization\ Rate_j = \frac{\sum_i Measured\ Generation\ (kW)}{\sum_i Dispatched\ Generation\ (kW)}$$

Program performance is tracked by aggregating measured generation and dispatched generation by event interval and day. Event-day plots facilitate the analysis of realization rate patterns for the entire program.

5.1.1.4 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 5-1. Input values for non-residential distributed generation impact analysis

Variable	Value	Unit	Source
Measured generation	Metered site data	kW	Dominion Energy

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Dispatched generation	Event-based resource requested by Dominion Energy	kW	Dominion Energy
Enrolled dispatchable generation	Per program terms, fixed per site	kW	Dominion Energy

5.1.1.5 Default savings

Default savings will not be credited to a non-residential DG customer for unmeasured generation.

5.1.1.6 Effective Useful Life

The effective useful life of this measure is 1.00 years since demand reductions do not persist. The demand reductions are associated with the participation and events of each year.

5.1.1.7 Source(s)

DNV developed the non-residential DG evaluation methodology according to standard EM&V protocols.[121]

5.1.1.8 Update summary

Updates made to this section are described in Table 5-2.

Table 5-2. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	None	No change
2020	None	No change
v10	None	No change

[121] Miriam L. Goldberg & G. Kennedy Agnew. Measurement and Verification for Demand Response, National Forum on the National Action Plan on Demand Response, https://www.ferc.gov/industries/electric/indus-act/demand-response/dr-potential/napdr-mv.pdf.

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6 NON-RESIDENTIAL SMALL MANUFACTURING PROGRAM, DSM PHASE VII

The Non-Residential Small Manufacturing Program provides qualifying business owners incentives to pursue one or more of the qualified energy efficiency measures through a local, participating contractor in Dominion Energy's contractor network. To qualify for this program, the customer must be responsible for the electric bill and must be the owner of the facility or reasonably able to secure permission to complete the measures. All program measures are summarized in Table 6-1.

Table 6-1. Non-Residential Small Manufacturing Program measure list

End use	Measure	Legacy program	Manual section
Compressed air	Compressed air nozzles	N/A	Section 6.1.1
	Leak repair	Non-residential small business improvement program	Section 6.1.2
	No loss drains	N/A	Section 6.1.3
	Add storage (5 gal/cfm)		Section 6.1.4
	Heat of compression dryer		Section 6.1.5
	Low pressure-drop filter		Section 6.1.6
	VSD air compressor		Section 6.1.7
	Cycling refrigerant dryer		Section 6.1.8
	Dewpoint controls		Section 6.1.9
	Pressure reduction		Section 6.1.10
	Downsized VFD compressor		Section 6.1.11

6.1 Compressed air end use

This section describes each measure and how energy and demand impacts are calculated. Due to the interactivity of the measures and the complexity of compressed air systems, savings are calculated in project-level spreadsheets. These spreadsheets are provided by the program implementer and reviewed by DNV. The desk reviews will verify that the appropriate baseline assumptions, operating hours, inputs, and calculations are used. The savings calculations and inputs shown in this section are in line with the implementer calculations.

6.1.1 Compressed air nozzle

6.1.1.1 Measure description

This measure realizes energy savings by replacing standard air nozzles with engineered air nozzles. Nozzles are used in industrial processes to deliver jets of compressed air to remove debris or liquid, cool parts, eject parts from conveyors, or to perform other manufacturing functions. Standard nozzles use 100% compressed air to perform these tasks whereas engineered nozzles use compressed air to entrain ambient air, thereby halving the compressed-air usage. Engineered nozzles provide the same force and functionality as standard nozzles, but use less compressed air and, therefore, less energy.

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Qualifying nozzles may use no more compressed air, at 80 psig, than the maximum flowrates shown in Table 6-2.

Table 6-2. Maximum compressed air usage for qualifying nozzles

Nozzle diameter (inch)	Maximum flow rate at 80 psig (scfm)
1/8	11
1/4	29
5/16	56
1/2	140

6.1.1.2 Impacts Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \left[scfm_{base} \times \left(\frac{kW}{scfm}\right)_{base} - scfm_{ee} \times \left(\frac{kW}{scfm}\right)_{ee}\right] \times Use \times HOU$$

The system air flow and loading values are calculated using the following equations:

$$scfm_{base} = scfm_{rated} \times Load_{base}$$

$$scfm_{ee} = scfm_{base} - \Delta scfm$$

$$Load_{ee} = \frac{scfm_{ee}}{scfm_{rated}}$$

If the system air flow and loading values are calculated using the following equations:

$$scfm_{ee} = scfm_{base} - \Delta scfm$$

$$Load_{ee} = \frac{scfm_{ee}}{scfm_{rated}}$$

To determine the reduction in flow rate from the standard to engineered nozzles, the following conditions and equations are used:

$$\Delta scfm = scfm_{80-psig,orifice} \times \left[\frac{p_{orifice} + 14.7}{(80 + 14.7)}\right]^n$$

Per-measure, gross coincident demand reduction is calculated according to the following equation:

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$$\left(\frac{kW}{scfm}\right)_{base} = \frac{hp \times 1.1 \times 0.746}{0.945 \times \eta_{VFD}} \times \frac{\left(X_2 \times Load_{base}{}^2 + X_1 \times Load_{base} + C\right)}{scfm_{base}}$$

$$\left(\frac{kW}{scfm}\right)_{ee} = \frac{hp \times 1.1 \times 0.746}{0.945 \times \eta_{VFD}} \times \frac{\left(X_2 \times Load_{ee}{}^2 + X_1 \times Load_{ee} + C\right)}{scfm_{ee}}$$

Per-measure, gross summer peak coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \left[scfm_{base} \times \left(\frac{kW}{cfm}\right)_{base} - scfm_{ee} \times \left(\frac{kW}{cfm}\right)_{ee}\right] \times Use \times CF_{summer}$$

Per-measure, gross winter peak coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \left[scfm_{base} \times \left(\frac{kW}{cfm}\right)_{base} - scfm_{ee} \times \left(\frac{kW}{cfm}\right)_{ee}\right] \times Use \times CF_{winter}$$

Where:

ΔkWh	= per-measure gross annual electric energy savings
ΔkW_{summer}	= per-measure gross summer peak coincident demand reduction
ΔkW_{winter}	= per-measure gross winter peak coincident demand reduction
hp	= trim compressor rated horsepower
$scfm_{rated}$	= trim compressor rated flow rate
$scfm_{base}$	= base trim compressor operating flow
$scfm_{ee}$	= efficient trim compressor operating flow
Δscfm	= reduction in trim compressor operating flow
$scfm_{80\text{-}psig,\ nozzle}$	= reduction in nozzle flow rate at 80 psig
$Load_{base}$	= average percent of rated flow for base trim compressor
$Load_{ee}$	= average percent of rated flow for base trim compressor with one engineered nozzle in operation
$kW/scfm_{base}$	= base trim compressor operating performance
$kW/scfm_{ee}$	= efficient trim compressor operating performance
p	= system operating pressure
n	= flowrate pressure adjustment coefficient
Dia	= diameter of nozzle
η_{VFD}	= VFD efficiency
X_2	= coefficient
X_1	= coefficient
C	= constant
Use	= percent of annual operating hours (HOU) that nozzle is in use
HOU	= annual hours of operation of compressor system
CF_{summer}	= summer coincidence factor
CF_{winter}	= winter coincidence factor

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6.1.1.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 6-3. Input values for compressed air nozzles savings calculations

Component	Type	Value	Unit	Source(s)
$scfm_{rated}$	Variable	See customer application	scfm	Customer application
$scfm_{80\text{-}psig,\ nozzle}$	Variable	See Table 6-2	scfm	IL TRM V8.0 Vol. 2, 2020, p. 574
$Load_{base}$	Variable	See customer application	-	Customer application
		Default = 0.60		Engineering estimate
p	Variable	See customer application	psig	Customer application
n	Fixed	1.0	-	Engineering estimate
Dia	Variable	See customer application	inches	Customer application
η_{VFD}	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Engineering estimate, only applicable if the control type is VFD
X_2	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
X_1	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
C	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
Use	Variable	See customer application	-	Customer application
		Default = 0.05		Minnesota TRM V3.1, 2020, pp. 451
HOU	Variable	See customer application	hours, annual	Customer application
		Default = 6,240		Minnesota TRM V3.1, 2020, pp. 451
CF_{summer}	Variable	See Table 17-21 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Illinois TRM V8.0 Volume 2, 2020, pp. 575
		Default =0.59		Default based on single shift (8/5) operating schedule from IL TRM V8.0 Volume 2, 2020, pp. 575
CF_{winter}	Variable	See Table 17-21 in Sub-Appendix F2-V: Non-residential compressed air end use factors		Illionois TRM V8.0 Volume 2, 2020, pp. 575[122]
		Default =0.59		Default based on single shift (8/5) operating schedule from IL

[122] The source TRM does not differentiate between winter and summer peak periods. Therefore, DNV applied the same CF for summer and winter peak periods.

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Component	Type	Value	Unit	Source(s)
				TRM V8.0 Volume 2, 2020, pp. 575

6.1.1.4 Default savings

If the necessary values are not available, some values have defaults savings. However, there are no default savings for this measure as some values are essential to calculate savings.

6.1.1.5 Effective Useful Life

The Effective Useful Life of this measure is provided in Table 6-4.

Table 6-4. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
VII	Non-Residential Small Manufacturing Program, DSM Phase VII	12.24	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

6.1.1.6 Source(s)

The system performance (kW/scfm) relies on performance curves for various control types as provided by Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004. Other sources include the IL TRM v.8.0 Vol.2 2020, pp. 573-575 and MN TRM v3.1 2020, pp. 450-452.

6.1.1.7 Update summary

Updates made to this section are described in Table 6-5.

Table 6-5. Summary of update(s)

Updates in Version	Update type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the IL TRM and MN TRM
	Table	Updated $scfm_{80\text{-}psig}$,values based on nozzle size
	New Table	Effective Useful Life (EUL) by program
	Equation	Added gross winter peak demand reduction equation
2020	None	No change
v10	-	Initial release

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6.1.2 Leak repair

6.1.2.1 Measure description

This measure realizes energy savings by repairing compressed air leaks. Reducing the amount of air leaked in the compressed air system reduces the load on the compressors and thereby saves energy.

Qualifying leaks must be identified, estimated, and tagged by a compressed-air professional.

6.1.2.2 Impacts Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \left(scfm_{base} \times \left(\frac{kW}{scfm}\right)_{base} - scfm_{ee} \times \left(\frac{kW}{scfm}\right)_{ee}\right) \times HOU$$

The baseline system air flow is calculated using the following equation:

$$scfm_{base} = scfm_{rated} \times Load_{base}$$

The efficient system air flow and loading values are calculated using the following equations:

$$scfm_{ee} = scfm_{base} - \Delta scfm$$

$$Load_{ee} = \frac{scfm_{ee}}{scfm_{rated}}$$

The baseline and efficient system operating performances are calculated using the following equations:

$$\left(\frac{kW}{scfm}\right)_{base} = \frac{hp \times 1.1 \times 0.746}{0.945 \times \eta_{VFD}} \times \frac{\left(X_2 \times {Load_{base}}^2 + X_1 \times Load_{base} + C\right)}{scfm_{base}}$$

$$\left(\frac{kW}{scfm}\right)_{ee} = \frac{hp \times 1.1 \times 0.746}{0.945 \times \eta_{VFD}} \times \frac{\left(X_2 \times {Load_{ee}}^2 + X_1 \times Load_{ee} + C\right)}{scfm_{ee}}$$

Per-measure, gross summer peak coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \left(scfm_{base} \times \left(\frac{kW}{cfm}\right)_{base} - scfm_{ee} \times \left(\frac{kW}{cfm}\right)_{ee}\right) \times CF_{summer}$$

Per-measure, gross winter peak coincident demand reduction is calculated according to the following equation:

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$$\Delta kW_{winter} = \left(scfm_{base} \times \left(\frac{kW}{cfm}\right)_{base} - scfm_{ee} \times \left(\frac{kW}{cfm}\right)_{ee} \right) \times CF_{winter}$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross summer peak coincident demand reduction
ΔkW_{winter} = per-measure gross winter peak coincident demand reduction
hp = trim compressor rated horsepower
$scfm_{rated}$ = trim compressor rated flow rate
$scfm_{base}$ = baseline trim compressor operating flow
$scfm_{ee}$ = efficient trim compressor operating flow
Δscfm = efficient trim compressor operating flow reduction
$Load_{base}$ = average percent of rated flow for base trim compressor
$Load_{ee}$ = average percent of system flow after leaks are repaired
kW/cfm_{base} = baseline system operating performance
kW/cfm_{ee} = efficient system operating performance
η_{VFD} = VFD efficiency
X_2 = coefficient
X_1 = coefficient
C = constant
HOU = annual hours of operation of compressor system
CF_{summer} = summer coincidence factor
CF_{winter} = winter coincidence factor

6.1.2.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 6-6. Input values for leak savings calculations

Component	Type	Value	Units	Sources
hp	Variable	See customer application	hp	See customer application
$scfm_{rated}$	Variable	See customer application	scfm	See customer application
Δscfm	Variable	See customer application	-	See customer application
$Load_{base}$	Variable	See customer application	-	See customer application
		Default = 0.60		Engineering estimate
η_{VFD}	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Engineering estimate; only applicable for VFD-controlled compressors
X_2	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
X_1	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004

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Component	Type	Value	Units	Sources
C	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
HOU	Variable	See customer application	hours, annual	See customer application
		Default=6,240		Minnesota TRM V3.1, 2020, p. 451
CF_{summer}	Variable	See Table 17-21 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Illinois TRM V8.0 Volume 2, 2020, pp. 575
		Default =0.59		Default based on single shift (8/5) operating schedule from IL TRM V8.0 Volume 2, 2020, p. 575
CF_{winter}	Variable	See Table 17-21 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Illinois TRM v8.0 Volume 2, 2020, p. 575[123]
		Default =0.59		Default based on single shift (8/5) operating schedule from IL TRM V8.0 Volume 2, 2020, p. 575

6.1.2.4 Default savings

If the proper values are not available, some values have defaults savings. However, there are no default savings for this measure as some values are needed to calculate savings.

6.1.2.5 Effective Useful Life

The effective useful life of this measure is provided in Table 6-7.

Table 6-7. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
VII	Non-Residential Small Manufacturing Program, DSM Phase VII	12.24	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

6.1.2.6 Source(s)

The system performance (kW/scfm) relies on performance curves for various control types as provided by Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004. Other sources include the IL TRM V8.0 Vol. 2, 2020, pp. 573-575 and MN TRM V3.1, 2020, pp. 450-452.

[123] The source TRM doesn't differentiate between winter and summer peak periods. Therefore, the summer CF is applied to the winter CF.

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6.1.2.7 Update summary

Updates made to this section are described in Table 6-8.

Table 6-8. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the IL TRM and MN TRM
	New table	Effective Useful Life (EUL) by program
	Equation	• Added gross winter peak demand reduction equation • Updated the $\Delta scfm$ value to customer application
2020	Input	Added default value for hours of use
v10	-	Initial release

6.1.3 No-loss condensate drain

6.1.3.1 Measure description

This measure involves the installation of a no-loss condensate drain on a compressed-air line. Timed drains open the drain at regular periods for a set amount of time. After timed drains open to drain the condensate, they allow compressed air to leak. Typically, these drains are set for the worst-case conditions resulting in a significant amount of wasted compressed air. No-loss drains use sensors to assess when the drain should open and for how long. This eliminates the loss of compressed air when the drain purges. Energy is saved by reducing the load on the compressed-air system.

Qualifying drains are no-loss drains that do not vent compressed air when draining condensate.

6.1.3.2 Impacts Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \left(scfm_{base} \times \left(\frac{kW}{scfm}\right)_{base} - scfm_{ee} \times \left(\frac{kW}{scfm}\right)_{ee}\right) \times HOU$$

To determine the reduction in flow rate from the leak repair, the following equation is used:

$$\Delta scfm = scfm_{100-psig,orifice} \times \left(\frac{p + 14.7}{(100 + 14.7)}\right)^{n}$$

The baseline system air flow is calculated using the following equation:

$$scfm_{base} = scfm_{rated} \times Load_{base}$$

The efficient system air flow and loading values are calculated using the following equations:

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$$scfm_{ee} = scfm_{base} - \Delta scfm$$

$$Load_{ee} = \frac{scfm_{ee}}{scfm_{rated}}$$

The base and efficient system operating performances are calculated by the following equations:

$$\left(\frac{kW}{scfm}\right)_{base} = \frac{hp \times 1.1 \times 0.746}{0.945 \times \eta_{VFD}} \times \frac{\left(X_2 \times Load_{base}{}^2 + X_1 \times Load_{base} + C\right)}{scfm_{base}}$$

$$\left(\frac{kW}{scfm}\right)_{ee} = \frac{hp \times 1.1 \times 0.746}{0.945 \times \eta_{VFD}} \times \frac{\left(X_2 \times Load_{ee}{}^2 + X_1 \times Load_{ee} + C\right)}{scfm_{ee}}$$

Per-measure, gross summer peak coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \left(scfm_{base} \times \left(\frac{kW}{scfm}\right)_{base} - scfm_{ee} \times Qty \times \left(\frac{kW}{scfm}\right)_{ee}\right) \times CF_{summer}$$

Per-measure, gross summer peak coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \left(scfm_{base} \times \left(\frac{kW}{scfm}\right)_{base} - scfm_{ee} \times Qty \times \left(\frac{kW}{scfm}\right)_{ee}\right) \times CF_{winter}$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross summer peak coincident demand reduction
ΔkW_{winter} = per-measure gross winter peak coincident demand reduction
hp = trim compressor rated horsepower
$scfm_{rated}$ = trim compressor rated flow rate
$scfm_{base}$ = baseline trim compressor operating flow
$scfm_{ee}$ = efficient trim compressor operating flow
Δscfm = efficient trim compressor operating flow
$scfm_{100\text{-psig, drain}}$ = reduction in flow rate at 100 psig
n = flowrate pressure adjustment coefficient
$Load_{base}$ = percent of trim compressor load with standard drains
$Load_{ee}$ = percent of trim compressor load with no loss drains
$kW/scfm_{base}$ = baseline system operating performance
$kW/scfm_{EE}$ = efficient system operating performance
p = system operating pressure
η_{VFD} = VFD efficiency
X_2 = coefficient
X_1 = coefficient
C = constant
HOU = annual hours of operation of compressor system
CF_{summer} = summer coincidence factor

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CF_{winter} = winter coincidence factor

6.1.3.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 6-9. Input parameters for no-loss condensate drain savings calculations

Component	Type	Value	Units	Source
hp	Variable	See customer application	hp	Customer application
$scfm_{rated}$	Variable	See customer application	scfm	Customer application
$scfm_{100\text{-}psig,drain}$	Fixed	3.0	scfm	Illinois TRM v.8.0 Vol. 2 2020, p. 571
n	Fixed	1.0	-	Engineering estimate
$Load_{base}$	Variable	See customer application; Default = 0.60	-	Customer application Engineering estimate
p	Variable	See customer application	psig	Customer application
η_{VFD}	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Engineering estimate, only applicable for VFD-controlled compressors
X2	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
X1	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
C	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
HOU	Variable	See customer application	hours, annual	See customer application
		Default=6,240		Minnesota TRM v 3.1 2020, p. 451
CF_{summer}	Variable	See Table 17-21 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Illinois TRM v 8.0 Volume 2 2020, p. 575
		Default =0.59		Default based on single shift (8/5) operating schedule from IL TRM v 8.0 Volume 2 2020, p. 575
CF_{winter}	Variable	See Table 17-21 in Sub-Appendix F2-V: Non-residential compressed air end use factors		Illinois TRM v 8.0 Volume 2 2020, p. 575[124]
		Default =0.59		Default based on single shift (8/5) operating schedule from IL TRM v 8.0 Volume 2 2020, p. 575

[124] The source TRM doesn't differentiate between winter and summer peak periods. Therefore, the summer CF is applied to the winter CF.

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6.1.3.4 Default savings

If the proper values are not available, some values have defaults savings. However, there are no default savings for this measure as some values are needed to calculate savings.

6.1.3.5 Effective Useful Life

The effective useful life of this measure is provided in Table 6-10.

Table 6-10. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
VII	Non-Residential Small Manufacturing Program, DSM Phase VII	12.24	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

6.1.3.6 Source(s)

The system performance (kW/scfm) relies on performance curves for various control types as provided by Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004.Other sources include the Illinois TRM V8.0 Vol.2, 2020, pp. 573-575 and Minnesota TRM V3.1, 2020, pp. 450-452.

6.1.3.7 Update summary

Updates made to this section are described in Table 6-11.

Table 6-11. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the IL TRM and MN TRM
	New table	Effective Useful Life (EUL) by program
	Equation	Added gross winter peak demand reduction equation
2020	Equation	• Added η_{VFD} to the kW/scfm equations. • Removed quantity from the Δscfm equation
	Inputs	Added default operating hours
v10	-	Initial release

6.1.4 Add storage

6.1.4.1 Measure description

This measure involves adding an air receiver with a flow controller on a load/no-load compressor system. Load/no-load compressors transition gradually from loaded to unloaded operation. Using storage and a flow controller the compressor has reduced cycling from loaded to unloaded operation. With fewer cycles the compressor spends less

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time transitioning, saving energy. The baseline case for savings is the existing storage capacity per cfm, which is expected to be 1 or 2 gallon/cfm.

Qualifying storage is at least 5 gallons of storage capacity per CFM capacity. This measure is eligible for load/no-load compressor systems.

6.1.4.2 Impacts Estimation Approach

Per-measure, gross annual electric energy savings are calculated per compressed air system according to the following equation:

$$\Delta kWh = scfm_{base} \times \left[\left(\frac{kW}{scfm}\right)_{base} - \left(\frac{kW}{scfm}\right)_{ee}\right] \times HOU$$

The baseline system air flow and is calculated using the following equation:

$$scfm = scfm_{rated} \times Load$$

The baseline and efficient system operating performance values are calculated by the following equations:

$$\left(\frac{kW}{scfm}\right)_{base} = \frac{hp \times 1.1 \times 0.746}{0.945} \times \frac{\left(X_{2,base} \times Load^2 + X_{1,base} \times Load + C_{base}\right)}{scfm}$$

$$\left(\frac{kW}{scfm}\right)_{ee} = \frac{hp \times 1.1 \times 0.746}{0.945} \times \frac{\left(X_{2,ee} \times Load^2 + X_{1,ee} \times Load + C_{ee}\right)}{scfm}$$

Per-measure, gross summer peak coincident demand reduction is calculated per compressed air system according to the following equation:

$$\Delta kW_{summer} = scfm_{base} \times \left[\left(\frac{kW}{scfm}\right)_{base} - \left(\frac{kW}{scfm}\right)_{ee}\right] \times CF_{summer}$$

Per-measure, gross summer peak coincident demand reduction is calculated per compressed air system according to the following equation:

$$\Delta kW_{winter} = scfm_{base} \times \left[\left(\frac{kW}{scfm}\right)_{base} - \left(\frac{kW}{scfm}\right)_{ee}\right] \times CF_{winter}$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross summer peak coincident demand reduction
ΔkW_{winter} = per-measure gross winter peak coincident demand reduction
scfm = trim compressor operating flow
$kW/scfm_{base}$ = base trim compressor operating performance

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$kW/scfm_{ee}$ = efficient trim compressor operating performance
$scfm_{rated}$ = trim compressor rated flow rate
$scfm_{rated}$ = trim compressor rated flow rate
hp = compressor rated horsepower[125]
Load = average operating airflow rate percent of full load conditions of trim compressor
$X_{2,base}$ = coefficient
$X_{1,base}$ = coefficient
C_{base} = constant
$X_{2,ee}$ = coefficient
$X_{1,ee}$ = coefficient
C_{ee} = constant
HOU = annual hours of operation of compressor system
CF_{summer} = summer coincidence factor
CF_{winter} = winter coincidence factor

6.1.4.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 6-12. Input parameters for add storage (5 gallon/cfm) savings calculations

Component	Type	Value	Units	Source
hp	Variable	See customer application	hp	Customer application
$scfm_{rated}$	Variable	See customer application	scfm	Customer application
Load	Variable	See customer application	-	Customer application
		Default = 0.60		Engineering estimate
$X_{2,base}$	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
$X_{1,base}$	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
C_{base}	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
$X_{2,ee}$	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
$X_{1,ee}$	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
C_{ee}	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
HOU	Variable	See customer application	hours	See customer application
		Default=6,240		Minnesota TRM v 3.1 2020, p. 451

[125] With multiple fully loaded compressors, and only one part loaded unit, the horsepower and capacity (cfm) relate to the horsepower and capacity of the partly loaded compressor.

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Component	Type	Value	Units	Source
CF_{summer}	Variable	See Table 17-21 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Illinois TRM v 8.0 Volume 2 2020, p. 575
		Default =0.59		Default based on single shift (8/5) operating schedule from IL TRM v 8.0 Volume 2 2020, p. 575
CF_{winter}	Variable	See Table 17-21 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	IL TRM v 8.0 Volume 2 2020, p. 575[126]
		Default =0.59		Default based on single shift (8/5) operating schedule from IL TRM v 8.0 Volume 2 2020, p. 575

6.1.4.4 Default savings

If the proper values are not available, some values have defaults savings. However, there are no default savings for this measure as some values are needed to calculate savings.

6.1.4.5 Effective Useful Life

The effective useful life of this measure is provided in Table 6-13.

Table 6-13. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
VII	Non-Residential Small Manufacturing Program, DSM Phase VII	12.24	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

6.1.4.6 Source(s)

The system performance (kW/scfm) relies on performance curves for various control types as provided by Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004. Other sources include the Illinois TRM V8.0 Vol.2, 2020, pp. 573-575 and Minnesota TRM V3.1, 2020, pp. 450-452.

6.1.4.7 Update summary

Updates made to this section are described in Table 6-14.

Table 6-14. Summary of update(s)

Version	Update type	Description
2022	None	No change

126 The source TRM doesn't differentiate between winter and summer peak periods. Therefore, the summer CF is applied to the winter CF.

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Version	Update type	Description
2021	Source	Updated page numbers / version of the IL TRM and MN TRM
	New table	Effective Useful Life (EUL) by program
	Equation	Added gross winter peak demand reduction equation
2020	Inputs	Added default operating hours and CF value
v10	-	Initial release

6.1.5 Heat-of-compression dryer

6.1.5.1 Measure description

This measure replaces a standard purge-desiccant dryer with a heat-of-compression dryer. Standard desiccant dryers use compressed air to purge moisture from the desiccant. These dryers can use a significant amount of a system's rated compressed air capacity for drying. Heat-of-compression dryers, however, utilize the waste heat from the compressed air to recharge (dry) the desiccant. This saves energy by reducing the need to use compressed air for drying. The baseline is a standard purge desiccant dryer.

The installed equipment is a rotating drum or twin tower desiccant dryer that utilizes the heat of compression from the air compressor to regenerate the desiccant material.

6.1.5.2 Impacts Estimation Approach

Per dryer, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \left[scfm_{base} \times \left(\frac{kW}{scfm}\right)_{base} + kW_{heater,base} + kW_{blower,base} + kW_{refrig,base} - (1 + PSF \times (p_{base} - p_{ee}))\left(scfm_{ee} \times \left(\frac{kW}{scfm}\right)_{ee}\right)\right] \times HOU$$

To determine the reduction in airflow rate due to the new dryer type, the following equation is used:

$$scfm_{reduced} = scfm_{dryer,rated,base} \times Purge_{base} - scfm_{dryer,rated,ee} \times Purge_{ee}$$

The baseline airflow rate and loading are calculated using the following equations:

$$scfm_{base} = scfm_{rated} \times Load_{base}$$

$$Load_{dryer,base} = \frac{scfm_{base}}{scfm_{dryer,rated,base}}$$

The efficient system air flow and loading is calculated using the following equations:

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$$scfm_{ee} = scfm_{base} - scfm_{reduced}$$

$$Load_{ee} = \frac{scfm_{ee}}{scfm_{rated}}$$

The base and efficient system operating performance values are calculated by the following equations:

$$\left(\frac{kW}{scfm}\right)_{base} = \frac{hp \times 1.1 \times 0.746}{0.945 \times \eta_{VFD}} \times \frac{\left(X_2 \times Load_{base}{}^2 + X_1 \times Load_{base} + C\right)}{scfm_{base}}$$

$$\left(\frac{kW}{scfm}\right)_{ee} = \frac{hp \times 1.1 \times 0.746}{0.945 \times \eta_{VFD}} \times \frac{\left(X_2 \times Load_{ee}{}^2 + X_2 \times Load_{ee} + C\right)}{scfm_{ee}}$$

The load due to each component is calculated using the following equations:

$$kW_{blower,base} = \frac{hp_{blower,base} \times 0.8 \times 0.746}{0.957}$$

$$kW_{heater,base} = kW_{heater,base} \times Use_{heater,base}$$

$$kW_{refrig,base} = kW_{refrig,base,rated} \times \left(R_1 \times Load_{dryer,\,base} + K\right)$$

Per dryer, the gross summer coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \left[scfm_{base} \times \left(\frac{kW}{scfm}\right)_{base} + kW_{heater,base} + kW_{blower,base} + kW_{refrig,base} - (1 + PSF \times (p_{base} - p_{ee}))\left((scfm_{ee}) \times \left(\frac{kW}{scfm}\right)_{ee}\right)\right] \times CF_{summer}$$

Per dryer, the gross summer coincident demand reduction is calculated according to the following equation:

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$$\Delta kW_{winter} = \left[scfm_{base} \times \left(\frac{kW}{scfm}\right)_{base} + kW_{heater,base} + kW_{blower,base} + kW_{refrig,base} - \left(1 + PSF \times (p_{base} - p_{ee})\right)\left((scfm_{ee}) \times \left(\frac{kW}{scfm}\right)_{ee}\right)\right] \times CF_{winter}$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross summer peak coincident demand reduction
ΔkW_{winter} = per-measure gross winter peak coincident demand reduction
hp = trim compressor rated horsepower
$scfm_{rated}$ = trim compressor rated flow
$scfm_{base}$ = base trim compressor operating flow
$scfm_{ee}$ = efficient trim compressor operating flow
$scfm_{reduced}$ = average reduction in flow resulting from replacing base dryer
$scfm_{dryer, rated, base}$ = base dryer rated flow
$scfm_{dryer, rated, ee}$ = efficient cycling dryer rated flow
$Type_{dryer,base}$ = baseline dryer type
$Purge_{base}$ = purge percent of base dryer
$Purge_{ee}$ = purge percent of EE dryer
$Load_{base}$ = average percent of rated flow for trim compressor
$Load_{dryer\ base}$ = average operating proportion of baseline dryer rated airflow
$Load_{ee}$ = average operating percent of trim compressor rated flow with the heat of compression dryer
$kW_{heater,base}$ = average operating kW of the baseline heater
$kW_{blower,base}$ = average operating kW of the baseline blower
$kW_{refrig,base}$ = average operating kW of the baseline refrigerated dryer
$hp_{blower.base}$ = rated hp of blower in baseline dryer
$Use_{heater,base}$ = proportion of operating time that heater is in use
$kW_{refrig,base,rated}$ = the rated kW of the baseline dryer
R_1 = coefficient
K = coefficient
$kW/scfm_{base}$ = baseline system operating performance
$kW/scfm_{ee}$ = efficient system operating performance
p_{base} = system operating pressure of baseline system
p_{ee} = system operating pressure of efficient system
PSF = pressure savings factor
η_{VFD} = VFD efficiency
X_2 = coefficient
X_1 = coefficient
C = constant
HOU = annual hours of use
CF_{summer} = summer coincidence factor
CF_{winter} = winter coincidence factor

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6.1.5.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 6-15. Input parameters for heat of compression dryer

Component	Type	Value	Units	Sources
hp	Variable	See customer application	hp	Customer application
$scfm_{rated}$	Variable	See customer application	scfm	Customer application
$scfm_{dryer,rated,base}$	Variable	see customer application	scfm	Customer application
$scfm_{dryer,rated\ ee}$	Variable	see customer application	scfm	Customer application
$Purge_{base}$	Variable	See Table 17-23 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Desiccant purge rates are from: Dryer Selection for Compressed Air Systems, Compressed Air Challenge, 1999. no purge for other dryer types
$Purge_{ee}$	Fixed	0.02	-	Engineering estimate
$Load_{base}$	Variable	See customer application	-	Customer application
		Default = 0.60		Engineering estimate
$hp_{blower,base}$	Variable	See customer application (for blower purge and heated blower purge, only)	hp	Customer application
$kW_{heater,base}$	Variable	See customer application (for heated blower purge and heated desiccant dryer types, only)	kW	Customer application
$Use_{heater,base}$	Variable	Assigned by baseline blower type: heated blower purge = 0.75 heated desiccant dryer = 1.00	-	Based on engineering judgment
$kW_{refrig,rated,base}$	Variable	See customer application, only applicable to: Non-cycling refrigerated Cycling refrigerated VFD refrigerated Digital Scroll refrigerated	kW	Customer application
R_1	Variable	See Table 17-22 in Sub-Appendix F2-V: Non-residential compressed air end use factors for refrigerated dryers, only	-	Compressed Air Challenge, Cycling Refrigerated Air Dryers - Are Savings Significant
K	Variable	See Table 17-22 in Sub-Appendix F2-V: Non-residential compressed air end use factors for refrigerated dryers, only	-	Compressed Air Challenge, Cycling Refrigerated Air Dryers - Are Savings Significant
p_{base}	Variable	See customer application	psig	Customer application
p_{ee}	Variable	See customer application	psig	Customer application
PSF	Fixed	0.005	1/psig	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
η_{VFD}	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Engineering estimate; only applicable if the control type is a VFD

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Component	Type	Value	Units	Sources
X_2	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
X_1	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
C	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
HOU	Variable	See customer application	hours, annual	See customer application
		Default=6,240		Minnesota TRM v 3.1 2020, p. 451
CF_{summer}	Fixed	See Table 17-21 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Illinois TRM v 8.0 Volume 2 2020, p. 575
		Default =0.59		Default based on single shift (8/5) operating schedule from IL TRM v 8.0 Volume 2 2020, p. 575
CF_{winter}	Variable	See Table 17-21 in Sub-Appendix F2-V: Non-residential compressed air end use factors		Illinois TRM v 8.0 Volume 2 2020, p. 575[127]
		Default =0.59		Default based on single shift (8/5) operating schedule from IL TRM v 8.0 Volume 2 2020, p. 575

6.1.5.4 Default savings

There are no default savings for this measure as site-specific values are required to calculate savings.

6.1.5.5 Effective Useful Life

The Effective Useful Life of this measure is provided in Table 6-16.

Table 6-16. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
VII	Non-Residential Small Manufacturing Program, DSM Phase VII	12.24	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

6.1.5.6 Source(s)

The system performance (kW/scfm) relies on performance curves for various control types as provided by Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004. Other sources include the Illinois TRM

127 The source TRM doesn't differentiate between winter and summer peak periods. Therefore, the summer CF is applied to the winter CF.

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v.8.0 Vol.2 2020, pp. 573-575, Minnesota TRM v3.1 2020, pp. 450-452 and Dryer Selection for Compressed Air Systems, Compressed Air Challenge, 1999.

6.1.5.7 Update summary

Updates made to this section are described in Table 6-17.

Table 6-17. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the IL TRM and MN TRM
	Equation	Added gross winter peak demand reduction equation
	New table	Effective Useful Life (EUL) by program
2020	Input	• Changed CF from fixed value to allow for more than one production shift • Added default operating hours
v10	-	Initial release

6.1.6 Low pressure-drop filter

6.1.6.1 Measure description

This measure involves replacing standard coalescing filters with low-pressure drop filters. Filters are used to remove contaminants from the compressed air system and protect equipment. Filters induce a static pressure drop and require increased air pressure setpoints to overcome the pressure drop. By replacing standard filters with low-pressure drop filters, the pressure setpoint can be reduced at the discharge to realize energy savings. Only positive-displacement compressors (rotary-screw and reciprocating) are eligible for this measure because lowering discharge pressure will result in approximately 0.5% drop in power for every 1-psig reduction of discharge pressure setpoint.[128] Furthermore, qualifying filters have a rated pressure drop of 1 psig or less. Centrifugal compressors are ineligible for this measure because they require compressor-specific performance curves to accurately calculate savings.

6.1.6.2 Savings estimation

Per-measure, gross annual electric energy savings are calculated per filter according to the following equation:

$$\Delta kWh = scfm_{base} \times \left(\frac{kW}{scfm}\right)_{base} \times PSF \times \Delta p \times HOU$$

The baseline airflow is calculated using the following equation:

$$scfm_{base} = scfm_{rated} \times Load_{base}$$

The base system operating performance is calculated using the following equation:

128 "Fundamentals of Compressed Air Systems", Compressed Air Challenge, 2004

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$$\left(\frac{kW}{scfm}\right)_{base} = \frac{hp \times 1.1 \times 0.746}{0.945 \times \eta_{VFD}} \times \frac{\left(X_2 \times Load_{base}{}^2 + X_1 \times Load_{base} + C\right)}{scfm_{base}}$$

The change in pressure due to the new filter is calculated using the following equation:

$$\Delta p = MIN\left(p_{base} - p_{ee}, \Delta p_{max}\right)$$

Per-measure, gross coincident summer peak demand reduction is calculated per filter according to the following equation:

$$\Delta kW_{summer} = scfm_{base} \times \left(\frac{kW}{scfm}\right)_{base} \times PSF \times \Delta p \times CF_{summer}$$

Per-measure, gross coincident winter peak demand reduction is calculated per filter according to the following equation:

$$\Delta kW_{winter} = scfm_{base} \times \left(\frac{kW}{scfm}\right)_{base} \times PSF \times \Delta p \times CF_{winter}$$

Where:

ΔkWh = per-measure, gross annual electric energy savings
ΔkW_{summer} = per-measure, gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure, gross coincident winter peak demand reduction
hp = compressor rated horsepower
p_{base} = base pressure setpoint
p_{ee} = system operating pressure after pressure reduction
Δp = the change in pressure setpoint
Δp_{max} = the maximum pressure reduction attributed to low-pressure filter
$scfm_{rated}$ = trim compressor rated flow
$scfm_{base}$ = base trim compressor operating flow
$Load_{base}$ = average percent of rated flow for trim compressor
$kW/scfm_{base}$ = base system operating performance
PSF = pressure savings factor
η_{VFD} = VFD efficiency
X_2 = coefficient
X_1 = coefficient
C = constant
HOU = annual hours of use
CF_{summer} = summer coincidence factor
CF_{winter} = winter coincidence factor

6.1.6.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

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Table 6-18. Input parameters for low-pressure drop filter savings calculations

Component	Type	Value	Units	Sources
p_{base}	Variable	See customer application	psig	Customer application
p_{ee}	Variable	See customer application	psig	Customer application
Δp_{max}	Fixed	5.00	psig	Assumed maximum amount of pressure reduction that can be attributed to measure (difference between base filter pressure reduction and low PD filter)
hp	Variable	See customer application	hp	See customer application
$scfm_{rated}$	Variable	See customer application	scfm	Customer application
$Load_{base}$	Variable	See customer application	-	Customer application
		Default = 0.60		Engineering estimate
PSF	Fixed	0.005	1/psig	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
η_{VFD}	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Engineering estimate, only applicable if the control type is VFD
X_2	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
X_1	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
C	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
HOU	Variable	See customer application	hours	See customer application
		Default=6,240		Minnesota TRM v 3.1 2020, p. 451
CF_{summer}	Variable	See Table 17-21 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Illinois TRM v 8.0 Volume 2 2020, p.575
		Default =0.59		Default based on single shift (8/5) operating schedule from IL TRM v 8.0 Volume 2 2020, p. 575
CF_{winter}	Variable	See Table 17-21 in Sub-Appendix F2-V: Non-residential compressed air end use factors		Illinois TRM v 8.0 Volume 2 2020, p. 575[129]
		Default =0.59		Default based on single shift (8/5) operating schedule from IL TRM v 8.0 Volume 2 2020, p. 575

129 The source TRM doesn't differentiate between winter and summer peak periods. Therefore, the summer CF is applied to the winter CF.

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6.1.6.4 Default savings

If the proper values are not available, some values have defaults savings. However, there are no default savings for this measure as some values are needed to calculate savings.

6.1.6.5 Effective Useful Life

The effective useful life of this measure is provided in Table 6-19.

Table 6-19. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
VII	Non-Residential Small Manufacturing Program, DSM Phase VII	12.24	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

6.1.6.6 Source

The system performance (kW/scfm) relies on performance curves for various control types as provided by Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004. The Illinois TRM v.8.0, Vol. 2. 2020, p. 575 and Minnesota TRM v 3.1 2020, p. 451 is also referenced.

6.1.6.7 Update summary

Updates made to this section are described in Table 6-20.

Table 6-20. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the IL TRM and MN TRM
	New table	Effective Useful Life (EUL) by program
	Equation	Added winter peak coincident demand reduction equation
2020	Inputs	Added default operating hours
v10	-	Initial release

6.1.7 VFD air compressor

6.1.7.1 Measure description

This measure installs an air compressor with variable frequency drive replacing an existing air compressor without a variable frequency drive. Variable frequency drives control the output airflow rate by varying the electrical frequency to the compressor motor. Inlet modulation with unloading, load/no-load, and centrifugal compressor systems vary the compressor capacity by physically changing the compressor operation. Variable frequency drive controls have much higher part-load efficiencies than the standard control types, thus saving energy under part-load conditions. Typical air compressors spend a small percent of the operation at or near full-load conditions.

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The qualifying equipment is an air compressor with a variable frequency drive. If this is installed as a replacement for an existing compressor, the compressor should be the same rated hp capacity as the existing compressor. Base-load units that serve multi-compressor systems do not qualify.

6.1.7.2 Impacts Estimation Approach

Per-measure, gross annual electric energy savings are calculated per VFD-controlled compressor according to the following equation:

$$\Delta kWh = \sum_{bin=1}^{7} scfm_{bin} \times \left(\left(\frac{kW}{scfm}\right)_{base,\ bin} - \left(\frac{kW}{scfm}\right)_{ee,\ bin}\right) \times HOU_{bin} \times HOU$$

The bin flow rate is calculated using the following equation:

$$scfm_{bin} = scfm_{rated} \times Load_{bin}$$

The base and efficient system operating performance is calculated by the following equations:

$$\left(\frac{kW}{scfm}\right)_{base,\,bin} = \frac{hp \times 1.1 \times 0.746}{0.945 \times \eta_{VFD}} \times \frac{\left(X_{2,base} \times {Load_{bin}}^{2} + X_{1,base} \times Load_{bin} + C_{base}\right)}{scfm_{bin}}$$

$$\left(\frac{kW}{scfm}\right)_{ee,\,bin} = \frac{hp \times 1.1 \times 0.746}{0.945 \times \eta_{VFD}} \times \frac{\left(X_{2,ee} \times {Load_{bin}}^{2} + X_{1,ee} \times Load_{bin} + C_{ee}\right)}{scfm_{bin}}$$

Gross coincident summer peak demand reduction is calculated per VFD-controlled compressor according to the following equation:

$$\Delta kW_{summer} = \sum_{bin=1}^{7} scfm_{bin} \times \left[\left(\frac{kW}{scfm}\right)_{base,\,bin} - \left(\frac{kW}{scfm}\right)_{ee,\,bin}\right] \times HOU_{bin} \times CF_{summer}$$

Gross coincident winter peak demand reduction is calculated per VFD-controlled compressor according to the following equation:

$$\Delta kW_{winter} = \sum_{bin=1}^{7} scfm_{bin} \times \left[\left(\frac{kW}{scfm}\right)_{base,\,bin} - \left(\frac{kW}{scfm}\right)_{ee,\,bin}\right] \times HOU_{bin} \times CF_{winter}$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure, gross coincident summer peak demand reduction

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ΔkW_{winter} = per-measure, gross coincident winter peak demand reduction
hp = trim compressor rated horsepower
$scfm_{rated}$ = trim compressor rated flow rate
$scfm_{bin}$ = flow rate of bin
$load_{bin}$ = percent of rated flow of base trim compressor for each bin
$kW/scfm_{base,bin}$ = base trim compressor operating performance for each bin
$kW/scfm_{ee,bin}$ = ee trim compressor operating performance for each bin
η_{VFD} = VFD efficiency
$X_{2,base}$ = coefficient
$X_{1,base}$ = coefficient
C_{base} = constant
C_{ee} = constant
$X_{2,ee}$ = coefficient
$X_{1,ee}$ = coefficient
HOU = annual hours of use
HOU_{bin} = percent of operating hours compressor operates at corresponding load
CF_{summer} = summer coincidence factor
CF_{winter} = winter coincidence factor

6.1.7.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 6-21. Input values VSD air compressor savings calculations

Component	Type	Value	Units	Sources
hp	Variable	See customer application	hp	Customer application
$scfm_{rated}$	Variable	See customer application	scfm	Customer application
$load_{bin}$	Variable	For default see Table 17-19 in Sub-Appendix F2-V: Non-residential compressed air end use factors. The $Load_{bins}$ are the median load range of each bin. The HOU_{bin} values are provided by the customer application and should total 1.00. If these values are unknown the defaults are used.	-	Average percent of bin definition, bins are 10% load ranges, from 100% to 40%, 30% assumed for <40% bin (bin 7)
η_{VFD}	Fixed	0.98	-	Engineering estimate
$X_{2,base}$	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
$X_{1,base}$	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
C_{base}	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
$X_{2,ee}$	Fixed	VFD = 0	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
$X_{1,ee}$	Fixed	VFD = 0.95	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004

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Component	Type	Value	Units	Sources
C_{ee}	Fixed	VFD = 0.05	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
HOU	Variable	See customer application	hour, annual	Customer application
		Default=6,240		Minnesota TRM v 3.1 2020, p. 451
HOU_{bin}	Variable	See customer application	-	Customer application; sum of HOU_{bins} must equal 1.00
		For default see Table 17-19 in Sub-Appendix F2-V: Non-residential compressed air end use factors. The $Load_{bins}$ are the median load range of each bin. The HOU_{bin} values are provided by the customer application and should total 1.00. If these values are unknown the defaults are used.		Engineering judgement
CF_{summer}	Variable	See Table 17-21 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Illinois TRM v 8.0 Volume 2 2020, p. 575
		Default =0.59		Default based on single shift (8/5) operating schedule from IL TRM v 8.0 Volume 2 2020, p. 575
CF_{winter}	Variable	See Table 17-21 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Illinois TRM v 8.0 Volume 2 2020, p. 575[130]
		Default =0.59		Default based on single shift (8/5) operating schedule from IL TRM v 8.0 Volume 2 2020, p. 575

6.1.7.4 Default savings

If the proper values are not available, some values have defaults savings. However, there are no default savings for this measure as some values are needed to calculate savings.

6.1.7.5 Effective Useful Life

The effective useful life of this measure is provided in Table 6-22.

Table 6-22. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
VII	Non-Residential Small Manufacturing Program, DSM Phase VII	12.24	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

130 The source TRM doesn't differentiate between winter and summer peak periods. Therefore, the summer CF is applied to the winter CF.

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6.1.7.6 Source(s)

The system performance (kW/scfm) relies on performance curves for various control types as provided by Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004. Other sources include the Illinois TRM v.8.0, Vol. 2. 2020, p. 575 and Minnesota TRM v 3.1 2020, p. 451.

6.1.7.7 Update summary

Updates made to this section are described in Table 6-23.

Table 6-23. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the IL TRM and MN TRM
	Equation	Added gross winter peak demand reduction equation
	New table	Effective Useful Life (EUL) by program
2020	Inputs	Added default operating hours
v10	-	Initial release

6.1.8 Cycling air dryer

6.1.8.1 Measure description

This measure replaces an existing standard refrigerated air dryer with a new cycling air dryer. Standard non-cycling refrigerated air dryers run their refrigerant compressors continuously regardless of the need. This wastes energy by running when the compressed air does not need to be dried. This occurs when the ambient conditions are cooler and drier than the design conditions. Cycling dryers operate only when the compressed air needs to be dried.

The cycling dryer must either be a thermal-mass dryer, a VFD-controlled dryer, or a digital scroll-compressor dryer that modulates to match load.

6.1.8.2 Impacts Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \left[scfm_{base} \times \left(\frac{kW}{scfm}\right)_{base} + kW_{heater} + kW_{blower} + kW_{refrig} - scfm_{ee} \times \left(\frac{kW}{scfm}\right)_{ee} - kW_{dryer,\ ee}\right] \times HOU$$

To determine the reduction in flow rate due to the new dryer type, the following equation is used:

$$scfm_{reduced} = scfm_{base\ dryer,rated} \times Purge_{base}$$

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The baseline air flow and loading are calculated using the following equations:

$$scfm_{system,base} = scfm_{system,\ rated} \times Load_{system,\ base}$$

$$scfm_{base} = scfm_{rated} \times Load_{base}$$

$$Load_{system,base} = \frac{scfm_{system,\ rated} - scfm_{rated} + scfm_{rated} \times Load_{base}}{scfm_{system,\ rated}}$$

$$Load_{dryer,base} = \frac{scfm_{system,\ base}}{scfm_{base\ dryer,\ rated}}$$

The efficient system air flow and loading is calculated using the following equations:

$$scfm_{\ ee} = scfm_{base} - scfm_{reduced}$$

$$Load_{ee} = \frac{scfm_{\ ee}}{scfm_{rated}}$$

$$Load_{dryer,ee} = \frac{scfm_{ee}}{scfm_{ee\ dryer,\ rated}}$$

The base and efficient system operating performance is calculated by the following equations:

$$\left(\frac{kW}{scfm}\right)_{base} = \frac{hp \times 1.1 \times 0.746}{0.945 \times \eta_{VFD}} \times \frac{\left(X_2 \times {Load_{base}}^2 + X_1 \times Load_{base} + C\right)}{scfm_{base}}$$

$$\left(\frac{kW}{scfm}\right)_{ee} = \frac{hp \times 1.1 \times 0.746}{0.945 \times \eta_{VFD}} \times \frac{\left(X_2 \times {Load_{ee}}^2 + X_1 \times Load_{ee} + C\right)}{scfm_{ee}}$$

The load due to each component is calculated using the following equations:

$$kW_{blower} = \frac{hp_{blower} \times 0.8 \times 0.746}{0.957}$$

$$kW_{heater} = kW_{heater,rated} \times Utilization_{heater}$$

$$kW_{refrig} = kW_{refrig.,rated} \times \left(R_{1,base} \times Load_{dryer,base} + K_{base}\right)$$

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$$kW_{dryer,ee} = kW_{dryer,rated,ee} \times \left(R_{1,ee} \times Load_{dryer,ee} + K_{ee}\right)$$

Per-measure, gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \left[scfm_{base} \times \left(\frac{kW}{scfm}\right)_{base} + kW_{heater} + kW_{blower} + kW_{refrig} - scfm_{ee} \times \left(\frac{kW}{scfm}\right)_{ee} - kW_{dryer,\ ee}\right] \times CF_{summer}$$

Per-measure, gross coincident winter peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \left[scfm_{base} \times \left(\frac{kW}{scfm}\right)_{base} + kW_{heater} + kW_{blower} + kW_{refrig} - scfm_{ee} \times \left(\frac{kW}{scfm}\right)_{ee} - kW_{dryer,\ ee}\right] \times CF_{winter}$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure, gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure, gross coincident winter peak demand reduction
hp = trim compressor rated horsepower
$scfm_{rated}$ = trim compressor rated flow
$scfm_{system,rated}$ = system rated flow
$scfm_{base}$ = base trim compressor operating flow
$scfm_{system,base}$ = base system operating flow
$scfm_{ee}$ = EE trim compressor operating flow
$scfm_{reduced}$ = average reduction in flow resulting from replacing base dryer
$scfm_{base\ dryer\ rated}$ = base dryer rated flow
$scfm_{ee\ dryer\ rated}$ = EE cycling dryer rated flow
$Purge_{base}$ = purge percent of base dryer
$Load_{base}$ = average percent of rated flow for trim compressor
$Load_{system,\ base}$ = average percent of rated flow for system
$Load_{dryer\ base}$ = average operating percent of base dryer rated flow
$Load_{dryer\ ,ee}$ = average operating percent of EE dryer rated flow
$Load_{ee}$ = average operating percent of EE dryer rated flow
kW_{heater} = average operating kW of the base heater
kW_{blower} = average operating kW of the base blower
kW_{refrig} = average operating kW of the base refrigerated dryer
$kW_{dryer,\ ee}$ = average operating kW of the base refrigerated dryer
hp_{blower} = blower rated hp of base dryer
$kW_{rated\ heater}$ = heater rated kW of base dryer
$Utilization_{heater}$ = heater operation time
$kW_{rated\ refrig}$ = the rated kW of the base dryer
$kW_{rated\ dryer,ee}$ = the rated kW of the EE dryer
$R_{1,base}$ = coefficient
K_{base} = coefficient

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$R_{1,ee}$ = coefficient
K_{ee} = coefficient
$kW/scfm_{base}$ = base system operating performance
$kW/scfm_{ee}$ = efficient system operating performance
η_{VFD} = VFD efficiency
X_2 = coefficient
X_1 = coefficient
C = constant
HOU = annual hours of use
CF_{summer} = summer coincidence factor
CF_{winter} = winter coincidence factor

6.1.8.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 6-24. Input parameters for cycling dryer

Component	Type	Value	Units	Sources
hp	Variable	Customer application	hp	See customer application
$scfm_{rated}$	Variable	Customer application	scfm	See customer application
$scfm_{system,rated}$	Variable	Customer application	scfm	See customer application
$scfm_{base,dryer,rated}$	Variable	Customer application	scfm	See customer application
$scfm_{ee,dryer,rated}$	Variable	Customer application	scfm	See customer application
$Purge_{base}$	Variable	See Table 17-23 in Sub-Appendix F2-V: Non-residential compressed air end use factors		Desiccant purge rates are from: Dryer Selection for Compressed Air Systems, Compressed Air Challenge, 1999 No purge for other dryer types
$Load_{base}$	Variable	Customer application,	-	See customer application
		Default = 60%		Engineering estimate
hp_{blower}	Variable	Customer application, only applicable to blower purge and heated blower purge	hp	See customer application
$kW_{heater,rated}$	Variable	Customer application, only applicable to heated blower purge and heated desiccant dryer types	kW	See customer application
$Utilization_{heater}$	Variable	Assigned by base blower type: heated blower purge = 0.75 heated desiccant dryer = 1.0	-	Heated desiccant dryer operates continuously, heated blower purge is based on engineering judgment
$kW_{refrig,rated}$	Variable	Customer application, only applicable to blower purge and heated blower purge dryer types	kW	See customer application
$kW_{ee,dryer,rated}$	Variable	Customer application, only applicable to blower purge and heated blower purge dryer types	kW	See customer application
$R_{1,\ base}$	Variable	See Table 17-22 in Sub-Appendix F2-V: Non-	-	Compressed Air Challenge, Cycling Refrigerated Air Dryers - Are Savings Significant

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Component	Type	Value	Units	Sources
		residential compressed air end use factors		
K_{base}	Variable	See Table 17-22 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Compressed Air Challenge, Cycling Refrigerated Air Dryers - Are Savings Significant
$R_{1, ee}$	Variable	See Table 17-22 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Compressed Air Challenge, Cycling Refrigerated Air Dryers - Are Savings Significant
K_{ee}	Variable	See Table 17-22 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Compressed Air Challenge, Cycling Refrigerated Air Dryers - Are Savings Significant
X_2	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
X_1	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
C	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
HOU	Variable	See customer application	hours, annual	See customer application
		Default=6,240		Minnesota TRM v 3.1 2020, p. 451
CF_{summer}	Variable	See Table 17-21 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Illinois TRM v 8.0 Volume 2 2020, p. 575
		Default =0.59		Default based on single shift (8/5) operating schedule from IL TRM v 8.0 Volume 2 2020, p. 575
CF_{winter}	Variable	See Table 17-21 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Illinois TRM v 8.0 Volume 2 2020, p. 575[131]
		Default =0.59		Default based on single shift (8/5) operating schedule from IL TRM v 8.0 Volume 2 2020, p. 575

6.1.8.4 Default savings

If the proper values are not available, some values have defaults savings. However, there are no default savings for this measure as some values are needed to calculate savings.

131 The source TRM doesn't differentiate between winter and summer peak periods. Therefore, the summer CF is applied to the winter CF.

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6.1.8.5 Effective Useful Life

The effective useful life of this measure is provided in Table 6-25.

Table 6-25. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
VII	Non-Residential Small Manufacturing Program, DSM Phase VII	12.24	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

6.1.8.6 Source(s)

The system performance (kW/scfm) relies on performance curves for various control types as provided by Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004, and Cycling Refrigerated Air Dryers - Are Savings Significant, Compressed Air Challenge. Other sources include the Illinois TRM v.8.0, Vol. 2. 2020, p 575 and Minnesota TRM v 3.1 2020, p. 451

6.1.8.7 Update summary

Updates made to this section are described in Table 6-26.

Table 6-26. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the IL TRM and MN TRM
	Equation	Added gross winter peak demand reduction equation
	New table	Effective Useful Life (EUL) by program
2020	Inputs	Added default operating hours
v10	-	Initial release

6.1.9 Dew point controls

6.1.9.1 Measure description

Typical desiccant dryers use compressed air to purge moisture from the desiccant. Standard desiccant dryer purge rates are fixed. Timer controls rotate the chambers of desiccant for recharging at a fixed rate determined based on the design conditions of the compressed air system, i.e., full load airflow and humid ambient conditions. Most systems operate at loads near the design conditions for only short periods of time. This measure is to install dew point controls that recharge desiccant only when the chamber is saturated. This is done by measuring the dew point of the dried air. This measure saves energy by limiting the compressed air purged to the amount needed to regenerate the desiccant.

Qualifying equipment must be installed on a twin tower desiccant dryer overriding fixed timer regeneration control and must use dew point-based controls.

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6.1.9.2 Impacts Estimation Approach

Per-measure, gross annual electric energy savings are calculated per dryer controlled according to the following equation:

$$\Delta kWh = \left[scfm_{base} \times \left(\frac{kW}{scfm}\right)_{base} + kW_{heater} + kW_{blower} - scfm_{ee} \times \left(\frac{kW}{scfm}\right)_{ee} - kW_{blower,\ ee} - kW_{heater,ee}\right] \times HOU$$

The reduction in airflow due to the new controls is calculated using the following equation:

$$scfm_{reduced} = scfm_{base\ dryer,rated} \times Purge_{base} - \left(scfm_{base,dryer,\ rated} \times Purge_{base} \times Load_{base,\ dryer}\right) \times (1 - Time)$$

The baseline air flow and loading are calculated using the following equations:

$$Load_{system,base} = \frac{scfm_{system,\ rated} - scfm_{rated} + scfm_{rated} \times Load_{base}}{scfm_{system,\ rated}}$$

$$scfm_{system,base} = scfm_{system,\ rated} \times Load_{system,\ base}$$

$$Load_{dryer,base} = \frac{scfm_{system,\ base}}{scfm_{dryer,rated}}$$

$$scfm_{base} = scfm_{rated} \times Load_{base}$$

The efficient air flow and loading are calculated using the following equation:

$$scfm_{ee} = scfm_{base} - scfm_{reduced}$$

$$Load_{ee} = \frac{scfm_{ee}}{scfm_{rated}}$$

The base and efficient system operating performance is calculated by the following equations:

$$\left(\frac{kW}{scfm}\right)_{base} = \frac{hp \times 1.1 \times 0.746}{0.945 \times \eta_{VFD}} \times \frac{\left(X_2 \times {Load_{base}}^2 + X_1 \times Load_{base} + C\right)}{scfm_{base}}$$

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$$\left(\frac{kW}{scfm}\right)_{ee} = \frac{hp \times 1.1 \times 0.746}{0.945 \times \eta_{VFD}} \times \frac{\left(X_2 \times Load_{ee}{}^2 + X_1 \times Load_{ee} + C\right)}{scfm_{ee}}$$

Where the kW load due to each component is calculated using the following equations:

$$kW_{blower,ee} = kW_{blower,base} \times Load_{ee}$$

$$kW_{blower,bas} = hp_{blower} \times 0.8 \times 0.746 \times 0.957 =$$

$$kW_{heater,base} = kW_{heater,rated,base} \times Utilization_{heater}$$

$$kW_{heater,ee} = kW_{heater,base} \times Load_{ee}$$

Per-measure, gross coincident summer peak demand reduction is calculated per dryer controlled according to the following equation:

$$\Delta kW_{summer} = \left[scfm_{base} \times \left(\frac{kW}{scfm}\right)_{base} + kW_{heater} + kW_{blower} - scfm_{ee} \times \left(\frac{kW}{scfm}\right)_{ee} - kW_{blower,\,ee} - kW_{heater,ee}\right] \times CF_{summer}$$

Per-measure, gross coincident winter peak demand reduction is calculated per dryer controlled according to the

$$\Delta kW_{winter} = \left[scfm_{base} \times \left(\frac{kW}{scfm}\right)_{base} + kW_{heater} + kW_{blower} - scfm_{ee} \times \left(\frac{kW}{scfm}\right)_{ee} - kW_{blower,\,ee} - kW_{heater,ee}\right] \times CF_{winter}$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure, gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure, gross coincident winter peak demand reduction
hp = trim compressor rated horsepower
$scfm_{rated}$ = trim compressor rated flow
$scfm_{system,rated}$ = system rated flow
$scfm_{base}$ = baseline trim compressor operating flow
$scfm_{system,base}$ = baseline system operating flow
$scfm_{reduced}$ = average reduction in flow resulting from dewpoint controls
$scfm_{base\ dryer,rated}$ = baseline dryer rated flow
$scfm_{ee}$ = energy-efficient trim compressor operating flow
$Purge_{base}$ = purge percent of baseline dryer
$Load_{base}$ = average percentage of rated flow for trim compressor

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$Load_{system,base}$ = average percentage of rated flow for baseline system
$Load_{dryer,base}$ = average operating percentage of base dryer rated flow
$Load_{ee}$ = average operating percentage of trim compressor rated flow with dewpoint control dryer
Time = proportion of time reduction due to dew-point controls
$kW_{heater, base}$ = average operating kW of the baseline heater
$kW_{blower, base}$ = average operating kW of the baseline blower
$kW_{heater,ee}$ = average operating kW of the energy-efficient heater
$kW_{blower, ee}$ = average operating kW of the energy-efficient blower
hp_{blower} = blower rated hp of baseline dryer
$kW_{rated\ heater}$ = heater rated kW of baseline dryer
$Utilization_{heater}$ = heater operation time
$kW/scfm_{base}$ = base system operating performance
$kW/scfm_{ee}$ = energy-efficient system operating performance
η_{VFD} = VFD efficiency
X2 = coefficient
X1 = coefficient
C = constant
HOU = annual hours of use
CF_{summer} = summer coincidence factor
CF_{winter} = winter coincidence factor

6.1.9.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 6-27. Input parameters for heat of compression dryer

Component	Type	Value	Units	Sources
hp	Variable	Customer application	hp	See customer application
$scfm_{rated}$	Variable	Customer application	scfm	See customer application
$scfm_{system, rated}$	Variable	Customer application	scfm	See customer application
$scfm_{base,dryer,rated}$	Variable	Customer application	scfm	See customer application
$Purge_{base}$	Variable	See Table 17-23 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Desiccant purge rates are from: Dryer Selection for Compressed Air Systems, Compressed Air Challenge, 1999. no purge for other dryer types
$Load_{base}$	Variable	Customer application,	-	See customer application
		Default = 0.60		Engineering estimate
Time	Fixed	0.25	-	Assumed, low RH during winter months
hp_{blower}	Variable	Customer application, only applicable to blower purge and heated blower purge	hp	See customer application
$kW_{rated\ heater}$	Variable	Customer application, only applicable to heated blower purge and heated desiccant dryer types	kW	See customer application
$Utilization_{heater}$	Variable	Assigned by base blower type: heated blower purge = 0.75 heated desiccant dryer = 1.0	-	Heated desiccant dryer operates continuously, heated blower purge is based on engineering judgment

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Component	Type	Value	Units	Sources
η_{VFD}	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	engineering estimate, only applicable if the control type is VFD
X2	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
X1	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
C	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
HOU	Variable	Customer application	hours, annual	See customer application
		Default = 6,240		Minnesota TRM v 3.1 2020, p. 451
CF_{summer}	Variable	See Table 17-21 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Illinois TRM v 8.0 Volume 2 2020, p. 575
		Default =0.59		Default based on single shift (8/5) operating schedule from IL TRM v 8.0 Volume 2 2020, p. 575
CF_{winter}	Variable	See Table 17-21 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Illinois TRM v 8.0 Volume 2 2020, p. 575[132]
		Default =0.59		Default based on single shift (8/5) operating schedule from IL TRM v 8.0 Volume 2 2020, p. 575

6.1.9.4 Default savings

If the proper values are not available, some values have defaults savings. However, there are no default savings for this measure as some values are needed to calculate savings.

6.1.9.5 Effective Useful Life

The effective useful life of this measure is provided in Table 6-28.

Table 6-28. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
VII	Non-Residential Small Manufacturing Program, DSM Phase VII	12.24	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

132 The source TRM doesn't differentiate between winter and summer peak periods. Therefore, the summer CF is applied to the winter CF.

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6.1.9.6 Source(s)

The system performance (kW/scfm) relies on performance curves for various control types as provided by Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004. Other sources include the Illinois TRM v.78.0, Vol. 2. 2020, p 575, Minnesota TRM v 3.1 2020, p. 451, Dryer Selection for Compressed Air Systems, Compressed Air Challenge, 1999.

6.1.9.7 Update summary

Updates made to this section are described in Table 6-29.

Table 6-29. Summary of update(s)

Version	Update Type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the IL TRM and MN TRM
	Equation	Added gross winter peak demand reduction equation
	New Table	Effective Useful Life (EUL) by program
2020	Inputs	Added default operating hours
v10	-	Initial release

6.1.10 Pressure reduction

6.1.10.1 Measure description

This measure is for reducing the pressure setpoint of a compressed air system. Pressure setpoints are often set higher than is needed to ensure that serviced equipment is able to maintain the pressure requirements. Air compressors require more power to produce the same cfm at a higher pressure. Reducing this pressure setpoint saves energy. Additionally, there is a reduction in uncontrolled flow resulting from reducing the pressure setpoint.

This measure requires that the pressure reduction must take place at the compressor rather than at a downstream pressure regulator. This measure is only applicable to positive displacement compressors (rotary screw and reciprocating compressors) centrifugal compressors are excluded, because they require compressor specific performance curves to accurately calculate savings.

6.1.10.2 Impacts Estimation Approach

Per-measure, gross annual electric energy savings are calculated per compressed air system according to the following equations:

$$\Delta kWh \quad = \Delta kWh_{artificial} + \Delta kWh_{pressure}$$

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$$\Delta kWh_{artificial} = \left(scfm_{base} \times \left(\frac{kW}{scfm}\right)_{base} - (scfm_{ee}) \times \left(\frac{kW}{scfm}\right)_{ee}\right) \times HOU$$

$$\Delta kWh_{pressure} = \left(scfm_{ee} \times \left(\frac{kW}{scfm}\right)_{ee} \times PSF \times \Delta p\right) \times HOU$$

To determine the reduction in flow rate from the change to the pressure set-point, the following equation is used:

$$scfm_{reduced} = (scfm_{base} \times \%scfm_{artificial}) - (scfm_{base} \times scfm_{artificial}) \times \left(\frac{(p_{ee} + 14.7)}{(p_{base} + 14.7)}\right)^{n}$$

The baseline system air flow is calculated using the following equation:

$$scfm_{base} = scfm_{rated} \times Load_{base}$$

The efficient system air flow and loading and is calculated using the following equation:

$$scfm_{ee} = scfm_{base} - scfm_{reduced}$$

$$Load_{ee} = \frac{scfm_{base} - scfm_{reduced}}{scfm_{rated}}$$

The baseline and efficient system operating performances are calculated by the following equations:

$$\left(\frac{kW}{scfm}\right)_{base} = \frac{hp \times 1.1 \times 0.746}{0.945 \times \eta_{VFD}} \times \frac{(X2 \times Load_{base}{}^{2} + X1 \times Load_{base} + C)}{scfm_{base}}$$

$$\left(\frac{kW}{scfm}\right)_{ee} = \frac{hp \times 1.1 \times 0.746}{0.945 \times \eta_{VFD}} \times \frac{(X2 \times Load_{ee}{}^{2} + X1 \times Load_{ee} + C)}{scfm_{ee}}$$

Per-measure, gross coincident summer peak demand reduction is calculated per compressed air system according to the following equations:

$$\Delta kW_{summer} = (\Delta kW_{artificial} + \Delta kW_{pressure}) \times CF_{summer}$$

$$\Delta kW_{artificial} = \left(scfm_{base} \times \left(\frac{kW}{scfm}\right)_{base} - (scfm_{ee}) \times \left(\frac{kW}{scfm}\right)_{ee}\right)$$

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$$\Delta kW_{pressure} = \left(scfm_{ee} \times \left(\frac{kW}{scfm}\right)_{ee} \times PSF \times \Delta p\right)$$

Per-measure, gross coincident winter peak demand reduction is calculated per compressed air system according to the following equation:

$$\Delta kW_{winter} = \left(\Delta kW_{artificial} + \Delta kW_{pressure}\right) \times CF_{winter}$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure, gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure, gross coincident winter peak demand reduction
$\Delta kWh_{artificial}$ = gross annual electric energy savings resulting from artificial load reduction
$\Delta kWh_{pressure}$ = gross annual electric energy savings resulting from pressure reduction
$\Delta kW_{artificial}$ = gross annual average demand reduction resulting from artificial load reduction
$\Delta kW_{pressure}$ = gross annual average demand reduction s resulting from pressure reduction
Δp = the pressure reduction
p_{base} = base system operating pressure of base system
p_{ee} = efficient system operating pressure of efficient system
PSF = pressure savings factor
n = flowrate pressure adjustment coefficient
hp = compressor system rated horsepower
$scfm_{rated}$ = compressor rated flow rate
$scfm_{base}$ = base compressor operating flow
$scfm_{ee}$ = efficient trim compressor operating flow
$scfm_{artificial}$ = percent compressed air artificial demand
$scfm_{reduced}$ = efficient compressor operating flow
$Load_{base}$ = average percent of rated flow for base system
$Load_{ee}$ = average percent of rated flow for efficient system
$kW/scfm_{base}$ = base system operating performance
$kW/scfm_{ee}$ = efficient system operating performance
η_{VFD} = VFD efficiency
X2 = coefficient
X1 = coefficient
C = constant
HOU = annual hours of operation of compressor system
CF_{summer} = summer coincidence factor
CF_{winter} = winter coincidence factor

6.1.10.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 6-30. Input parameters for pressure reduction

Component	Type	Value	Units	Sources
p_{base}	Variable	See customer application	psig	Customer application

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Component	Type	Value	Units	Sources
p_{ee}	Variable	See customer application	psig	Customer application
Δp	Variable	The lesser of the difference between customer application p_{base} and p_{ee} or 10	psig	Customer application values and capped at 10 psig reduction
PSF	Fixed	0.05	1/psig	"Fundamentals of Compressed Air Systems", Compressed Air Challenge, 2004
n	Fixed	1.0	-	Engineering estimate
hp	Variable	See customer application	hp	Customer application
$scfm_{rated}$	Variable	See customer application	scfm	Customer application
$scfm_{artificial}$	Fixed	0.30	-	"Fundamentals of Compressed Air Systems", Compressed Air Challenge, 2004
$Load_{base}$	Variable	See customer application	-	Customer application
		Default = 0.60		Engineering estimate
η_{VFD}	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Engineering estimate, only applicable if the control type is VFD
X_2	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	"Fundamentals of Compressed Air Systems", Compressed Air Challenge, 2004
X_1	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	"Fundamentals of Compressed Air Systems", Compressed Air Challenge, 2004
C	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	"Fundamentals of Compressed Air Systems", Compressed Air Challenge, 2004
HOU	Variable	See customer application	hours, annual	Customer application
		Default=6,240		Minnesota TRM v 3.1 2020, p. 451
CF_{summer}	Variable	See Table 17-21 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Illinois TRM v 8.0 Volume 2 2020, p. 575
		Default =0.59		Default based on single shift (8/5) operating schedule from IL TRM v 8.0 Volume 2 2020, p. 575
CF_{winter}	Variable	See Table 17-21 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Illinois TRM v 8.0 Volume 2 2020, p. 575[133]
		Default =0.59		Default based on single shift (8/5) operating schedule from IL TRM v 8.0 Volume 2 2020, p. 575

133 The source TRM doesn't differentiate between winter and summer peak periods. Therefore, the summer CF is applied to the winter CF.

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6.1.10.4 Default savings

This measure does not have default savings. The savings depend on the rated power and system pressures before and after implementing this measure. However, there are defaults for other variables.

6.1.10.5 Effective Useful Life

The effective useful life of this measure is provided in Table 6-31.

Table 6-31. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
VII	Non-Residential Small Manufacturing Program, DSM Phase VII	12.24	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

6.1.10.6 Source(s)

The system performance (kW/scfm) relies on performance curves for various control types as provided by Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004. Other sources include the Illinois TRM v.78.0, Vol. 2. 2020, p 575 and the 2022Minnesota TRM v 3.1 2020, p. 451.

6.1.10.7 Update summary

Updates made to this section are described in Table 6-32.

Table 6-32. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the IL TRM and MN TRM
	Equation	Added gross winter peak demand reduction equation Modified ΔkWh equation to fix error in calculation by separating into separate terms of $\Delta kWh_{artificial}$ and $\Delta kWh_{pressure}$ for clarity
	Table	Effective Useful Life (EUL) by program
2020	Inputs	Added default operating hours
v10	-	Initial release

6.1.11 Downsized VFD compressor

6.1.11.1 Measure description

This measure installs an air compressor with variable frequency drive (VFD) replacing a larger air compressor without VFD controls. Air compressors can be oversized and hence, never operate near their rated capacity. Variable frequency drives control the output airflow rate by varying the electrical frequency to the compressor motor. Standard control types such as inlet valve modulation with unloading, load/unload, and centrifugal compressor systems vary

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the compressor capacity by physically changing the compressor operation. Variable frequency drive controls have much better part-load efficiencies than standard control types, thus saving energy under part load conditions. Additionally, energy is saved by installing a smaller compressor that still meets system airflow requirements.

The qualifying equipment is an air compressor with a variable frequency drive and replaces an existing compressor of larger size without variable frequency drive controls. It is assumed that the typical size reduction is one standard size. Base load units that serve multi-compressor systems do not qualify.

6.1.11.2 Impacts Estimation Approach

Per-measure, gross annual electric energy savings are calculated per VFD-controlled compressor according to the following equation:

$$\Delta kWh = \sum_{bin=1}^{7} scfm_{bin} \times \left[\left(\frac{kW}{scfm} \right)_{base,\,bin} - \left(\frac{kW}{scfm} \right)_{ee,\,bin} \right] \times HOU_{bin} \times HOU$$

The airflow and load of each bin is calculated using the following equations:

$$scfm_{bin} = scfm_{rated,base} \times Load_{base,\,bin}$$

$$Load_{ee,\,bin} = \frac{scfm_{bin}}{scfm_{rated,\,ee}}$$

$$scfm_{bin} = scfm_{rated,base} \times Load_{base,bin}$$

$$Load_{ee,\,bin} = \frac{scfm_{bin}}{scfm_{rated,\;ee}}$$

The base and efficient system operating performance (of each bin) is calculated by the following equations:

$$\left(\frac{kW}{scfm} \right)_{base,\,bin} = \frac{hp_{base} \times 1.1 \times 0.746}{0.945} \times \frac{\left(X_{2,base} \times Load_{base,\;bin}{}^2 + X_{1,base} \times Load_{base,\;bin} + C_{base} \right)}{scfm_{bin}}$$

$$\left(\frac{kW}{scfm} \right)_{ee,\,bin} = \frac{hp_{ee} \times 1.1 \times 0.746}{0.945 * \times \eta_{VFD}} \times \frac{\left(X_{2,ee} \times Load_{ee,\,bin}{}^2 + X_{1,ee} \times Load_{ee,\,bin} + C_{ee} \right)}{scfm_{bin}}$$

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Per-measure, gross coincident summer peak demand reduction is calculated per VFD-controlled compressor according to the following equation:

$$\Delta kW_{summer} = \sum_{bin=1}^{7} scfm_{bin} \times \left[\left(\frac{kW}{cfm}\right)_{base,bin} - \left(\frac{kW}{cfm}\right)_{ee,bin}\right] \times HOU_{bin} \times CF_{summer}$$

Per-measure, gross coincident winter peak demand reduction is calculated per VFD-controlled compressor according to the following equation:

$$\Delta kW_{winter} = \sum_{bin=1}^{7} scfm_{bin} \times \left[\left(\frac{kW}{cfm}\right)_{base,bin} - \left(\frac{kW}{cfm}\right)_{ee,bin}\right] \times HOU_{bin} \times CF_{winter}$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure gross coincident winter peak demand reduction
Hp_{base} = base trim compressor rated horsepower
$scfm_{rated,base}$ = base trim compressor rated flow rate
hp_{ee} = efficient trim compressor rated horsepower
$scfm_{rated,ee}$ = efficient trim compressor rated flow rate
$scfm_{bin}$ = flow rate of bin
$Load_{base,bin}$ = percent of rated flow of base trim compressor for each bin
$Load_{ee,bin}$ = percent of rated flow of EE trim compressor for each bin
$kW/scfm_{basebin}$ = base trim compressor operating performance for each bin
$kW/scfm_{eebin}$ = efficient trim compressor operating performance for each bin
η_{VFD} = VFD efficiency
$X_{2,base}$ = coefficient
$X_{1,base}$ = coefficient
C_{base} = constant
$X_{2,ee}$ = coefficient
$X_{1,ee}$ = coefficient
C_{ee} = constant
HOU = annual hours of use
HOU_{bin} = proportion of operating hours compressor at corresponding load
CF_{summer} = summer peak coincidence factor
CF_{winter} = winter peak coincidence factor

6.1.11.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 6-33. Input values downsized VSD air compressor savings calculations

Component	Type	Value	Units	Sources
hp_{base}	Variable	See customer application	hp	Customer application
$scfm_{rated, base}$	Variable	See customer application	scfm	Customer application

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Component	Type	Value	Units	Sources
hp_{ee}	Variable	See customer application	hp	Customer application
$scfm_{rated, ee}$	Variable	See customer application	scfm	Customer application
$Load_{base, bin}$	Variable	For default see Table 17-19 in Sub-Appendix F2-V: Non-residential compressed air end use factors. The $Load_{bins}$ are the median load range of each bin. The HOU_{bin} values are provided by the customer application and should total 1.00. If these values are unknown the defaults are used.	-	Average percent of bin definition, bins are 10% load ranges, from 100% to 40%, 30% assumed for <40% bin (bin 7)
$X_{2,base}$	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	"Fundamentals of Compressed Air Systems", Compressed Air Challenge, 2004
$X_{1,base}$	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	"Fundamentals of Compressed Air Systems", Compressed Air Challenge, 2004
C_{base}	Variable	See Table 17-20 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	"Fundamentals of Compressed Air Systems", Compressed Air Challenge, 2004
η_{VFD}	Fixed	0.98	-	Engineering estimate
$X_{2,EE}$	Fixed	VFD = 0.00	-	"Fundamentals of Compressed Air Systems", Compressed Air Challenge, 2004
$X_{1,EE}$	Fixed	VFD = 0.95	-	"Fundamentals of Compressed Air Systems", Compressed Air Challenge, 2004
C_{EE}	Fixed	VFD = 0.05	-	"Fundamentals of Compressed Air Systems", Compressed Air Challenge, 2004
HOU	Variable	See customer application	hours, annual	Customer application
		Default=6,240		MN TRM v 3.1 2020, p. 451
HOU_{bin}	Variable	See customer application	-	Customer application
		For default see Table 17-19 in Sub-Appendix F2-V: Non-residential compressed air end use factors. The $Load_{bins}$ are the median load range of each bin. The HOU_{bin} values are provided by the customer application and should total 1.00. If these values are unknown the defaults are used.		Engineering assumption
CF_{summer}	Variable	See Table 17-21 in Sub-Appendix F2-V: Non-residential compressed air end use factors	-	Illinois TRM v 8.0 Volume 2 2020, p. 575
		Default =0.59		Default based on single shift operating schedule

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Component	Type	Value	Units	Sources
CF_{winter}	Variable	See Table 17-21 in Sub-Appendix F2-V: Non-residential compressed air end use factors		Illinois TRM v 8.0 Volume 2 2020, p. 575[134]
		Default =0.59		Default based on single shift (8/5) operating schedule[122]

6.1.11.4 Default savings

This measure does not have default savings. The savings depend on the rated power. However, some variables have default values.

6.1.11.5 Effective Useful Life

The effective useful life of this measure is provided in Table 6-34.

Table 6-34. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
VII	Non-Residential Small Manufacturing Program, DSM Phase VII	12.24	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

6.1.11.6 Source(s)

The system performance (kW/scfm) relies on performance curves for various control types as provided by Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004. Other sources include the Illinois TRM v.78.0, Vol. 2. 2020, p 575, and the Minnesota TRM v 3.1 2020, p. 451.

6.1.11.7 Update summary

Updates made to this section are described in Table 6-35.

Table 6-35. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the IL TRM and MN TRM
	Equation	Added gross winter peak demand reduction equation
	Table	Effective Useful Life (EUL) by program
2020	Inputs	Added default operating hours
v10	-	Initial release

134 The source TRM doesn't differentiate between winter and summer peak periods. Therefore, the summer CF is applied to the winter CF.

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7 NON-RESIDENTIAL OFFICE PROGRAM, DSM PHASE VII

The Non-Residential Office Program provides qualifying business owners incentives to pursue one or more of the qualified energy efficiency measures through a local, participating contractor in Dominion Energy's contractor network. This program offers controls measures such as adjusting schedules and setpoints to operate more efficiently. Participants may receive a facility assessment and measure implementation, as well as incentives to offset the cost of making recommended improvements. To qualify for this program, the customer must be responsible for the electric bill and must be the owner of the facility or reasonably able to secure permission to complete the measures. All program measures are summarized in Table 7-1.

Table 7-1. Non-residential office program measure list

End Use	Measure	Legacy program	Manual section
Lighting	Reduce lighting schedule	N/A	Section 7.2.1
HVAC	HVAC unit scheduling	N/A	Section 7.3.1
	HVAC temperature setback		Section 7.3.2
	Condensing		Section 7.3.3
	HVAC discharge air temperature reset		Section 7.3.4
	HVAC static pressure reset		Section 7.3.5
	HVAC VAV minimum flow reduction		Section 7.3.6
	Dual enthalpy air-side economizer	Non-Residential Heating and Cooling Efficiency Program, DSM Phase VII	Section 2.1.5

Except for the Dual enthalpy air-side economizer measure (Section 7.3.7), analyses for all the measure savings are based on building model simulations.

7.1 Building model simulation description

Measures that utilize the building model simulation approach are described in this section. The U.S. Department of Energy (DOE) reference building "Large Office" with code vintage defined as ASHRAE 90.1-2007 is used as the basis for the baseline and installed case building models.[135] The DOE Commercial Large Office Reference building was scaled down to a 4-story building. Current energy code in Virginia is 2018 IECC and ASHRAE 90.1-2016 with amendments.[136] It is DNV's expert engineering judgement that buildings and systems from the 2007 vintage would be appropriate candidates for the retro-commissioning measures in this program because the end-use systems being retro-commissioned in this program are generally assumed to be functioning properly but aged and should benefit from re-programming controls.

There are baseline and efficient building models for each measure case. Energy savings are calculated using these models and simulated using TMY3 weather data for selected weather stations in Virginia and North Carolina.

[135] U.S. Department of Energy. Office of Energy Efficiency & Renewable Energy. Commercial Reference Buildings. https://www.energy.gov/eere/buildings/commercial-reference-buildings, accessed on 08/03/2021

[136] U.S. Department of Energy. Office of Energy Efficiency & Renewable Energy. Building Energy Codes Program. Virginia. https://www.energycodes.gov/status/states/virginia, accessed on 11/15/2022

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7.1.1 Building models

The baseline energy model is derived from DOE's Commercial Large Office Reference Building. That model assumes a baseline annual energy consumption of 19.17 kWh/sq.ft. and 0.06 therm/sq.ft. Electricity usage includes a data center that is typical of such buildings along with typical interior equipment load. The reference building is a large office (12-stories plus a basement totaling 498,600 sq. ft. or 38,350 sq.ft./floor).

For those program participant buildings smaller than this, DOE's Commercial Large Office Reference Building was also scaled down to a 4-story building from simulations of the large building, as is standard practice in building energy simulation modelling. The reference 12-story building model was modified by removing eight of the interior floors—thereby reducing the building to four stories plus a basement data center. In fact, the interior floors of the 12-story DOE reference model were modelled using the EnergyPlus™ engine—developed by DOE—with floors "multipliers" which means that the simulator itself was scaling results for the interior floors. The 4-story models were further modified by changing the said floors multipliers from ten to two. In addition, the number of central HVAC equipment, namely chiller and cooling tower, to 1 compared to 2 in the large office model. The capacities of the HVAC equipment in the 4-story building are left to auto-sized. This 4-story model totaled 191,764 sq. ft. gross with about 150,000 sq. ft. in the above-ground floors subject to controls improvements.

There are three different models for HVAC system types representing the most likely HVAC systems to be encountered in small offices. The HVAC system types include: packaged VAV, and chilled water VAV. Additionally, the heating fuel type is considered for each of these systems where the options are either electric or non-electric.

Scaling of results can be used to predict savings for medium to large multi-story office buildings. Loads on HVAC systems in offices tend to be dominated less by shell or envelop loads (e.g., passive stored heat) than internal loads such as occupants, lighting, and plug-load waste heat. Small buildings with relatively large exterior surface areas compared to floor area (or larger sprawling buildings with only one or two floors) would not be modeled as well by scaling these results. On the other hand, small buildings would rarely be heated and cooled by VAV air-handlers with central hot water and chilled water plants.

The basement includes an 8,400-sq. ft. data center (e.g., server rooms) and each floor includes its own small 390-sq.ft. data center (e.g., IT closet). Savings factors are normalized with a building area of 498,600 sq. ft. for the large office model and 191,765 sq. ft. for the 4-story models.

Each measure has an efficient model. The efficient building models were created by modifying the baseline energy models in ways that the measure is intended to operate. This is done by modifying the applicable setpoints and schedules for each measure, in just the end-use building systems that are affected by the energy efficient measure.

7.1.1.1 Impacts Estimation Approach

Modeled savings are calculated by subtracting the energy consumption of the efficient model from the baseline model, for each weather station. The total building savings are divided by the applicable model parameters to get a savings per unit (i.e. floor area sq.ft. or supply fan cfm) to produce the applicable energy savings factors. For each record, energy savings factors are multiplied by the customer-specific units to calculate the customer-specific gross savings. Additionally, the savings may be scaled to account for the level of adjustment relative to the models assumptions. An example of this is that the lighting schedule reduction measure assumes the schedule is reduced 10 hours per week. If the record has a reduction higher or lower than this, the savings are scaled linearly.

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Per measure, gross annual electric energy savings are calculated in each of the following measure sections. In general, they follow the same structure, as follows:

$$\Delta kWh = ESF \times quantity \times MAF$$

Per-measure, gross coincident summer and winter peak demand reduction for measures in this program are shown below:

$$\Delta kW_{summer} = DRF_{summer} \times quantity \times MAF$$

$$\Delta kW_{winter} = DRF_{winter} \times quantity \times MAF$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross summer coincident demand reduction
ΔkW_{winter} = per-measure gross winter coincident demand reduction
ESF = annual energy savings factor per unit based on measure by weather station
DRF_{summer} = summer coincident demand reduction factor
DRF_{winter} = winter coincident demand reduction factor
quantity = quantity of measure-specific units
MAF = measure adjustment factor to scale savings from the modeled assumptions to the application depth of measure

7.1.1.2 Input Variables

The input variables are defined in each of the following measure sections. The ESF and DRF values for each of the modeled measures are in Table 7-2 and Table 7-3.

Table 7-2. Energy savings factor by measure

Weather station	Measure Name								
	Schedule Lighting (kWh/sq. ft.)	Schedule HVAC (kWh/cfm)		Night temperature Setback (kWh/cfm)	Condenser temperature Reset (kWh/ton)	Discharge air temperature Reset (kWh/cfm)	Static pressure reset (kWh/cfm)	Reduce VAV box minimum Position (kWh/sq. ft.)	
Heating type	Both	Non-electric	Electric	Both	Both	Electric	Both	Non-electric	Electric
Charlottesville	0.489	0.658	0.893	0.386	146.8	0.306	0.629	0.127	0.447
Sterling	0.477	0.635	0.936	0.509	142.1	0.474	0.615	0.152	0.528
Farmville	0.486	0.642	0.893	0.421	146.2	0.337	0.650	0.115	0.449
Norfolk	0.477	0.706	0.968	0.391	195.5	0.358	0.638	0.134	0.451
Arlington	0.475	0.686	0.979	0.500	165.3	0.453	0.632	0.149	0.533
Richmond	0.486	0.679	0.952	0.439	170.8	0.366	0.649	0.132	0.459
Roanoke	0.482	0.639	0.911	0.401	140.3	0.410	0.633	0.135	0.481
Fredericksburg	0.487	0.661	0.943	0.421	160.4	0.385	0.649	0.118	0.466
Rocky Mount-Wilson	0.490	0.698	0.914	0.312	167.9	0.236	0.668	0.114	0.382
Elizabeth City	0.488	0.753	0.971	0.352	221.6	0.231	0.677	0.133	0.403

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Table 7-3. Demand reduction factor (DRF)

Weather station	Measure	
	Static pressure reset (kW/cfm)	
DRF period	DRF_{summer}	DRF_{winter}
Heating type	Both	
Charlottesville	0.00017837941	0.00009425006
Sterling	0.00019140228	0.00011121182
Farmville	0.00017938315	0.00008622703
Norfolk	0.00018539720	0.00013525152
Arlington	0.00018239536	0.00013601769
Richmond	0.00018739927	0.00013724999
Roanoke	0.00018238656	0.00008819459
Fredericksburg	0.00018238924	0.00009240189
Rocky Mount-Wilson	0.00017838515	0.00009932243
Elizabeth City	0.00018839097	0.00004126336

7.1.1.3 Default savings

No default savings will be awarded for this measure if the proper values are not provided in the customer application.

7.1.1.4 Effective Useful Life

The effective useful life of this measure is provided in Table 7-4.

Table 7-4. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
XI	Non-Residential Building Optimization Program, DSM Phase IX	5.00	years	Wisconsin TRM 2022, p. 369[137]
VI	Non-Residential Office Program, DSM Phase VII	7.00		Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

7.1.1.5 Source(s)

The primary source for this deemed savings approach is prototypical building energy models derived from DOE's Commercial Large Office Reference Building and modified to represent Dominion Energy's Virginia and North Carolina weather zones, using typical meteorological year 3 (TMY3) data along with various program-specific measures.

137 The chiller plant setpoint adjustment measure life is assigned for all measures in this program. The measures in this program will have a similar measures life as they are all related to retro-commissioning and controls measures.

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7.1.1.6 Update summary

Updates made to this section are described in Table 7-5.

Table 7-5. Summary of update(s)

Version	Update type	Description
2022	Equations and assumptions	Updated methodology to scale the modeled savings to project specific values and added demand impacts for the static pressure reset value
2021	Inputs	Added large office building type and expanded to 10 weather stations
2020	Inputs	Revised kWh/sq.ft. with results from updated building models
v10	-	Initial release

7.2 Lighting end use

7.2.1 Reduce lighting schedule

7.2.1.1 Measure description

Lighting fixtures must be turned on and off by an automation system. The customer or controls vendor must provide documentation that lighting operating hours are reduced by at least 30 minutes per workday. For this measure, we assumed it is implemented in a large office building with a chilled water VAV system and heating fuel type of electric and gas. This model is selected since the measure itself is not very sensitive to building size or heating system type.

7.2.1.2 Impact Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = ESF \times SqFt \times MAF$$

$$MAF = \left(\frac{(HPD_{base} \times DPW_{base}) - (HPD_{ee} \times DPW_{ee})}{10 \frac{hrs}{week}} \right)$$

Per-measure, gross coincident summer and winter peak demand reduction is assigned as zero because these measures have a negligible demand reduction as shown below:

$$\Delta kW_{summer} = 0$$

$$\Delta kW_{winter} = 0$$

Where:

ΔkWh	= per-measure gross annual electric energy savings
ΔkW_{summer}	= per-measure gross coincident summer peak demand reduction
ΔkW_{winter}	= per-measure gross coincident winter peak demand reduction

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ESF	= annual energy savings factor
MAF	= measure adjustment factor to scale savings from the modeled assumptions to the application depth of measure
HPD_{base}	= baseline occupied hours per day of occupied schedule
HPD_{ee}	= energy-efficient case occupied hours per day of occupied schedule
DPW_{base}	= baseline occupied days per week of occupied schedule
DPW_{ee}	= energy-efficient case days occupied per week of occupied schedule
SqFt	= condition area impacted by measure

7.2.1.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 7-6. Input values for office buildings

Component	Type	Value	Unit	Source(s)
ESF	Variable	See Table 7-2	kWh/Unit	OpenStudio® energy modeling software outputs using EnergyPlus™ engine
HPD_{base}	Variable	See customer application	hours/day	Customer application
HPD_{ee}	Variable	See customer application	hours/day	Customer application
DPW_{base}	Variable	See customer application	days/week	Customer application
DPW_{ee}	Variable	See customer application	days/week	Customer application
SqFt	Variable	See customer application	sq. ft.	Customer application

7.2.1.4 Default savings

This measure does not have default savings.

7.2.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 7-10.

Table 7-7. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
XI	Non-Residential Building Optimization Program, DSM Phase IX	5.00	years	Wisconsin TRM 2022, p. 369[138]
VI	Non-Residential Office Program, DSM Phase VII	7.00		Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

[138] The chiller plant setpoint adjustment measure life is assigned for all measures in this program. The measures in this program will have a similar measures life as they are all related to retro-commissioning and controls measures.

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7.2.1.6 Source(s)

The primary source for this deemed savings approach is prototypical building energy models derived from DOE's Commercial Large Office Reference Building and modified to represent Dominion Energy's Virginia and North Carolina weather zones, using typical meteorological year 3 (TMY3) data.

7.2.1.7 Update summary

Updates made to this section are described in Table 7-8.

Table 7-8. Summary of update(s)

Version	Update type	Description
2022	Equations	Revised energy savings factors and applied scaling savings by additional parameters than just the sq. ft.
2021	Inputs	Added large office building type and expanded to 10 weather stations
2020	Inputs	Revised kWh/sq.ft. with results from updated building models
v10	-	Initial release

7.3 Heating, Ventilation, and Air Conditioning (HVAC) end use

7.3.1 HVAC unit scheduling

7.3.1.1 Measure description

HVAC air handling equipment (air handling units, unitary HVAC, or split system HVAC) must be scheduled to an unoccupied mode by an automation system. The unoccupied mode must shut outdoor air dampers to remove ventilation loads. The customer or controls vendor must provide documentation that HVAC equipment operating hours are reduced by at least 30 minutes per workday. For this measure, we assumed it is implemented in a 4-Story office building with a chilled water VAV system and heating fuel type of electric and gas.

These measures are based on the frequent observation during commercial facility audits that many facilities maintain comfort conditions, including ventilation, well beyond the occupied hours of the facility. The simulation of these measures assumes that scheduling of fans and outside air can be decreased by one hour in the morning and half-hour in the afternoon. In cases with greater reduction in operating hours, savings can be scaled based on the number of hours of correction. The two measures and their savings differ in their heating type. Therefore, savings in both gas heating system and electric heating system were modeled on a 4-story medium size office building.

The following schedules were modified to determine the energy impact:

- VAV fan schedule for each of the 12 systems. This schedule essentially dictates when occupied hours occur, running the fan continuously and ensuring a constant supply of outside air (OA)
- Heating set point schedule for all zones served by VAV
- Cooling set points were not changed
- As with other measures that reduce OA, fan savings are limited due to reduction in free-cooling

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7.3.1.2 Impact Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = ESF \times scfm_{supplyfan} \times MAF$$

$$MAF = \left(\frac{(HPD_{base} \times DPW_{base}) - (HPD_{ee} \times DPW_{ee})}{12 \frac{hrs}{week}} \right)$$

Per-measure, gross coincident summer and winter peak demand reduction is assigned as zero because these measures have a negligible demand reduction as shown below:

$$\Delta kW_{summer} = 0$$

$$\Delta kW_{winter} = 0$$

Where:

ΔkWh	= per-measure gross annual electric energy savings
ΔkW_{summer}	= per-measure gross coincident summer peak demand reduction
ΔkW_{winter}	= per-measure gross coincident winter peak demand reduction
ESF	= annual energy savings factor
MAF	= measure adjustment factor to scale savings from the modeled assumptions to the application depth of measure
HPD_{base}	= baseline occupied hours per day of occupied schedule
HPD_{ee}	= energy-efficient case occupied hours per day of occupied schedule
DPW_{base}	= baseline occupied days per week of occupied schedule
DPW_{ee}	= energy-efficient case occupied days per week of occupied schedule
$scfm_{supply\ fan}$	= supply fan flow rate

7.3.1.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 7-9. Input values for office buildings

Component	Type	Value	Unit	Source(s)
ESF	Variable	See Table 7-2	kWh/Unit	OpenStudio® energy modeling software outputs using EnergyPlus™ engine
HPD_{base}	Variable	See customer application	hours/day	Customer application
HPD_{ee}	Variable	See customer application	hours/day	Customer application
DPW_{base}	Variable	See customer application	days/week	Customer application
DPW_{ee}	Variable	See customer application	days/week	Customer application
$Scfm_{supply\ fan}$	Variable	See customer application	scfm	Customer application

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7.3.1.4 Default savings

This measure does not have default savings.

7.3.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 7-10.

Table 7-10. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
XI	Non-Residential Building Optimization Program, DSM Phase IX	5.00	years	Wisconsin TRM 2022, p. 369[139]
VI	Non-Residential Office Program, DSM Phase VII	7.00		Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

7.3.1.6 Source(s)

The primary source for this deemed savings approach is prototypical building energy models derived from DOE's Commercial Large Office Reference Building and modified to represent Dominion Energy's Virginia and North Carolina weather zones, using typical meteorological year 3 (TMY3) data.

7.3.1.7 Update summary

Updates made to this section are described in Table 7-11.

Table 7-11. Summary of update(s)

Version	Update type	Description
2022	Equations	Revised energy savings factors and applied scaling savings by additional parameters than just the sq. ft.
2021	Inputs	Added large office building type and expanded to 10 weather stations
2020	Inputs	Revised kWh/sq.ft. with results from updated building models
v10	-	Initial release

7.3.2 HVAC temperature setback

7.3.2.1 Measure description

The unoccupied temperature must be set lower than it was previously in the baseline condition. The temperature must be reduced at least two degrees below the occupied set point. This measure is offered to buildings with either gas or electric heat. The customer or controls vendor must provide documentation of the existing and new

[139] The chiller plant setpoint adjustment measure life is assigned for all measures in this program. The measures in this program will have a similar measures life as they are all related to retro-commissioning and controls measures.

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unoccupied temperature set points and their schedules. For this measure, we assumed it is implemented in a large office building with a chilled water VAV system and heating fuel type of electric and gas.

In the simulations, temperature setpoints during unoccupied hours are set back by nine degrees. Other spaces such as the data center are not modified. Since the baseline HVAC schedules had already implemented temperature setback, this measure was "modeled in reverse" by eliminating the setback schedules in the reference energy model (which were set to nine degrees). Other schedule/setbacks can be scaled accordingly.

Code requires setback controls (but not setup) for ASHRAE Zone 4A, per ASHRAE 90.1-2007 section 6.4.3.2.2. Implementing this measure involves restoring functionality that is intended by code.

- Setback temperature: 60.8 °F
- Occupied hours set point: 69.8 °F

7.3.2.2 Impact Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = ESF \times scfm_{supply\ fan} \times MAF$$

$$MAF = \left(\frac{T_{unoccupied,base} - T_{unoccupied,ee}}{9°\text{F}}\right)$$

Per-measure, gross coincident summer and winter peak demand reduction is assigned as zero because these measures have a negligible demand reduction as shown below:

$$\Delta kW_{summer} = 0$$

$$\Delta kW_{winter} = 0$$

Where:

ΔkWh	= per-measure gross annual electric energy savings
ΔkW_{summer}	= per-measure gross coincident summer peak demand reduction
ΔkW_{winter}	= per-measure gross coincident winter peak demand reduction
ESF	= annual energy savings factor
MAF	= measure adjustment factor to scale savings from the modeled assumptions to the application depth of measure
$T_{unoccupied,base}$	= baseline unoccupied temperature setpoint
$T_{unoccupied, ee}$	= energy-efficient case unoccupied temperature setpoint
$scfm_{supply\ fan}$	= supply fan flow rate

7.3.2.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

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Table 7-12. Input values for office buildings

Component	Type	Value	Unit	Source(s)
ESF	Variable	See Table 7-2	kWh/Unit	OpenStudio® energy modeling software outputs using EnergyPlus™ engine
$T_{unoccuiped,base}$	Variable	See customer application	°F	Customer application
$T_{unoccuiped,ee}$	Variable	See customer application	°F	Customer application
$scfm_{supply\ fan}$	Variable	See customer application	scfm	Customer application

7.3.2.4 Default savings

This measure does not have default savings.

7.3.2.5 Effective Useful Life

The effective useful life of this measure is provided in Table 7-13.

Table 7-13. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
XI	Non-Residential Building Optimization Program, DSM Phase IX	5.00	years	Wisconsin TRM 2022, p. 369[140]
VI	Non-Residential Office Program, DSM Phase VII	7.00		Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

7.3.2.6 Source(s)

The primary source for this deemed savings approach is prototypical building energy models derived from DOE's Commercial Large Office Reference Building and modified to represent Dominion Energy's Virginia and North Carolina weather zones, using typical meteorological year 3 (TMY3) data.

7.3.2.7 Update summary

Updates made to this section are described in Table 7-14.

Table 7-14. Summary of update(s)

Version	Update type	Description
2022	Equations	Revised energy savings factors and applied scaling savings by additional parameters than just the sq. ft.
2021	Inputs	Added large office building type and expanded to 10 weather stations
2020	Inputs	Revised kWh/sq.ft. with results from updated building models
v10	-	Initial release

[140] The chiller plant setpoint adjustment measure life is assigned for all measures in this program. The measures in this program will have a similar measures life as they are all related to retro-commissioning and controls measures.

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7.3.3 Condensing water temperature reset

7.3.3.1 Measure description

The condenser temperature on an air-cooled or water-cooled chiller system must be allowed to reset (lower) by at least five degrees from the summer design conditions during periods of partial load. The customer or controls vendor should provide documentation of implementation of the enhanced reset schedule compared to the baseline system control strategy. For this measure, we assumed it is implemented in a large office building with a chilled water VAV system and heating fuel type of electric and gas. Reset schedule as modeled for the efficient case reflects:

- For outside air temperature of 60°F, the chilled water setpoint temperature is changed to 60°F
- For outside air temperature of 75°F, the chilled water setpoint temperature is changed to 70°F
- The measure accounts for the presence of two stages in the cooling tower that had not existed in the baseline case.

7.3.3.2 Impact Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = ESF \times Size_{cool} \times MAF$$

$$MAF = \left(\frac{T_{condenser,base} - T_{condenser\ reset,ee}}{10°\text{F}}\right)$$

Per-measure, gross coincident summer and winter peak demand reduction is assigned as zero because these measures have a negligible demand reduction as shown below:

$$\Delta kW_{summer} = 0$$

$$\Delta kW_{winter} = 0$$

Where:

ΔkWh	= per-measure gross annual electric energy savings
ΔkW_{summer}	= per-measure gross coincident summer peak demand reduction
ΔkW_{winter}	= per-measure gross coincident winter peak demand reduction
ESF	= annual energy savings factor
MAF	= measure adjustment factor to scale savings from the modeled assumptions to the application depth of measure
$T_{condenser,base}$	= baseline condenser temperature setpoint
$T_{condenser\ reset,\ ee}$	= energy-efficient case condenser reset temperature setpoint
$Size_{cool}$	= chiller cooling capacity

7.3.3.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

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Table 7-15. Input values for office buildings

Component	Type	Value	Unit	Source(s)
ESF	Variable	See Table 7-2	kWh/Unit	OpenStudio® energy modeling software outputs using EnergyPlus™ engine
$T_{condenser,base}$	Variable	See customer application	°F	Customer application
$T_{condenser\ reset,ee}$	Variable	See customer application	°F	Customer application
$size_{cool}$	Variable	See customer application	sq. ft.	Customer application

7.3.3.4 Default savings

This measure does not have default savings.

7.3.3.5 Effective Useful Life

The effective useful life of this measure is provided in Table 7-16.

Table 7-16. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
XI	Non-Residential Building Optimization Program, DSM Phase IX	5.00	years	Wisconsin TRM 2022, p. 369[141]
VI	Non-Residential Office Program, DSM Phase VII	7.00		Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

7.3.3.6 Source(s)

The primary source for this deemed savings approach is prototypical building energy models derived from DOE's Commercial Large Office Reference Building and modified to represent Dominion Energy's Virginia and North Carolina weather zones, using typical meteorological year 3 (TMY3) data.

7.3.3.7 Update summary

Updates made to this section are described in Table 7-17.

Table 7-17. Summary of update(s)

Version	Update type	Description
2022	Equations	Revised energy savings factors and applied scaling savings by additional parameters than just the sq. ft.
2021	Inputs	Added large office building type and expanded to 10 weather stations
2020	Inputs	Revised kWh/sq.ft. with results from updated building models
v10	-	Initial release

[141] The chiller plant setpoint adjustment measure life is assigned for all measures in this program. The measures in this program will have a similar measures life as they are all related to retro-commissioning and controls measures.

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7.3.4 HVAC discharge air temperature reset

7.3.4.1 Measure description

The discharge air temperature from a variable air volume or constant volume re-heat air handling system must be allowed to reset (increase) at least two degrees from the summer design conditions during periods of partial load. The customer or controls vendor should provide documentation of implementation of the enhanced reset schedule compared to how the system was previously controlled. For this measure, we assumed it is implemented in a large office building with a chilled water VAV system and heating fuel type of electric. Systems that are eligible for this measure include those with electric reheat coils or baseboard heaters. This is not required by ASHRAE 90.1-2007.

7.3.4.2 Impact Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = ESF \times scfm_{supply\ fan} \times MAF$$

$$MAF = \left(\frac{T_{discharge\ reset,ee} - T_{discharge,base}}{6°\text{F}}\right)$$

Per-measure, gross coincident summer and winter peak demand reduction is assigned as zero because these measures have a negligible demand reduction as shown below:

$$\Delta kW_{summer} = 0$$

$$\Delta kW_{winter} = 0$$

Where:

ΔkWh	= per-measure gross annual electric energy savings
ΔkW_{summer}	= per-measure gross coincident summer peak demand reduction
ΔkW_{winter}	= per-measure gross coincident winter peak demand reduction
ESF	= annual energy savings factor
MAF	= measure adjustment factor to scale savings from the modeled assumptions to the application depth of measure
$T_{discharge\ reset,\ ee}$	= energy-efficient case discharge max reset temperature setpoint
$T_{discharge,\ base}$	= energy-efficient case unoccupied temperature setpoint
$scfm_{supply\ fan}$	= supply fan flow rate

7.3.4.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

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Table 7-18. Input values for office buildings

Component	Type	Value	Unit	Source(s)
ESF	Variable	See Table 7-2	kWh/Unit	OpenStudio® energy modeling software outputs using EnergyPlus™ engine
$T_{dischange\ reset,\ ee}$	Variable	See customer application	°F	Customer application
$T_{discharge,\ base}$	Variable	See customer application	°F	Customer application
$scfm_{supply\ fan}$	Variable	See customer application	scfm.	Customer application

7.3.4.4 Default savings

This measure does not have default savings.

7.3.4.5 Effective Useful Life

The effective useful life of this measure is provided in Table 7-19.

Table 7-19. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
XI	Non-Residential Building Optimization Program, DSM Phase IX	5.00	years	Wisconsin TRM 2022, p. 369[142]
VI	Non-Residential Office Program, DSM Phase VII	7.00		Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

7.3.4.6 Source(s)

The primary source for this deemed savings approach is prototypical building energy models derived from DOE's Commercial Large Office Reference Building and modified to represent Dominion Energy's Virginia and North Carolina weather zones, using typical meteorological year 3 (TMY3) data.

7.3.4.7 Update summary

Updates made to this section are described in Table 7-20

Table 7-20. Summary of update(s)

Version	Update type	Description
2022	Equations	Revised energy savings factors and applied scaling savings by additional parameters than just the sq. ft.
2021	Inputs	Added large office building type and expanded to 10 weather stations
2020	Inputs	Revised kWh/sq.ft. with results from updated building models
v10	-	Initial release

[142] The chiller plant setpoint adjustment measure life is assigned for all measures in this program. The measures in this program will have a similar measures life as they are all related to retro-commissioning and controls measures.

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7.3.5 HVAC static pressure reset

7.3.5.1 Measure description

Supply fans controlled by variable-frequency drives (VFDs) must be converted from a fixed static-pressure supply setpoint to a control sequence that resets the static-pressure supply setpoint based on the variable air volume box position. The customer or controls vendor should provide documentation showing the existing set point and new static pressure reset control sequence. For this measure, we assumed it is implemented in a large office building with a chilled water VAV system and heating fuel type of electric and gas.

See section 6.5.3.2.3 of ASHRAE 90.1-2007. This measure was required by code for air systems with zone boxes integrated into DDC control system. Implementing it would appear to restore the condition intended by code, though not all systems would have such controls. The base model did not have this control implemented. VAV fan curves in the base model correspond to fixed duct static pressure.

The baseline and efficient case inputs to model this measure were derived from the National Renewable Energy Laboratory.

Fan curve coefficients used were as shown in Table 7-21.

Table 7-21. Fan curve coefficients

Coefficient	Fixed static pressure (baseline)	Reset static pressure (efficient)
Coefficient 1	0.00130	0.04076
Coefficient 2	0.14700	0.08810
Coefficient 3	0.95060	-0.07290
Coefficient 4	-0.09980	0.94370
Coefficient 5	0.00000	0.00000
Minimum percent power	20%	10%

7.3.5.2 Impact Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = ESF \times scfm_{supply\ fan}$$

Per-measure, gross coincident summer and winter peak demand reduction is assigned as zero because these measures have a negligible demand reduction as shown below:

$$\Delta kW_{summer} = DRF_{summer} \times scfm_{supply\ fan}$$

$$\Delta kW_{winter} = DRF_{winter} \times scfm_{supply\ fan}$$

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Where:

ΔkWh	= per-measure gross annual electric energy savings
ΔkW_{summer}	= per-measure gross coincident summer peak demand reduction
ΔkW_{winter}	= per-measure gross coincident winter peak demand reduction
ESF	= annual energy savings factor
DRF_{summer}	= summer coincident demand reduction factor
DRF_{winter}	= winter coincident demand reduction factor
$scfm_{supply\ fan}$	= supply fan flow rate

7.3.5.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 7-22. Input values for office buildings

Component	Type	Value	Unit	Source(s)
ESF	Variable	See Table 7-2	kWh/scfm	OpenStudio® energy modeling software outputs using EnergyPlus™ engine
$scfm_{supply\ fan}$	Variable	See customer application	scfm	Customer application
DRF_{summer}	Variable	See Table 7-3	kW/ scfm	EnergyPlus™ energy modeling software outputs
DRF_{winter}	Variable	See Table 7-3	kW/ scfm	EnergyPlus™ energy modeling software outputs

7.3.5.4 Default savings

This measure does not have default savings.

7.3.5.5 Effective Useful Life

The effective useful life of this measure is provided in Table 7-23.

Table 7-23. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
XI	Non-Residential Building Optimization Program, DSM Phase IX	5.00	years	Wisconsin TRM 2022, p. 369[143]
VI	Non-Residential Office Program, DSM Phase VII	7.00		Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

143 The chiller plant setpoint adjustment measure life is assigned for all measures in this program. The measures in this program will have a similar measures life as they are all related to retro-commissioning and controls measures.

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7.3.5.6 Source(s)

The primary source for this deemed savings approach is prototypical building energy models derived from DOE's Commercial Large Office Reference Building and modified to represent Dominion Energy's Virginia and North Carolina weather zones, using typical meteorological year 3 (TMY3) data.

7.3.5.7 Update summary

Updates made to this section are described in Table 7-24.

Table 7-24. Summary of update(s)

Version	Update Type	Description
2022	Equations	Revised energy savings factors and applied scaling savings by additional parameters than just the sq. ft.
2021	Inputs	Added large office building type and expanded to 10 weather stations
2020	Inputs	Revised kWh/sq.ft. with results from updated building models
v10	-	Initial release

7.3.6 HVAC VAV minimum flow reduction

7.3.6.1 Measure description

VAV minimums were assumed to be set higher than necessary to meet winter heating loads. They were reduced by 10%. It is assumed that this measure can be implemented while continuing to provide code required ventilation levels and meeting winter heating set points in all zones (e.g., perhaps occupancy of the building has changed and not as much ventilation air is needed and/or insulation has been added so winter shell loads are smaller than before). Verifying these conditions in an actual building would take a fair amount of analysis. For this measure, we assumed it is implemented in a 4-story office building with a chilled water VAV system and heating fuel type of electric and gas. The presence of electric re-heats results in savings approximately double that for VAV with fossil fuel HW boilers.

7.3.6.2 Impact Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = ESF \times SqFt \times MAF$$

$$MAF = \left(\frac{VAV_{min\ position,base} - VAV_{min\ position,ee}}{0.10}\right)$$

Per-measure, gross coincident summer and winter peak demand reduction is assigned as zero because these measures have a negligible demand reduction as shown below:

$$\Delta kW_{summer} = 0$$

$$\Delta kW_{winter} = 0$$

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Where:

ΔkWh	= per-measure gross annual electric energy savings
ΔkW_{summer}	= per-measure gross coincident summer peak demand reduction
ΔkW_{winter}	= per-measure gross coincident winter peak demand reduction
ESF	= annual energy savings factor
MAF	= measure adjustment factor to scale savings from the modeled assumptions to the application depth of measure
$VAV_{min\ position,\ base}$	= baseline VAV box minimum damper position
$VAV_{min\ position,\ ee}$	= energy-efficient case VAV box minimum damper position
SqFt	= condition area impacted by measure

7.3.6.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 7-25. Input values for office buildings

Component	Type	Value	Unit	Source(s)
ESF	Variable	See Table 7-2	kWh/Unit	OpenStudio® energy modeling software outputs using EnergyPlus™ engine
$VAV_{min\ position,\ base}$	Variable	See customer application	hours/day	Customer application
$VAV_{min\ position,\ ee}$	Variable	See customer application	hours/day	Customer application
SqFt	Variable	See customer application	sq. ft.	Customer application

7.3.6.4 Default savings

This measure does not have default savings.

7.3.6.5 Effective Useful Life

The effective useful life of this measure is provided in Table 7-26.

Table 7-26. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
XI	Non-Residential Building Optimization Program, DSM Phase IX	5.00	years	Wisconsin TRM 2022, p. 369[144]
VI	Non-Residential Office Program, DSM Phase VII	7.00		Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

[144] The chiller plant setpoint adjustment measure life is assigned for all measures in this program. The measures in this program will have a similar measures life as they are all related to retro-commissioning and controls measures.

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7.3.6.6 Source(s)

The primary source for this deemed savings approach is prototypical building energy models derived from DOE's Commercial Large Office Reference Building and modified to represent Dominion Energy's Virginia and North Carolina weather zones, using typical meteorological year 3 (TMY3) data.

7.3.6.7 Update summary

Updates made to this section are described in Table 7-27.

Table 7-27. Summary of update(s)

Version	Update type	Description
2022	Equations	Revised energy savings factors and applied scaling savings by additional parameters than just the sq. ft.
2021	Inputs	Added large office building type and expanded to 10 weather stations
2020	Inputs	Revised kWh/sq.ft. with results from updated building models
v10	-	Initial release

7.3.7 Dual enthalpy air-side economizer

This measure does not use the building simulation approach that is applied to other measures in this program. Instead, it utilizes the Non-Residential Heating and Cooling Efficiency Program, DSM Phase VII savings approach described in Section 2.1.5.

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8 NON-RESIDENTIAL SMALL BUSINESS IMPROVEMENT ENHANCED PROGRAM, DSM PHASE VIII

The Non-Residential Small Business Improvement Enhanced Program provides mall businesses an energy use assessment and tune-up or re-commissioning of electric heating and cooling systems, along with financial incentives for the installation of specific energy efficiency measures. Participating small businesses would be required to meet certain size and connected load requirements. All non-residential customers who do not exceed the 100-kW demand threshold.

The measures offered through the program and the sections that contain the savings algorithms for each measure are presented in Table 8-1.

Table 8-1. Non-Residential small business improvement enhanced program measure list

End Use	Measure	Legacy program	Manual section
Building envelope	Window film installation	Non-Residential Window Film Program, DSM Phase VII	Section 3.1.1
HVAC	Duct testing & sealing	Non-Residential Prescriptive Program, DSM Phase VI	Section 4.2.1.
	Heat Pump tune-up	Non-Residential Prescriptive Program, DSM Phase VI	Section 4.2.2
	Refrigerant charge correction	-	Section 8.2.3
	Heat pump upgrade	Non-Residential Heating and Cooling Efficiency Program, DSM Phase VII	Section 2.1.1
	Dual enthalpy air-side economizer	Non-Residential Heating and Cooling Efficiency Program, DSM Phase VII	Section 2.1.5
	Programmable thermostat	-	Section 8.2.6
	HVAC variable frequency drives	-	Section 8.2.7
Lighting	Lighting, fixtures, lamps, and delamping	Non-Residential Lighting Systems and Controls Program, DSM Phase VII	Section 1.1.1
	Sensors and controls	Non-Residential Lighting Systems and Controls Program, DSM Phase VII	Section 1.1.2
	LED exit signs	-	Section 8.3.3
Appliance or Plug Load	Vending machine miser	Non-Residential Prescriptive Program, DSM Phase VI	Section 4.3.2
Refrigeration	Refrigeration variable frequency drives	New Measure	Section 8.5.1
	Refrigeration	Non-Residential Prescriptive Program, DSM Phase VI	Section 4.4.9
	Evaporator fan electronically commutated motor (ECM) retrofit	Non-Residential Prescriptive Program, DSM Phase VI	Section 4.4.5
	Evaporator fan motor controls	Non-Residential Prescriptive Program, DSM Phase VI	Section 4.4.6
	Door closer	Non-Residential Prescriptive Program, DSM Phase VI	Section 4.4.1
	Anti-sweat heater controls	-	Section 8.5.6
	Strip curtain (cooler and freezer)	Non-Residential Prescriptive Program, DSM Phase VI	Section 4.4.12

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8.1 Building envelope end use

8.1.1 Window film installation

This measure is also offered through the Non-Residential Window Film Program, DSM Phase VII. The savings approach is described in Section 3.1.1.

8.2 Heating, Ventilation, and Air Conditioning (HVAC) end use

8.2.1 Duct testing & sealing

This measure is also offered through the Non-Residential Prescriptive Program, DSM Phase VI. The savings approach is described in Section 4.2.1.

8.2.2 Heat pump tune-up

This measure is also offered through the Non-Residential Prescriptive Program, DSM Phase VI. The savings approach is described in Section 4.2.2.

8.2.3 Refrigerant charge correction

8.2.3.1 Measure description

This measure involves adjusting the amount of refrigerant charge at air conditioners and heat pumps for packaged and split systems at small commercial and industrial sites. All HVAC applications other than space cooling and heating—such as process cooling—are ineligible for this measure.

8.2.3.2 Impacts estimation approach

Algorithms and inputs to calculate cooling, heating and demand reduction for unitary/split air-conditioning and heating pump systems that receive refrigerant charge adjustments are provided below. Gross annual electric energy savings are calculated according to the equations that follow.

Cooling energy savings

For heat pumps and AC units <65,000 Btu/h, the per-measure gross annual electric cooling energy savings are calculated according to the following equation:

$$\Delta kWh_{cool} = Size_{cool} \times \frac{12\ kBtuh/ton}{SEER} \times EFLH_{cool} \times RCF$$

For heat pumps and AC units ≥65,000 Btu/h, the per-measure gross annual electric cooling energy savings are calculated according to the following equation:

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$$\Delta kWh_{cool} = Size_{cool} \times \frac{12\ kBtuh/ton}{IEER} \times EFLH_{cool} \times RCF$$

Heating energy savings

For heat pump units <65,000 Btu/h, the per-measure gross annual electric heating energy savings are calculated according to the following equation:

$$\Delta kWh_{heat} = Size_{heat} \times \frac{1}{HSPF} \times EFLH_{heat} \times RCF$$

For heat pump units ≥65,000 Btu/h, the per-measure gross annual electric heating energy savings are calculated according to the following equation:

$$\Delta kWh_{heat} = Size_{heat} \times \left(\frac{1}{COP \times 3.412\ Btuh/W}\right) \times EFLH_{heat} \times RCF$$

Cooling and heating savings are added to calculate the per-measure gross annual electric energy savings as follows:

$$\Delta kWh = \Delta kWh_{cool} + \Delta kWh_{heat}$$

Per-measure, gross coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = Size_{cool} \times \frac{12\ kBtuh/ton}{EER} \times RCF \times CF_{summer}$$

Per-measure, gross coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \frac{\Delta kWh_{heat}}{EFLH_{heat}} \times CF_{winter}$$

Where,

ΔkWh = per-measure gross annual electric energy savings
ΔkW = per-measure gross coincident demand reduction
ΔkWh_{cool} = per-measure gross annual electric cooling energy savings
ΔkWh_{heat} = per-measure gross annual electric heating energy savings
$Size_{cool}$ = unit capacity for cooling
$Size_{heat}$ = unit capacity for heating
EER = energy efficiency ratio (EER) at full load
SEER = seasonal energy efficiency ratio (SEER) of the installed air conditioning equipment. It is used for heat pumps and AC units that are smaller than 65,000 Btu/h.
IEER = integrated energy efficiency ratio (IEER) of the existing or baseline air conditioning equipment. IEER is a weighted average of a unit's efficiency at four load points: 100%, 75%, 50%, and 25% of full cooling capacity. It is used for heat pumps and AC units that are 65,000 Btu/h or larger.
HSPF = heating seasonal performance factor
COP = coefficient of performance (heating)

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$EFLH_{cool}$ = equivalent full load hours for cooling
$EFLH_{heat}$ = equivalent full load hours for heating
RCF = refrigerant charge factor
CF = demand coincidence factor

8.2.3.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 8-2. Input variables for refrigerant charge adjustment

Component	Type	Value	Units	Source(s)
$Size_{cool}$	Variable	See customer application	tons (cooling capacity)	Customer application
$Size_{heat}$	Variable	See customer application[145] Default: = $Size_{cool}$ x 12 kBtu/h /ton	kBtu/h	Customer application
$EFLH_{cool}$	Variable	See Table 17-4 in Sub-Appendix F2-II: Non-residential HVAC	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 422
$EFLH_{heat}$	Variable	See Table 17-5 in Sub-Appendix F2-II: Non-residential HVAC	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 423
EER/SEER	Variable	See customer application[146]	Btu/W-hr	Customer application
		See Table 17-8 and Table 17-9 in Sub-Appendix F2-III: Non-residential HVAC		ASHRAE 90.1 2013
HSPF/COP	Variable	See customer application[146]	Btu/W-hr (for HSPF); COP is -	Customer application
		See Table 17-9 in Sub-Appendix F2-III: Non-residential HVAC		ASHRAE 90.1 2013
RCF[147]	Variable	AC units: 0.027 HP units: 0.022	-	Maryland/Mid-Atlantic TRM v.10, p. 315 and California 2013-2014 Evaluation Report[148]
CF_{summer}	Variable	Use system capacity to assign CF as follows: < 11.25 tons = 0.588 ≥ 11.25 tons = 0.874	-	Maryland/Mid-Atlantic TRM v.10, p. 316

145 When customer-provided heating system size is <80% or >156% of customer-provided cooling system size, a default value will be used, instead. In such instances, it is assumed that the heating system size was incorrectly documented. The acceptable range is based on a review of the AHRI database across numerous manufacturers and heat pump types.

146 The customer provided efficiency values are reviewed for reasonability. If the efficiency value is outside acceptable bounds the applicable default value is applied. The bounds were determined from a review of the AHRI database. Bounds are as follows: 9.90 < SEER < 46.2, 7.92 < EER < 22.11, 8.10 < IEER < 34.82, 8.82 < CEER < 16.50, 5.85 < HSPF < 15.07, 2.70 < COP < 15.01.

147 RCF values were calculated utilizing the AC Tune-Up measure in the Maryland/Mid-Atlantic TRM v.10 and electric savings due to coil cleaning and refrigerant charge adjustments found via extensive literature review.

148 California Public Utilities Commission (2016). Impact Evaluation of 2013-14 Commercial Quality Maintenance Programs (HVAC3), https://www.calmac.org/publications/HVAC3ImpactReport_0401ES.pdf, While these proportions were not provided in the report, DNV analyzed the same supporting data—though owned by the CPUC and not publicly available—used to produce the tables provided on pages BB-2 and BB-3 of Appendix BB of the report. Whereas the tables provided in Appendix BB were aggregated by program, DNV aggregated the raw data by HVAC-system type to determine appropriate TUF values. This analysis showed that for packaged air-conditioning systems, an average of 54.7% of the overall tune-up savings were attributable to the RCA treatment; for packaged heat pump systems, 44.7% of the overall tune-up savings were attributable to the RCA treatment.

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Component	Type	Value	Units	Source(s)
CF_{winter}	Variable	Use system capacity to assign CF as follows: < 11.25 tons = 0.588 ≥ 11.25 tons = 0.874	-	Maryland/Mid-Atlantic TRM v.10, p. 316[149]

8.2.3.4 Default savings

No default savings will be awarded for this measure if the proper values are not provided in the customer application.

8.2.3.5 Effective Useful Life

The effective useful life of this measure is provided in Table 8-3.

Table 8-3. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
VIII	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	5.00	years	Maryland/Mid-Atlantic TRM v.10, p. 316

8.2.3.6 Source(s)

The primary sources for this deemed savings approach include the ASHRAE 90.1-2013, Maryland/Mid-Atlantic TRM v.10, pp. 315 - 316 and 422-423 as well as the California 2013-14 Impact Evaluation Report, pp. BB-2 to BB-3.

8.2.3.7 Update summary

Updates made to this section are described in Table 8-4.

Table 8-4. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page number(s)/version of the Maryland/Mid-Atlantic TRM
	Equation	Added gross winter peak demand reduction equation
	New table	Effective Useful Life (EUL) by program
2020	Equation	Added size condition of <65,000 Btu/h and ≥65,000 Btu/h for determining which equation to use for ground-source heat pumps. Previously all ground-source heat pumps used equations with IEER and COP efficiency metrics.
v10	Source	Updated page number(s)/version of Maryland/Mid-Atlantic TRM Clarified citation footnote of CPUC report
	Input variable	Update to weather stations in North Carolina resulted in revised EFLHs for weather-sensitive measures Equipment efficiency levels were revised per update to ASHRAE 2013 in VA and NC

[149] The source TRM does not provide a winter CF. Therefore, the summer CF is applied to the winter CF.

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8.2.4 Heat pump upgrade

This measure is also offered through the Non-Residential Heating and Cooling Efficiency Program, DSM Phase VII. The savings approach is described in Section 2.1.1.

8.2.5 Dual enthalpy air-side economizer

This measure is also offered through the Non-Residential Heating and Cooling Efficiency Program, DSM Phase VII. The savings approach is described in Section 2.1.5.

8.2.6 Programmable thermostat

8.2.6.1 Measure description

This measure involves the installation of programmable thermostats[150] for cooling and/or heating systems in spaces with no existing setback control. The programmable thermostat shall set back the temperature setpoint during unoccupied periods. The savings will be realized from reducing the system usage during unoccupied times. The baseline operation of the HVAC units is assumed to be in continuous ON mode during the unoccupied period with fans cycling to maintain the occupied-period temperature setpoints.

8.2.6.2 Impacts Estimation Approach

AC units

Per-measure, gross annual electric energy savings are calculated according to the following equation for units <65,000 Btu/h:

$$\Delta kWh = \left[Size_{cool} \times \left(\frac{12}{SEER}\right) \times EFLH_{cool} \times ESF_{cool}\right]$$

Per-measure, gross annual electric energy savings are calculated according to the following equation for units ≥65,000 Btu/h:

$$\Delta kWh = \left[Size_{cool} \times \left(\frac{12}{IEER}\right) \times EFLH_{cool} \times ESF_{cool}\right]$$

Per-measure, gross coincident summer peak demand reduction is considered to be zero since space conditioning equipment typically operates at maximum capacity during peak periods. There is no gross coincident winter peak demand reduction as AC units.

$$\Delta kW_{summer} = 0$$

$$\Delta kW_{winter} = 0$$

150 Non-communicating thermostats are not eligible for the demand response programs.

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Heat pumps

Per-measure, gross annual electric energy savings are calculated according to the following equation for units <65,000 Btu/h:

$$\Delta kWh = \left[Size_{cool} \times \left(\frac{12}{SEER}\right) \times EFLH_{cool} \times ESF_{cool}\right] + \left[Size_{heat} \times EFLH_{heat} \times \left(\frac{1}{HSPF}\right) \times ESF_{heat}\right]$$

Per-measure, gross annual electric energy savings are calculated according to the following equation for units ≥65,000 Btu/h:

$$\Delta kWh = \left[Size_{cool} \times \left(\frac{12}{IEER}\right) \times EFLH_{cool} \times ESF_{cool}\right] + \left[Size_{heat} \times EFLH_{heat} \times \left(\frac{1}{3.412 \times COP}\right) \times ESF_{heat}\right]$$

Per-measure, gross coincident demand reduction is considered to be zero since space-conditioning equipment typically operates at maximum capacity during peak periods.

$$\Delta kW_{summer} = 0$$

$$\Delta kW_{winter} = 0$$

Where,

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident demand reduction
$Size_{cool}$ = unit capacity for cooling
$Size_{heat}$ = unit capacity for heating
SEER = seasonal energy efficiency ratio (SEER) of the installed air conditioning equipment. It is used for heat pumps and AC units that are smaller than 65,000 Btu/h.
IEER = integrated energy efficiency ratio (IEER) of the existing or baseline air conditioning equipment. IEER is a weighted average of a unit's efficiency at four load points: 100%, 75%, 50%, and 25% of full cooling capacity. It is used for heat pumps and AC units that are 65,000 Btu/h or larger.
HSPF = heating seasonal performance factor
COP = coefficient of performance (heating)
$EFLH_{cool}$ = equivalent full load hours for cooling
$EFLH_{heat}$ = equivalent full load hours for heating
ESF_{cool} = energy savings factor for cooling energy
ESF_{heat} = energy savings factor for heating energy

8.2.6.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

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Table 8-5. Input parameters for programmable thermostat measure

Component	Type	Value	Units	Source(s)
$Size_{cool}$	Variable	See customer application	tons of cooling capacity	Customer application
$Size_{heat}$	Variable	See customer application Default[151] = $Size_{cool}$ x 12 kBtu/h / ton	kBtu/h	Customer application
$EFLH_{heat}$	Variable	See Table 17-5 in Sub-Appendix F2-II: Non-residential HVAC	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 423
$EFLH_{cool}$	Variable	Refer to Table 17-4 in Sub-Appendix F2-II: Non-residential HVAC	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 422
SEER/IEER	Variable	See customer application[152] See Table 17-8 and Table 17-9 in Sub-Appendix F2-III: Non-residential HVAC	kBtu/kW-hour	Customer application ASHRAE 90.1 2013, Table 6.8.1-1 and Table 6.8.1B
HSPF/COP	Variable	See customer application[152] See Table 17-9 in Sub-Appendix F2-III: Non-residential HVAC	kBtu/kW-hour (except COP is dimensionless)	Customer application ASHRAE 90.1 2013, Table 6.8.1-1 and Table 6.8.1-2
ESF_{cool}	Fixed	0.090	-	NY TRM 2018, p. 263
ESF_{heat}	Fixed	0.068	-	NY TRM 2018, p. 263

8.2.6.4 Default savings

No default savings will be awarded for this measure if the proper values are not provided in the customer application.

8.2.6.5 Effective Useful Life

The effective useful life of this measure is provided in Table 8-6.

Table 8-6. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
VIII	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	11.00	years	New York TRM 2018, p. 264

8.2.6.6 Source(s)

The primary source for this deemed savings approach is the ASHRAE 90.1-2013, New York TRM 2018, pp. 262-264, and Maryland/Mid-Atlantic TRM v.10, pp. 422-423.

151 When customer-provided heating system size is <80% or >156% of customer-provided cooling system size, a default value will be used, instead. In such instances, it is assumed that the heating system size was incorrectly documented. The acceptable range is based on a review of the AHRI database across numerous manufacturers and heat pump types.

152 The customer provided efficiency values are reviewed for reasonability. If the efficiency value is outside acceptable bounds the applicable default value is applied. The bounds were determined from a review of the AHRI database. Bounds are as follows: 9.90 < SEER < 46.2, 7.92 < EER < 22.11, 8.10 < IEER < 34.82, 8.82 < CEER < 16.50, 5.85 < HSPF < 15.07, 2.70 < COP < 15.01.

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8.2.6.7 Update summary

Updates made to this section are described in Table 8-7.

Table 8-7. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the Mid-Atlantic TRM
	New table	Effective Useful Life (EUL) by program
2020	None	No change
v10	Source	Updated page numbers / version of the New York TRM
	Input variable	• Update to weather stations in North Carolina resulted in revised EFLHs for weather-sensitive measures • Equipment efficiency levels were revised per update to ASHRAE 2013 in VA and NC

8.2.7 Variable frequency drives

8.2.7.1 Measure description

This measure defines savings that result from installing a variable frequency drive (VFD) control on a HVAC motor with application to supply fans, return fans, exhaust fans, cooling tower fans, chilled water pumps, condenser water pumps, and hot water pumps. The HVAC application must also have a variable load and proper controls in place: feedback control loops to fan/pump motors and variable air volume (VAV) boxes on air-handlers.

The algorithms and inputs to calculate energy and demand reduction for VFDs are provided below. The baseline equipment fan/pump type should be determined from the program application, if available. Otherwise, the minimum savings factors will be applied. This measure is also delivered through the Non-Residential Heating and Cooling Efficiency Program, DSM Phase VII as indicated in section 2.1.4. That program uses a different savings methodology.

The energy savings calculations will include the following baseline applications:

Fans

- Constant Volume (CV) Fan
- Airfoil / Backward-Inclined (AF / BI) Fan
- Airfoil / Backward-Inclined w/Inlet Guide Vanes (AF / BI IGV) Fan
- Forward Curved (FC) Fan
- Forward Curved w/Inlet Guide Vanes (FC IGV) Fan
- Unknown (Default)

Pumps

- Chilled Water Pump (CHW-Pump)
- Condenser Water Pump (CW-Pump)
- Hot Water Pump (HW-Pump)
- Unknown (Default)

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This measure is offered through different programs listed in Table 8-8. The uses a different method than the impacts estimation approach described in this section.

Table 8-8. Programs that offer this measure

Program name	Section
Non-Residential Heating and Cooling Efficiency Program, DSM Phase VII	Section 2.1.4
Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 8.2.7

8.2.7.2 Impacts Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \frac{hp \times 0.746 \times LF}{\eta} \times HOU \times ESF$$

Per-measure, gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \frac{hp \times 0.746 \times LF}{\eta} \times CF_{summer} \times DRF$$

Per-measure, gross coincident winter peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \frac{hp \times 0.746 \times LF}{\eta} \times CF_{winter} \times DRF$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure gross coincident winter peak demand reduction
hp = motor rated horsepower
LF = motor load factor (%) at fan design airflow rate or pump design flowrate
η = NEMA-rated efficiency of motor
HOU = annual hours of use
ESF = energy savings factor
DRF = demand reduction factor
CF_{summer} = summer peak coincidence factor
CF_{winter} = winter peak coincidence factor

8.2.7.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 8-9. Input values for non-residential variable frequency drives

Component	Type	Value	Unit	Source(s)
hp	Variable	See customer application	horsepower	Customer application

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Component	Type	Value	Unit	Source(s)
LF	Fixed	0.65	-	Maryland/Mid-Atlantic TRM v.10, p. 297
η	Variable	Default see Table 2-16. Baseline motor efficiency	-	NEMA Standards Publication Condensed MG 1-2007
ESF	Variable	Default see Table 8-11	-	Mid-Atlantic TRM 2015 p. 370; Mid-Atlantic TRM v10, p. 301
DRF	Variable	Default see Table 8-11	-	Mid-Atlantic TRM 2015 p. 370; Mid-Atlantic TRM v10, p. 301
HOU	Variable	See Table 17-6 in Sub-Appendix F2-II: Non-residential HVAC	hours, annual	Maryland/Mid-Atlantic TRM v.10, pp. 299-301
CF_{summer}	Variable	0.28 for fan applications 0.55 for pump applications	-	Mid-Atlantic TRM 2015 p. 370; Maryland/Mid-Atlantic TRM v.10, p. 299
CF_{winter}	Variable	0.28 for fan applications 0.55 for pump applications	-	Mid-Atlantic TRM 2015 p. 370; Maryland/Mid-Atlantic TRM v.10, p. 299[153]

Table 8-10 provides the baseline motor efficiencies that are consistent with the minimum federal accepted motor efficiencies provided by the National Electrical Manufacturers Association (NEMA).[154]

Table 8-10. Baseline Motor Efficiency[155]

Horsepower (hp)	η	Horsepower (hp)	η
1	0.855	**60**	0.950
1.5	0.865	**75**	0.954
2	0.865	**100**	0.954
3	0.895	**125**	0.954
5	0.895	**150**	0.958
7.5	0.917	**200**	0.962
10	0.917	**250**	0.962
15	0.924	**300**	0.962
20	0.930	**350**	0.962
25	0.936	**400**	0.962
30	0.936	**450**	0.962
40	0.941	**500**	0.962
50	0.945		

153 The source TRM does not provide a winter CF. Therefore, the summer CF is applied to the winter CF.

154 Refer to NEMA Standards Publication Condensed MG 1-2007 - Information Guide for General Purpose Industrial AC Small and Medium Squirrel-Cage Induction Motor Standards and Table 52 ‘Full-Load Efficiencies for 60 Hz NEMA Premium Efficiency Electric Motors Rated 600 Volts or Less (Random Wound)’ in the above mentioned NEMA Standard.

155 NEMA Standards Publication Condensed MG 1-2007 - Information Guide for General Purpose Industrial AC Small and Medium Squirrel-Cage Induction Motor Standards. Assumed Totally Enclosed Fan-Cooled (TEFC), Premiums Efficiency, 1800 RPM (4 Pole).

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Table 8-11 provides the energy savings and demand reduction factors by the application and the baseline control types.

Table 8-11. Energy savings and demand reduction factors by application

VFD applications	ESF	DRF
Unknown VFD (Minimum)[156]	0.123	0.039
HVAC fan VFD savings factors[157]		
Constant volume	0.717	0.466
Airfoil / backward inclined (AF/BI-Fan)	0.475	0.349
Airfoil / backward inclined w/Inlet guide vanes (AF/BI IGV-Fan)	0.304	0.174
Forward curved (FC-Fan)	0.240	0.182
Forward curved w/Inlet guide vanes (FC IGV-Fan)	0.123	0.039
Unknown fan (Average)	0.372	0.242
HVAC pump VFD savings factors[158]		
Chilled water pump	0.633	0.460
Hot water pump	0.652	0.000
Unknown/other pump (Average)[159]	0.643	0.230

8.2.7.4 Default savings

No default savings will be awarded for this measure if the proper values are not provided in the customer application.

8.2.7.5 Effective Useful Life

The effective useful life of this measure is provided in Table 8-12.

Table 8-12. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program Name	Value	Units	Source(s)
VIII	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	15.00	years	Maryland/Mid-Atlantic TRM v.10, p. 301

8.2.7.6 Source(s)

The primary sources for this deemed savings approach are Mid-Atlantic TRM 2015, pp. 367-371 (for fans) and Maryland/Mid-Atlantic TRM v.10, pp. 296-301 (for pumps).

8.2.7.7 Update summary

Updates made to this section are described in Table 8-13.

156 Assigned for applications such as compressors, based on DNV research and judgement.
157 Mid-Atlantic TRM 2015, p. 370
158 Maryland/Mid-Atlantic TRM v.10, p. 301.
159 Assigned for pumps not specifically listed in this table, such as condenser water pump.

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Table 8-13. Summary of update(s)

Version	Update Type	Description
2022	Section	Moved from the Non-Residential Small Business Improvement Program, DSM Phase V Section as that program is no longer active.
2021	Source	Updated page numbers / version of the Maryland/Mid-Atlantic TRM
	Equation	Added gross winter peak demand reduction equation
	New table	Effective Useful Life (EUL) by program
2020	Section	Moved methodology from the retired Non-Residential Heating and Cooling Efficiency Program DSM III Section to this section.
v10	Source	Updated page numbers / version of the Mid-Atlantic TRM
	HOU	Update to weather stations in North Carolina resulted in revised HOUs for weather-sensitive measures
	Clarification	Clarified that this methodology is only used for measures implemented during DSM Phase III

8.3 Lighting end use

8.3.1 Lighting, fixtures, lamps, and delamping

This measure is also offered through the Non-Residential Lighting Systems and Controls Program, DSM Phase VII. The savings approach is described in Section 1.1.1.

8.3.2 Sensors and controls

This measure is also offered through the Non-Residential Lighting Systems and Controls Program, DSM Phase VII. The savings approach is described in Section 1.1.2.

8.3.3 LED exit signs

8.3.3.1 Measure description

This measure realizes energy savings by installing an exit sign that is illuminated with light emitting diodes (LED). This measure should be limited to retrofit installations.

This measure is offered through different programs listed in Table 8-14 and uses the impacts estimation approach described in this section.

Table 8-14. Programs that offer this measure

Program name	Section
Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 8.3.3
Non-Residential Multifamily Program, DSM Phase VIII	Section 10.4.2

8.3.3.2 Impacts Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

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$$\Delta kWh = \frac{(Qty_{base} \times watts_{base} - Qty_{ee} \times watts_{ee})}{1{,}000\, W/kW} \times HOU \times WHF_e \times ISR$$

Per-measure, gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \frac{(Qty_{base} \times watts_{base} - Qty_{ee} \times watts_{ee})}{1{,}000\, W/kW} \times WHF_{d,summer} \times CF_{summer} \times ISR$$

Per-measure, gross coincident winter peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \frac{(Qty_{base} \times watts_{base} - Qty_{ee} \times watts_{ee})}{1{,}000\, W/kW} \times WHF_{d,winter} \times CF_{winter} \times ISR$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure gross coincident winter peak demand reduction
$watts_{base}$ = connected load of the baseline exit sign
$watts_{ee}$ = connected load of the efficient exit sign
Qty_{base} = number of baseline exit signs
Qty_{ee} = number of efficient exit signs
HOU = average hours of use per year
WHF_e = waste heat factor for energy to account for cooling savings from efficient lighting
$WHF_{d,summer}$ = waste heat factor for demand to account for cooling savings from efficient lighting
$WHF_{d,winter}$ = waste heat factor for demand to account for heating savings from efficient lighting
CF_{summer} = summer peak coincidence factor
CF_{winter} = winter peak coincidence factor
ISR = in-service rate, the percentage of rebated measures actually installed

8.3.3.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 8-15. Input values for LED exit sign calculations

Component	Type	Value	Unit	Source(s)
Qty_{base}	Variable	See customer application	-	Customer application
Qty_{ee}	Variable	See customer application Default: $Qty_{ee} = Qty_{base}$	-	Customer application
$watts_{base}$	Variable	See customer application	watts	Customer application
		Default: 16 W		Maryland/Mid-Atlantic TRM v.10, p. 215, ENERGY STAR[160]
$watts_{ee}$	Variable	See customer application	watts	Customer application

[160] LED exit sign default values come from an ENERGY STAR® report: Save Energy, Money and Prevent Pollution with Light-Emitting Diode (LED) Exit Signs: https://www.energystar.gov/sites/default/files/buildings/tools/led_exitsigns_techsheet.pdf

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Component	Type	Value	Unit	Source(s)
		Default: 5 W LED		Maryland/Mid-Atlantic TRM v.10, p. 314, ENERGY STAR
HOU	Fixed	8,760	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 215
WHF_e	Variable	See Table 17-15 in Default savings assumed as lighting condition as Unconditioned space, WHFe=1.0	-	Maryland/Mid-Atlantic TRM v.10, p. 215
$WHF_{d,summer}$	Variable	See Table 17-15 in Default savings assumed as lighting condition as Unconditioned space, WHFe=1.0	-	Maryland/Mid-Atlantic TRM v.10, p. 216
$WHF_{d,winter}$	Variable	See Table 17-15 in Default savings assumed as lighting condition as Unconditioned space, WHFe=1.0	-	Maryland/Mid-Atlantic TRM v.10, p. 216
CF_{summer}	Fixed	1.0	-	Maryland/Mid-Atlantic TRM v.10, p. 216[161]
CF_{winter}	Fixed	1.0	-	Maryland/Mid-Atlantic TRM v.10, p. 216[162]
ISR	Fixed	1.0	-	Maryland/Mid-Atlantic TRM v.10, p. 215[163]

Note that the coincidence factor (CF) is 1 for this measure since exit signs are on continuously, including during the entirety of the peak period.

8.3.3.4 Default savings

If the proper values are not supplied, a default savings may be applied using conservative input values. The default per-measure gross annual electric energy savings will be assigned according to the following calculation:

$$\Delta kWh = \frac{(Qty_{base} \times watts_{base} - Qty_{ee} \times watts_{ee})}{1{,}000\, W/kW} \times HOU \times WHF_e \times ISR$$

$$= \frac{(1 \times 16\, W - 1 \times 5\, W)}{1{,}000\, W/kW} \times 8{,}760\, hour \times 1.0 \times 1.0$$

$$= 96.36\, kWh$$

161 Efficiency Vermont Technical Reference Manual 2009-55, December 2008.

162 Ibid.

163 EmPOWER Maryland DRAFT Final Impact Evaluation Report Evaluation Year 4 (June 1, 2012 – May 31, 2013) Commercial & Industrial Prescriptive & Small Business Programs, Navigant, March 31, 2014.

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The default per-measure gross coincident summer peak demand reduction is calculated using the following calculation:

$$\Delta kW_{summer} = \frac{(Qty_{base} \times watts_{base} - Qty_{ee} \times watts_{ee})}{1{,}000\, W/kW} \times WHF_{d,summer} \times CF_{summer} \times ISR$$

$$= \frac{(1 \times 16\, W - 1 \times 5\, W)}{1{,}000\, W/kW} \times 1.0 \times 1.0 \times 1.0$$

$$= 0.011\, kW$$

The default per-measure gross coincident winter demand reduction is calculated using the following calculation:

$$\Delta kW_{winter} = \frac{(Qty_{base} \times watts_{base} - Qty_{ee} \times watts_{ee})}{1{,}000\, W/kW} \times WHF_{d,winter} \times CF_{winter} \times ISR$$

$$= \frac{(1 \times 16\, W - 1 \times 5\, W)}{1{,}000\, W/kW} \times 1.0 \times 1.0 \times 1.0$$

$$= 0.011\, kW$$

8.3.3.5 Effective Useful Life

The effective useful life of this measure is provided in Table 8-16.

Table 8-16. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
VIII	Non-Residential Multifamily Program, DSM Phase VIII Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	5.00	years	Maryland/Mid-Atlantic TRM v.10, p. 216

8.3.3.6 Source(s)

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v.10, pp. 215-216.

8.3.3.7 Update summary

Updates made to this section are described in Table 8-17.

Table 8-17. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	Source	Updated page numbers / version of the Mid-Atlantic TRM

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Version	Update type	Description
	Equation	Added gross winter peak demand reduction equation
	New table	Effective Useful Life (EUL) by program
2020	None	No change
v10	Source	Updated page numbers / version of the Mid-Atlantic TRM

8.4 Appliance or Plug Load end use

8.4.1 Vending machine miser

This measure is also offered through the Non-Residential Prescriptive Program, DSM Phase VI. The savings approach is described in Section 4.3.2

8.5 Refrigeration end use

8.5.1 Refrigeration variable frequency drives

Variable frequency drive (VFD) compressors are used to control and reduce the speed of the compressor during times when the refrigeration system does not require the motor to run at full capacity. VFD control is an economical and efficient retrofit option for existing compressor installations. The performance of variable speed compressors can more closely match the variable refrigeration load requirements thus minimizing energy consumption.

This measure, VFD control for refrigeration systems and its eligibility targets applies to retrofit construction in the commercial and industrial building sectors; it is most applicable to grocery stores or food processing applications with refrigeration systems. This protocol is for a VSD control system replacing a slide valve control system. The savings algorithms are shown below. There are two distinct sets of algorithms – one for if the refrigeration system is rated in tonnage, and another for if the refrigeration system is rated in horsepower.

8.5.1.1 Impacts Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equations:

$$\Delta kWh = tons_{cool} \times ESF$$

If the refrigeration system is rated in horsepower:

$$tons_{cool} = 0.212 \times \frac{1}{COP} \times hp_{compressor}$$

Per-measure, gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = tons_{cool} \times DSF_{summer}$$

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Per-measure, gross coincident winter peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = tons_{cool} \times DSF_{winter}$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure gross coincident winter peak demand reduction
$tons_{cool}$ = refrigeration cooling capacity of the system, in tons
ESF = energy saving factor in kWh per ton
DSF_{summer} = summer demand saving factor, in kW per ton
DSF_{winter} = winter demand saving factor, in kW per ton
COP = coefficient of performance
$hp_{compressor}$ = rated horsepower of refrigeration compressor

8.5.1.2 Input variable

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 8-18. Input variables for refrigeration variable frequency drives

Component	Type	Value	Unit	Source(s)
$hp_{compressor}$	Variable	See customer application	horsepower	Customer application
ESF	Fixed	1,696	kWh/ton	Pennsylvania TRM 2019 Vol.3, p. 164
DSF_{summer}	Fixed	0.22	kW/ton	Pennsylvania TRM 2019 Vol.3, p. 164
DSF_{winter}	Fixed	0.22	kW/ton	Pennsylvania TRM 2019 Vol.3, p. 164
COP	Variable	See customer application	-	Customer application
		Default: Reach-in coolers = 2.04 Reach-in freezers = 1.25 Reach-in unknown = 1.80 Walk-in coolers = 3.42 Walk-in freezers = 1.00 Walk-in unknown = 2.67		Pennsylvania TRM 2019 Vol. 3, p. 164

8.5.1.3 Default savings

No default savings will be awarded for this measure if the proper values are not provided in the customer application.

8.5.1.4 Effective Useful Life

The effective useful life of this measure is provided in Table 8-19.

Table 8-19. Effective Useful Life for lifecycle savings calculations

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DSM Phase	Program name	Value	Units	Source(s)
VIII	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	15.00	years	Pennsylvania TRM 2019, Vol. 3, p. 163

8.5.1.5 Source

The primary sources for this deemed savings approach Pennsylvania TRM 2019, Vol. 3, pp. 163-165.

8.5.1.6 Update summary

Updates made to this section are described in Table 8-20.

Table 8-20. Summary of update(s)

Version	Update Type	Description
2022	None	No change
2021	-	Initial release

8.5.2 Night cover

This measure is also offered through the Non-Residential Prescriptive Program, DSM Phase VI. The savings approach is described in Section 4.4.9.

8.5.3 Evaporator fan electronically commutated motor (ECM) retrofit

This measure is also offered through the Non-Residential Prescriptive program. The savings approach is described in Section 4.4.5.

8.5.4 Evaporator fan motor controls

This measure is also offered through the Non-Residential Prescriptive program. The savings approach is described in Section 4.4.6.

8.5.5 Door closer

This measure is also offered through the Non-Residential Prescriptive program. The savings approach is described in Section 4.4.1.

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8.5.6 Anti-sweat heater controls

Anti-sweat door heaters (ASDH) prevent condensation from forming on cooler and freezer doors. By installing a control device to turn off door heaters when there is little or no risk of condensation, significant energy savings can be realized. There are two commercially available control strategies—On/Off controls and micro-pulse controls—that respond to a call for heating. Heating is typically triggered based on a door-moisture sensor or an indoor-air temperature and humidity-sensor to calculate the dew point. In the first strategy, the On/Off controls turn the heaters on and off for minutes at a time, resulting in a reduction in run time. In the second strategy, the micro pulse controls turn on the door heaters for fractions of a second, in response to the call for heating. Either of these strategies result in annual energy and coincident peak demand reduction. Additional savings come from refrigeration interactive effects. When the heaters run less, they introduce less heat into the refrigerated spaces and reduce the cooling load.

The baseline condition is assumed to be a commercial glass door cooler or refrigerator with a standard heated door running 24 hours per day, seven days per week (24/7) with no controls installed. The efficient equipment is assumed to be a door heater control on a commercial glass door cooler or refrigerator utilizing either On/Off or micro-pulse controls.

8.5.6.1 Impacts Estimation Approach

Per-measure, gross annual electric energy savings are assigned according to the following equation:

$$\Delta kWh \quad = kW_{load} \times (\%On_{base} - \%On_{ee}) \times \ HOU \times WHF_e$$

Per-measure, gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} \quad = kW_{load} \times WHF_d \times CF_{summer}$$

Per-measure, gross coincident winter peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} \quad = kW_{load} \times WHF_d \times CF_{winter}$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure gross coincident winter peak demand reduction
kW_{load} = connected load kW per connected door
$\%On_{base}$ = effective run time of uncontrolled anti-sweat door heaters (ASDH)
$\%On_{ee}$ = effective run time of ASDH with controls
HOU = annual hours of operation
WHF_e = waste heat factor for energy
WHF_d = waste heat factor for demand
CF_{summer} = summer coincidence factor
CF_{winter} = winter coincidence factor

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8.5.6.2 Input variable

Table 8-21. Input values for anti-sweat heater controls

Component	Type	Value	Units	Source(s)
kW_{load}	Variable	See customer application Default: 0.13	kW	Customer application Maryland/Mid-Atlantic TRM v.10, p. 344
$\%On_{base}$	Fixed	0.907	-	Maryland/Mid-Atlantic TRM v.10, p. 344
$\%On_{ee}$	Variable	Default: On/Off control=0.589 Micro-pulse control=0.428	-	Maryland/Mid-Atlantic TRM v.10, p. 345
HOU	Fixed	8,760	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 345
CF_{summer}	Variable	Default: Refrigerator: ON/OFF controls: 0.25 Micro-pulse control: 0.36 Freezer: ON/OFF controls: 0.21 Micro-pulse control: 0.30	-	Maryland/Mid-Atlantic TRM v.10, p. 345
CF_{winter}	Variable	Default: Refrigerator: On/Off controls: 0.24 Micro-pulse: 0.35 Freezer: On/off controls: 0.20 Micro-pulse: 0.29	-	Maryland/Mid-Atlantic TRM v.10, pp. 345[164].
WHF_e	Variable	High temp (31˚F - 55˚F): 1.25 Med temp (0˚F - 30˚F): 1.50 Low temp (-35˚F - -1˚F): 1.50	-	Maryland/Mid-Atlantic TRM v.10, p. 345
WHF_d	Variable	High temp (31˚F - 55˚F): 1.25 Med temp (0˚F - 30˚F): 1.50 Low temp (-35˚F - -1˚F): 1.50	-	Maryland/Mid-Atlantic TRM v.10, p. 345

8.5.6.3 Default savings

No default savings will be awarded for this measure if the necessary values are not provided in the customer application.

8.5.6.4 Effective Useful Life

The effective useful life of this measure is provided in Table 8-22.

[164] Applied the same methodology that Maryland/Mid-Atlantic TRM v.10, pp. 345 uses for summer CF and applied to the winter peak values provided by Cadmus. 2015. Commercial Refrigeration Loadshape Project

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Table 8-22. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program name	Value	Units	Source(s)
VIII	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	12.00	years	Maryland/Mid-Atlantic TRM v.10, p. 345

8.5.6.5 Source

The primary sources for this deemed savings approach Maryland/Mid-Atlantic TRM v.10, pp. 344-345.

8.5.6.6 Update summary

Updates made to this section are described in Table 8-23.

Table 8-23. Summary of update(s)

Version	Update type	Description
2022	None	No change
2020	-	Initial release

8.5.7 Strip curtain (cooler and freezer)

This measure is also offered through the Non-Residential Prescriptive program. The savings approach is described in Section 4.4.12.

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9 NON-RESIDENTIAL MIDSTREAM ENERGY EFFICIENCY PRODUCTS PROGRAM, DSM PHASE VIII

The Non-Residential Midstream Energy Efficiency Products Program consists of enrolling equipment distributors into the Program through an agreement to provide point-of-sales data in an agreed upon format each month. These monthly data sets will contain, at minimum, the data necessary to validate and quantify the eligible equipment that has been delivered for sale in the Company's service territory. In exchange for the data sets, the distributor will discount the rebate-eligible items sold to end customers. This Program aims to increase the availability and uptake of efficient equipment for the Company’s non-residential customers.

The measures offered through the program and the sections that contain the savings algorithms for each measure are presented in Table 9-1.

Table 9-1. Non-Residential Midstream Energy Efficiency Products Improvement Enhanced Program measure list

End use	Measure	Legacy program	Manual section
Cooking	Commercial combination oven	Non-Residential Prescriptive Program, DSM Phase VI	Section 4.1.2
	Commercial convection oven	Non-Residential Prescriptive Program, DSM Phase VI	Section 4.1.1
	Commercial griddle	Non-Residential Prescriptive Program, DSM Phase VI	Section 4.1.4
	Commercial fryer	Non-Residential Prescriptive Program, DSM Phase VI	Section 4.1.3
	Commercial steam cooker	Non-Residential Prescriptive Program, DSM Phase VI	Section 4.1.6
	Commercial hot food holding cabinet	Non-Residential Prescriptive Program, DSM Phase VI	Section 4.1.5
HVAC	Unitary/split HVAC, package terminal air conditioners and heat pumps	Non-Residential Heating and Cooling Efficiency Program, DSM Phase VII	Section 2.1.1
	Mini-split systems	Non-Residential Heating and Cooling Efficiency Program, DSM Phase VII	Section 2.1.2
	Electric chillers	Non-Residential Heating and Cooling Efficiency Program, DSM Phase VII	Section 2.1.3
Refrigeration	Commercial freezers and refrigerators	Non-Residential Prescriptive Program, DSM Phase VI	Section 4.4.3

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9.1 Cooking end use

9.1.1 Commercial combination oven

This measure is also offered through the Non-Residential Prescriptive Program, DSM Phase VI. The savings approach is described in Section 4.1.2.

9.1.2 Commercial convection oven

This measure is also offered through the Non-Residential Prescriptive Program, DSM Phase VI. The savings approach is described in Section 4.1.1.

9.1.3 Commercial griddle

This measure is also offered through the Non-Residential Prescriptive Program, DSM Phase VI. The savings approach is described in Section 4.1.4.

9.1.4 Commercial fryer

This measure is also offered through the Non-Residential Prescriptive Program, DSM Phase VI. The savings approach is described in Section 4.1.3.

9.1.5 Commercial steam cooker

This measure is also offered through the Non-Residential Prescriptive Program, DSM Phase VI. The savings approach is described in Section 4.1.6.

9.1.6 Commercial hot food holding cabinet

This measure is also offered through Non-Residential Prescriptive Program, DSM Phase VI. The savings approach is described in Section 4.1.5.

9.2 Heating, Ventilation, and Air Conditioning (HVAC) end use

9.2.1 Unitary/split HVAC, package terminal air conditioners and heat pumps

This measure is also offered through the Non-Residential Heating and Cooling Efficiency Program, DSM Phase VII. The savings approach is described in Section 2.1.1.

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9.2.2 Mini-split systems

This measure is also offered through the Non-Residential Heating and Cooling Efficiency Program, DSM Phase VII. The savings approach is described in Section 2.1.2.

9.2.3 Electric chiller

This measure is also offered through the Non-Residential Heating and Cooling Efficiency Program, DSM Phase VII. The savings approach is described in Section 2.1.3.

9.3 Refrigeration end use

9.3.1 Commercial freezers and refrigerators

This measure is also offered through the Non-Residential Prescriptive program. The savings approach is described in Section 4.4.3.

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10 NON-RESIDENTIAL MULTIFAMILY PROGRAM, DSM PHASE VIII

The Multifamily Program is designed to encourage investment in both the residential and commercial areas of multifamily properties. The Program design is based on a whole-building approach where the implementation vendor will identify as many cost-effective measure opportunities as possible in the entire building (both residential and commercial metered) and encourage property owners to address the measures as a bundle. This approach provides "one-stop shop" programming for multifamily property owners with solutions to include direct-install measures and incentives for prescriptive efficiency improvements. The Program will identify, track, and report residential (in-unit) and commercial (common space) savings separately, according to the account type. The Program will be delivered through an expanded network of local trade allies that the implementation vendor will recruit and support while also establishing a robust relationship with property management companies—the gatekeepers for determining enrollment for their multifamily communities. Once a property management company has decided to enroll a property into the Program, the implementation vendor will send the tenants a letter that will provide information about Program benefits along with an opportunity to opt-out of participating within a defined period of time. If a tenant does not take action to notify the program implementation vendor that they are opting out of participation, their unit will be included in the enrolled locations to receive the installed measures during the delivery phase.

The implementation vendor intends to complete site assessments at the time of the enlistment visit—or within two weeks—to identify all eligible measures. Subsequently, the property owner or manager will receive an assessment report identifying and quantifying savings opportunities with estimated project costs and available incentives. The program implementation vendor or trade ally auditor will perform a walk-through audit covering the envelope and all energy systems in the buildings, paying particular attention to the condition of domestic hot water (DHW) and HVAC systems, building-envelope insulation, and lighting. After assessing the entire structure and living units, the auditor will use an assessment tool to perform appropriate calculations and generate a report showing projected energy and potential cost savings specific to each unit and/or common area. The auditor will review the findings and recommendations of the assessment with the property owner and assist them in making measure installation and investment decisions. Participation will require that all services or installations qualifying for an incentive be completed by a participating contractor or properly-credentialed building maintenance staff. The measures offered through the program and the sections that contain the savings algorithms for each measure are presented in Table 10-1.

Table 10-1. Non-Residential Multifamily Program measure list

End use	Measure	Legacy program	Non-Residential manual section
Building envelope	Air sealing	Residential Manufactured Housing Program, DSM Phase VIII	Section 10.1.1
	Building insulation/ drill & fill wall insulation	Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV	Section 10.1.2
Domestic hot water	Domestic hot water pipe insulation	Residential Income and Age Qualifying Home Improvement Program, DSM Phase IV	Section 10.2.1
	Water heater temperature setback/turndown	Residential Home Energy Assessment Program, DSM Phase VII	Section 10.2.2

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End use	Measure	Legacy program	Non-Residential manual section
HVAC	HVAC upgrade/ unitary AC	Non-Residential Heating and Cooling Efficiency Program, DSM Phase VII	Section 2.1.1
	HVAC tune-up	Non-Residential Prescriptive Program, DSM Phase VI	Section 4.2.2
	Duct sealing	Non-Residential Prescriptive Program, DSM Phase VI	Section 4.2.1.
	Energy star room/wall AC units	Residential Home Energy Assessment Program, DSM Phase VII	Section 10.3.4
	Smart thermostat installation	-	Section 10.3.5
Lighting	Lighting, fixtures, lamps, and delamping	Non-Residential Lighting Systems and Controls Program, DSM Phase VII	Section 1.1.1
	LED exit signs	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 8.3.3
	Sensors and controls	Non-Residential Lighting Systems and Controls Program, DSM Phase VII	Section 1.1.2
Appliance or Plug Load	ENERGY STAR clothes dryer	Residential Efficient Products Marketplace Program, DSM Phase VII	Section 10.5.1
	ENERGY STAR clothes washer		Section 10.5.2
Recreation	Two-speed & variable speed pool pump	-	Section 10.6.1

10.1 Building envelope end use

10.1.1 Air sealing

This measure is also offered through the Residential Manufactured Housing Program, DSM Phase VIII. The savings approach is described in Appendix F1: Technical Reference Manual for Residential Programs v.2022, Section 10.1.1.

10.1.2 Building insulation/drill & fill wall insulation

This measure is also offered through the Residential Energy Efficient Kits Program, DSM Phase VIII. The savings approach is described in Appendix F1: Technical Reference Manual for Residential Programs v.2022, Section 10.1.2.

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10.2 Domestic hot water end use

10.2.1 Domestic hot water pipe insulation

This measure is also offered through the Residential Home Energy Assessment Program, DSM Phase VIII. The savings approach is described in Appendix F1: Technical Reference Manual for Residential Programs v.2022, Section 4.2.1.

10.2.2 Water heater temperature setback/turndown

This measure is also offered through the Residential Home Energy Assessment Program, DSM Phase VIII. The savings approach is described in Appendix F1: Technical Reference Manual for Residential Programs v.2022, Section 4.2.5.

10.3 Heating, Ventilation, and Air-Conditioning (HVAC) end use

10.3.1 HVAC Upgrade/ Unitary AC

This measure is also offered through the Non-Residential Heating and Cooling Efficiency Program, DSM Phase VII. The savings approach is described in Section 2.1.1.

10.3.2 HVAC Tune-up

This measure is also offered through the Non-Residential Prescriptive Program, DSM Phase VI. The savings approach is described in Section 4.2.2.

10.3.3 Duct sealing

This measure is also offered through the Non-Residential Prescriptive Program, DSM Phase VI. The savings approach is described in Section 4.2.1.

10.3.4 ENERGY STAR® Room/Wall AC units

This measure is also offered through the Residential Home Energy Assessment Program, DSM Phase VII. The savings approach is described in Appendix F1: Technical Reference Manual for Residential Programs v.2022, Section 4.3.1.

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10.3.5 Smart thermostat installation

10.3.5.1 Measure description

The smart thermostat measure involves the replacement of a manually operated or conventional programmable thermostat with a smart thermostat that meets or exceeds the ENERGY STAR® requirements.[165] A “smart” or communicating thermostat allows remote set point adjustment and control via remote application. The system requires an outdoor-air-temperature algorithm in the control logic to operate heating and cooling systems.

The baseline is a mix of manual and programmable thermostats; the efficient condition is a smart thermostat that has earned ENERGY STAR certification.

10.3.5.2 Impacts Estimation Approach

Per-measure, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = kWh_{cool} + kWh_{heat}$$

For heat pumps, and AC units <65,000 Btu/h, per-measure, gross annual electric cooling energy savings are calculated according to the following equation:

$$\Delta kWh_{cool} = Size_{cool} \times \frac{1\ kBtuh}{1{,}000\ Btuh} \times \frac{EFLH_{cool}}{SEER} \times ESF_{cool}$$

For heat pumps and AC units ≥65,000 Btu/h, per-measure, gross annual electric cooling energy savings are calculated according to the following equation:

$$\Delta kWh_{cool} = Size_{cool} \times \frac{1\ kBtuh}{1{,}000\ Btuh} \times \frac{EFLH_{cool}}{IEER} \times ESF_{cool}$$

Heating savings are only applicable to spaced conditioned using heat pumps. For heat pumps <65,000 Btu/h, per-measure gross annual electric heating energy savings are calculated according to the following equation

$$\Delta kWh_{heat} = Size_{heat} \times \frac{1\ kBtuh}{1{,}000\ Btuh} \times \frac{EFLH_{heat}}{HSPF} \times ESF_{heat}$$

For heat pumps ≥65,000 Btu/h, and water-source heat pumps of all sizes, and package terminal HP units of all sizes, per-measure gross annual electric heating energy savings are calculated according to the following equation:

$$\Delta kWh_{heat} = Size_{heat} \times \frac{1\ W}{3.412\ Btuh} \times \frac{1\ kBtuh}{1{,}000\ Btuh} \times \frac{EFLH_{heat}}{COP} \times ESF_{heat}$$

This measure does not provide gross coincident summer or winter peak demand reductions.

[165] The key product criteria for Smart thermostats can be found at https://www.energystar.gov/products/heating_cooling/smart_thermostats/key_product_criteria

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Where:

ΔkWh	= per-measure gross annual electric energy savings
$Size_{cool}$	= cooling capacity of HVAC system
$Size_{heat}$	= heating capacity of heat pump
SEER	= seasonal energy efficiency ratio (SEER)
IEER	= integrated energy efficiency ratio (IEER)
HSPF	= heating seasonal performance factor (HSPF)
COP	= coefficient of performance (COP)
$EFLH_{cool}$	= equivalent cooling full load hours
$EFLH_{heat}$	= equivalent heating full load hours
ESF_{cool}	= cooling annual energy savings factor
ESF_{heat}	= heating annual energy savings factor

10.3.5.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 10-2. Input variables for Smart Thermostat savings calculations

Component	Type	Value	Units	Source(s)
$Size_{cool}$	Variable	See customer application	Btu/h	Customer application
$Size_{heat}$	Variable	See customer application[166] Default = $Size_{cool}$	Btu/h	Customer application
$EFLH_{cool}$	Variable	See Sub-Appendix F2-II: Non-residential HVAC , Table 17-4 and Table 17-5 use multifamily (common area)	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 423, scaled using CDD
$EFLH_{heat}$	Variable	See Sub-Appendix F2-II: Non-residential HVAC , Table 17-5 use multifamily (common area)	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 423, scaled using HDD
SEER/IEER/ HSPF/COP	Variable	See Sub-Appendix F2-III: Non-residential HVAC , Table 17-8 and Table 17-9	Btu/Wh (COP is unitless)	ASHRAE 90.1-2013
ESF_{cool}	Variable	Manual thermostat existing: 0.050 Programmable thermostat existing: 0.020	-	Maryland/Mid-Atlantic TRM v10, p. 319
		Default = 0.030		DNV, Dominion Energy 2020 Commercial Energy Survey, Appendix B, p.60 (Q25)[167]
ESF_{heat}	Variable	Manual thermostat existing: 0.040 Programmable thermostat existing: 0.020	-	Maryland/Mid-Atlantic TRM v10, p. 319
		Default = 0.027		DNV, Dominion Energy2020 Commercial Energy Survey, Appendix B, p. 60 (Q25)[167]

166 When customer-provided heating system size is <80% or >156% of customer-provided cooling system size, a default value will be used, instead. In such instances, it is assumed that the heating system size was incorrectly documented. The acceptable range is based on a review of the AHRI database across numerous manufacturers and heat pump types.

167 Used weighted average of programmable thermostat and manual thermostat responses to determine the ESF.

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10.3.5.4 Default savings

If the proper values are not available, zero savings will be given for gross annual electric energy savings.

10.3.5.5 Effective Useful Life

The effective useful life of this measure is provided in Table 10-3.

Table 10-3. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
VIII	Non-Residential Multifamily Program, DSM Phase VIII	7.50	years	Maryland/Mid-Atlantic TRM v10, pp. 317-320

10.3.5.6 Source

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v10, pp. 317-320.

10.3.5.7 Update summary

Updates to this section are described in Table 10-4.

Table 10-4. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	-	Initial release

10.4 Lighting end use

10.4.1 LED lamps, advanced lighting, and delamping

This measure is also offered through the Non-Residential Lighting Systems and Controls Program, DSM Phase VII. The savings approach is described in Section 1.1.1.

10.4.2 LED exit signs

This measure is also offered through the Non-Residential Lighting Systems and Controls Program, DSM Phase VII. The savings approach is described in Section 8.3.3.

10.4.3 Sensors and controls

This measure is also offered through the Non-Residential Lighting Systems and Controls Program, DSM Phase VII. The savings approach is described in Section 1.1.2.

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10.5 Appliance or Plug Load end use

10.5.1 Clothes dryer

This measure is also provided by the Residential Efficient Products Marketplace Program, DSM Phase VII. The savings are determined using the methodology described in Section 6.2.3.

10.5.2 Clothes washer

This measure is also provided by the Residential Efficient Products Marketplace Program, DSM Phase VII. The savings are determined using the methodology described in Section 6.2.2.

10.6 Recreation end use

10.6.1 Two-speed & variable-speed pool pump

10.6.1.1 Measure description

This measure replaces a single-speed pool filter pump with a variable-speed or dual-speed pump of equivalent horsepower. This measure is only applicable to self-priming pool filter pumps which are typically used with permanent, in-ground pools in Residential: single-family; Non-residential: multifamily and commercial buildings. Non-self-priming pool filter pumps, which are typically used with rigid, above-ground pools, are not eligible for this measure. The baseline efficiency equipment is a single-speed, self-priming pool filter pump. The efficient equipment is a variable-speed or dual-speed self-priming pool filter pump.

This measure is offered through different programs listed in Table 10-5 and uses the impacts estimation approach described in this section.

Table 10-5. Programs that offer this measure

Program name	Section
Non-Residential Multifamily Program, DSM Phase VIII	Section 10.6.1
Non-Residential Prescriptive Enhanced Program, DSM Phase IX	Section 16.5.3

10.6.1.2 Impacts Estimation Approach

Per-measure, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \left(kWh_{daily,base} - kWh_{daily,ee}\right) \times Days$$

Per-measure, the gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \left[\left(\frac{kWh_{daily,base}}{Hours_{daily,base}}\right) \times CF_{base,summer}\right] - \left[\left(\frac{kWh_{daily,e}}{Hours_{daily,ee}}\right) \times CF_{ee,summer}\right]$$

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Per-measure, the gross coincident winter peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \left[\left(\frac{kWh_{daily,base}}{Hours_{daily,base}}\right) \times CF_{base,winter}\right] - \left[\left(\frac{kWh_{daily,ee}}{Hours_{daily,ee}}\right) \times CF_{ee,winter}\right]$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure gross coincident winter peak demand reduction
$kWh_{daily,base}$ = typical daily energy consumption of a single speed motor in a cool climate
$kWh_{daily,ee}$ = typical daily energy consumption for an efficient variable-speed or two-speed pump motor
Days = number of days the pump operates in a year
$Hours_{dailybase}$ = daily runtime of baseline pump
$Hours_{daily\ ee}$ = daily runtime of dual speed or variable-speed pump
$CF_{base,summer}$ = summer coincidence factor of baseline pump
$CF_{ee,summer}$ = summer coincidence factor of dual speed or variable-speed pump
$CF_{base,winter}$ = winter coincidence factor of baseline pump
$CF_{ee,winter}$ = winter coincidence factor of dual speed or variable-speed pump

10.6.1.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 10-6. Input Variables for two speed & variable speed pool pump

Component	Type	Value	Units	Source(s)
$Size_{base}$	Variable	See customer application	hp (pump motor)	Customer application
$Size_{ee}$	Variable	See customer application	hp (pump motor)	Customer application
$kWh_{daily,base}$	Variable	Residential: See Table 10-7 based on $Type_{base}$ and $Bin_{size,base}$ Commercial: See Table 10-8 based on $Type_{base}$ and $Bin_{size,base}$	kWh, daily	Hawaii TRM 2021, p.191 and p.321
$kWh_{daily,ee}$	Variable	Residential: See Table 10-7 based on $Type_{base}$ and $Bin_{size,base}$ Commercial: See Table 10-8 based on $Type_{base}$ and $Bin_{size,base}$	kWh, daily	Hawaii TRM 2021, p.191 and p.321
$Type_{base}$	Fixed	Default: Single-Speed Pump	-	Program requirement
$Type_{ee}$	Variable	Default: 1. Dual-Speed Pump 2. Variable Speed Pump	-	Customer application
Days	Variable	See customer application		Customer application

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Component	Type	Value	Units	Source(s)
		Default: 100	days, annual	Maryland/Mid-Atlantic TRM v.10, p.195
$Bin_{size,base}$	Variable	See Table 10-7 and Table 10-8	-	Hawaii TRM 2021, p.191 and p.321
$Bin_{size,ee}$	Variable	See Table 10-7 and Table 10-8	-	Hawaii TRM 2021, p.191 and p.321
$Hours_{daily,base}$	Variable	Residential: See Table 10-7 based on $Type_{base}$ and $Bin_{size,base}$ Commercial: See Table 10-8 based on $Type_{base}$ and $Bin_{size,base}$	hours, annual	Hawaii TRM 2021, p.191 and p.321
$Hours_{daily,ee}$	Variable	Residential: See Table 10-7 based on $Type_{base}$ and $Bin_{size,base}$ Commercial: See Table 10-8 based on $Type_{base}$ and $Bin_{size,base}$	hours, annual	Hawaii TRM 2021, p.191 and p.321
$CF_{base,summer}$	Variable	Residential: See Table 10-7 based on $Type_{base}$ and $Bin_{size,base}$ Commercial: See Table 10-8 based on $Type_{base}$ and $Bin_{size,base}$	-	Hawaii TRM 2021, p.191 and p.321
$CF_{ee,summer}$	Variable	Residential: See Table 10-7 based on $Type_{base}$ and $Bin_{size,base}$ Commercial: See Table 10-8 based on $Type_{base}$ and $Bin_{size,base}$	-	Hawaii TRM 2021, p.191 and p.321
$CF_{base,winter}$	Variable	If Days < 365: 0.00 If Days = 365: Residential: See Table 10-7 based on $Type_{base}$ and $Bin_{size,base}$ Commercial: See Table 10-8 based on $Type_{base}$ and $Bin_{size,base}$	-	Hawaii TRM 2021, p.192 and p.322[168]
$CF_{ee,winter}$	Variable	If Days < 365: 0.00 If Days = 365: Residential: See Table 10-7 based on $Type_{base}$ and $Bin_{size,base}$ Commercial: See Table 10-8 based on $Type_{base}$ and $Bin_{size,base}$	-	Hawaii TRM 2021, p.192 and p.322[168]

[168] Source TRM does not have winter CF. If the pool is only used seasonally, it is assumed that it will not be used during the winter. Therefore, Winter CF is zero. However, the pool is used year-round (Days = 365), the summer CF to winter CF as an approximation.

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Table 10-7. Typical residential pool pump energy consumption, operating hours, and coincidence factor for various pump size strategies and pump type

$Type_{pump}$	Metric	Bin, based on pump size (hp)			
		> 0 and ≤ 1	> 1 and ≤ 2	> 2 and ≤ 3	> 3 and ≤ 4
Single-speed	$kWh_{daily,base}$ (kWh)	6.4	11.5	15.0	16.0
	$Hours_{daily,base}$ (hr)	5.6	6.8	6.1	5.8
	$CF_{base,summer}$	0.23	0.28	0.26	0.24
	$CF_{base,winter}$				
Two-speed	$kWh_{daily,ee}$ (kWh)	4.1	7.1	8.2	9.1
	$Hours_{daily,ee}$ (hr)	11.0	13.3	12.1	11.9
	$CF_{ee,summer}$	0.46	0.56	0.50	0.50
	$CF_{ee,winter}$				
Variable-speed	$kWh_{daily,ee}$ (kWh)	1.7	2.9	4.1	4.4
	$Hours_{daily,ee}$ (hr)	13.3	16.3	17.1	17.9
	$CF_{ee,summer}$	0.56	0.68	0.71	0.75
	$CF_{ee,winter}$				

Table 10-8. Typical commercial pool pump energy consumption, operating hours, and coincidence factor for various pump size strategies and pump type

$Type_{pump}$	Metric	Bin, based on pump size (hp)			
		> 0 and ≤ 1	> 1 and ≤ 2	> 2 and ≤ 3	> 3 and ≤ 4
Single-speed	$kWh_{daily,base}$ (kWh)	20.3	29.3	43.7	51.8
	$Hours_{daily,base}$ (hr)	17.6	17.2	17.8	18.9
	$CF_{base,summer}$	0.73	0.72	0.74	0.79
	$CF_{base,winter}$				
Two-speed	$kWh_{daily,ee}$ (kWh)	19.0	30.3	39.2	49.4
	$Hours_{daily,ee}$ (hr)	24.0			
	$CF_{ee,summer}$	1.00			
	$CF_{ee,winter}$				
Variable-speed	$kWh_{daily,ee}$ (kWh)	9.2	13.9	21.6	27.0
	$Hours_{daily,ee}$ (hr)	22.7			23.5
	$CF_{ee,summer}$	0.95			
	$CF_{ee,winter}$				

10.6.1.4 Default savings

If the proper values are not available, zero savings will be given for both gross annual electric energy savings and gross demand energy savings.

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10.6.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 10-9.

Table 10-9. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	10.00	years	Hawaii TRM 2021, p.193 and p.223
VIII	Non-Residential Multifamily Program, DSM Phase VIII			

10.6.1.6 Source

The primary source for this deemed savings approach is the Hawaii TRM 2021, pp. 190-193 and pp. 320-323, and Maryland/Mid-Atlantic TRM v.10, p.195.

10.6.1.7 Update summary

Updates to this section are described in Table 10-10.

Table 10-10. Summary of update(s)

Version	Update type	Description
2022	Input table	Added new table for the residential pool pump application
	Source	Updated page numbers/version of the Hawaii TRM 2021
2021	-	Initial release

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11 NON-RESIDENTIAL NEW CONSTRUCTION PROGRAM, DSM PHASE VIII

The Non-Residential New Construction Program provides incentives to non-residential customers to implement energy efficiency measures in their new construction project. Program engineers determine which energy efficiency upgrades are of interest to the owner and feasible within their budget. These measures—coupled with basic facility design data—are analyzed to determine the optimized building design. This in-depth analysis will be performed using building energy simulation models that will allow “bundles” of measures to be analyzed for energy savings while accounting for interactive effects between the measures within a given “bundle.” The results are presented to the facility owner to facilitate their selection of the measures(s) to be installed. This program has been offered in Virginia and North Carolina beginning in March 2021.

To be eligible for a rebate, the new building must be eligible for a rate schedule that is not exempt by statute.

The measures offered through this program and the sections describing the measures are listed in Table 11-1. The following sections include measure descriptions. Note that while some measures may be the same as those offered by other programs, the savings methodology will differ. That is because this program is designed to determine savings using building energy simulations. This approach accounts for measure interactivity across all measures to be implemented at a specific new building.

Table 11-1. Non-Residential New Construction Program measure list

End use	Measure	Section
Building envelope	Optimal choice of vertical fenestration	Section 11.2.1
HVAC	High-efficiency and variable speed chillers (air-cooled)	Section 11.3.1
	High-efficiency DX cooling equipment	Section 11.3.2
	High-efficiency and variable speed packaged DX cooling equipment	Section 11.3.3
	High-efficiency packaged air-source heat pumps	Section 11.3.4
	Demand-controlled ventilation/CO2 controls	Section 11.3.5
	VAV dual-max controls	Section 11.3.6
	VAV supply air temperature reset	Section 11.3.7
	Chiller controls	Section 11.3.8
Appliance or Plug Load	Supervisory plug load management systems	Section 11.4.1
Lighting	High performance interior lighting	Section 11.5.1
	LED exterior lighting	Section 11.5.2

11.1 Building simulation description

Energy savings and demand reductions for this program are estimated using building energy simulations. The basic geometry and floor plan is created and imported into OpenStudio®, a front-end software platform for building models to analyze using DOE’s EnergyPlus™ engine. OpenStudio is used to assign space types and apply thermal zones and develop the baseline building. Default construction, equipment, setpoints, and building occupancy schedules are applied. The baseline building meets state and local building codes. The models are created to meet IECC 2015 and

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adjusted to meet local requirements. For other default inputs not determined by code, reasonable assumptions and standard practices are applied.

There are baseline and efficient building models for each measure case. Energy savings are calculated using these models and simulated using TMY3 weather data for selected weather stations in Virginia and North Carolina.

11.1.1 Model review

To perform data validation and provide feedback to participating builders, DNV will request building models for a select sample of projects for review. The sample selection may consider the reported savings, building square footage, measures, and building type.

The models will be reviewed for relevant code compliance, default assumptions, equipment sizing, measure case assumptions, weather location, and savings results.

11.1.2 Impacts Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = kWh_{base} - kWh_{ee}$$

Per-measure, gross coincident summer and winter peak demand reduction is calculated using the following equations:

$$\Delta kW_{summer} = kW_{base,summer} - kW_{ee,summer}$$

$$\Delta kW_{winter} = kW_{base,winter} - kW_{ee,winter}$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure gross coincident winter peak demand reduction
kWh_{base} = annual energy consumption of the baseline model
kWh_{ee} = annual energy consumption of the efficient model
$kW_{base,summer}$ = coincident summer peak demand of baseline model
$kW_{ee,summer}$ = coincident summer peak demand of efficient model
$kW_{base,winter}$ = coincident winter peak demand of baseline model
$kW_{ee,winter}$ = coincident winter peak demand of efficient model

11.1.2.1 Measure sequence

All input variables used for calculating energy savings and demand reductions are generated by the building energy model runs. For each measure there is a baseline model and an efficient model. For facilities with multiple measures, the measures are applied sequentially to account for measure interactivity. The sequence for applying measures is

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provided in Table 11-2. The first implemented measure on the list will have a baseline model and an efficient model. Each subsequent measure will use the preceding measure's efficient model as its baseline model. The sequence affects the way savings are attributed to each measure, but the total project impacts are not affected by the sequence.

Table 11-2. Non-residential new construction measure sequence for modeling

Sequence	Measure
1	Optimal choice of vertical fenestration
2	High performance interior lighting
3	Supervisory plug load management systems
4	LED exterior lighting
5	High-efficiency and variable speed chillers (air-cooled)
6	High-efficiency DX cooling equipment
7	High-efficiency and variable speed packaged DX cooling equipment
8	High-efficiency packaged air-source heat pumps
9	Demand-controlled ventilation/CO2 controls
10	VAV supply air temperature reset
11	VAV dual-max controls
12	Chiller controls

11.1.2.2 Default savings

There are no default savings as model savings are required for each measure.

11.1.2.3 Effective Useful Life

The effective useful life of this measure is provided in Table 11-3.

Table 11-3. Effective Useful Life for lifecycle savings calculations

DSM Phase	Measure	Value	Units	Source(s)
VIII	Optimal choice of vertical fenestration	25.00	years	Ohio TRM_2010, p. 142[169]
	High-efficiency and variable speed chillers (air-cooled)	23.00		Maryland/Mid-Atlantic TRM v.10, p. 304
	High-efficiency DX cooling equipment	15.00		Maryland/Mid-Atlantic TRM v.10, p. 291
	High-efficiency and variable speed packaged DX cooling equipment	15.00		Maryland/Mid-Atlantic TRM v.10, p. 291
	High-efficiency packaged air-source heat pumps	15.00		Maryland/Mid-Atlantic TRM v.10, p. 291
	Demand controlled ventilation/CO2 controls	8.00		Illinois TRM commercial v.9 Volume 2, p. 258
	VAV dual-max controls	10.00		Massachusetts TRM 2019-2021, p. 451[170]

169 This reference is for residential new construction. Commercial new construction building design measures like this are not included in most TRMs. Therefore, the residential new construction measure life is applied as an approximation.

170 Energy Management System (EMS) measure life is applied for most HVAC controls measures.

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DSM Phase	Measure	Value	Units	Source(s)
	VAV supply air temperature reset	10.00		Massachusetts TRM 2019-2021, p. 451
	Chiller controls	10.00		Massachusetts TRM 2019-2021, p. 451
	Supervisory plug load management systems	10.00		Massachusetts TRM 2019-2021, p. 451
	High performance interior lighting	15.00		Maryland/Mid-Atlantic TRM v.10, p. 219
	LED exterior lighting	15.00		Maryland/Mid-Atlantic TRM v.10, p. 219

11.1.2.4 Source(s)

The primary source for this program is the building energy models.

11.1.2.5 Update summary

Updates made to this section are described in Table 11-4.

Table 11-4. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	-	Initial release

11.2 Building envelope end use

11.2.1 Optimal choice of vertical fenestration

This measure upgrades the window assemblies relative to minimum building code requirements with assemblies having high insulative properties (low U-values), low Solar Heat Gain Coefficients (SHGC), and low visible sunlight transmittance (Tvis-glass).

11.3 Heating, Ventilation, Air Conditioning (HVAC) end use

11.3.1 High-efficiency and variable speed chillers (air-cooled)

This measure upgrades a constant-speed, chilled-water system to one that includes variable-speed, air-cooled chillers and variable-speed chilled-water pumps. The baseline chiller performance and the VFD pump curves from ASHRAE 90.1-2013 are used.

11.3.2 High-efficiency DX cooling equipment

This measure upgrades from standard-efficiency DX cooling equipment to high-efficiency DX cooling equipment. The baseline equipment meets 90.1-2013 efficiency requirements.

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11.3.3 High-efficiency and variable speed packaged DX cooling equipment

This measure upgrades from a constant-speed rooftop unit (RTU) to a variable-speed RTU. This measure may utilize either a natural gas heating coil or a direct-expansion (DX) heating coil. The variable-speed RTU model stages the fan in response to the amount of heating/cooling required. The measure adjusts the fan flow according to the heating/cooling required at each stage.

11.3.4 High-efficiency packaged air-source heat pumps

This measure upgrades from a standard-efficiency air-source heat pump to a high-efficiency air-source heat pump. The baseline equipment meets 90.1-2013 efficiency values.

11.3.5 Demand controlled ventilation/CO2 controls

This measure varies the outside airflow based on the actual number of occupants in the space rather than the nominal number of occupants as required by building code. The baseline for this measure is a constant outside airflow based on the design conditions. This measure reduces the outside airflow and the amount of space conditioning needed for outside air.

11.3.6 VAV Dual-Max Controls (electric heat)

This measure modifies the control strategy for airflow of VAV boxes with electric reheat. In the efficient case, the minimum airflow is determined by the maximum of the lowest airflow setpoint allowed by the VAV box controls and the zone’s minimum outdoor airflow rate. In the baseline case, the supply airflow rate operates at the maximum flow rate that meets the cooling load. The airflow is reset proportionally until the zone minimum when there is no cooling load. This minimum airflow setpoint is maintained throughout the heating periods and the deadband zone. This measure allows the minimum airflow to be lower during the deadband zone and resets proportional to the heating load. Energy is saved by reducing fan load, electric heating load, and electric reheat load.

11.3.7 VAV supply air temperature reset (electric heat)

This measure replaces a constant supply-air temperature setpoint with a temperature reset. A constant supply-air temperature provides more cooling than is required to meet cooling loads. By allowing the supply-air temperature setpoint to adjust to operating conditions, energy savings are achieved. There are energy savings by not cooling the supply air temperature more than is needed and minimizing reheating. Inputs to this control strategy can include the outside air temperature, the return air temperature, or the cooling demand across all zones.

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11.3.8 Chiller controls

This measure resets the chilled-water supply temperature or the condenser water temperature setpoint based on the chilled-water return temperature. The baseline maintains a constant condenser water temperature and chilled-water supply temperature setpoint. For condenser water reset, the condenser operates at a higher pressure than is needed when the building load is lower than the design conditions. By reducing the condenser-water temperature setpoint when feasible, the compressor lift, or the difference between condenser and evaporator saturation temperatures, energy consumption is reduced.

11.4 Appliance or plug load end use

11.4.1 Supervisory plug load management systems

This measure reduces the Equipment Power Density (EPD) associated with select spaces. A supervisory plug load management system reduces plug-in and hardwired electrical loads in a building that are not associated with HVAC, lighting, or water heating. The system allows for review of plug load usage and identification of opportunities for reducing energy consumption and allows for scheduling of equipment. The baseline is no plug load management system present.

11.5 Lighting end use

11.5.1 High performance interior lighting

This measure is for a reduction in lighting power density (LPD) relative to the code LPD for a given space type or building type. Lower LPD uses less energy while providing a comparable level of lighting. This measure is applicable only to interior lighting.

11.5.2 LED exterior lighting

This measure replaces baseline exterior lighting with LEDs. The efficient lighting provides similar lighting levels at a lower wattage than the baseline wattage, resulting in energy savings.

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12 NON-RESIDENTIAL AGRICULTURAL ENERGY EFFICIENCY PROGRAM, DSM PHASE IX

The Non-Residential Agricultural Energy Efficiency Program provides qualifying non-residential customers with incentives to implement specific energy efficiency measures to help agribusiness replace aging, inefficient equipment and systems with high-efficiency agricultural equipment, lighting, irrigation, and more.

To be eligible for a rebate, you must be a Dominion Energy Virginia non-residential customer who is not exempt by statute or under special contract and is the owner of the facility or is reasonably able to secure permission to complete installation of measures.

The measures offered through this program and the sections describing the measures are listed in Table 12-1. The following sections include measure descriptions.

Table 12-1. Non-residential agricultural energy efficiency program measure list

End use	Measure	Legacy program	Section
HVAC	Circulation fan	N/A	Section 12.1.1
	High volume low-speed fan		Section 12.1.2
	Ventilation fan		Section 12.1.3
Lighting	Dairy lighting controls		Section 12.2.1
	Horticultural LED		Section 12.2.2
	Poultry LED		Section 12.2.3
	T5/T8 Lamps	Non-Residential Lighting Systems and Controls Program, DSM Phase VII	Section 1.1.1
Process	Automatic milker take-off	N/A	Section 12.3.112.3.1
	Dairy plate cooler		Section 12.3.2
	Grain storage aeration fan controls		Section 12.3.3
	Low pressure irrigation		Section 12.3.4
	VFD for dust collection		Section 12.3.512.3.4
	VFD for irrigation pump		Section 12.3.6
	VFD for tobacco curing		Section 12.3.7

12.1 Heating, Ventilation, Air Conditioning (HVAC) end use

12.1.1 Circulation fan

12.1.1.1 Measure description

The measure applies to newly installed circulation fans or replacing an existing unit that reached the end of its useful life in agricultural applications. The baseline condition is assumed to be a new fan that does not meet program requirements. This characterization assumes that the baseline condition uses on/off thermostatic controls to automatically operate the fans above a designated temperature threshold and shut them off when temperature drops below setpoint. The efficient equipment must be certified by BESS Labs[171] with fan diameters of at least 36 inches

[171] University of Illinois, Department of Agricultural and Biological Engineering. http://bess.illinois.edu/

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and meet program minimum efficiency requirements and efficient fans are assumed to be governed by thermostatic on/off controls. The program efficiency requirements are show in Table 12-2.

Table 12-2. Program qualifying efficiency requirements

Fan diameter (in)	Tier 1 Qualifying efficiency ratio (cfm/W)	Tier 2 Qualifying efficiency ratio (cfm/W)
36-47	-	21.0
48-52	23.1	25.2
52+	23.1	25.0

12.1.1.2 Impacts Estimation Approach

Per-measure, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \left(\frac{watts_{base} - watts_{ee}}{1{,}000}\right) \times HOU$$

Per-measure, the gross summer coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \left(\frac{watts_{base} - watts_{ee}}{1{,}000}\right) \times CF_{summer}$$

Per-measure, the gross winter coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \left(\frac{watts_{base} - watts_{ee}}{1{,}000}\right) \times CF_{winter}$$

Where:

ΔkWh	= per-measure gross annual electric energy savings
ΔkW_{summer}	= per-measure gross coincident summer peak demand reduction
ΔkW_{winter}	= per-measure gross coincident winter peak demand reduction
$Watts_{base}$	= baseline fan rated power
$watts_{ee}$	= efficient fan rated power
HOU	= equipment operating hours of use
CF_{summer}	= summer peak coincidence factor
CF_{winter}	= winter peak coincidence factor

12.1.1.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

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Table 12-3. Input variables for circulation fans

Component	Type	Value	Units	Source(s)
$watts_{base}$	Variable	See Table 12-4	watts	BESS Database[172]
$Watts_{ee}$	Variable	See customer application	watts	BESS Database[173]
		For defaults see Table 12-4		Iowa TRM v5.0, Vol.3.0, 2020, p.8
HOU	Variable	See customer application	hours, annual	Customer application
		For defaults see Table 12-5		Iowa TRM v5.0, Vol.3.0, 2020, pp. 7-8
CF_{summer}	Fixed	1.00	-	Iowa TRM v5.0, Vol.3.0, 2020, p.9
CF_{winter}	Fixed	0.00	-	Iowa TRM v5.0, Vol.3.0, 2020, p. 9[174]

Table 12-4. Default base and efficient fan power

Fan diameter (in)	$watts_{base}$ (W)	$Watts_{ee}$ (W)
36-47 (default)[175]	599	458
48-52	1,123	897
52+	1,352	999

Table 12-5. Circulation fan hours of use by facility type

Facility type	HOU (hours)
Hog	3,597
Poultry	2,862
Dairy	2,578
Unknown/other (default)	3,249

12.1.1.4 Default savings

If the application does not provide the input variables, savings are calculated using default values where applicable.

Per-measure, the gross annual electric energy savings are calculated as follows:

$$\Delta kWh = \left(\frac{watts_{base} - watts_{ee}}{1{,}000}\right) \times HOU$$

[172] BESS fan database downloaded on 2/22/2023. Average watts from models below standard (minimum efficiency requirement detailed in the efficient equipment definition).

[173] BESS fan database downloaded on 2/22/2023. Average watts from models above standard (minimum efficiency requirement detailed in the efficient equipment definition).

[174] The source TRM doesn't provide a winter demand value. The maximum ventilation is needed at temperatures above 72°F with a 67°F balance point assumed. For winter peak periods, it is assumed that little ventilation will be needed, and peak savings will be negligible.

[175] If fan diameter is not provided in the customer application, then smallest range is assigned as default with the most conservative savings.

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$$= \left(\frac{599\ watts - 458\ watts}{1{,}000}\right) \times 3{,}249\ hours$$

$$= 458.11\ kWh$$

Per-measure, the gross summer coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \left(\frac{wats_{base} - watts_{ee}}{1{,}000}\right) \times CF_{summer}$$

$$= \left(\frac{599\ watts - 458\ watts}{1{,}000}\right) \times 1.00$$

$$= 0.141\ kW$$

Per-measure, the gross winter coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \left(\frac{watts_{base} - watts_{ee}}{1{,}000}\right) \times CF_{winter}$$

$$= \left(\frac{599\ watts - 458\ watts}{1{,}000}\right) \times 0.00$$

$$= 0.000\ kW$$

12.1.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 12-6.

Table 12-6. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Agriculture Energy Efficiency Program, DSM Phase IX	10.0	years	Iowa TRM v5.0 Vol.3, 2020, p.7

12.1.1.6 Source

The primary source for this deemed savings approach is the Iowa TRM v.5.0, Vol.3.0, 2021, pp.7-9 and the BESS Database.

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12.1.1.7 Update summary

Updates to this section are described in Table 12-7.

Table 12-7. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

12.1.2 High volume low-speed fan

High volume low speed (HVLS) fans provide air circulation to improve thermal comfort and indoor air quality. The measure applies to HVLS fans that are replacing multiple less efficient conventional fans in agricultural applications.

To qualify, the efficient equipment must be a fan with a diameter above 16 feet that meets program minimum efficiency requirements. Baseline is taken as the total operating wattage of conventional fans required to match the flow rate (CFM) rating of the efficient equipment. The CFM rating are estimated by HVLS fan diameter.

12.1.2.1 Impacts Estimation Approach

Per-measure, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \left(\frac{watts_{base} - watts_{ee}}{1{,}000}\right) \times HOU$$

Per-measure, the gross summer coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \left(\frac{watts_{base} - watts_{ee}}{1{,}000}\right) \times CF_{summer}$$

Per-measure, the gross winter coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \left(\frac{watts_{base} - watts_{ee}}{1{,}000}\right) \times CF_{winter}$$

Where:

ΔkWh	= per-measure gross annual electric energy savings
ΔkW_{summer}	= per-measure gross coincident summer peak demand reduction
ΔkW_{winter}	= per-measure gross coincident winter peak demand reduction
$Watts_{base}$	= operating demand (W) of baseline fan
$watts_{ee}$	= operating demand (W) of efficient fan
HOU	= equipment operating hours of use
CF_{summer}	= summer peak coincidence factor
CF_{winter}	= winter peak coincidence factor

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12.1.2.2 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 12-8. Input variables for high volume low speed fan

Component	Type	Value	Units	Source(s)
$watts_{base}$	Variable	See Table 12-4	watts	Iowa TRM v5.0, Vol.3.0, 2020, p. 14
$Watts_{ee}$	Variable	See customer application	watts	Customer application
		For defaults see Table 12-4		Iowa TRM v5.0, Vol.3.0, 2020, p. 14
HOU	Variable	See customer application	hours, annual	Customer application
		For defaults see Table 12-5		Iowa TRM v5.0, Vol.3.0, 2020, p.15
CF_{summer}	Fixed	1.00	-	Iowa TRM v5.0, Vol.3.0, 2020, p. 15[176]
CF_{winter}	Fixed	0.00	-	Iowa TRM v5.0, Vol.3.0, 2020, p. 15[177]

In Table 12-9 $Watts_{base}$ is determined by assumed installed cfm for the given fan diameter.

Table 12-9. Default base and efficient fan power

Fan diameter (ft)	$Watts_{base}$ (W)	$Watts_{ee}$ (W)
16-17.9 (default) [178]	4,497	761
18-19.9	5,026	850
20-23.9	5,555	940
24+	6,613	1,119

12.1.2.3 Default savings

If the proper values are not available, zero savings will be given for both the gross annual electric energy savings and the gross coincident peak demand reduction.

12.1.2.4 Effective Useful Life

The effective useful life of this measure is provided in Table 12-10.

Table 12-10. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Agriculture Energy Efficiency Program, DSM Phase IX	10.00	years	Iowa TRM v5.0 Vol.3, 2020, p. 13

[176] Iowa TRM v5.0, Vol.3.0, 2020, p. 14. Industrial Ventilation CF from eQuest

[177] The source TRM doesn't provide a winter demand value. The maximum ventilation is needed at temperatures above 72°F with a 67°F balance point assumed. For winter peak periods, it is assumed that little ventilation will be needed, and peak savings will be negligible.

[178] If fan diameter is not provided in the customer application, then smallest range is assigned as default with the most conservative savings.

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12.1.2.5 Source

The primary source for this deemed savings approach is the Iowa TRM v.5.0, Vol.3.0, 2020, pp.13-15.

12.1.2.6 Update summary

Updates to this section are described in Table 12-11.

Table 12-11. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

12.1.3 Ventilation fan

Agricultural ventilation fans provide ventilation air to keep animals cool. The measure applies to newly installed ventilation fans or replacing an existing unit that reached the end of its useful life in agricultural applications. The baseline condition is assumed to be a new fan that does not meet program requirements. This characterization assumes that the baseline condition uses on/off thermostatic controls to automatically operate the fans above a designated temperature threshold and shut them off when temperature drops below setpoint. The efficient equipment must be certified by BESS Labs[179] with fan diameters of at least 36 inches that meet program minimum efficiency requirements. The program requirements are shown in Table 12-14 below.

Table 12-12. Program Qualifying Efficiency Requirements

Fan diameter (in)	Tier 1 Qualifying Ventilation Efficiency Ratio (cfm/W)	Tier 2 Qualifying Ventilation Efficiency Ratio (cfm/W)
36-47	-	21.0
48-52	23.1	25.2
52+	23.1	25.0

12.1.3.1 Impacts Estimation Approach

Per-measure, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \left(\frac{watts_{base} - watts_{ee}}{1{,}000}\right) \times HOU$$

Per-measure, the gross summer coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \left(\frac{watts_{base} - watts_{ee}}{1{,}000}\right) \times CF_{summer}$$

Per-measure, the gross winter coincident demand reduction is calculated according to the following equation:

179 University of Illinois, Department of Agricultural and Biological Engineering. http://bess.illinois.edu/

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$$\Delta kW_{winter} = \left(\frac{watts_{base} - watts_{ee}}{1{,}000}\right) \times CF_{winter}$$

Where:

ΔkWh	= per-measure gross annual electric energy savings
ΔkW_{summer}	= per-measure gross coincident summer peak demand reduction
ΔkW_{winter}	= per-measure gross coincident winter peak demand reduction
$Watts_{base}$	= operating demand (W) of baseline fan
$watts_{ee}$	= operating demand (W) of efficient fan
HOU	= equipment operating hours of use
CF_{summer}	= summer peak coincidence factor
CF_{winter}	= winter peak coincidence factor

12.1.3.2 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 12-13. Input variables for ventilation fans

Component	Type	Value	Units	Source(s)
$Watts_{base}$	Variable	See Table 12-4	watts	BESS database[180]
$Watts_{ee}$	Variable	See customer application	watts	Customer application
		For defaults see Table 12-4		BESS database[181]
HOU	Variable	See customer application	hours, annual	Customer application
		For defaults see Table 12-5		Iowa TRM v5.0, Vol.3.0, 2020, p.11
CF_{summer}	Fixed	1.00	-	Iowa TRM v5.0, Vol.3.0, 2020, p. 11
CF_{winter}	Fixed	0.00	-	Iowa TRM v5.0, Vol.3.0, 2020, p. 11[182]

Table 12-14. Default base and efficient fan power

Fan Diameter (in)	$watts_{base}$ (W)	$Watts_{ee}$ (W)
36-47 (default)[183]	762	542
48-52	1,321	994
52+	1,478	1,203

180 BESS fan database downloaded on 2/22/2023. Average watts from models below standard (minimum efficiency requirement detailed in the efficient equipment definition).

181 BESS fan database downloaded on 2/22/2023. Average watts from models above standard (minimum efficiency requirement detailed in the efficient equipment definition).

182 The source TRM doesn't provide a winter demand value. The maximum ventilation is needed at temperatures above 72°F with a 67°F balance point assumed. For winter peak periods, it is assumed that little ventilation will be needed, and peak savings will be negligible.

183 If fan diameter is not provided in the customer application, then smallest range is assigned as default with the most conservative savings.

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Table 12-15. Ventilation fan hours of use by facility type

Facility type	HOU (hours)
Hog	4,923
Poultry	4,794
Dairy	4,205
Unknown/other (default)	4,800

12.1.3.3 Default savings

If the application does not provide the input variables, savings are calculated using default values where applicable.

Per-measure, the gross annual electric energy savings are calculated as follows:

$$\Delta kWh = \left(\frac{watts_{base} - watts_{ee}}{1{,}000}\right) \times HOU$$

$$= \left(\frac{762\ watts - 542\ watts}{1{,}000}\right) \times 4{,}800$$

$$= 1056.00\ kWh$$

Per-measure, the gross summer coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \left(\frac{wats_{base} - watts_{ee}}{1{,}000}\right) \times CF_{summer}$$

$$= \left(\frac{762\ watts - 542\ watts}{1{,}000}\right) \times 1.00$$

$$= 0.220\ kW$$

Per-measure, the gross winter coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \left(\frac{watts_{base} - watts_{ee}}{1{,}000}\right) \times CF_{winter}$$

$$= \left(\frac{762\ watts - 542\ watts}{1{,}000}\right) \times 0.00$$

$$= 0.000\ kW$$

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12.1.3.4 Effective Useful Life

The effective useful life of this measure is provided in Table 12-16.

Table 12-16. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Agriculture Energy Efficiency Program, DSM Phase IX	7.00	years	Iowa TRM v5.0 Vol.3, 2020, p. 10

12.1.3.5 Source

The primary source for this deemed savings approach is the Iowa TRM v.5.0, Vol.3.0, 2020, pp.10-12 and the BESS Database.

12.1.3.6 Update Summary

Updates to this section are described in Table 12-17.

Table 12-17. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

12.1.4 VFD for greenhouse ventilation fan and poultry fan

In farming facilities and greenhouses, ventilation fans are used to cool livestock and poultry to relieve the heat stress and are often used in conjunction with water sprayers or misters to enhance evaporative cooling. The airflow demand for farm animals is variable and is highly dependent on outside air temperature; fan operation at 100% fan speed is not always required. A variable frequency drive (VFD) enables the fan to operate at a reduced speed during part load conditions to match the demand; typically, there are outdoor mounted temperature sensors in the system that send control signals to the VFD. The VFD saves energy due to the cubic nature of the fan affinity laws. Fan power is proportional to the fan speed, e.g. operating at half speed theoretically requires only one-eighth of the power draw than operating at full speed.

12.1.4.1 Impacts Estimation Approach

Per-measure, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh \quad = HP \times ESF$$

It is assumed that the VSD will operate at 100% speed during peak period. Therefore, summer and winter peak demand reduction is not likely to result from this measure and was therefore not estimated.

Where:

ΔkWh = per-measure gross annual electric energy savings
HP = motor nameplate power

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ESF = deemed kWh savings per horsepower

12.1.4.2 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 12-18. Input variables for horticultural LED

Component	Type	Value	Units	Source(s)
HP	Variable	See customer application	horsepower	Customer application
ESF	Variable	Poultry: 1,851 Greenhouse: 1,853	kWh/hp	CA eTRM SWPR006-01 VSD for ventilation Fan and scaled the operation hours based on Iowa TRM v5.0 2020 page 11

12.1.4.3 Default savings

If the proper values are not available, zero savings will be given for both the gross annual electric energy savings and the gross coincident peak demand reduction.

12.1.4.4 Effective Useful Life

The effective useful life of this measure is provided in Table 12-27.

Table 12-19. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Agriculture Energy Efficiency Program, DSM Phase IX	15.00	years	CA eTRM Measure SWPR006-01

12.1.4.5 Source

The primary source for this deemed savings approach is the CA eTRM Measure SWPR006-01.

12.1.4.6 Update summary

Updates to this section are described in Table 12-20.

Table 12-20: Summary of update(s)

Version	Update type	Description
2022	-	Initial release

12.2 Lighting end use

12.2.1 Dairy lighting controls

12.2.1.1 Measure description

For agriculture applications, the lighting level are reduced using timeclock controls. Baseline is providing full illuminance for 24 hours a day, 365 days per year. This measure reduces lighting levels for six hours per day. Reduced lighting produce a sustainable increase in milk yield and save energy by reducing the power for this period.

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12.2.1.2 Impacts Estimation Approach

For retrofit application:

Per-measure, gross annual electric energy savings are coincident demand reduction is calculated according to the following equation:

$$\Delta kWh = \left[\frac{Qty_{base} \times watts_{base}}{1{,}000\ W/kW} - \left(\frac{Qty_{ee} \times watts_{ee}}{1{,}000\ W/kW} \times (1 - ESF)\right)\right] \times HOU$$

$$ESF = F_{low} \times \left(1 - \frac{watts_{ee,low}}{watts_{ee}}\right)$$

Per-measure, gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \left(\frac{Qty_{base} \times watts_{base} - Qty_{ee} \times watts_{ee}}{1{,}000\ W/kW}\right) \times CF_{summer}$$

Per-measure, gross coincident winter peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \left(\frac{Qty_{base} \times watts_{base} - Qty_{ee} \times watts_{ee}}{1{,}000\ W/kW}\right) \times CF_{winter}$$

For new construction application:

Per-measure, gross annual electric energy savings are coincident demand reduction is calculated according to the following equation:

$$\Delta kWh = \frac{Qty_{ee} \times watts_{ee}}{1{,}000\ W/kW} \times ESF \times HOU$$

$$ESF = F_{low} \times \left(1 - \frac{watts_{ee,low}}{watts_{ee}}\right)$$

Per-measure, gross coincident summer peak demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \frac{Qty_{ee} \times watts_{ee}}{1{,}000\ W/kW} \times ESF \times CF_{summer}$$

Per-measure, gross coincident winter peak demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \frac{Qty_{ee} \times watts_{ee}}{1{,}000\ W/kW} \times ESF \times CF_{winter}$$

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Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure gross coincident winter peak demand reduction
Qty_{base} = quantity of baseline fixtures
Qty_{ee} = quantity of installed fixtures equipped with bi-level occupancy control
$watts_{base}$ = baseline wattage per fixture
$watts_{ee,low}$ = installed wattage per fixture at low-power output
$watts_{ee}$ = installed wattage per fixture at full-power output, if bi-level occupancy controls are installed on existing fixtures, $watts_{ee}$ = $watts_{base}$.
F_{low} = proportion of annual operating time that fixture operates at low power
ESF = energy savings factor
HOU = hours of use per year
CF_{summer} = summer peak coincidence factor
CF_{winter} = winter peak coincidence factor

12.2.1.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 12-21. Input values for occupancy sensors and controls-stairwell integrated measure

Component	Type	Value	Unit	Source(s)
Qty_{base}	Variable	See customer application	-	Customer application
Qty_{ee}	Variable	See customer application	-	Customer application
$watts_{base}$	Variable	See customer application	watts	Customer application
$watts_{ee,low}$	Variable	See customer application	watts	Customer application
$watts_{ee}$	Variable	See customer application	watts	Customer application
F_{low}	Fixed	0.25	-	New York TRM v9, p. 834 Engineering Judgement[184]
HOU	Variable	See customer application Default: 8,760	hours, annual	Customer application New York TRM v9, p. 834
CF_{summer}	Fixed	1.00	-	New York TRM v9, p. 834
CF_{winter}	Fixed	1.00	-	New York TRM v9, p. 834[185]

12.2.1.4 Default savings

No default savings will be awarded for this measure if the proper values are not provided in the customer application.

12.2.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 12-25.

[184] This value is based on the assumed ratio of hours of light that will be in low power to existing high power operation. The assumed existing is 24/7 and low power reduction is 6 hours per day. Study from 'American Society of Agricultural and Biological Engineers', p.12 - "16 to 18 hour continuous block of light. Providing illuminance for 24 hours a day does not produce a sustainable increase in milk yield and operating the lighting system more than necessary wastes energy".

[185] The source TRM doesn't differentiate between winter and summer peak periods. Therefore, the summer CF is also applied to winter peak periods.

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Table 12-22. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Agricultural Energy Efficiency Program, DSM Phase IX	15.00	years	New York TRM v9, Appendix P186

12.2.1.6 Source(s)

The primary source for this deemed savings approach is the New York TRM v9, pp. 832-836.

12.2.1.7 Update summary

Updates made to this section are described in Table 12-26.

Table 12-23. Summary of update(s)

Version	Update Type	Description
2022	-	Initial release

12.2.2 Horticultural LED

12.2.2.1 Measure description

This measure replaces HID lighting with LED horticultural lighting fixtures. The applications include stacked indoor lighting, non-stacked indoor lighting and supplemented greenhouse lighting. Supplemented greenhouses use electric lighting to extend the hours of daylight, supplement low levels of sunlight on cloudy days, or disrupt periods of darkness to alter plant growth. Non-stacked indoor lighting grow plants in a single layer along the floor, under ceiling-mounted lighting. Stack indoor lighting

12.2.2.2 Impacts Estimation Approach

Per-measure, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \left(\frac{Qty_{base} \times watts_{base} - Qty_{ee} \times watts_{ee}}{1{,}000}\right) \times HOU$$

Per-measure, the gross summer coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \left(\frac{Qty_{base} \times watts_{base} - Qty_{ee} \times watts_{ee}}{1{,}000}\right) \times CF_{summer}$$

There are no per-measure gross winter coincident demand reduction for this measure.

[186] ComEd Luminaire Level Lighting Control IPA Program Impact Evaluation Report prepared by Navigant, 2018-06-05

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Where:

ΔkWh	= per-measure gross annual electric energy savings
ΔkW_{summer}	= per-measure gross coincident summer peak demand reduction
ΔkW_{winter}	= per-measure gross coincident winter peak demand reduction
$Watts_{base}$	= power consumption of baseline lighting fixtures
Qty_{base}	= quantity of existing or baseline fixtures/lamps
Qty_{ee}	= quantity of installed energy-efficient (ee) fixtures/lamps
$watts_{ee}$	= power consumption of efficient lighting fixtures
HOU	= equipment operating hours of use
CF_{summer}	= summer peak coincidence factor
CF_{winter}	= winter peak coincidence factor

12.2.2.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 12-24. Input variables for horticultural LED

Component	Type	Value	Units	Source(s)
Qty_{base}	Variable	See customer application	-	Customer application
		For new construction projects, $Qty_{base} = Qty_{ee}$	-	Engineering Judgement
Qty_{ee}	Variable	See customer application	-	Customer application
$watts_{base}$	Variable	See customer application	watts	Customer application
		For new construction projects, Table 12-25		U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy. "Energy Savings Potential of SSL in Horticultural Applications, 2017[187]
$Watts_{ee}$	Variable	See customer application	watts	Customer application
HOU	Variable	See customer application[188]	hours, annual	Customer application
		For defaults see Table 12-26		Wisconsin TRM 2021, p. 27
CF_{summer}	Variable	For defaults see Table 12-26	-	Wisconsin TRM 2021, p. 28

Table 12-25. Default base and efficient horticultural LED lighting fixture wattage

Facility	$Watts_{base}$ (W)
Non-Stacked Indoor	$= Watts_{ee} \times 1.43$
Stacked Indoor (default)	$= Watts_{ee} \times 1.10$

[187] The Wisconsin TRM 2021 methodology only offers discrete wattage ranges, to accommodate various fixtures sizes, the Watts per sq. ft. weighted by lighting technology and the location. https://www.energy.gov/sites/prod/files/2017/12/f46/ssl_horticulture_dec2017.pdf

[188] The HOU = customer application hours/day x 365 days per year. The WI TRM references this study "Energy Savings Potential of SSL in Horticultural Applications", and it assumes 365 days

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Facility	$Watts_{base}$ (W)
Supplemented Greenhouse	$= Watts_{ee} \times 1.42$

Table 12-26. Horticultural LED lighting fixture hours of use by facility type

Facility	HOU (hours)	CF_{summer}
Non-stacked indoor	5,475	1.0
Stacked indoor (default)	6,278	1.0
Supplemented greenhouse	2,120	0

12.2.2.4 Default savings

If the proper values are not available, zero savings will be given for both the gross annual electric energy savings and the gross coincident peak demand reduction.

12.2.2.5 Effective Useful Life

The effective useful life of this measure is provided in Table 12-27.

Table 12-27. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Agriculture Energy Efficiency Program, DSM Phase IX	For Non-Stacked Indoor 10.00 Supplemented Greenhouse 20.00	years	Wisconsin TRM 2021, p. 28

12.2.2.6 Source

The primary source for this deemed savings approach is the Wisconsin TRM 2021, pp.26-31.

12.2.2.7 Update summary

Updates to this section are described in Table 12-28.

Table 12-28. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

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12.2.3 Poultry LED

12.2.3.1 Measure description

This measure applies to the replacement of high-intensity discharge (HID), incandescent, and fluorescent fixtures with light emitting diode (LED) fixtures in poultry farms.

12.2.3.2 Impacts Estimation Approach

Per-measure, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \left(\frac{Qty_{base} \times watts_{base} - Qty_{ee} \times watts_{ee}}{1{,}000}\right) \times HOU \times Days$$

Per-measure, the gross summer coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \left(\frac{Qty_{base} \times watts_{base} - Qty_{ee} \times watts_{ee}}{1{,}000}\right) \times CF_{summer}$$

Per-measure, the gross winter coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \left(\frac{Qty_{base} \times watts_{base} - Qty_{ee} \times watts_{ee}}{1{,}000}\right) \times CF_{winter}$$

Where:

ΔkWh	= per-measure gross annual electric energy savings
ΔkW_{summer}	= per-measure gross coincident summer peak demand reduction
ΔkW_{winter}	= per-measure gross coincident winter peak demand reduction
Qty_{base}	= quantity of existing or baseline fixtures/lamps
Qty_{ee}	= quantity of installed energy-efficient (ee) fixtures/lamps
$Watts_{base}$	= power consumption of baseline lighting fixtures
$watts_{ee}$	= power consumption of efficient lighting fixtures
HOU	= equipment operating hours of use
CF_{summer}	= summer peak coincidence factor
CF_{winter}	= winter peak coincidence factor

12.2.3.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 12-29. Input variables for Horticultural LED

Component	Type	Value	Units	Source(s)
Qty_{base}	Variable	See customer application	-	Customer application
Qty_{ee}	Variable	See customer application	-	Customer application
$watts_{base}$	Variable	See customer application	watts	Customer application

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Component	Type	Value	Units	Source(s)
		Default: 60W		Minnesota TRM v3.2, p.568
$Watts_{ee}$	Variable	See customer application	watts	Customer application
		Default: 10W		Minnesota TRM v3.2, p.568
HOU	Variable	See customer application	hours, daily	Customer application
		Default: 16		Minnesota TRM v3.2, p.568
Days	Variable	See customer application	days, annual	Customer application
		365		Minnesota TRM v3.2, p.568
CF_{summer}	Fixed	1.0	-	Minnesota TRM v3.2, p.568[189]
CF_{winter}	Fixed	1.0	-	Minnesota TRM v3.2, p.568[189]

12.2.3.4 Default savings

If the proper values are not available, zero savings will be given for both the gross annual electric energy savings and the gross coincident peak demand reduction.

12.2.3.5 Effective Useful Life

The effective useful life of this measure is provided in Table 12-30.

Table 12-30. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Agriculture Energy Efficiency Program, DSM Phase IX	7.00	years	Wisconsin TRM 2021, p. 28

12.2.3.6 Source

The primary source for this deemed savings approach is the Wisconsin TRM 2021, pp.26-31.

12.2.3.7 Update summary

Updates to this section are described in Table 12-31.

Table 12-31. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

[189] Minnesota TRM v3.2, doesn't specify the season coincidence factor (CF), we apply CF value for both summer and winter seasons.

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12.2.4 T5/T8 Lamps

This measure is also provided by the Non-Residential Lighting Systems and Controls Program, DSM Phase VII. The savings are determined using the methodology described in Section 1.1.1.

12.3 Process end use

12.3.1 Automatic milker take-off

12.3.1.1 Measure description

This measure characterizes the energy savings for the installation of automatic milker takeoffs on dairy milking vacuum pump systems. Automatic milker takeoff measure reduces energy use by shutting off the milking vacuum pump suction once a minimum flowrate has been achieved.

This measure requires the installation of automatic milker takeoffs to replace pre-existing manual takeoffs on dairy milking vacuum pump systems. Equipment with existing automatic milker takeoffs is not eligible. In addition, the vacuum pump system serving the impacted milking units must be equipped with a variable speed drive (VSD) to qualify for incentives. Without a VSD, little or no savings will be realized.

12.3.1.2 Impacts Estimation Approach

Per-measure, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = N_{cows} \times N_{milkings} \times ESC$$

Per-measure, the gross summer coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \frac{\Delta kWh}{FLH} \times CF_{summer}$$

Per-measure, the gross winter coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \frac{\Delta kWh}{FLH} \times CF_{winter}$$

Where:

ΔkWh	= per-measure gross annual electric energy savings
ΔkW_{summer}	= per-measure gross coincident summer peak demand reduction
ΔkW_{winter}	= per-measure gross coincident winter peak demand reduction
N_{COWS}	= number of cows milked per day
$N_{milkings}$	= number of milkings per day
ESC	= annual energy savings per cow
FLH	= full load hours
CF_{summer}	= summer peak coincidence factor
CF_{winter}	= winter peak coincidence factor

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12.3.1.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 12-32. Input variables for automatic milker take off

Component	Type	Value	Units	Source(s)
ESC	Fixed	50.0	kWh/cow/milking	Iowa TRM Vol. 3, Non-Residential Measures TRM v.7, 2022, p.18
N_{cows}	Variable	See customer application	cows/farm	Customer application
		Default: 83		2017 Census of Agriculture – State Data, USDA, National Agricultural Services, Virginia state average cows per farm[190]
$N_{milkings}$	Variable	See customer application	milkings/day	Customer application
		Default: 2.0		Iowa TRM Vol. 3, Non-Residential Measures TRM v.7, 2022, p.18
FLH	Fixed	2,703	hours	Iowa TRM Vol. 3, Non-Residential Measures TRM v.7, 2022, p.19
CF_{summer}	Fixed	0.793	-	Iowa TRM Vol. 3, Non-Residential Measures TRM v.7, 2022, p.19
CF_{winter}	Fixed	0.793	-	Iowa TRM Vol. 3, Non-Residential Measures TRM v.7, 2022, p.19

12.3.1.4 Default savings

If the application does not provide the input variables, savings are calculated using default values where applicable.

Per-measure, the gross annual electric energy savings are calculated as follows:

$$\Delta kWh = N_{cows} \times N_{milkings} \times ESC$$

$$= 83\ cows \times 2.0\ milkings \times 50\ kWh/cow/\ milking$$

$$= 8{,}300.00\ kWh$$

Per-measure, the gross summer coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \frac{\Delta kWh}{FLH} \times CF_{summer}$$

190 https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_1_State_Level/Virginia/st51_1_0017_0019.pdf

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$$= \frac{8{,}300\ kWh}{2{,}703} \times 0.793$$

$$= 2.435\ kW$$

Per-measure, the gross winter coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \frac{\Delta kWh}{FLH} \times CF_{winter}$$

$$= \frac{8{,}300\ kWh}{2{,}703} \times 0.793$$

$$= 2.435\ kW$$

12.3.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 12-33.

Table 12-33. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Agriculture Energy Efficiency Program, DSM Phase IX	10.00	years	Iowa TRM Vol. 3, Non-Residential Measures TRM v.7, 2022, p.18

12.3.1.6 Source

The primary source for this deemed savings approach is the Iowa TRM Vol. 3, Non-Residential Measures TRM v.7, 2022, p.18 Vol. 3, pp.18-19.

12.3.1.7 Update summary

Updates to this section are described in Table 12-34.

Table 12-34. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

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12.3.2 Dairy plate cooler

12.3.2.1 Measure description

This measure characterizes the energy savings from the installation of plate-style milk precoolers on a dairy parlor milk refrigeration system. A plate cooler uses incoming well water to precool the milk before it enters the bulk tank reducing the cooling load on the compressors and resulting in energy savings.

The criterion for this measure is the installation of a plate-style milk precooler in a dairy parlor with no additional efficiency or system requirements. The baseline is dairy parlor milk refrigeration systems, without existing plate-style milk precooler.

12.3.2.2 Impacts Estimation Approach

Per-measure, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh \quad = \Delta kWh_{cow} \times N_{cows}$$

$$\Delta kWh_{cow} \quad = \left(Days \times C_{p,milk} \times Lbs_{milk} \times \Delta T - Heat\ Recovery\right) \times \frac{1}{ERR} \times \frac{1\ W}{1000\ kW}$$

Per-measure, the gross summer coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} \quad = \frac{\Delta kWh}{FLH} \times CF_{summer}$$

Per-measure, the gross winter coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} \quad = \frac{\Delta kWh}{FLH} \times CF_{winter}$$

Where:

ΔkWh	= per-measure gross annual electric energy savings
ΔkWh_{cow}	= per cow annual energy savings from plate-style milk precooler
ΔkW_{summer}	= per-measure gross coincident summer peak demand reduction
ΔkW_{winter}	= per-measure gross coincident winter peak demand reduction
N_{cows}	= number of cows
Days	= number of milking days per year
$C_{p,milk}$	= specific heat of milk
Lbs_{Milk}	= the pounds of milk produced per day per cow that needs to be cooled
ΔT	= temperature reduction of the milk across precooler
Heat Recovery	= difference in Btu/h per cow per year recovered by heat reclaimer system with and without precooler
EER	= efficiency of the existing compressor on the milk refrigeration system
FLH	= full load hours. The refrigeration is assumed to be in operation every day of the year, but because of compressor cycling the full load hours are based on the run time of compressors for medium temperature refrigeration applications.

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CF_{summer} = summer peak coincidence factor
CF_{winter} = winter peak coincidence factor

12.3.2.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 12-35. Input variables for dairy plate cooler

Component	Type	Value	Units	Source(s)
N_{cows}	Variable	See customer application	cows/farm	Customer application
		For default N_{cows} = 83		2017 Census of Agriculture – State Data, USDA, National Agricultural Services, Virginia state average cows per farm[191]
Days	Fixed	365	days, annual	Iowa TRM v5.0 Vol.3, 2021, p. 41
$C_{p,milk}$	Fixed	0.93	Btu/(lb-°F)	Iowa TRM v5.0 Vol.3, 2021, p. 41
Lbs_{Milk}	Fixed	51.6	lb/day/cow	Iowa TRM v5.0 Vol.3, 2021, p. 41
ΔT	Fixed	40.0	°F	Iowa TRM v5.0 Vol.3, 2021, p. 41
Heat Recovery	Variable	See Table 12-36	Btu/h / cow/year	Customer application
EER	Variable	See Table 16-29	kBtu/kW-hour	Customer application
FLH	Fixed	3,910	-	Iowa TRM v5.0 Vol.3, 2021, p. 42
CF_{summer}	Fixed	0.79	-	Iowa TRM v5.0 Vol.3, 2021, p. 42
CF_{winter}	Fixed	0.79	-	Iowa TRM v5.0 Vol.3, 2021, p. 42[192]

Table 12-36. Difference in Btu/h recovered by heat reclaimer (heat recovery) for water heater type

Water heater type	Heat Recovery (Btu/h-cow-year)
Non-electric	0
Electric with heat reclaimer on-site (default)	131,562

Table 12-37. Energy Efficiency Ratio (EER) for various compressor types

Compressor type	EER
Reciprocating compressor	8.4
Scroll compressor	10.9
Unknown compressor (default)	9.3

[191] https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_1_State_Level/Virginia/st51_1_0017_0019.pdf

[192] The summer CF value is applied for winter CF as the source TRM does not provided. As milkings are spread throughout the day, this assumption is reasonable.

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12.3.2.4 Default savings

If the application does not provide the input variables, savings are calculated using default values where applicable.

Per-measure, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh_{cow} = \left(Days \times C_{p,milk} \times Lbs_{milk} \times \Delta T - Heat\ Recovery\right) \times \frac{1}{ERR} \times \frac{1\ W}{1000\ kW}$$

$$= (365\ days \times (0.93Btu/(lb.°F)) \times 51.6\ lb/day/cow \times 40.0\ °F - 131{,}562Btuh/cow/year) \times \frac{1}{9.3\ kBtu/kW.hour} \times \frac{1\ W}{1000\ kW}$$

$$= 61.2\ kWh$$

$$\Delta kWh = kWh_{cow} \times N_{cows}$$

$$= 61.2\ kWh \times 83$$

$$= 5{,}079.6\ kWh$$

Per-measure, the gross summer coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \frac{\Delta kWh}{FLH} \times CF_{summer}$$

$$= \frac{5079.6\ kWh}{3{,}910\ hours} \times 0.79$$

$$= 1.026\ kW$$

Per-measure, the gross winter coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \frac{\Delta kWh}{FLH} \times CF_{winter}$$

$$= \frac{5079.6\ kWh}{3{,}910\ hours} \times 0.79$$

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$$= 1.026\ kW$$

12.3.2.5 Effective Useful Life

The effective useful life of this measure is provided in Table 12-38.

Table 12-38. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Agricultural Energy Efficiency Program, DSM Phase IX	15.00	years	Iowa TRM v5.0 Vol.3, 2021, p. 40

12.3.2.6 Source

The primary source for this deemed savings approach is the Iowa TRM v 3, 2021, pp.40-42

12.3.2.7 Update summary

Updates to this section are described in Table 12-39.

Table 12-39. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

12.3.3 Grain storage aeration fan controls

12.3.3.1 Measure description

This measure involves replacing existing manual controls on grain storage bin aeration fans with controls that use temperature and moisture sensors to modulate fan operation automatically. Electric savings are achieved by reducing the aeration fan run hours. With manual controls, the fans are run more frequently and for longer than needed. The inclusion of controls, including moisture and temperature sensors, allow the fans to be run only when needed.

Grain bins using heating grain drying are not eligible for participation in this measure. The reported height of the grain bin must be the eave height and not the height of the peak. This measure is limited to bins equal to, or less than, 105 ft. in diameter or 100 ft. in eave height.

12.3.3.2 Impacts Estimation Approach

Per-measure, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = hp_{fan} \times \Delta kWh_{hp}$$

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$$\Delta kWh_{hp} = 0.746 \times (HOU_{base} - HOU_{ee}) \times \left(\frac{1}{\eta}\right)$$

There are no gross summer and winter coincident demand reductions associated with this measure.

$$\Delta kW_{summer} = 0\ kW$$

$$\Delta kW_{winter} = 0\ kW$$

Where:

ΔkWh	= per-measure gross annual electric energy savings
ΔkW_{summer}	= per-measure gross coincident summer peak demand savings
ΔkW_{winter}	= per-measure gross coincident winter peak demand savings
hp_{fan}	= required fan brake horsepower (including motor loading) of controlled fan to provide the necessary aeration to grain bin
ΔkWh_{fan}	= the kWh savings per brake horsepower for grain bin aeration fans
0.746	= conversion factor for horsepower to kilowatt
HOU_{base}	= hours of use for baseline condition
HOU_{ee}	= hours of use for energy efficient condition
η	= nameplate efficiency of the fan motor

12.3.3.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 12-40. Input variables for grain storage aeration fan control

Component	Type	Value	Units	Source(s)
hp_{fan}	Variable	See customer application	hp	Customer application
		Default: See Table 16-29		Iowa TRM v.5.0, Vol 3.2, p. 52
HOU_{base}	Variable	See customer application	hours, annual	Customer application
		720[193]		Iowa TRM v.5.0, Vol 3.2, p. 50
HOU_{ee}	Variable	See customer application	hours, annual	Customer application
		180[194]		Iowa TRM v.5.0, Vol 3.2, p. 50
η	Variable	See customer application	-	Customer application
		Default: 0.936195		Iowa TRM v.5.0, Vol 3.2, p. 50

The following table provides the default fan based on the grain bin dimensions. The height of the storage bin walls is measured from before the roof begins; not to be confused with peak height, which is the top of the roof.

193 The default manual control hours are sourced from Alliant Energy Custom Rebate Project Data from 2013-2015.

194 The default hours of operation of the fans with controls is sourced from Alliant Energy Custom Rebate Project Data from 2013-2015, leveraging Integris fan control runtime models.

195 Motor efficiency is based on a NEMA Premium Efficient, 60 hp, ODP, 3600 RPM motor. This is a typical fan motor for larger bin sizes, as supported by Alliant Energy Custom Rebate Project Data from 2013-2015.

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Table 12-41. Required fan brake horsepower (hp_{fan}) based on grain bin size

Eave height (ft)	Diameter of grain bin (ft)										
	24	36	42	48	54	60	72	75	78	90	105
20	0.50	1	1	1	1	2	2	2	3	3	5
30	1	1	2	2	3	4	5	5	6	8	11
35	1	2	3	3	4	5	8	8	9	12	17
40	1	3	4	5	7	8	12	13	14	18	25
45	2	4	6	8	10	12	17	19	20	27	37
50	3	6	8	11	14	17	24	26	29	38	52
55	4	8	11	15	19	23	33	36	39	52	71
60	5	11	15	20	25	31	45	48	52	70	95
65	6	15	20	26	33	40	58	63	68	91	124
70	8	19	25	33	42	52	75	81	88	117	159
75	10	23	32	42	53	65	94	102	110	147	200
80	13	29	40	52	65	81	116	126	137	182	247
85	16	36	48	63	80	99	142	154	167	222	302
90	19	43	58	76	97	119	172	186	202	268	365
95	23	51	70	91	115	142	205	223	241	321	436
100	27	61	83	108	137	169	243	263	285	379	516

12.3.3.4 Default savings

There are no default savings for this measure because if the proper fan power is not available, the savings are dependent on the grain bin dimensions and corresponding default fan power that is needed to provide the necessary aeration to the grain bin.

12.3.3.5 Effective Useful Life

The effective useful life of this measure is provided in Table 12-42.

Table 12-42. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Agricultural Energy Efficiency Program, DSM Phase IX	7.00	years	Iowa TRM v.5.0, Vol 3.2, p. 49

12.3.3.6 Source

The primary source for this deemed savings approach is the Iowa TRM v5.0, Vol 3.2, pp. 48-53.

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12.3.3.7 Update summary

Updates to this section are described in Table 12-43.

Table 12-43: Summary of update(s)

Version	Update type	Description
2022	-	Initial release

12.3.4 Low-pressure irrigation

12.3.4.1 Measure description

This measure characterizes the energy savings from the replacement of an existing irrigation system with a more energy-efficient system. Low-pressure nozzles are used to decrease the necessary pump pressure. The criterion for this measure is a new irrigation system that reduces the pump pressure of an existing system by at least 50%. The baseline for this measure is the existing irrigation system.

12.3.4.2 Impacts Estimation Approach

Per-measure, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \frac{HOU \times GPM \times (PSI_{base} - PSI_{ee}) \times Area}{\left(\frac{1{,}714\,PSI \times GPM}{HP}\right) \times \eta_{pump}} \times \left(\frac{0.746\ kW}{HP}\right)$$

Per-measure, the gross summer coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \left(\frac{\Delta kWh}{FLH}\right) \times CF_{summer}$$

Per-measure, the gross winter coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \left(\frac{\Delta kWh}{FLH}\right) \times CF_{winter}$$

Where:

ΔkWh	= per-measure gross annual electric energy savings
ΔkW_{summer}	= per-measure gross coincident summer peak demand reduction
ΔkW_{winter}	= per-measure gross coincident winter peak demand reduction
PSI_{base}	= pump pressure before retrofit
PSI_{ee}	= pump pressure resulting from retrofit
GPM	= pump flow rate per acre for agriculture applications
Area	= Irrigated land area
HOU	= hours of use of irrigation system
η_{ee}	= pump motor efficiency
FLH	= operating hours of use
CF_{summer}	= summer peak coincidence factor

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CF_{winter} = winter peak coincidence factor

12.3.4.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 12-44. Input variables for low-pressure irrigation

Component	Type	Value	Units	Source(s)
PSE_{base}	Variable	See customer application	psi	Customer application
PSE_{ee}	Variable	See customer application	psi	Customer application
Area	Variable	See customer application	acres	Customer application
GPM	Fixed	5.0	gallons/ minute/acre	Iowa TRM vol.3, 2021, p.36
HOU	Fixed	864	hours, annual	Iowa TRM vol.3, 2021, p.36
η_{ee}	Fixed	0.70	-	Iowa TRM vol.3, 2021, p.36
FLH	Fixed	6,768	hours, annual	Iowa TRM vol.3, 2021, p.36
CF_{summer}	Fixed	0.793	-	Iowa TRM vol.3, 2021, p.37
CF_{winter}	Fixed	0.00	-	Iowa TRM vol.3, 2021, p.37

12.3.4.4 Default savings

If the proper values are not available, zero savings will be given for both the gross annual electric energy savings and the gross coincident peak demand reduction.

12.3.4.5 Effective Useful Life

The effective useful life of this measure is provided in Table 12-45.

Table 12-45. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Agriculture Energy Efficiency Program, DSM Phase IX	5.00	years	Iowa TRM vol.3, 2021, p.36

12.3.4.6 Source

The primary source for this deemed savings approach is the Iowa TRM vol.3, 2021, pp.36-37.

12.3.4.7 Update summary

Updates to this section are described in Table 12-46.

Table 12-46. Summary of update(s)

Version	Update Type	Description
2022	-	Initial release

12.3.5 VFD for dust collection

12.3.5.1 Measure description

This measure pertains to the installation of a variable speed drive (VSD) on an existing fan for a dust collection fan system, commonly known as a baghouse, utilized by agricultural and industrial customers. The use of a VSD for dust collection systems allows for fan speed modulation based on the real time load of the system while maintaining the air velocity needed for the particulates. Controls such as pressure transducers, flow sensors, or velocity sensors are needed to provide feedback to the VSD during operation.

12.3.5.2 Impacts Estimation Approach

Per-measure, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = kWh_{Baseline} - kWh_{Measure}$$

$$kWh_{Baseline} = \frac{HP \times LF \times 0.746}{Eff_{Motor}} \times Hours$$

$$kWh_{Measure} = kWh_{Baseline} \times \frac{Ave\ Speed \times AfflawExp}{Eff_{VFD}}$$

It is assumed that the VSD will operate at 100% speed during peak period. Therefore, summer and winter peak demand reductions are not likely to result from this measure and was therefore not estimated.

Where:

ΔkWh	= per-measure gross annual electric energy savings
$\Delta kWh_{Baseline}$	= per-measure gross annual electric energy consumption in baseline case
$\Delta kWh_{Measure}$	= per-measure gross annual electric energy consumption in measure case
HP	= motor nameplate power
LF	= load factor
Hours	= annual operation hours
Eff_{Motor}	= efficiency of the motor
Ave Speed	= average operation speed of VFD
AfflawExp	= affinity law exponent
Eff_{VFD}	= efficiency of the VFD

12.3.5.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

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Table 12-47. Input variables for dust collection

Component	Type	Value	Units	Source(s)
HP	Variable	See customer application	hp	Customer application
LF	Variable	See customer application	-	Customer application
		Default: 0.65		CA eTRM Measure SWPR005-02, SWPR005-02, VFD for Dust Collection Fan
Hours	Variable	See customer application	hour, annual	Customer application
		Default: 5,544		CA eTRM Measure SWPR005-02, SWPR005-02, VFD for Dust Collection Fan
Eff_{Motor}	Fixed	0.94	-	CA eTRM Measure SWPR005-02, SWPR005-02, VFD for Dust Collection Fan
Ave Speed	Variable	See Table 12-48	-	CA eTRM Measure SWPR005-02, SWPR005-02, VFD for Dust Collection Fan
AfflawExp	Fixed	2.7	-	CA eTRM Measure SWPR005-02, SWPR005-02, VFD for Dust Collection Fan
Eff_{VFD}	Fixed	0.97	-	CA eTRM Measure SWPR005-02, SWPR005-02, VFD for Dust Collection Fan

Table 12-48. VFD Average Speed

Motor size (hp)	VFD Average operating speed
10	94.97%
15	85.26%
20	83.08%
25	73.86%
30	76.88%
40	76.71%
50	85.31%
60	75.57%
75	77.13%
100	79.92%
125	82.93%
150	86.17%

12.3.5.4 Default savings

If the proper values are not available, zero savings will be given for both the gross annual electric energy savings and the gross coincident peak demand reduction.

12.3.5.5 Effective Useful Life

The effective useful life of this measure is provided in Table 12-49.

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Table 12-49. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Agriculture Energy Efficiency Program, DSM Phase IX	13.00	years	CA eTRM Measure SWPR005-02, SWPR005-02, VFD for Dust Collection Fan

12.3.5.6 Source

The primary source for this deemed savings approach is the CA eTRM Measure SWPR005-02, VFD for Dust Collection Fan.

12.3.5.7 Update summary

Updates to this section are described in Table 12-50.

Table 12-50. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

12.3.6 VFD for irrigation pump

12.3.6.1 Measure description

This measure pertains to the installation of a variable frequency drive (VFD) on an existing irrigation pump. The existing pump operates at constant speed while irrigating. Irrigation systems are designed to meet the worst-case hydraulic conditions. This results in the typical operation to provide more pressure than is necessary. Additionally, the number of blocks that are irrigated may vary over time. In the efficient case, the VFD adjusts the motor speed to maintain minimum setpoints while reducing the motor power.

12.3.6.2 Impacts Estimation Approach

Per-measure, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh \quad = HP \times ESF$$

Per-measure, the gross summer coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} \quad = HP \times DSF$$

There are no gross winter coincident demand reductions for this measure.

Where:

ΔkWh = per-measure gross annual electric energy savings
HP = motor nameplate power
ESF = deemed kWh savings per horsepower
DSF = deemed kW reduction per horsepower

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12.3.6.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 12-51. Input variables for irrigation pump

Component	Type	Value	Units	Source(s)
HP	Variable	See customer application	horsepower	Customer application
ESF	Variable	For HP ≤ 75 hp: 284 For HP > 75 hp: 276	kWh/hp	CA eTRM SWP0005-02 Enhanced Variable Frequency Drive on Irrigation Pump
DSF	Variable	For HP ≤ 75 hp: 0.120 For HP > 75 hp: 0.177	kW/hp	CA eTRM SWP0005-02 Enhanced Variable Frequency Drive on Irrigation Pump

12.3.6.4 Default savings

If the proper values are not available, zero savings will be given for both the gross annual electric energy savings and the gross coincident peak demand reduction.

12.3.6.5 Effective Useful Life

The effective useful life of this measure is provided in Table 12-52.

Table 12-52. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Agriculture Energy Efficiency Program, DSM Phase IX	10.00	years	CA eTRM Measure SWP0005-02 Enhanced Variable Frequency Drive on Irrigation Pump

12.3.6.6 Source

The primary source for this deemed savings approach is the Wisconsin TRM 2021, pp.26-31.

12.3.6.7 Update summary

Updates to this section are described in Table 12-53.

Table 12-53. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

12.3.7 VFD for tobacco curing

12.3.7.1 Measure description

This measure pertains to the installation of a variable frequency drive (VFD) on an existing fan for the tobacco curing process. The existing fan operates at constant speed throughout the curing process. In the efficient case, the VFD adjusts the fan speed to maintain minimum setpoints while reducing the fan power.

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12.3.7.2 Impacts Estimation Approach

Per-measure, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \frac{HP \times LF \times 0.746}{Eff_{Motor}} \times Hours \times ESF$$

It is assumed that the VSD will operate at 100% speed during peak period. Therefore, summer and winter peak demand reductions are not likely to result from this measure and was therefore not estimated.

Where:

ΔkWh	= per-measure gross annual electric energy savings
$\Delta kWh_{Baseline}$	= per-measure gross annual electric energy consumption in baseline case
$\Delta kWh_{Measure}$	= per-measure gross annual electric energy consumption in measure case
HP	= motor nameplate power
LF	= motor load factor
Hours	= annual operation hours
Eff_{Motor}	= efficiency of the motor
ESF	= energy savings factor of VFD

12.3.7.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 12-54. Input variables for tobacco curing

Component	Type	Value	Units	Source(s)
HP	Variable	See customer application	hp	Customer application
LF	Variable	See customer application	-	Customer application
		Default: 0.65		Maryland/Mid-Atlantic TRM v.10, p. 297[196]
Hours	Variable	See customer application	hour, annual	Customer application
		Default: 1,920		Engineering estimate[197]
Eff_{Motor}	Fixed	0.917	-	NEMA Standards Publication Condensed MG 1-2007[198]
ESF	Fixed	0.20	-	NC State University 2011 Natural Resources & Conservation, Research Impacts, Part 1[199]

12.3.7.4 Default savings

If the proper values are not available, zero savings will be given for both the gross annual electric energy savings and the gross coincident peak demand reduction.

196 Assigned HVAC LF
197 Assumed an eight-day cycle and 10 cycles (8 days/cycle x 24 hours x 10 cycles= 1,920 hours)
198 10 hp motor is assumed
199 An estimate of 20% to 25% savings is estimated from a case study" https://harvest.cals.ncsu.edu/research/?p=52403

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12.3.7.5 Effective Useful Life

The effective useful life of this measure is provided in Table 12-55.

Table 12-55. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Agriculture Energy Efficiency Program, DSM Phase IX	15.00	years	Maryland/Mid-Atlantic TRM v.10, p. 301[200]

12.3.7.6 Source

The primary source for this deemed savings approach is the NC State University 2011 Natural Resources & Conservation, Research Impacts, Part 1.

12.3.7.7 Update summary

Updates to this section are described in Table 12-56.

Table 12-56. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

[200] Assigned HVAC LF

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13 NON-RESIDENTIAL BUILDING AUTOMATION SYSTEM PROGRAM, DSM PHASE IX

The Non-Residential Building Automation System Program provides qualifying non-residential customers with incentives to install new building automation systems in facilities that do not have centralized controls or have an antiquated system that requires full replacement. With the new control system, the control strategies are customized based on the facility and HVAC system type. During the project design phase, the program provides recommended design improvements, which may include adding control points and features, and revises control sequences to capture more savings.

The building must be an existing building and at least 50,000 sq. ft. Both electric and gas heating HVAC systems are eligible. Once the new system is installed on site, the program includes a thorough system test to validate energy savings and performance.

13.1 Cross-cutting end uses

13.1.1 Building automation system

13.1.1.1 Measure description

This measure involves the replacement of existing control systems with centralized control system. Centralized controls and new control sequences allow for the more efficient operation of equipment savings energy. The new control system must be DDC control system and serve HVAC equipment.

Recommendations are made based on industry best practices. Potential measures include:

- Chilled Water Temperature Reset
- Cooling Tower Condenser Water Temperature Reset
- Variable-Speed Pumping with Valve Position Feedback
- Air Handling Unit Adaptive Optimal Start
- Single-Zone Constant-Volume AHU to Variable-Volume Conversion
- Constant-Volume Dual-Duct AHU to Variable-Volume Conversion
- Partial Airside Economizer Integration with Mechanical Cooling
- Multi-Zone VAV AHU Static Pressure Reset with Zone Damper Position Feedback
- Ventilation Optimization, Dynamic Ventilation Reset, based on ASHRAE 62.1
- CO2-based Demand Control Ventilation (DCV)
- Modulating Building Relief Control
- Dual-Maximum VAV Terminal Unit Logic
- Fan-Powered VAV Terminal Unit Fan Speed Control

13.1.1.2 Impacts Estimation Approach

The initial methodology for calculating impacts utilizes a fixed percent of whole building annual consumption. Additionally, the program develops regression models to assess and validate savings. These weather-normalized consumption models use 12 months of baseline consumption and 12 months of post installation consumption data.

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Due to the nature of this approach, the results are not available at the time the project is implementer. Therefore, these savings cannot be applied directly. Results will be considered in assessing if adjustments to the impact methodology is needed in the future.

Per-measure, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh \quad = ESF \times kWh_{whole\ facility}$$

This measure may have some gross coincident summer or winter peak demand reductions depending on which recommendations are implemented. However, impacts are assumed to be primarily focused on energy savings. No demand impacts are calculated.

Where:

ΔkWh = per-measure gross annual electric energy savings
$kWh_{whole\ facility}$ = whole facility annual energy consumption
ESF = energy savings factor

13.1.1.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 13-1. Input variables for Building Automation System

Component	Type	Value	Units	Source(s)
$kWh_{whole\ facility}$	Variable	See customer application	kWh	Customer application
ESF	Fixed	0.05	-	Building Commissioning Costs and Savings Across Three Decades and 1,500 North American Buildings[201]

13.1.1.4 Default savings

If the proper values are not available, zero savings will be given for gross annual electric energy savings.

13.1.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 13-2.

[201] Berkeley Lad, Building Technology & Urban Systems Division, https://buildings.lbl.gov/publications/building-commissioning-costs-and

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Table 13-2. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Building Automation System Program, DSM Phase IX	5.00	years	Wisconsin TRM 2022, p. 369[202]

13.1.1.6 Source

The primary source for this Update summary

Updates to this section are described in Table 13-3.

Table 13-3. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

[202] The chiller plant setpoint adjustment measure life is used as the control system will have a similar measures life.

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14 NON-RESIDENTIAL BUILDING OPTIMIZATION PROGRAM, DSM PHASE IX

The Non-Residential Building Optimization Program is an expansion of the Non-Residential Office Program, DSM Phase VII. The program offers the same measures available in DSM Phase VII Non-Residential Office Program, along with seven additional measures. This program offers rebates for retro-commissioning improvements to the facilities energy management system. Participants may receive a facility assessment and measure implementation, as well as incentives to offset the cost of making recommended improvements. To qualify for this program, the customer must be responsible for the electric bill and must be the owner of the facility or reasonably able to secure permission to complete the measures. All program measures are summarized in Table 14-1.

Table 14-1. Non-Residential Building Optimization Program measure list

End use	Measure	Legacy program	Manual section
Lighting	Reduce lighting schedule	Non-Residential Office Program, DSM Phase VII	Section 7.2.1
HVAC	HVAC unit scheduling		Section 7.3.1
	HVAC temperature setback		Section 7.3.2
	Condensing		Section 7.3.3
	HVAC discharge air temperature reset		Section 7.3.4
	HVAC static pressure reset		Section 7.3.5
	HVAC VAV minimum flow reduction		Section 7.3.6
	Dual enthalpy air-side economizer		Section 2.1.5
	Temperature setup	N/A	Section 14.3.8
	Chilled water reset		Section 14.3.9
	Outdoor air reduction		Section 14.3.10
	Coil cleaning		Section 14.3.11
	Pump pressure reduction		Section 14.3.12
	Schedule equipment		Section 14.3.13
	Custom retro-commissioning measure		Section 14.3.14

Energy savings for the majority of measures are based on building model simulations. Measures that do not use this approach are Dual enthalpy air-side economizer (Section 2.1.5). Schedule Equipment, and Custom Retro-commissioning measures. The following sections describe the building model simulation approach as well as energy savings factors. Measure descriptions and how energy savings factors are applied are describing in each measure section.

14.1.1 Building model simulation description

Measures that are not from the legacy Office Program and utilize the building model simulation approach are described in this section. The U.S. Department of Energy (DOE) reference building “Medium Office” with code vintage defined as ASHRAE 90.1-2007 is used as the basis for the baseline and installed case building models.[203] Current

[203] U.S. Department of Energy. Office of Energy Efficiency & Renewable Energy. Commercial Reference Buildings. https://www.energy.gov/eere/buildings/commercial-reference-buildings, accessed on 08/03/2022

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energy code in Virginia is 2018 IECC and ASHRAE 90.1-2016 with amendments.[204] It is DNV's engineering judgement that buildings and systems from the 2007 vintage would be appropriate candidates for the retro-commissioning measures in this program. This is because the end-use systems being retro-commissioned in this program are generally assumed to be functioning properly but aged and should benefit from re-programming controls.

There are baseline and efficient building models for each measure case. Energy savings are calculated using these models and simulated using TMY3 weather data for selected weather stations in Virginia and North Carolina.

14.1.1.1 Building models

The baseline energy model is derived from DOE's Commercial Medium Office Building in climate zone 4A. This model assumes a baseline annual energy consumption of 12.51 kWh/sq.ft. and 0.03 therm/sq.ft. The reference building is a medium-size office (3-stories totaling 53,627 sq. ft., 17,876 sq. ft.per floor). Savings are normalized to a unit according to the measure.

There are two different models for HVAC system types representing the most likely HVAC systems to be encountered in small offices. The HVAC system types include packaged VAV and chilled water VAV. Additionally, the heating fuel type is considered for each of these systems where the options are either electric or non-electric.

Loads on HVAC systems in offices tend to be dominated less by shell or envelop loads (e.g., passive stored heat) than internal loads such as occupants, lighting, and plug-load waste heat. Small buildings with relatively large exterior surface areas compared to floor area (or larger sprawling buildings with only one or two floors) would not be modeled as well by scaling these results.

Each measure has a baseline and efficient model. The efficient building models were created by modifying the baseline energy models in ways that the measure is intended to operate. This is done by modifying the applicable setpoints and schedules for each measure.

14.1.1.2 Impacts Estimation Approach

Modeled savings are calculated by subtracting the energy consumption of the efficient model from the baseline model, for each weather station. The total building savings are divided by the applicable model parameters to get a savings per unit (i.e. supply fan cfm or chiller tons of cooling) to produce the applicable energy savings factors. Energy savings factors are multiplied by the customer-specific units to calculate the gross savings. Additionally, the savings may be scaled to account for the level of adjustment relative to the model's assumptions. An example of this is the temperature setup measure which assumes the temperature is increased 10°F during unoccupied periods. The customer-specific temperature increase is used to scale the modeled savings. If the record has a reduction higher or lower than this, the savings are linearly scaled.

Per-measure, gross annual electric energy savings are calculated in each of the following measure sections. In general, they follow the same structure, as follows:

$$\Delta kWh \quad = ESF \; \times quantity \times \; MAF$$

[204] U.S. Department of Energy. Office of Energy Efficiency & Renewable Energy. Building Energy Codes Program. Virginia. https://www.energycodes.gov/status/states/virginia, accessed on 08/03/2022

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Per-measure, gross coincident summer demand reduction for measures in this program are shown below:

$$\Delta kW_{summer} = DRF_{summer} \times quantity \times MAF$$

There are not gross coincident winter demand reductions for the measures that use the building model simulation approach.

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident demand reduction
ESF = annual energy savings factor per unit based on measure by weather station
DRF_{summer} = summer coincident demand reduction factor
DRF_{winter} = winter coincident demand reduction factor
quantity = quantity of measure-specific units
MAF = measure adjustment factor to scale savings from the modeled assumptions to the application depth of measure

14.1.1.3 Input variables

The input variables are defined in each of the following measure sections. The ESF values for each of the modeled measures are in Table 14-2 and Table 14-3.

Table 14-2. Energy savings factor by measure

Weather Station	Measure Name				
	Temperature setup (kWh/cfm)	Chilled water reset (kWh/ton)	Outdoor air reduction (kWh/cfm)	Coil cleaning (kWh/cfm)	Pump pressure reduction (kWh/gpm)
Heating type	**Electric**	**Both**	**Both**	**Both**	**Both**
Charlottesville	0.280	17.798	0.026	0.106	11.356
Sterling	0.219	15.162	0.035	0.100	11.155
Farmville	0.250	15.662	0.039	0.110	9.345
Norfolk	0.244	14.931	0.053	0.124	4.588
Arlington	0.229	14.546	0.034	0.109	5.796
Richmond	0.254	15.701	0.043	0.118	9.404
Roanoke	0.242	16.413	0.020	0.100	12.714
Fredericksburg	0.248	15.643	0.044	0.112	9.871
Rocky Mount-Wilson	0.298	17.933	0.036	0.123	9.433
Elizabeth City	0.279	16.932	0.060	0.139	8.353

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Table 14-3. Summer demand reduction factor by measure

Weather station	Measure Name	
	Outdoor air reduction (kW/cfm)	Coil cleaning (kW/cfm))
Heating type	**Both**	**Both**
Charlottesville	0.000051	0.000066
Sterling	0.000092	0.000087
Farmville	0.000085	0.000086
Norfolk	0.000096	0.000086
Arlington	0.000098	0.000087
Richmond	0.000095	0.000091
Roanoke	0.000050	0.000063
Fredericksburg	0.000100	0.000093
Rocky Mount-Wilson	0.000063	0.000070
Elizabeth City	0.000086	0.000081

14.1.1.4 Update summary

Updates made to this section are described in Table 14-4.

Table 14-4. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

14.2 Lighting end use

14.2.1 Reduce lighting schedule by one hour on weekdays

This measure is also provided by the Non-Residential Office Program, DSM Phase VII. The savings are determined using the methodology described in Section 7.2.1.

14.3 Heating, Ventilation, and Air Conditioning (HVAC) end use

14.3.1 HVAC unit scheduling

This measure is also provided by the Non-Residential Office Program, DSM Phase VII. The savings are determined using the methodology described in Section 7.3.1.

14.3.2 HVAC temperature setback

This measure is also provided by the Non-Residential Office Program, DSM Phase VII. The savings are determined using the methodology described in Section 7.3.2.

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14.3.3 HVAC condensing water temperature reset

This measure is also provided by the Non-Residential Office Program, DSM Phase VII. The savings are determined using the methodology described in Section 7.3.3.

14.3.4 HVAC discharge air temperature reset

This measure is also provided by the Non-Residential Office Program, DSM Phase VII. The savings are determined using the methodology described in Section 7.3.4.

14.3.5 HVAC static pressure reset

This measure is also provided by the Non-Residential Office Program, DSM Phase VII. The savings are determined using the methodology described in Section 7.3.5.

14.3.6 HVAC VAV minimum flow reduction

This measure is also provided by the Non-Residential Office Program, DSM Phase VII. The savings are determined using the methodology described in Section 7.3.6.

14.3.7 Dual enthalpy air-side economizer

This measure does not use the building simulation approach that is applied to other measures in this program. Instead, it utilizes the Non-Residential Heating and Cooling Efficiency Program, DSM Phase VII savings approach described in Section 2.1.5.

14.3.8 Temperature setup

14.3.8.1 Measure description

This measure involves modifying space cooling temperature setpoints upward during unoccupied hours. The cooling temperature setpoint must be increased at least five degrees above the occupied setpoint. If the facility is weekday based occupied, a higher unoccupied temperature setpoint in the weekend is recommended. The customer or controls vendor must provide documentation of the existing and new unoccupied temperature set points and their schedules.

In the simulations, temperature setpoints during unoccupied hours are set up by 10 degrees while the cooling temperature setpoint of occupied hours remains unchanged.

14.3.8.2 Impact Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = ESF \times scfm_{supply\ fan} \times MAF$$

$$MAF = \left(\frac{T_{unoccupied,ee} - T_{unoccuied,base}}{10°\text{F}}\right)$$

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Per-measure, gross coincident summer and winter peak demand reduction is assigned as zero because these measures have a negligible demand reduction as shown below:

$$\Delta kW_{summer} = 0$$

$$\Delta kW_{winter} = 0$$

Where:

ΔkWh	= per-measure gross annual electric energy savings
ΔkW_{summer}	= per-measure gross coincident summer peak demand reduction
ΔkW_{winter}	= per-measure gross coincident winter peak demand reduction
ESF	= annual energy savings factor
MAF	= measure adjustment factor to scale savings from the modeled assumptions to the application depth of measure
$T_{unoccupied,\ base}$	= baseline unoccupied temperature setpoint
$T_{unoccupied.,\ ee}$	= energy-efficient case unoccupied temperature setpoint
$scfm_{supply\ fan}$	= supply fan flow rate

14.3.8.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 14-5. Input values for office buildings with electric and non-electric heating fuels

Component	Type	Value	Unit	Source(s)
ESF	Variable	See Table 14-2	kWh/scfm	EnergyPlus™ energy modeling software outputs
$T_{unoccupied,base}$	Variable	See customer application	°F	Customer application
$T_{unoccupied,ee}$	Variable	See customer application	°F	Customer application
$scfm_{supply\ fan}$	Variable	See customer application	scfm	Customer application

14.3.8.4 Default savings

No default savings will be awarded for this measure if the proper values are not provided in the customer application.

14.3.8.5 Effective Useful Life

The effective useful life of this measure is provided in Table 14-6.

Table 14-6. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
XI	Non-Residential Building Optimization Program, DSM Phase IX	5.00	years	Wisconsin TRM 2022, p. 369[205]

[205] The chiller plant setpoint adjustment measure life is assigned for all measures in this program. The measures in this program will have a similar measures life as they are all related to retro-commissioning and controls measures.

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14.3.8.6 Source(s)

The primary source for this deemed savings approach is prototypical building energy models derived from DOE's Commercial Medium Office Reference Building and modified to represent Dominion Energy's Virginia and North Carolina weather zones, using typical meteorological year 3 (TMY3) data.

14.3.8.7 Update summary

Updates made to this section are described in Table 14-7.

Table 14-7. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

14.3.9 Chilled Water (CHW) supply temperature reset

14.3.9.1 Measure description

This measure involves implementing a strategy to relax CHW supply temperature when cooling loads permit. Ultimately, this relaxes the lift of chiller compressors, allowing them to operate with greater efficiency. The set point temperature could be based on outdoor air temperature (OAT), schedule/time-of day, OA enthalpy, or 2-way valve position. The strategy chosen depends on the type of controls available.

In the building simulations, the baseline model sets a fixed CHW supply temperature of 44°F. The proposed model sets the CHW supply temperature at 44°F when OAT is above 80°F and implements the CHW supply temperature to 48°F when OAT is below 60°F. A supply air temperature (SAT) reset schedule was implemented in both base/proposed models to maintain sufficient approach between chilled water supply and air-system discharge air temperature (DAT).

14.3.9.2 Impact Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = ESF \times Size \times MAF$$

$$MAF = \left(\frac{T_{chiller\ reset,ee} - T_{chiller,base}}{5°F}\right)$$

Per-measure, gross coincident summer and winter peak demand reduction is assigned as zero because these measures have a negligible demand reduction as shown below:

$$\Delta kW_{summer} = 0$$

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$$\Delta kW_{winter} \quad = 0$$

Where:

ΔkWh	= per-measure gross annual electric energy savings
ΔkW_{summer}	= per-measure gross coincident summer peak demand reduction
ΔkW_{winter}	= per-measure gross coincident winter peak demand reduction
ESF	= annual energy savings factor
MAF	= measure adjustment factor to scale savings from the modeled assumptions to the application depth of measure
$T_{chiller,base}$	= baseline condenser temperature setpoint
$T_{chiller\ reset,\ ee}$	= energy-efficient case condenser reset temperature setpoint
Size	= chiller rated capacity

14.3.9.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 14-8. Input values for office buildings with electric and non-electric heating fuels

Component	Type	Value	Unit	Source(s)
ESF	Variable	See Table 14-2	kWh/ton	EnergyPlus™ energy modeling software outputs
$T_{chiller,base}$	Variable	See customer application	°F	Customer application
$T_{chiller\ reset,ee}$	Variable	See customer application	°F	Customer application
Size	Variable	See customer application	tons	Customer application

14.3.9.4 Default savings

This measure does not have default savings for this measure.

14.3.9.5 Effective Useful Life

The effective useful life of this measure is provided inTable 14-9.

Table 14-9. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
XI	Non-Residential Building Optimization Program, DSM Phase IX	5.00	years	Wisconsin TRM 2022, p. 369[206]

[206] The chiller plant setpoint adjustment measure life is assigned for all measures in this program. The measures in this program will have a similar measures life as they are all related to retro-commissioning and controls measures.

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14.3.9.6 Source(s)

The primary source for this deemed savings approach is prototypical building energy models derived from DOE's Commercial Medium Office Reference Building and modified to represent Dominion Energy's Virginia and North Carolina weather zones, using typical meteorological year 3 (TMY3) data.

14.3.9.7 Update summary

Updates made to this section are described in Table 14-10.

Table 14-10. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

14.3.10 Outdoor Air (OA) reduction

14.3.10.1 Measure description

This measure involves reviewing zone fresh air requirements and system fresh air and zone damper controls (if any). Depending on the system and control types, this involves adjusting the control set points to reduce intake of fresh air according to existing occupancy requirements.

This measure might address situations in which fresh air requirements were overdesigned or building occupancy has changed resulting in a lower OA requirement. OA requirements are based on the occupant density or space type. Examples of systems that might be addressed by this would include constant volume single zone (CVSZ) systems with fixed minimum damper positions or motorized dampers, or VAV systems (packaged or built-up). For VAV systems, this measure would address OA reduction strategies that are not already addressed by the "Min Damper Position" measure of the existing DSM7 Office Program.

This measure might also include repairs or adjustments to outside air dampers. OA dampers are exposed to the outdoors and frequently fail without regular maintenance. Failures can be costly and cause operating issues if the damper is stuck too far open. Restoring the proper OA minimum after maintenance can save energy. Converting a fixed damper to a motorized damper would allow the damper to respond flexibly to air-handler volume changes.

In the simulations, the OA volumes in proposed model are all reduced by 10% and minimum outdoor air schedule is also 90% of the baseline model. Simply reducing the OA may not necessarily lead to energy reduction since during certain period of time, the OA can act as free cooling instead of load. In the simulation, this is accounted for by adding an economizer to both the baseline and the proposed models. An economizer is not required in the ASHRAE 90.1 2007 code for climate 4A, but the succeeding codes did require it. A motorized damper is assumed to deliver a fixed minimum OA under all system flow conditions.

14.3.10.2 Impact Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = ESF \times scfm_{supply\ fan} \times MAF$$

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$$MAF = 10 \times \left(\frac{(scfm_{OA,base} - scfm_{OA,ee})}{scfm_{OA,base}} \right)$$

Per-measure, gross coincident summer demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = DRF_{summer} \times scfm_{supply\ fan} \times MAF$$

There is no gross coincident winter demand reduction for this measure.

Where:

ΔkWh	= per-measure gross annual electric energy savings
ΔkW_{summer}	= per-measure gross coincident summer peak demand reduction
ESF	= annual energy savings factor
MAF	= measure adjustment factor to scale savings from the modeled assumptions to the application depth of measure
$scfm_{OA,\ base}$	= baseline outdoor air flow rate
$scfm_{OA,\ ee}$	= energy-efficient outdoor air flow rate
$scfm_{supply\ fan}$	= supply fan flow rate
DRF_{summer}	= summer coincident demand reduction factor
DRF_{winter}	= winter coincident demand reduction factor

14.3.10.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 14-11. Input values for office buildings with electric and non-electric heating fuels

Component	Type	Value	Unit	Source(s)
ESF	Variable	See Table 14-2	kWh/scfm	EnergyPlus™ energy modeling software outputs
$scfm_{OA,\ base}$	Variable	See customer application	scfm	Customer application
$scfm_{OA,\ ee}$	Variable	See customer application	scfm	Customer application
$scfm_{supply\ fan}$	Variable	See customer application	scfm	Customer application
DRF_{summer}	Variable	See Table 14-3	kW/scfm	EnergyPlus™ energy modeling software outputs
DRF_{winter}	Variable	See Table 14-3	kWh/scfm	EnergyPlus™ energy modeling software outputs

14.3.10.4 Default savings

This measure does not have default savings for this measure.

14.3.10.5 Effective Useful Life

The effective useful life of this measure is provided in Table 14-12.

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Table 14-12. Effective Useful Life for Lifecycle Savings Calculations

DSM Phase	Program name	Value	Units	Source(s)
XI	Non-Residential Building Optimization Program, DSM Phase IX	5.00	years	Wisconsin TRM 2022, p. 369[207]

14.3.10.6 Source(s)

The primary source for this deemed savings approach is prototypical building energy models derived from DOE's Commercial Medium Office Reference Building and modified to represent Dominion Energy's Virginia and North Carolina weather zones, using typical meteorological year 3 (TMY3) data.

14.3.10.7 Update summary

Updates made to this section are described in Table 14-13.

Table 14-13. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

14.3.11 Coil cleaning

14.3.11.1 Measure description

This measure involves cleaning the air-side of air-handler CHW and/or HW coils. Dirty coils require additional fan horsepower to force air through them. Cleaning coils will reduce fan power during all hours of fan operation. It will also increase coil U-value, improving cooling system performance and drying air more effectively.

In the simulations, any effect on heating is not modeled. In the proposed situation, fan motor efficiency and DX cooling coil's COP are set to 3% higher than the baseline.

14.3.11.2 Impact Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = ESF \times scfm_{supply\ fan}$$

Per-measure, gross coincident summer demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = DRF_{summer} \times scfm_{supply\ fan}$$

[207] The chiller plant setpoint adjustment measure life is assigned for all measures in this program. The measures in this program will have a similar measures life as they are all related to retro-commissioning and controls measures.

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There is no gross coincident winter demand reduction for this measure.

Where:

ΔkWh	= per-measure gross annual electric energy savings
ΔkW_{summer}	= per-measure gross coincident summer peak demand reduction
ESF	= annual energy savings factor
DRF_{summer}	= summer coincident demand reduction factor
DRF_{winter}	= winter coincident demand reduction factor
$scfm_{supply\ fan}$	= supply fan flow rate

14.3.11.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 14-14. Input values for office buildings with electric and non-electric heating fuels

Component	Type	Value	Unit	Source(s)
ESF	Variable	See Table 14-2	kWh/scfm	EnergyPlus™ energy modeling software outputs
$scfm_{supply\ fan}$	Variable	See customer application	scfm	Customer application
DRF_{summer}	Variable	See Table 14-3	kW/scfm	EnergyPlus™ energy modeling software outputs
DRF_{winter}	Variable	See Table 14-3Table 7-3	kW/scfm	EnergyPlus™ energy modeling software outputs

14.3.11.4 Default savings

No default savings will be awarded for this measure if the proper values are not provided in the customer application.

14.3.11.5 Effective Useful Life

The effective useful life of this measure is provided in Table 14-15.

Table 14-15. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
XI	Non-Residential Building Optimization Program, DSM Phase IX	5.00	years	Wisconsin TRM 2022, p. 369[208]

14.3.11.6 Source(s)

The primary source for this deemed savings approach is prototypical building energy models derived from DOE's Commercial Medium Office Reference Building and modified to represent Dominion Energy's Virginia and North Carolina weather zones, using typical meteorological year 3 (TMY3) data.

[208] The chiller plant setpoint adjustment measure life is assigned for all measures in this program. The measures in this program will have a similar measures life as they are all related to retro-commissioning and controls measures.

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14.3.11.7 Update summary

Updates made to this section are described in Table 14-16.

Table 14-16. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

14.3.12 Pump pressure reduction

14.3.12.1 Measure description

This measure assumes that a hydronic loop (hot or chilled water) is variable-flow with 2-way valves and a variable-speed pump. The loop could be a secondary loop with a separate primary loop or a primary loop which directly serves terminal coils. The analysis bears out that the differential pressure set point, which ensures a sufficient minimum flow to the most remote terminal coils, is unnecessarily high or can be re-set depending on conditions.

There are other cases where the pump pressure might be reduced that do not involve a mere set point change. For example, the differential pressure control valve may be too close to the pump, which defeats the purpose and results in excessive pumping energy. Relocating the control valve and re-establishing a proper set point would save pumping energy. Another situation addressed by this measure includes removal of unnecessary valves, such as balancing valves, after implementing variable flow in a formerly constant-volume loop.

In the simulations, the baseline pump is changed to variable speed the design pump head is set to 60 ft H_2O comparing to DOE prototype. The design pump head pressure is reduced by 10 ft in the proposed model.

14.3.12.2 Impact Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = ESF \times flow_{pump} \times MAF$$

$$MAF = \left(\frac{pressure_{pump,base} - pressure_{pump,ee}}{10}\right)$$

Per-measure, gross coincident summer and winter peak demand reduction is assigned as zero because these measures have a negligible demand reduction as shown below:

$$\Delta kW_{summer} = 0$$

$$\Delta kW_{winter} = 0$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction

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ΔkW_{winter} = per-measure gross coincident winter peak demand reduction
ESF = annual energy savings factor
MAF = measure adjustment factor to scale savings from the modeled assumptions to the application depth of measure
$pressure_{pump, base}$ = baseline pump pressure setpoint
$pressure_{pump, ee}$ = energy-efficient case pump pressure setpoint
$flow_{pump}$ = pump design flow rate

14.3.12.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 14-17. Input values for office buildings with electric and non-electric heating fuels

Component	Type	Value	Unit	Source(s)
ESF	Variable	See Table 14-2	kWh/gpm	EnergyPlus™ energy modeling software outputs
$pressure_{pump, base}$	Variable	See customer application	feet head	Customer application
$preassure_{pump, ee}$	Variable	See customer application	feet head	Customer application
$Flow_{pump}$	Variable	See customer application	gpm	Customer application

14.3.12.4 Default savings

No default savings will be awarded for this measure if the proper values are not provided in the customer application.

14.3.12.5 Effective Useful Life

The effective useful life of this measure is provided in Table 14-18.

Table 14-18. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
XI	Non-Residential Building Optimization Program, DSM Phase IX	5.00	years	Wisconsin TRM 2022, p. 369[209]

14.3.12.6 Source(s)

The primary source for this deemed savings approach is prototypical building energy models derived from DOE's Commercial Medium Office Reference Building and modified to represent Dominion Energy's Virginia and North Carolina weather zones, using typical meteorological year 3 (TMY3) data.

14.3.12.7 Update summary

Updates made to this section are described in Table 14-19.

[209] The chiller plant setpoint adjustment measure life is assigned for all measures in this program. The measures in this program will have a similar measures life as they are all related to retro-commissioning and controls measures.

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Table 14-19. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

14.3.13 Schedule equipment

14.3.13.1 Measure description

This measure involves bringing uncontrolled loads, such as ventilation fans, under control with the building operation schedule.

The deemed savings values for this measure are calculated based on the site-specific load that is being scheduled and the change in the operating schedule. The measure savings will be calculated using the kW of the actual equipment controlled and the reduction in the hours of operation.

14.3.13.2 Impact Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \left((HPD_{base} \times DPW_{base}) - (HPD_{ee} \times DPW_{ee}) \right) \times 52 \times Load$$

The equipment load is calculated depending on the equipment type. For fans and pumps, the following equation is applied:

$$Load = \frac{hp \times 0.746 \times LF}{\eta}$$

For scheduling HVAC equipment, when the equipment is <65,000 Btu/h, the load is calculated according to the following equation[210]:

$$Load = Size_{cool} \times \left[\frac{EFLH_{cool}}{SEER \times 8{,}760} \right] \times \frac{1\ kBtuh}{1{,}000\ Btuh}$$

For scheduling HVAC equipment, when the equipment is ≥65,000 Btu/h, the load is calculated according to the following equation:

$$Load = Size_{cool} \times \left[\frac{EFLH_{cool}}{IEER \times 8{,}760} \right] \times \frac{1\ kBtuh}{1{,}000\ Btuh}$$

[210] Note that the annual average cooling equipment load is used for this measure. A cooling load factor is approximated by dividing the EFLHs hours by 8,760 hours/year. This approach does not account for when the scheduling equipment change is occurring but is intended to be representative over the course of the year.

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For equipment load for equipment other than fans, pumps, and HVAC, the following equation is applied:

$$Load \quad = Size_{equipment}$$

Per-measure, gross coincident summer and winter peak demand reduction is assigned as zero because these measures have a negligible demand reduction as shown below:

$$\Delta kW_{summer} \quad = 0$$

$$\Delta kW_{winter} \quad = 0$$

Where:

ΔkWh	= per-measure gross annual electric energy savings
ΔkW_{summer}	= per-measure gross coincident summer peak demand reduction
ΔkW_{winter}	= per-measure gross coincident winter peak demand reduction
Load	= load being scheduled off
HPD_{base}	= baseline occupied hours per day of occupied schedule
HPD_{ee}	= energy-efficient case occupied hours per day of occupied schedule
DPW_{base}	= baseline occupied days per week of occupied schedule
DPW_{ee}	= energy-efficient case occupied per week of occupied schedule
SqFt	= condition area impacted by measure
hp	= motor rated horsepower
LF	= motor load factor (%) at fan design airflow rate or pump design flowrate
η	= NEMA-rated efficiency of motor
$Size_{cool}$	= equipment cooling capacity of HVAC equipment
$SEER_{ee}$	= seasonal energy efficiency ratio (SEER) of the installed air conditioning equipment. It is used for heat pumps and AC units that are smaller than 65,000 Btu/h.
$IEER_{base}$	= integrated energy efficiency ratio (IEER) of the existing or baseline air conditioning equipment. IEER is a weighted average of a unit's efficiency at four load points: 100%, 75%, 50%, and 25% of full cooling capacity. It is used for heat pumps and AC units that are 65,000 Btu/h or larger.
$EFLH_{cool}$	= equivalent full-load cooling hours
$Size_{equipment}$	= equipment capacity that is scheduled off

14.3.13.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 14-20. Input values for office buildings with electric and non-electric heating fuels

Component	Type	Value	Unit	Source(s)
HPD_{base}	Variable	See customer application	hours/day	Customer application
HPD_{ee}	Variable	See customer application	hours/day	Customer application
DPW_{base}	Variable	See customer application	days/week	Customer application
DPW_{ee}	Variable	See customer application	days/week	Customer application
hp	Variable	See customer application	horsepower	Customer application

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Component	Type	Value	Unit	Source(s)
LF	Fixed	0.65	-	Maryland/Mid-Atlantic TRM v.10, p. 297
η	Variable	Default see Table 2-16. Baseline motor efficiency	-	NEMA Standards Publication Condensed MG 1-2007
$Size_{cool}$	Variable	See customer application	Btu/h	Customer application
$EFLH_{cool}$	Variable	See Table 17-4 in Sub-Appendix F2-II: Non-residential HVAC	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 422
SEER/ IEER	Variable	See Table 17-8 in Sub-Appendix F2-III: Non-residential HVAC	kBtu/kW-hour (except COP is dimension-less)	ASHRAE 90.1 2013, Table 6.8.1-1
$Size_{equipment}$	Variable	See customer application	kW	Customer application

14.3.13.4 Default savings

No default savings will be awarded for this measure if the proper values are not provided in the customer application.

14.3.13.5 Effective Useful Life

The effective useful life of this measure is provided in Table 14-21.

Table 14-21. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
XI	Non-Residential Building Optimization Program, DSM Phase IX	5.00	years	Wisconsin TRM 2022, p. 369[211]

14.3.13.6 Source(s)

The primary source for this deemed savings approach relies on customer-specific inputs.

14.3.13.7 Update summary

Updates made to this section are described in Table 14-22.

Table 14-22. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

[211] The chiller plant setpoint adjustment measure life is assigned for all measures in this program. The measures in this program will have a similar measures life as they are all related to retro-commissioning and controls measures.

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14.3.14 Custom retrocommissioning

14.3.14.1 Measure description

This measure is for HVAC or lighting measures that do not fit in any of the other measure categories and are identified through a 3rd party energy audit.

14.3.14.2 Impact Estimation Approach

Savings will be calculated using custom calculations. Implementer project files will be desk reviewed. Initially all projects will be reviewed though depending on project volume, projects may be sampled for review.

14.3.14.3 Default savings

This measure does not have default savings for this measure.

14.3.14.4 Effective Useful Life

The effective useful life of this measure is provided in Table 14-23.

Table 14-23. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
XI	Non-Residential Building Optimization Program, DSM Phase IX	5.00	years	Wisconsin TRM 2022, p. 369[212]

14.3.14.5 Source(s)

The primary source for this deemed savings approach is prototypical building energy models derived from DOE's Commercial Large Office Reference Building and modified to represent Dominion Energy's Virginia and North Carolina weather zones, using typical meteorological year 3 (TMY3) data.

14.3.14.6 Update summary

Updates made to this section are described in Table 14-24.

Table 14-24. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

212 The chiller plant setpoint adjustment measure life is assigned for all measures in this program. The measures in this program will have a similar measures life as they are all related to retro-commissioning and controls measures.

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15 NON-RESIDENTIAL ENGAGEMENT PROGRAM, DSM PHASE IX

This Program engages commercial buildings in energy management best practices that increase awareness of operational and behavioral energy savings opportunities. The Program supports the Company's facility heroes to achieve energy savings by optimizing building energy performance and integrating ongoing commissioning best practices into their operations through a combination of education and training. Participants receive no-cost engineering support and targeted energy-saving suggestions intended to encourage actions or measure installations by providing information and assistance. The incentive to participate is the electric bill savings as a result of actions taken through participation in the program.

Through a customer engagement portal, building operators can also access educational content and technical resources as part of a series of operator challenges. By completing these challenges, participants will review and implement energy efficient operational best practices, earning them points while competing against facility teams from other participating buildings.

15.1 Cross-cutting end uses

15.1.1 Building operator training

15.1.1.1 Measure description

The non-residential engagement program's operator energy challenges were designed to include technical resources and advice to educate building operators on how they can evaluate their building system performance and take corrective action. The energy challenges include but are not limited to the following building retuning activities:

- Review outside air damper operation
- Minimize the introduction of outside air
- Review of supply fan operation and minimum flow setpoints
- Review of airside economizer operation and performance
- Review of air-handler supply air temperature sequences and setpoints
- Review of HVAC schedules and zone temperature setbacks
- Review lighting schedules and alignment with occupancy and use
- Review lighting levels
- Review condenser water setpoint and sequencing
- Review chilled water temperature setpoint and sequencing
- Review off-peak heating loads and lockouts
- Review AHU static pressure setpoints and sequencing
- VAV box sequencing

15.1.1.2 Impacts Estimation Approach

The initial methodology for calculating impacts utilizes a fixed percent of whole building annual consumption. Additionally, the program develops regression models to assess and validate savings. These weather-normalized consumption models use 12 months of baseline consumption and 12 months of post installation consumption data. Due to the nature of this approach, the results are not available at the time the project is implementer. Therefore,

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these savings cannot be applied directly. Results will be considered in assessing if adjustments to the impact methodology is needed in the future.

Per-measure, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = ESF \times kWh_{whole\ facility}$$

This measure may have some gross coincident summer or winter peak demand reductions depending on which recommendations are implemented. However, impacts are assumed to be primarily focused on energy savings. No demand impacts are calculated.

Where:

ΔkWh	= per-measure gross annual electric energy savings
$kWh_{whole\ facility}$	= whole facility annual energy consumption
ESF	= energy savings factor

15.1.1.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 15-1. Input variables for Building Operator Training

Component	Type	Value	Units	Source(s)
$kWh_{whole\ facility}$	Variable	See customer application	kWh	Customer application
ESF	Fixed	0.05	-	Building Commissioning Costs and Savings Across Three Decades and 1,500 North American Buildings[213]

15.1.1.4 Default savings

If the proper values are not available, zero savings will be given for gross annual electric energy savings.

15.1.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 15-2.

[213] Berkeley Lad, Building Technology & Urban Systems Division, https://buildings.lbl.gov/publications/building-commissioning-costs-and

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Table 15-2. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Engagement Program, DSM Phase IX	5.00	years	Wisconsin TRM 2022, p. 369[214]

15.1.1.6 Source

The primary source for this Update summary

Updates to this section are described in Table 15-3.

Table 15-3. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

[214] The chiller plant setpoint adjustment measure life is used as the control system will have a similar measures life.

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16 NON-RESIDENTIAL PRESCRIPTIVE ENHANCED PROGRAM, DSM PHASE IX

The Non-Residential Prescriptive Program provides qualifying non-residential customers with incentives for the installation of refrigeration, commercial kitchen equipment, HVAC improvements and maintenance and installation of other program specific, energy efficiency measures.

To be eligible for a rebate, you must be a Dominion Energy Virginia non-residential customer who is not exempt by statute or under a special contract.

The measures offered through this program and the sections describing the measures are listed in Table 16-1. The energy savings methodology is provided in Section 18.1. The following sections include measure descriptions.

Table 16-1. Non-residential prescriptive program measure list

End use	Measure	Legacy program	Section
Cooking	Commercial convection oven	Non-Residential Prescriptive Program, DSM Phase VI	Section 4.1.1
	Commercial combination oven		Section 4.1.2
	Commercial fryer		Section 4.1.3
	Commercial griddle		Section 4.1.4
	Commercial hot food holding cabinet		Section 4.1.5
	Commercial steam cooker		Section 4.1.6
	Variable speed drives on kitchen exhaust fan	Non-Residential Prescriptive Program, DSM Phase VI	Section 4.1.7
Domestic hot water	Heat pump water heater	-	Section 16.2.1
	Pre-rinse sprayer		Section 16.2.2
HVAC	Air conditioning tune-up	Non-Residential Prescriptive Program, DSM Phase VI	Section 4.2.2
	Duct test and seal		Section 4.2.1
	Electronically commutated motor	-	Section 16.3.3
	Guest room occupancy		Section 16.3.4
	Parking ventilation		Section 16.3.5
Appliance or Plug Load	Commercial dishwasher	-	Section 16.4.1
	Commercial dryer		Section 16.4.2
	Commercial washing machine		Section 16.4.3
	Food seal wrapper		Section 16.4.4
	Ozone laundry		Section 16.4.5
Recreation	Heat pump pool heater		Section 16.5.1
	Pool spa cover		Section 16.5.2
	Variable speed pool pump	Non-Residential Multifamily Program, DSM Phase VIII	Section 10.6.1
Refrigeration	Commercial freezers and refrigerators	Non-Residential Prescriptive Program, DSM Phase VI	Section 4.4.3
	Commercial ice maker		Section 4.4.4
	Door closer (cooler and freezer)		Section 4.4.1
	Door gasket (cooler and freezer)		Section 4.4.2
	Evaporator fan electronically commutated motor (ECM) retrofit		Section 4.4.5
	Low/anti-sweat door film		Section 4.4.8

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End use	Measure	Legacy program	Section
	Refrigeration condenser coil cleaning		Section 4.4.10
	Strip curtain (cooler and freezer)		Section 4.4.12

16.1 Cooking end use

16.1.1 Commercial convection oven

This measure is also provided by the Non-Residential Prescriptive Program, DSM Phase VI. The savings are determined using the methodology described in Section 4.1.1.

16.1.2 Commercial combination oven

This measure is also provided by the Non-Residential Prescriptive Program, DSM Phase VI. The savings are determined using the methodology described in Section 4.1.2.

16.1.3 Commercial fryer

This measure is also provided by the Non-Residential Prescriptive Program, DSM Phase VI. The savings are determined using the methodology described in Section 4.1.3.

16.1.4 Commercial griddle

This measure is also provided by the Non-Residential Prescriptive Program, DSM Phase VI. The savings are determined using the methodology described in Section 4.1.4.

16.1.5 Commercial hot food holding cabinet

This measure is also provided by the Non-Residential Prescriptive Program, DSM Phase VI. The savings are determined using the methodology described in Section 4.1.5.

16.1.6 Commercial steam cooker

This measure is also provided by the Non-Residential Prescriptive Program, DSM Phase VI. The savings are determined using the methodology described in Section 4.1.6.

16.1.7 Variable speed drive on kitchen exhaust fan

This measure is also provided by the Non-Residential Prescriptive Program, DSM Phase VI. The savings are determined using the methodology described in Section 4.1.7.

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16.2 Domestic hot water end use

16.2.1 Heat pump water heater

16.2.1.1 Measure description

This measure involves replacing an electric storage water heater with a heat-pump water heater (HPWH). The baseline condition is a new electric storage water. For this measure, the ENERGY STAR-qualified heat-pump water heater[215] is considered to be the efficient condition.

16.2.1.2 Impacts Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equations:

$$\Delta kWh = \frac{kBtu_{load}}{3{,}412\ Btu/kWh} \times \left(\frac{1}{UEF_{base}} - \frac{1}{UEF_{ee}}\right)$$

$$kBtu_{load} = Gallon_{day} \times 365\ days\ \times 8.33\frac{lb}{gallon} \times 1.0\frac{Btu}{lb - {}^{\circ}\mathrm{F}} \times (T_{out} - T_{in})$$

Per-measure, gross coincident summer peak demand reduction is fixed as follows:

$$\Delta kW_{summer} = \frac{\Delta kWh}{HOU} \times\ CF_{summer}$$

Per-measure, gross coincident winter peak demand reduction is fixed as follows:

$$\Delta kW_{winter} = \frac{\Delta kWh}{HOU} \times\ CF_{winter}$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand savings
ΔkW_{winter} = per-measure gross coincident winter peak demand savings

$Gallon_{day}$ = gallons per day of hot water use per person
EF_{base} = uniform energy factor (UEF) of electric storage water heater based on minimum federal standards
EF_{ee} = uniform energy factor of efficient heat pump water heater
T_{out} = tank temperature
T_{in} = incoming temperature from well or municipal system
HOU = hours of use
CF_{summer} = summer peak coincidence factor

215 ENERGY STAR® v3.2 Program Requirements for Residential Water Heaters. Maryland/ Maryland/Mid-Atlantic TRM v10, p. 352.

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CF_{winter} = winter peak coincidence factor

16.2.1.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 16-2. Input values for the heat pump domestic hot water heater savings calculations

Component	Type	Value	Unit	Source(s)
$Gallon_{day}$	Variable	Schools = 180 Office = 25.0	gallon/day	Maryland/Mid-Atlantic TRM v10, p. 352
UEF_{base}	Fixed	0.904	-	Maryland/Mid-Atlantic TRM v10, p. 352
UEF_{ee}	Variable	See customer application	-	Customer application
		Default = 2.0		Maryland/Mid-Atlantic TRM v10, p. 352[216]
T_{out}	Fixed	140.0	°F	Maryland/Mid-Atlantic TRM v10, p.352
T_{in}	Fixed	60.0	°F	Maryland/Mid-Atlantic TRM v10, p. 352
HOU	Variable	Schools =2,218 Office = 5,885		Maryland/Mid-Atlantic TRM v10, p. 353
CF_{summer}	Variable	Schools =0.58 Office = 0.63	-	Maryland/Mid-Atlantic TRM v10, p. 353
CF_{winter}	Variable	Schools = 180 Office = 25.0	-	Maryland/Mid-Atlantic TRM v10, p. 353[217]

16.2.1.4 Default savings

If the proper values are not supplied, a default savings may be applied using conservative input values. The default gross annual electric energy savings will be assigned according to the sequence of equations that follow. The values used assume a office building.

$$\Delta kWh = \frac{kBtu_{load}}{3{,}412\ kBtu/kWh} \times \left(\frac{1}{UEF_{base}} - \frac{1}{UEF_{ee}}\right)$$

$$kBtu_{load} = Gallon_{day} \times 365\ days\ \times 8.33\frac{lb}{gallon} \times 1.0\frac{Btu}{lb-°F} \times (T_{out} - T_{in})$$

$$= 25.0\ \frac{gallon}{day} \times 365\ days\ \times 8.33\frac{lb}{gallon} \times 1.0\frac{Btu}{lb-°F} \times (140.0°F - 60.0°F)$$

$$= 6{,}080{,}900.00\ kBtu$$

[216] ENERGY STAR minimum qualifying requirements are used as the default value.
[217] The source TRM doesn't provide a winter CF.Therefore, the summer CF is applied as the winter CF.

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$$\Delta kWh = \frac{kBtu_{load}}{3{,}412\ kBtu/kWh} \times \left(\frac{1}{UEF_{base}} - \frac{1}{UEF_{ee}}\right)$$

$$= \frac{6{,}080{,}900\ kBtu}{3{,}412\ kBtu/kWh} \times \left(\frac{1}{0.904} - \frac{1}{2.0}\right)$$

$$= 1{,}080.37\ kWh$$

Per-measure, gross coincident summer peak demand reduction is fixed as follows:

$$\Delta kW_{summer} = \frac{\Delta kWh}{HOU} \times CF_{summer}$$

$$= \frac{1{,}080\ kWh}{5{,}885\ hour} \times 0.63$$

$$= 0.116\ kW$$

Per-measure, gross coincident winter peak demand reduction is fixed as follows:

$$\Delta kW_{winter} = \frac{\Delta kWh}{HOU} \times CF_{winter}$$

$$= \frac{1{,}080\ kWh}{5{,}885\ hour} \times 0.63$$

$$= 0.116\ kW$$

16.2.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 16-3.

Table 16-3. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	10.00	years	Maryland/Mid-Atlantic TRM v10, p. 354

16.2.1.6 Source

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v10, pp. 352-354.

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16.2.1.7 Update summary

Updates to this section are described in Table 16-4.

Table 16-4. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

16.2.2 Pre-rinse sprayer

16.2.2.1 Measure description

Pre-rinse spray valves (PRSVs) are handheld devices that are designed to remove food waste from dishes prior to dishwashing. They reduce water consumption, water heating cost, and waste water (sewer) charges. This measure involves retrofitting existing standard flow PRSVs with new low-flow PRSVs in order to reduce hot water consumption, resulting in corresponding energy savings.

16.2.2.2 Impacts Estimation Approach

The baseline equipment is assumed to be an existing spray valve with a flow rate of 3 gallons per minute. The efficient equipment is assumed to be a pre-rinse spray valve with a flow rate of 1.6 gallons per minute, and with a cleanability performance of 26 seconds per plate or less.

Per-measure, the gross annual water savings are calculated according to the following equation:

$$\Delta Water = (FLO_{base} - FLO_{ee}) \times \frac{60\ min.}{1\ hour} \times Hours_{daily} \times Days$$

If the water heater fuel type is non-electric, there are no electric energy savings. If the water heater is electric, per-measure, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \frac{\Delta Water \times HOT \times 8.33 \times \Delta T}{\eta_{WH} \times 3{,}413\ Btuh/kWh}$$

Per-measure, the gross summer coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = 0$$

Per-measure, the gross winter coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = 0$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction savings

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ΔkW_{winter}	= per-measure gross coincident winter peak demand reduction savings
$\Delta Water$	= per-measure gross annual water savings
HOT	= the percentage of water used by the pre-rinse spray valve that is heated
8.33	= the energy content of heated water (BTU/gallon/°F)
ΔT	= temperature rise through water heater
η_{HW}	= water heater thermal efficiency
3,413	= factor to convert BTU to kwh
FLO_{base}	= the flow rate of the baseline equipment
FLO_{ee}	= the flow rate of the efficient equipment
60	= minutes per hour
$Hours_{daily}$	= average daily operating hours
Days	= annual days of operation

16.2.2.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 16-5. Input variables for measure name

Component	Type	Value	Units	Source(s)
HOT	Fixed	0.69	-	Maryland/Mid-Atlantic TRM v10, p. 355[218]
ΔT	Fixed	70.00	°F	Maryland/Mid-Atlantic TRM v10, p. 355[219]
η_{HW}	Fixed	0.97	-	Maryland/Mid-Atlantic TRM v10, p. 355[220]
FLO_{base}	Fixed	3.00	gpm	Maryland/Mid-Atlantic TRM v10, p. 356
FLe_{e}	Fixed	1.60	gpm	Maryland/Mid-Atlantic TRM v10, p. 356
Days	Fixed	365	day, annual	Maryland/Mid-Atlantic TRM v10, p. 356
$Hours_{daily}$	Variable	See Table 16-6	hour, day	Maryland/Mid-Atlantic TRM v10, p. 356[221]

Table 16-6. Daily operation hours for various facility types

Facility type	$Hours_{daily}$
Full-service restaurant	4
Limited service (fast food) restaurant	1
Other	2

218 Measures and Assumptions for DSM Planning (2009). Navigant Consulting. Prepared for the Ontario Energy Board. This factor is a candidate for future improvement through evaluation.

219 Engineering judgment; assumes typical supply water temperature of 70°F and a hot water storage tank temperature of 140°F.

220 Federal Standards. http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/51

221 Hours estimates based on PG&E savings estimates, algorithms, sources (2005). Food Service Pre-Rinse Spray Valves

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16.2.2.4 Default savings

There are no default savings for this measure because the savings are dependent on the facility type which the equipment is servicing.

16.2.2.5 Effective Useful Life

The effective useful life of this measure is provided in Table 16-7.

Table 16-7. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	5.00	years	Maryland/Mid-Atlantic TRM v10, p. 356

16.2.2.6 Source

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v10, pp. 355-356

16.2.2.7 Update summary

Updates to this section are described in Table 16-8.

Table 16-8. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

16.3 Heating, Ventilation, Air-Conditioning (HVAC) end use

16.3.1 Air conditioning tune up

This measure is also offered through the Non-Residential Prescriptive Program, DSM Phase VI. The savings approach is described in Section 4.2.2.

16.3.2 Duct test and seal

This measure is also provided by the Non-Residential Prescriptive Program, DSM Phase VI. The savings are determined using the methodology described in Section 4.2.1.

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16.3.3 Electrically commutated motor

16.3.3.1 Measure description

This measure applies to the installation of an electronically commutated motor (ECM) with ≥1 hp on air handling equipment such as exhaust fans, fan coil units, variable air volume (VAV) boxes, and cabinet heaters. These are typically induction motors and are covered by NEMA standards. Residential type furnaces with an ECM are excluded from this measure, as they are covered by other measures. Single package vertical units for multifamily are also excluded.

The baseline condition is an existing shaded pole (SP) or permanent split capacitor (PSC) motor.

16.3.3.2 Impacts Estimation Approach

Per-measure, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = hp \times 0.746 \times \left(\frac{1}{\eta_{base}} - \frac{1}{\eta_{ee}}\right) \times HOU$$

Per-measure, the gross summer coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = hp \times 0.746 \times \left(\frac{1}{\eta_{base}} - \frac{1}{\eta_{ee}}\right) \times CF_{summer}$$

Per-measure, the gross winter coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = hp \times 0.746 \times \left(\frac{1}{\eta_{base}} - \frac{1}{\eta_{ee}}\right) \times CF_{winter}$$

Where:

ΔkWh	= per-measure gross annual electric energy savings
ΔkW_{summer}	= per-measure gross coincident summer peak demand reduction
ΔkW_{winter}	= per-measure gross coincident winter peak demand reduction
0.746	= conversion factor from horsepower to kW
hp	= motor horsepower
HOU	= hours of use, annual
η_{base}	= efficiency of baseline equipment
η_{ee}	= efficiency of energy-efficient equipment
CF_{summer}	= summer coincidence factor
CF_{winter}	= winter coincidence factor

16.3.3.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

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Table 16-9. Input variables for measure name

Component	Type	Value	Units	Source(s)
hp	Variable	See customer application	hp	Customer application
HOU	Variable	See Table 16-10	hours, annual	Wisconsin TRM 2022, p. 299
η_{base}	Fixed	0.3625	-	Wisconsin TRM 2022, p.299
η_{ee}	Fixed	0.7000	-	Wisconsin TRM 2022, p. 299
CF_{summer}	Variable	Default: See Table 16-10	-	Wisconsin TRM 2022, p. 299
CF_{winter}	Variable	Default: See Table 16-10	-	Wisconsin TRM 202, p. 299

Table 16-10. Hours of use (HOU) and coincidence factor (CF) for various control strategies

Fan type	Building type	HOU	CF_{summer}	CF_{winter}[222]
Heating fan	All	2,285	0.0	0.8
Cooling fan	All	678	0.8	0.0
Occupied ventilation	Commercial	3,730	0.9	0.9
	Industrial	4,745		
	Agriculture	4,698		
	Schools and government	3,239		
	Residential-multifamily (common areas)	5,950		
24/7 ventilation	All	8,760	1.0	1.0

Assumptions and equipment descriptions are as follows:

- Heating fan includes cabinet heaters, unit heaters, and heating-only fan coil units.
- Cooling fan includes cooling-only fan coil units.
- Occupied ventilation includes any equipment that is normally on during occupied hours all year, regardless of season. This includes fan powered VAV boxes, fan coil units that provide both heating and cooling, and exhaust fans with timer controls to only run during occupied hours.
- 24/7 ventilation includes any items that run continuously year-round. Typically, this would be exhaust fans without controls, but may also include fan powered VAV boxes and fan coil units for facilities that operate 24/7.

222 The source TRM does not provide CF_{winter} values. The following assumptions were made: summer cooling fan CF is applied to the winter CF for heating fan, cooling fan CF will be 0.0 during winter peak period, occupied ventilation summer CF is applied as the winter CF, and 24/7 ventilation has a winter CF of 1.0.

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16.3.3.4 Default savings

There are no default savings for this measure because the savings are dependent on the type of air handling equipment the ECM is installed on and the sector the equipment is servicing.

16.3.3.5 Effective Useful Life

The effective useful life of this measure is provided in Table 16-11.

Table 16-11. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	18.00	years	Wisconsin TRM 2022, p. 300

16.3.3.6 Source

The primary source for this deemed savings approach is the Wisconsin TRM 2022, pp. 298-302.

16.3.3.7 Update summary

Updates to this section are described in Table 16-12.

Table 16-12. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

16.3.4 Guest room occupancy

16.3.4.1 Measure description

This measure involves the installation of a control system in hotel guest rooms to automatically adjust the temperature setback during unoccupied periods. Savings are based on the management of the guest room's set temperatures and controlling the HVAC unit for various occupancy modes. The savings are per guestroom controlled, rather than per sensor, for multi-room suites.

The baseline condition is standard thermostats with no automatic temperature setbacks controlling the HVAC systems serving hotel guest rooms or similar rooms.

16.3.4.2 Savings Estimation Approach

Per-measure, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh \quad = \Delta kWh_{cool} + \Delta kWh_{heat}$$

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For packaged terminal heat pumps (PTHP) and air conditioners (PTAC), the per-measure, cooling kWh energy savings are calculated according to the following equation:

$$\Delta kWh_{cool} = Size_{cool} \times EFLH_{cool} \times \frac{1}{SEER} \times ESF$$

For chilled water fan coil units, the per-measure, cooling kWh energy savings are calculated according to the following equation:

$$\Delta kWh_{cool} = Size_{cool} \times EFLH_{cool} \times \frac{kW}{ton_{IPLV}} \times ESF$$

For packaged terminal heat pumps (PTHP), the per-measure, heating kWh energy savings are calculated according to the following equation:

$$\Delta kWh_{heat} = Size_{heat} \times EFLH_{heat} \times \frac{1}{HSPF} \times ESF$$

For non-electric heating system types, there are no electric energy heating savings. For packaged terminal air conditioners (PTAC) and chilled water fan coil units that have electric heating system types, the per-measure, heating kWh energy savings are calculated according to the following equation:

$$\Delta kWh_{heat} = Size_{heat} \times EFLH_{heat} \times \frac{1}{COP \times 3.412 \frac{Btuh}{W}} \times ESF$$

Per-measure, gross coincident summer and winter peak demand reduction is assigned no reduction, as follows:

$$\Delta kW_{summer} = 0$$

$$\Delta kW_{winter} = 0$$

Where:

ΔkWh	= per-measure gross annual electric energy savings
ΔkWh_{cool}	= per-measure gross cooling annual electric energy savings
ΔkWh_{heat}	= per-measure gross heating annual electric energy savings
ΔkW_{summer}	= per-measure gross coincident summer peak demand reduction
ΔkW_{winter}	= per-measure gross coincident winter peak demand reduction
$Size_{cool}$	= cooling capacity of existing AC unit, in kBTU/hr.
$Size_{heat}$	= heating capacity of existing heat pump or electric resistance unit, in kBTU/hr.
SEER	= seasonal energy efficiency ratio (SEER). It is used for heat pumps and AC units that are smaller than 65,000 Btu/h.
HSPF	= heating seasonal performance factor (HSPF) of existing heat pump. HSPF is used in heating savings for air-source heat pumps.
ESF	= energy savings factor

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$\frac{kW}{ton_{IPLV}}$	= energy efficiency of water-cooled chiller system at integrated part load value (IPLV)
COP	= coefficient of performance (heating)
$EFLH_{cool}$	= equivalent full load cooling hours
$EFLH_{heat}$	= equivalent full load heating hours

16.3.4.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 16-13. Input variables for measure name

Component	Type	Value	Units	Source(s)
$Size_{cool}$	Variable	See customer application	tons of cooling capacity (per unit)	Customer application
$Size_{heat}$	Variable	See customer application[223]	kBtu/h (per unit)	Customer application
		Default = $Size_{cool}$ x 12 kBtu/ton		
SEER	Variable	See customer application[224]		Customer application
		Default: See Table 17-8 and Table 17-9 in Sub-Appendix F2-III: Non-residential HVAC based on equipment type	kBtu/kW-hour	ASHRAE 90.1-2013
HSPF	Variable	See customer application[225]	kBtu/kW-hour	Customer application
		Default: See Table 17-9 in Sub-Appendix F2-III: Non-residential HVAC based on equipment type		ASHRAE 90.1-2013
COP	Variable	See Table 17-12 in Sub-Appendix F2-II: Non-residential HVAC	-	Standard electric resistance COP
kW/ton_{IPLV}	Variable	See Table 17-11 in Sub-Appendix F2-III: Non-residential HVAC based on equipment type, assume water cooled chiller, unknown, 75 tons to 300 tons	kW/ton	ASHRAE 90.1-2013
ESF	Fixed	0.184	-	Wisconsin TRM 2022, p. 376
$EFLH_{cool}$	Variable	See Table 17-4 in Sub-Appendix F2-II: Non-residential HVAC	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 423
$EFLH_{heat}$	Variable	See Table 17-5 in Sub-Appendix F2-II: Non-residential HVAC	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 422

223 When customer-provided heating system size is <80% or >156% of customer-provided cooling system size, a default value will be used, instead. In such instances, it is assumed that the heating system size was incorrectly documented. The acceptable range is based on a review of the AHRI database across numerous manufacturers and heat pump types.

224 Customer application SEER values should be between 14.0 and 42.0, based on a review of AHRI equipment. If the provided value is outside of these bounds, the default value is assigned.

225 Customer application HSPF values should be between 8.0 and 9.5, based on a review of AHRI equipment. If the provided value is outside of these bounds, the default value is assigned.

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16.3.4.4 Default savings

There are no default savings for this measure because the savings are dependent on the ventilation fan motor(s) installed, as well as the sector which the equipment is servicing.

16.3.4.5 Effective Useful Life

The effective useful life of this measure is provided in Table 16-14.

Table 16-14. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	8.00	years	Wisconsin TRM 2022, p. 377

16.3.4.6 Source

The primary source for this deemed savings approach is the Wisconsin TRM 2022, pp. 375-380. The equivalent full load hours are developed from the Mid-Atlantic TRM v10.

16.3.4.7 Update summary

Updates to this section are described in Table 16-15.

Table 16-15. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

16.3.5 Parking ventilation

16.3.5.1 Measure description

This measure involves controlling ventilation airflow in enclosed parking garages based on carbon monoxide concentrations, while maintaining code required run hours. By controlling airflow based on need rather than running it constantly, the system will save energy and maintain a safe environment. The measure with heating applies only to garages with heated exhaust air—not to heated garages in general, which generally meet space heating needs via separate unit heaters.

The baseline condition is 24-hour garage exhaust fan operation. The efficient condition is garage exhaust fan(s) that are controlled by carbon monoxide sensor(s) with a minimum five hours of daily operation.

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16.3.5.2 Savings Estimation Approach

Per-measure, gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \Delta kWh_{base} - \Delta kWh_{ee}$$

$$\Delta kWh_{base} = hp_{fan} \times 0.746 \times HOU_{base} \times Days$$

$$\Delta kWh_{ee} = hp_{fan} \times 0.746 \times HOU_{ee} \times Days$$

Per-measure, gross coincident summer and winter peak demand reduction is assigned no reduction, as follows:

$$\Delta kW_{summer} = 0$$

$$\Delta kW_{winter} = 0$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure gross coincident winter peak demand reduction
hp_{fan} = total horsepower of garage ventilation fan motor
HOU_{base} = daily run hours for base case
HOU_{ee} = average daily exhaust fan run hours with carbon monoxide control system
Days = days per year
CF_{summer} = summer peak coincidence factor
CF_{winter} = winter peak coincidence factor

16.3.5.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 16-16. Input variables for measure name

Component	Type	Value	Units	Source(s)
hp_{fan}	Variable	See customer application	hp	Customer application
HOU_{base}	Variable	See customer application	hours, daily	Customer application
		Default = 24.00		Wisconsin TRM 2021, p.308
HOU_{ee}	Fixed	7.00	hours, daily	Wisconsin TRM 2021, p.307
Days	Variable	See customer application	days, annual	Customer application
		Default = 365		Wisconsin TRM 2021, p.307

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16.3.5.4 Default savings

There are no default savings for this measure because the savings are dependent on the ventilation fan motor horsepower.

16.3.5.5 Effective Useful Life

The effective useful life of this measure is provided in Table 16-17.

Table 16-17. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	5.00	years	Wisconsin TRM 2021, p.308

16.3.5.6 Source

The primary source for this deemed savings approach is the Wisconsin TRM 2021, pp.306-310.

16.3.5.7 Update summary

Updates to this section are described in Table 16-18.

Table 16-18. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

16.4 Appliance or Plug Load end use

16.4.1 Commercial dishwasher

16.4.1.1 Measure description

This measure describes the installation of an ENERGY STAR qualified, high-efficiency stationary and conveyor-type commercial dishwashers used in commercial kitchen establishments that use non-disposable dishes, glassware, and utensils. Commercial dishwashers can clean and sanitize a large quantity of kitchenware in a short amount of time by utilizing hot water, soap, rinse chemicals, and significant amounts of energy. Energy Star qualified models use less water and have lower idling rates than non-Energy Star rated models.

The baseline condition is a standard non-ENERGY STAR commercial dishwasher. The efficient condition is a high-efficiency commercial dishwasher meeting ENERGY STAR Version 2.0
requirements.

16.4.1.2 Savings Estimation Approach

Per-measure, the gross annual electric energy savings are calculated according to the following equation:

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$$\Delta kWh \quad = kWh_{base} - kWh_{ee}$$

Per-measure, the gross summer coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} \quad = \frac{\Delta kWh \times CF_{summer}}{HOU}$$

Per-measure, the gross winter coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} \quad = \frac{\Delta kWh \times CF_{winter}}{HOU}$$

Per-measure, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta Water \quad = Water_{base} - Water_{ee}$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross summer peak coincident demand reduction
ΔkW_{winter} = per-measure gross winter peak coincident demand reduction
$\Delta Water$ = per-measure gross annual water savings
kWh_{base} = kWh consumption per year of the baseline unit
kWh_{ee} = kWh consumption per year of the energy efficient unit
HOU = hours of use, annual
CF_{summer} = summer coincidence factor
$CF_{winterr}$ = winter coincidence factor
$Watter_{base}$ = summer coincidence factor
$Water_{ee}$ = winter coincidence factor

16.4.1.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 16-19. Input variables for measure name

Component	Type	Value	Units	Source(s)
kWh_{base}	Variable	See Table 16-29	kWh	Maryland/Mid-Atlantic TRM v10, p. 400
kWh_{ee}	Variable	See Table 16-29	kWh	Maryland/Mid-Atlantic TRM v10, p. 400
HOU	Fixed	5,634[226]	hours, annual	Maryland/Mid-Atlantic TRM v10, p. 401
CF_{summer}	Fixed	0.90	-	Maryland/Mid-Atlantic TRM v10, p. 401

226 Maryland/Mid-Atlantic TRM v10, p. 401. The ENERGY STAR default value of 365 days per year seems excessive. 6 day operation is assumed (365 * 6/7) = 313 days/year at 18 hours per day, or 5,634 hours per year..

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Component	Type	Value	Units	Source(s)
CF_{winter}	Fixed	0.90	-	Maryland/Mid-Atlantic TRM v10, p. 401[227]
$Water_{base}$	Variable	See Table 16-21	gallons	Maryland/Mid-Atlantic TRM v10, p. 401
$Water_{ee}$	Variable	See Table 16-21	gallons	Maryland/Mid-Atlantic TRM v10, p. 401

The following table provides the base and efficient case annual energy consumption by the type of dishwasher. The savings are grouped by building hot water fuel type and for high temperature dishwashers, the booster fuel type is considered.

Table 16-20. Annual energy use of use (kWh) for various commercial dishwasher[228]

Building hot water fuel type / Booster water heater fuel type	Electric / Electric		Electric / Non-electric		Non-electric / Electric	
	kWh_{base}	kWh_{ee}	kWh_{base}	kWh_{ee}	kWh_{base}	kWh_{ee}
Low temperature						
Under counter	9,403	7,225	9,403	7,225	2,426	2,426
Stationary single tank door	33,683	19,832	33,683	19,832	2,066	2,066
Single tank conveyor	36,189	24,504	36,189	24,504	8,013	8,013
Multi tank conveyor	42,943	26,812	42,943	26,812	9,390	9,390
High temperature						
Under counter	10,595	7,876	8,083	5,894	6,199	4,408
Stationary single tank door	34,151	23,978	23,053	16,321	14,729	10,578
Single tank conveyor	39,070	31,171	28,378	22,568	20,358	16,115
Multi tank conveyor	62,148	38,645	44,265	28,690	30,853	21,223
Pot, pan, and utensil	18,064	15,225	12,041	10,235	7,525	6,492

The following table provides the water savings by dishwasher type.

Table 16-21. Annual water use of use for various commercial dishwasher

Dishwasher type	$Water_{base}$ (gallons)	$Water_{ee}$ (gallons)
Low temperature		
Under counter	40,616	27,900
Stationary single tank door	184,008	103,374

[227] Rhe source TRM does not provide a winter CF value. Therefore, the summer CF is applied for this period.

[228] Maryland/Mid-Atlantic TRM v10, p. 401. Savings Calculator for ENERGY STAR Certified Commercial Kitchen Equipment based on 5,634 annual hours of operation. <http://www.energystar.gov/buildings/sites/default/uploads/files/commercial_kitchen_equipment_calculator.xlsx>

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Dishwasher type	$Water_{base}$ (gallons)	$Water_{ee}$ (gallons)
Single tank conveyor	164,036	98,886
Multi tank conveyor	195,303	101,429
High temperature		
Under counter	25,582	20,196
Stationary single tank door	113,023	78,016
Single tank conveyor	108,909	87,666
Multi tank conveyor	182,138	101,429
Pot, pan, and utensil	61,336	50,864

16.4.1.4 Default savings

There are no default savings for this measure because the savings are dependent on the type of commercial dishwasher.

16.4.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 16-22.

Table 16-22. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Dishwasher type	Value	Units	Source(s)
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	Under counter	10.00	years	Maryland/Mid-Atlantic TRM v10, pp. 399-403
		Stationary single tank door	15.00		
		Single tank conveyor	20.00		
		Multi tank conveyor	20.00		
		Pot, pan, and utensil	10.00		

16.4.1.6 Source

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v10, pp. 399-403.

16.4.1.7 Update summary

Updates to this section are described in Table 16-23.

Table 16-23. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

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16.4.2 Commercial dryer

16.4.2.1 Measure description

This measure is for the installation of a residential clothes dryer, utilized in a commercial setting, meeting the ENERGY STAR® criteria. ENERGY STAR® qualified clothes dryers save energy through a combination of more efficient drying and reduced runtime of the drying cycle. More efficient drying is achieved through increased insulation, modifying operating conditions (such as air flow and/or heat input rate) improving air circulation through better drum design or booster fans, and improving efficiency of motors. Reducing the runtime of dryers through automatic termination by temperature and moisture sensors is believed to have the greatest potential for reducing energy use in clothes dryers. ENERGY STAR® provides criteria for both gas and electric clothes dryers.

The baseline condition is a clothes dryer meeting the minimum federal requirements for units manufactured on or after January 1, 2015.

16.4.2.2 Savings Estimation Approach

Per-measure, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \left(\frac{Load}{CEF_{base}} - \frac{Load}{CEF_{ee}}\right) \times N_{cycles} \times Dryer_{electric}$$

Per-measure, the gross summer coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \frac{\Delta kWh}{hours_{summer}}$$

Per-measure, the gross winter coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \frac{\Delta kWh}{hours_{winter}}$$

Where:

ΔkWh	= per-measure gross annual electric energy savings
ΔkW_{summer}	= per-measure gross summer coincident demand reduction
ΔkW_{winter}	= per-measure gross winter coincident demand reduction
Load	= size of equipment
N_{cycles}	= number of dryer cycles per year
$Dryer_{electric}$	= the percent of overall savings coming from electricity
HOU	= hours of use, annual
CEF_{base}	= efficiency of baseline equipment
CEF_{ee}	= efficiency of energy-efficient equipment
$hours_{ummer}$	= summer peak coincident hours of use to adjust from annual kWh to peak period kW
$hours_{winterr}$	= winter peak coincident hours of use to adjust from annual kWh to peak period kW

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16.4.2.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 16-24. Input variables for commercial dryer

Component	Type	Value	Units	Source(s)
Load	Variable	Compact = 3.0 Standard (default) = 8.45	lbs	Missouri TRM Vol. 2, 2019-24 MEEIA Plan, p. 11
CEF_{base}	Variable	See Table 16-25	lbs/kWh	Missouri TRM Vol. 2, 2019-24 MEEIA Plan, p. 11
CEF_{ee}	Variable	See customer application	lbs/kWh	Customer application
		Default: see Table 16-25		Missouri TRM Vol. 2, 2019-24 MEEIA Plan, p. 11
N_{cycle}	Variable	Laundromat (default) = 1,483 On-premise laundromat = 3,607	-	Missouri TRM Vol. 2, 2019-24 MEEIA Plan, p. 12
$Dryer_{electric}$	Variable	Electric dryer (default) = 1.0 Non-electric = 0.05	-	Missouri TRM Vol. 2, 2019-24 MEEIA Plan, p. 12
$hours_{summer}$	Fixed	7,249	hours	Missouri TRM Vol. 2, 2019-24 MEEIA Plan, p. 12[229]
$hours_{winter}$	Fixed	7,249	hours	Missouri TRM Vol. 2, 2019-24 MEEIA Plan, p. 12[230]

Table 16-25. Product class CEF values

Product class	CEF_{base} (lbs/kWh)	CEF_{ee} (lbs/kWh)
Compact vented, 120 V	3.01	3.80
Compact vented, 240 V	2.73	3.45
Compact ventless, 120 V	3.01	3.80
Compact ventless, 240 V	2.13	2.68
Standard vented (default)	3.11	3.93
Standard ventless	3.11	3.93

16.4.2.4 Default savings

The default per-measure gross annual electric energy savings per unit will be assigned according to the following calculation:

$$\Delta kWh = \left(\frac{Load}{CEF_{base}} - \frac{Load}{CEF_{ee}}\right) \times N_{cycles} \times Dryer_{electric}$$

$$= \left(\frac{8.45}{3.11} - \frac{8.45}{3.93}\right) \times 1{,}483 \times 1.0$$

229 The source TRM provides a term as a coincind factor, as coincince factors are typically applied to kW not kWh, the factor was converted to the peak hours adjustment factor as the inverse of the coincinde factor (1/0.0001379439 = 7,249 hours).

230 The source TRM does not provide a winter peak adjustment factor, therefore the summer peak value is applied.

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$$= 840.73\ kWh$$

The default per-measure gross summer coincident demand reduction is calculated according to the following equation:

$$\Delta kW = \frac{\Delta kWh}{hours_{summer}}$$

$$= \frac{840.73}{7{,}249}$$

$$= 0.116\ kW$$

The default per-measure gross winter coincident demand reduction is calculated according to the following equation:

$$\Delta kW = \frac{\Delta kh}{hours_{winter}}$$

$$= \frac{840.7}{7{,}249}$$

$$= 0.116\ kW$$

16.4.2.5 Effective Useful Life

The effective useful life of this measure is provided in Table 16-26.

Table 16-26. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	14.00	years	Missouri TRM Vol. 2, 2019-24 MEEIA Plan, p. 11

16.4.2.6 Source

The primary source for this deemed savings approach is the Missouri TRM Vol. 2, 2019-24 MEEIA Plan, pp. 10-14.

16.4.2.7 Update summary

Updates to this section are described in Table 16-27.

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Table 16-27. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

16.4.3 Commercial washing machine

16.4.3.1 Measure description

This measure relates to the purchase (time of sale) and installation of a commercial clothes washer (i.e., soft-mounted front-loading or soft-mounted top-loading clothes washer that is designed for use in applications in which the occupants of more than one household will be using the clothes washer, such as multi-family housing common areas and coin laundries) exceeding the ENERGY STAR minimum qualifying efficiency standards.

The baseline for this measure is the Federal Standard for the installed load type.

16.4.3.2 Impacts Estimation Approach

Per-measure, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = \Delta kWh_{CW} + \Delta kWh_{DHW} + \Delta kWh_{Dryer}$$

$$\Delta kWh_{CW} = \left(kWh_{Unit,base} - kWh_{Unit,ee} \right) \times CW$$

$$\Delta kWh_{DHW} = \left(kWh_{Unit,base} - kWh_{Unit,ee} \right) \times DHW \times DHW_{electric}$$

$$\Delta kWh_{Dryer} = \left[\left(kWh_{Total,base} - kWh_{Total,ee} \right) - \left(kWh_{Unit,base} - kWh_{Unit,ee} \right) \right] \times Load_{dryed} \times Dryer_{usage} \times Dryer_{usage,mod} \times Dryer_{electric}$$

$$kWh_{Unit,i} = \frac{kWh_{Unit,rated,i} \times N_{cycles}}{N_{cycles,ref}}$$

$$kWh_{Total,i} = \frac{Size \times N_{cycles}}{MEF_i}$$

Per-measure, the gross summer coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \frac{\Delta kWh}{HOU} \times CF_{summer}$$

Per-measure, the gross winter coincident demand reduction is calculated according to the following equation:

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$$\Delta kW_{winter} = \frac{\Delta kWh}{HOU} \times CF_{winter}$$

Where:

ΔkWh	= per-measure gross annual electric energy savings
ΔkW_{summer}	= per-measure gross coincident summer peak demand savings
ΔkW_{winter}	= per-measure gross coincident winter peak demand savings
ΔkW_{CW}	= total electrical energy savings for clothes washer
ΔkW_{DHW}	= total electrical energy savings for water heater
ΔkW_{Dryer}	= total electrical energy savings for dryer
$\Delta kWh_{Unit,base}$	= unit electricity consumption of the baseline unit excluding the dryer
$\Delta kWh_{Unit,ee}$	= unit electricity consumption of the energy efficient unit excluding the dryer
$\Delta kWh_{Total,base}$	= unit electricity consumption per year of the baseline unit including the dryer (assumed electric)
$\Delta kWh_{Total,ee}$	= unit electricity consumption per year of the energy efficient unit including the dryer (assumed electric)
CW	= proportion of unit energy consumption used for clothes washer operation
DHW	= proportion of unit energy consumption used for heating water
$DHW_{electric}$	= water heater fuel type factor to account for DHW fuel type
$Load_{dryed}$	= proportion of washer loads dried in machine
$Dryer_{usage}$	= dryer usage factor
$Dryer_{usage,mod}$	= dryer usage in buildings with dryer and washer
$Dryer_{electric}$	= dryer fuel type factor to account for dryer fuel type
$kWh_{Unit.rated,base}$	= rated unit electricity consumption per year of the baseline unit
$kWh_{Unit.rated,ee}$	= rated unit electricity consumption per year of the energy efficient unit
N_{cycles}	= number of cycles per year
$N_{cycles,ref}$	= reference number of cycles per year
MEF_i	= energy factor of baseline and energy efficient unit
Size	= clothes washer capacity
HOU	= hours of use, annual
CF_{summer}	= summer coincidence factor
$CF_{winterr}$	= winter coincidence factor

16.4.3.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 16-28. Input variables for measure name

Component	Type	Value	Units	Source(s)
CW	Variable	See customer application	-	Customer application
		Default: 0.2		Maryland/Mid-Atlantic TRM v10, p. 364
DHW	Variable	See customer application	-	Customer application
		Default: 0.8		Maryland/Mid-Atlantic TRM v10, p. 364
$DHW_{electric}$	Variable	See Table 16-30	-	Maryland/Mid-Atlantic TRM v10, p. 364
$Load_{dryer}$	Fixed	1.00	-	Maryland/Mid-Atlantic TRM v10, p. 365

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Component	Type	Value	Units	Source(s)
$Dryer_{usage}$	Fixed	0.84	-	Maryland/Mid-Atlantic TRM v10, p. 365
$Dryer_{usage\_mod}$	Fixed	0.95	-	Maryland/Mid-Atlantic TRM v10, p. 365
$Dryer_{electric}$	Fixed	See Table 16-31	-	Maryland/Mid-Atlantic TRM v10, p. 365
$kWh_{Unit, rated. base}$	Variable	See customer application	kWh/year	Customer application
		Default: 241		Maryland/Mid-Atlantic TRM v10, p. 364
$kWh_{Unit, ee}$	Variable	See customer application	kWh/year	Customer application
		Default: 97		Maryland/Mid-Atlantic TRM v10, p. 364
N_{cycles}	Variable	See Table 16-32	cycles/year	Maryland/Mid-Atlantic TRM v10, p. 365
$N_{cycles,ref}$	Fixed	392	cycles/year	Maryland/Mid-Atlantic TRM v10, p. 365
Size	Variable	See customer application	ft^3	Customer application
		Default: 3.43		Maryland/Mid-Atlantic TRM v10, p. 364
MEF_{base}	Variable	See Table 16-29	ft^3/kWh	Maryland/Mid-Atlantic TRM v10, p. 364
MEF_{ee}	Variable	See Table 16-29	ft^3/kWh	Maryland/Mid-Atlantic TRM v10, p. 364
HOU	Fixed	265[231]	hours, annual	Maryland/Mid-Atlantic TRM v10, p. 365
CF_{summer}	Fixed	0.029[232]	-	Maryland/Mid-Atlantic TRM v10, p. 365
CF_{winter}	Fixed	0.029[233]	-	Maryland/Mid-Atlantic TRM v10, p. 365

Table 16-29. MEF based on Efficiency Level and Loading Type

Efficiency level	Loading type	
	Front loading	Top loading
Federal standard (baseline)	>=2.0	>=1.35
Energy Star (efficient)	>=2.20	

Table 16-30. DHW fuel factor

DHW Fuel	$DHW_{electric}$
Electric	1.00
Non-electric	0.00
Unknown (default)	0.69

231 Metered data from Navigant Consulting "EmPOWER Maryland Draft Final Evaluation Report Evaluation Year 4 (June 1, 2012 – May 31, 2013) Appliance Rebate Program." March 21, 2014, page 36. This data applies to residential applications. In the absence of metered data specific to multifamily common area and commercial laundromat applications, this coincidence value is used as a proxy given consistency with the PJM peak definition; however, this value is likely conservatively low for commercial applications and is a candidate for update should more applicable data become available.

232 Ibid

233 Source TRM does not provide a winter CF. Therefore the summer CF is applied unlit beter information is available.

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Table 16-31. Dryer fuel factor

DHW Fuel	$DHW_{electric}$
Electric	1.00
Non-electric	0.00
Unknown (default)[234]	0.69

Table 16-32. Number of washer cycles per year based on the building type

Building type	Nc_{cycles}
Multi-family	1,241
Laundromat (default)[235]	2,190

16.4.3.4 Default savings

If the proper values are not available, zero savings will be given for both the gross annual electric energy savings and the gross coincident peak demand reduction.

16.4.3.5 Effective Useful Life

The effective useful life of this measure is provided in Table 16-33.

Table 16-33. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	7.00	years	Maryland/Mid-Atlantic TRM v10, p. 365

16.4.3.6 Source

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v10, pp. 363-367.

16.4.3.7 Update summary

Updates to this section are described in Table 16-34.

Table 16-34. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

234 The source TRM does not include a default value for dryer fuel type factor. Therefore, the DHW Fuel Factor default is applied as an approximation.

235 Dominion Commercial Energy Use Survey 2019 – 2020, Appendix B, p. 72, Q39 percent of respondents with electric DHW (720/1,041 = 69%).

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16.4.4 Food seal wrapper

16.4.4.1 Measure description

This measure involves replacing existing food wrappers without a means of automatically turning off the equipment when not in use, with a new food wrapper with the capability to sense when the equipment is in use, and automatically turn off the equipment when not in use.

This measure is applicable to grocery, convenience store, deli, bakery, butcher, and other commercial facilities

The baseline equipment is a food wrapper without a micro-processor and optical sensor control, and for which there is no alternative automation or programmed controls to turn off the equipment when not in use.

The efficient equipment is an on-demand food wrapper with a micro-processor and optical sensor, advanced control strategy, or programming able to sense when the equipment is in use. It can automatically turn off the food wrapper equipment when the equipment is not in use.

16.4.4.2 Savings Estimation Approach

Per-measure, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = kWh_{base} - kWh_{ee}$$

Per-measure, the gross summer coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = (kW_{base} - kW_{ee}) \times CF_{summer}$$

Per-measure, the gross winter coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = (kW_{base} - kW_{ee}) \times CF_{winter}$$

Where:

ΔkWh = per-measure gross annual electric energy savings
ΔkW_{summer} = per-measure gross coincident summer peak demand reduction
ΔkW_{winter} = per-measure gross coincident winter peak demand reduction
kWh_{base} = average baseline energy consumption
kWh_{ee} = average energy efficient energy consumption
kW_{base} = average typical baseline operation profile
kW_{ee} = average typical energy efficient operation profile
CF_{summer} = summer coincidence factor
CF_{winter} = winter coincidence factor

16.4.4.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

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Table 16-35. Input variables for measure name

Component	Type	Value	Units	Source(s)
kWh_{base}	Fixed	1,950	kWh	CA eTRM, Commercial Hand-Wrap Machine, vSWFS010-02[236]
kWh_{ee}	Fixed	405	kWh	CA eTRM, Commercial Hand-Wrap Machine, vSWFS010-02
kW_{base}	Fixed	0.23	kW	CA eTRM, Commercial Hand-Wrap Machine, vSWFS010-02
kW_{ee}	Fixed	0.05	kW	CA eTRM, Commercial Hand-Wrap Machine, vSWFS010-02
CF_{winter}	Fixed	1.0	-	CA eTRM, Commercial Hand-Wrap Machine, vSWFS010-02[237]
CF_{summer}	Fixed	1.0	-	CA eTRM, Commercial Hand-Wrap Machine, vSWFS010-02

16.4.4.4 Default savings

The default per-measure, gross annual electric energy savings per unit will be assigned according to the following calculation:

$$\Delta kWh = kWh_{base} \times kWh_{ee}$$

$$= 1{,}950\ kWh - 405\ kWh$$

$$= 1{,}545\ kWh$$

The default per-measure, gross summer coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = (\ kW_{base} - kW_{ee}) \times CF_{summer}$$

$$= (0.23\ kW - 0.05\ kW) \times 1.0$$

$$= 0.18\ kW$$

The default per-measure, the gross winter coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = (\ kW_{base} - kW_{ee}) \times CF_{winter}$$

236 Original source was the Commercial Hand Wrap Machines for Food Service Applications Field Test study conducted by Southern California Edison (SCE).

237 The Source TRM uses kW values from measured peak demand values during the Database of Energy Efficient Resources (DEER) peak period of 4:00 p.m. to 9:00 p.m, as these measured values occurred during the peak period no CF was applied, or an implied CF of 1.0. There was no winter peak period data available, therefore the summer peak values are applied to the winter peak.

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$$= (0.23\ kW - 0.05\ kW) \times 1.0$$

$$= 0.18\ kW$$

16.4.4.5 Effective Useful Life

The effective useful life of this measure is provided in Table 16-36.

Table 16-36. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	10.00	years	CA eTRM, Commercial Hand-Wrap Machine vSWFS010-02.

16.4.4.6 Source

The primary source for this deemed savings approach is the CA eTRM, Commercial Hand-Wrap Machine, vSWFS010-02. This TRM uses a field the Commercial Hand Wrap Machines for Food Service Applications Field Test study conducted by Southern California Edison (SCE). This study monitored 10 stores across 4 chains for deli, bakery, and meat departments.

16.4.4.7 Update summary

Updates to this section are described in Table 16-37.

Table 16-37. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

16.4.5 Ozone laundry

16.4.5.1 Measure description

A new ozone laundry system(s) is added-on to new or existing commercial washing machine(s) using hot water heated with natural gas. The system generates ozone (O3), a naturally occurring molecule, which helps clean fabrics by chemically reacting with soils in cold water. Adding an ozone laundry system(s) will reduce the amount of chemicals, detergents, and hot water needed to wash linens.

Electric savings can be realized through reduced washer cycle length and reduced pumping load at the boiler feeding the commercial washers. The increased usage associated with operating the ozone system should also be accounted for when determining total kWh impact.

The base case equipment is a conventional washing machine system with no ozone generator installed. The washing machines are provided hot water from a gas-fired boiler.

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In the efficient case, a new ozone laundry system(s) is added-on to new or existing commercial washing machine(s) using hot water heated with natural gas. The ozone laundry system(s) must transfer ozone into the water through:

- Venturi Injection
- Bubble Diffusion

For laundromats, the ozone laundry system(s) must be connected to both the hot and cold water inlets of the clothes washing machine(s) so that hot water is no longer provided to the clothes washer.

The measure only applies to the following facilities with on-premise laundry operations: Hotels/motels, Fitness and recreational sports centers, Healthcare (excluding hospitals), Assisted living facilities, Laundromats.

This measure is offered through different programs listed in Table 6-13 and uses the impacts estimation approach described in this section.

16.4.5.2 Impacts Estimation Approach

Per-measure, the gross annual electric energy savings per system are calculated according to the following equation:

$$\Delta kWh \quad = HP \times 0.746 \times HOU \times WRF$$

Per-measure, the gross annual water savings per pounds of laundry are calculated according to the following equation:

$$\Delta Water \quad = W_{use} \times Capacity \times N_{cycles} \times WRF$$

Per-measure, the gross summer and winter coincident demand reduction is zero[238], as shown in the following equations:

$$\Delta kW_{summer} \quad = 0$$

$$\Delta kW_{winter} \quad = 0$$

Where:

ΔkWh	= per-measure gross annual electric energy savings from reducing the pump load
ΔkW_{summer}	= per-measure gross summer peak coincident demand reduction
ΔkW_{winter}	= per-measure gross winter peak coincident demand reduction
ΔWater	= per-measure gross annual water savings
HOU	= hours of use, annual
HP	= brake horsepower of boiler feed water pump
WRF	= water reduction factor: how much more efficient an ozone injection washing machine is compared to a typical conventional washing machine as a rate of hot and cold water reduction
WU_{base}	= water use for the base case
Capacity	= total capacity of washers

[238] Illinois TRM v.9.0 Vol.2, 2020, p. 152. at this moment peak demand savings cannot be associated with this measure as not enough study has been done regarding operation of ozone laundry systems and coincident peak demand.

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N_{cycles} = number of annual loads of laundry

16.4.5.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 16-38. Input variables for measure name

Component	Type	Value	Units	Source(s)
HP	Variable	See customer application	hp	Customer application
		Default: 5		Illinois TRM v10.0 Vol.2, 2020, p. 186
HOU	Fixed	800	hours, annual	Illinois TRM v10.0 Vol.2, 2020, p. 186
WRF	Variable	See Table 6-8	-	Illinois TRM v10.0 Vol.2, 2020, p. 186
Capacity	Variable	See customer application	lb	Customer application
		default: 254.4		Illinois TRM v10.0 Vol.2, 2020, p. 187
W_{use}	Variable	See Table 16-39	gallon/lb	Illinois TRM v10.0 Vol.2, 2020, p. 189
N_{cycles}	Variable	See Table 16-39	cycles, annual	Illinois TRM v10.0 Vol.2, 2020, p. 190

Table 16-39. Water Reduction Factor (WRF) and capacity values for various applications

Application	WRF	W_{use} (gallon/lb)	N_{cycles} (loads/year)
Laundromat	0.10	1.09	2,190
Hotel/motel	0.25	2.03	4,745
Fitness and recreation			
Healthcare			
Assisted living			

16.4.5.4 Default savings

The default savings depend on the application type. As an example, the default calculations are provided for laundromat.

Per-measure, the gross annual electric energy savings per system of laundry are calculated as follows:

$$\Delta kWh = HP \times 0.746 \times HOU \times WRF$$

$$= 5\ hp \times 0.746\ \frac{kW}{hp} \times 800\ hours \times 0.1$$

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$$= 298.40\ kWh$$

Per-measure, the gross summer and winter coincident demand reduction is zero, as shown in the following equations:

$$\Delta kW_{summer} = 0$$

$$\Delta kW_{winter} = 0$$

Per-measure, the gross annual water savings per pounds of laundry are calculated according to the following equation:

$$\Delta Water = W_{use} \times Capacity \times N_{cycles} \times WRF$$

$$= 1.09\ \frac{gallon}{lb} \times 254.4\ lb \times 2{,}190\ cycles \times 0.1$$

$$= 60{,}728\ gallons$$

16.4.5.5 Effective Useful Life

The effective useful life of this measure is provided in Table 16-40.

Table 16-40. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	10.00	years	Illinois TRM v.10.0 Vol.2, 2020, p. 185

16.4.5.6 Source

The primary source for this deemed savings approach is the Illinois TRM v.10.0 Vol.2, 2020, pp. 184–191.

16.4.5.7 Update summary

Updates to this section are described in Table 16-41.

Table 16-41. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

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16.5 Recreation end use

16.5.1 Heat pump pool heater

16.5.1.1 Measure description

This measure applies to the installation of a heat pump pool heater in place of a standard electric pool heater on an outdoor pool at a commercial location. The baseline equipment is a new, standard-efficiency electric resistance pool heater. To qualify for this measure, the installed equipment must be a new heat pump pool heater meeting program requirements.

16.5.1.2 Impacts Estimation Approach

Per-measure, the gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = Q_{pool} \times \left(\frac{1}{\eta_{WH,base}} - \frac{1}{\eta_{WH,ee}}\right)$$

Per-measure, the gross summer coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{summer} = \frac{\Delta kWh \times CF_{summer}}{HOU}$$

Per-measure, the gross winter coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \Delta kWh \times CF_{winter}$$

Where:

ΔkWh	= per-measure gross annual electric energy savings
ΔkW_{summer}	= per-measure gross coincident summer peak demand reduction
ΔkW_{winter}	= per-measure gross coincident winter peak demand reduction
Q_{pool}	= required annual heat transfer to pool water (kWh)
Area	= pool area
EFF_{base}	= efficiency of electric resistance pool heater
EFF_{ee}	= efficiency (COP) of heat pump pool heater
CF_{summer}	= summer coincidence factor
$CF_{winterr}$	= winter coincidence factor

16.5.1.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 16-42. Input variables for measure name

Component	Type	Value	Units	Source(s)
Q_{pool}	Variable	For an uncovered pool: =53.075×area+1,631.1	kWh	Customer application and Missouri TRM Vol.2, 2019-2024 MEEIA Plan, p.171

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Component	Type	Value	Units	Source(s)
		For a covered pool: =8.079×area+1,295.4		
Area	Variable	See customer application	ft^2	Customer application
EFF_{base}	Fixed	1.0	-	Missouri TRM Vol.2, 2019-2024 MEEIA Plan, p.171
EFF_{ee}	Variable	See customer application	-	Customer application
		For default: 3.0		Energy.gov Heat Pump Swimming Pool Heaters conservative value of provide range[239]
CF_{summer}	Fixed	0.000138	-	Missouri TRM Vol.2, 2019-2024 MEEIA Plan, p.172
CF_{winter}	Fixed	0.0	-	DNV judgment

16.5.1.4 Default savings

If the proper values are not available, zero savings will be given for both the gross annual electric energy savings and the gross coincident peak demand reduction.

16.5.1.5 Effective Useful Life

The effective useful life of this measure is provided in Table 16-43.

Table 16-43. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
VIII	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	15.00	years	Missouri TRM Vol.2, 2019-2024 MEEIA Plan, p.171

16.5.1.6 Source

The primary source for this deemed savings approach is the Missouri TRM Vol.2, 2019-2024 MEEIA Plan, pp. 171-172. It is noted that the heat load of the pool will be dependent on the weather conditions and the pool season. The Missouri provides a reasonable estimate for this value, but this value may be calculated for Virginia and North Carolina locations in the future.

[239] A range of 3.0 to 7.0 COP is provided, https://www.energy.gov/energysaver/heat-pump-swimming-pool-heaters. Accessed on 09/12/2022

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16.5.1.7 Update summary

Updates to this section are described in Table 16-44.

Table 16-44. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

16.5.2 Pool spa cover

16.5.2.1 Measure description

This measure refers to the installation of covers on commercial use pools that are heated with electric equipment located either indoors or outdoors. By installing pool covers, the heating load will be reduced by reducing the heat loss from the water to the environment and the amount of actual water lost due to evaporation (which then requires additional heated water to make up for it).

The main source of energy loss in pools is through evaporation. This is particularly true of outdoor pools where wind plays a larger role. The point of installing pool covers is threefold. First, it will reduce convective losses due to the wind or air movement by shielding the water surface. Second, it will insulate the water from the colder surrounding air. And third, it will reduce radiative losses to the night sky (for outdoor pools). In doing so, evaporative losses will also be minimized, and the heater will not need to work as hard in replenishing the pool with hot water to keep the desired temperature.

For indoor pools, the base case is an uncovered indoor pool that operates all year, and for outdoor pools, the base case is an outdoor pool that is uncovered and is open through the summer season.

This measure can be used for pools that (1) currently do not have pool covers, (2) have pool covers that are past the useful life of the existing cover, or (3) have pool covers that are past their warranty period and have failed.

16.5.2.2 Impacts Estimation Approach

Per-measure, the gross annual electric energy savings are only for pool pump heaters with electric fuel type. Energy and water savings are calculated according to the following equation:

$$\Delta kWh = ESF \times Size_{pool}$$

$$\Delta Water = WSF \times Size_{pool}$$

Per-measure, the gross summer and winter coincident demand reduction is zero, as shown in the following equation:

$$\Delta kW_{summer} = 0$$

$$\Delta kW_{winter} = 0$$

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Where:

ΔkWh_{water} = per-measure gross annual electric energy savings for water supply and wastewater treatment
ΔkW_{summer} = per-measure gross summer peak coincident demand reduction
ΔkW_{winter} = per-measure gross winter peak coincident demand reduction
$\mathrm{Size}_{\mathrm{pool}}$ = size of the pool
ESF = energy savings factor
WSF = water savings factor
$\Delta\mathrm{Water}$ = water savings

16.5.2.3 Input variables

The following table provides the inputs and the source of the inputs used for calculating impacts for this measure.

Table 16-45. Input variables for measure name

Component	Type	Value	Units	Source(s)
ESF	Variable	See Table 16-46	kWh/sq-ft	Illinois TRM v10.0 Vol.2, p. 182[240]
WSF	Variable	See Table 16-46	gallons/sq-ft	Illinois TRM v10.0 Vol.2, p. 182
$Size_{pool}$	Variable	See customer application	sq-ft	Customer application

Table 16-46. Water savings factor (WSF) for various locations

Location	ESF (kWh/sq-ft)	WSF (gallons/sq-ft)
Indoor	61.2	15.28
Outdoor	23.68	8.94

16.5.2.4 Default savings

No default savings will be awarded for this measure if the proper values are not provided in the customer application.

16.5.2.5 Effective Useful Life

The effective useful life of this measure is provided in Table 16-47.

Table 16-47. Effective Useful Life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
VIII	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	6.00	years	Illinois TRM v10.0 Vol.2, p. 182

240 The source TRM calculates savings in therms for a gas fired pool heater. The ESF was converted to kWh assuming a gas heater efficiency of 80% and an electric heater efficiency of 100%.

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16.5.2.6 Source

The primary source for this deemed savings approach is the Illinois TRM v10.0 Vol.2, pp. 180–182.

16.5.2.7 Update summary

Updates to this section are described in Table 16-48.

Table 16-48. Summary of update(s)

Version	Update type	Description
2022	-	Initial release

16.5.3 Variable speed pool pump

This measure is also provided by the Non-Residential Multifamily Program, DSM Phase VIII. The savings are determined using the methodology described in Section 10.6.1.

16.6 Refrigeration end use

16.6.1 Commercial freezers and refrigerators

This measure is also provided by the Non-Residential Prescriptive Program, DSM Phase VI. The savings are determined using the methodology described in Section 4.4.3.

16.6.2 Commercial ice maker

This measure is also provided by the Non-Residential Prescriptive Program, DSM Phase VI. The savings are determined using the methodology described in Section 4.4.4.

16.6.3 Door closer (cooler and freezer)

This measure is also provided by the Non-Residential Prescriptive Program, DSM Phase VI. The savings are determined using the methodology described in Section 4.4.1.

16.6.4 Door gasket

This measure is also provided by the Non-Residential Prescriptive Program, DSM Phase VI. The savings are determined using the methodology described in Section 4.4.2.

16.6.5 Evaporator fan electronically commutated motor (ECM) retrofit

This measure is also provided by the Non-Residential Prescriptive Program, DSM Phase VI. The savings are determined using the methodology described in Section 4.4.5.

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16.6.6 Low/anti-sweat door film

This measure is also provided by the Non-Residential Prescriptive Program, DSM Phase VI. The savings are determined using the methodology described in Section 4.4.8.

16.6.7 Refrigeration condenser coil cleaning

This measure is also provided by the Non-Residential Prescriptive Program, DSM Phase VI. The savings are determined using the methodology described in Section 4.4.10.

16.6.8 Strip curtain (cooler and freezer)

This measure is also provided by the Non-Residential Prescriptive Program, DSM Phase VI. The savings are determined using the methodology described in Section 4.4.12.

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17 SUB-APPENDICES

17.1 Sub-Appendix F2-I: Cooling and heating degree days and hours

This section appears in Appendix F1 as Sub-appendix F1-III: Cooling and Heating Degree Days and Hours (a.k.a. Section 24.3).

Table 17-1. Base Temperatures by Sector and End Use

This table appears in Appendix F1 as Sub-appendix F1-III: Cooling and Heating Degree Days and Hours (a.k.a. Section 24.3).

Table 17-2. Reference Cooling and Heating Degree Days

This table appears in Appendix F1 as Sub-appendix F1-III: Cooling and Heating Degree Days and Hours (a.k.a. Section 24.3).

Table 17-3. Reference Cooling and Heating Degree Hours

This table appears in Appendix F1 as Sub-appendix F1-III: Cooling and Heating Degree Days and Hours (a.k.a. Section 24.3).

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17.2 Sub-Appendix F2-II: Non-residential HVAC equivalent full load hours

This sub-appendix provides the default heating and cooling the equivalent full load hours (EFLH)s for non-residential HVAC equipment and VFDs. Table 17-4 and Table 17-5 provide the EFLHs for HVAC equipment by facility type and location. Table 17-17 provides annual run hours for VFDs by facility type and VFD application.

The EFLH are determined using the methodology used in the Maryland/Mid-Atlantic TRM v.10. The methodology adapts EFLH from the Pennsylvania TRM 2016 and adjusted for locally design temperatures and degree days from 2013 ASHREA Handbook Fundamentals[241]. DNV calculates EFLHs for various locations in Dominion Energy's service territory using the same adjustment method and TMY3 weather data. Baltimore is used as the reference location and EFLHs is scaled using local TMY3 weather data.

The scaling method is shown in the following example calculation, using Education – Elementary and Middle School for Richmond, VA:

$$\text{Mid-Atlantic TRM Baltimore EFLHcool} = 295\ hour/year$$

$$\text{Baltimore CDD} = 1{,}222\ hour/year$$

$$\text{Richmond CDD} = 1{,}448\ hour/year$$

$$\text{STEP Richmond EFLHcool} = Richmond\ CDD \times \frac{Baltimore\ EFLH_{cool}}{Baltimore\ CDD}$$

$$= 1{,}448\ hour/year \times \frac{295\ hur/year}{1{,}222\ hour/year}$$

$$= 349\ hour/year$$

241 See pages 422 - 423, footnote 885 and 886 in the Maryland/Mid-Atlantic TRM v. 10

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17.2.1 Annual equivalent full-load cooling hours for unitary air conditioners, heat pumps, chiller, VRF, room/wall AC, and mini-split systems

Table 17-4. Heat pump, unitary AC, chiller, VRF, room/wall AC, and mini split equivalent full-load cooling hours for non-residential buildings

Building type by weather station	Maryland	North Carolina		Virginia								Building weight used for midstream
	Baltimore	Elizabeth City	Rocky Mount	Char-lottesville	Sterling	Farmville	Norfolk	Arlington	Richmond	Roanoke	Fredericksburg	
Education – elementary and middle school	295	422	327	260	262	307	389	363	349	265	327	1.5%
Education – high school	340	486	377	300	302	354	448	419	403	306	377	1.5%
Education – college and university242	750	1,072	832	662	666	780	988	923	888	675	831	1.5%
Food sales - grocery	678	969	752	598	602	705	893	835	803	610	751	1.8%
Food sales – convenience store	923	1,320	1,023	815	820	960	1,216	1,136	1,093	831	1,023	1.8%
Food sales – gas station convenience store	923	1,320	1,023	815	820	960	1,216	1,136	1,093	831	1,023	1.8%
Food service - full service	768	1,098	852	678	682	799	1,011	946	910	691	851	4.5%
Food service - fast food	730	1,044	809	644	649	760	961	899	865	657	809	4.5%
Health care - inpatient	1,223	1,748	1,356	1,079	1,086	1,273	1,611	1,506	1,449	1,100	1,355	3.0%
Health care - outpatient	650	929	721	574	577	676	856	800	770	585	720	3.0%
Lodging – (hotel, motel	1,831	2,618	2,030	1,616	1,627	1,905	2,411	2,254	2,169	1,648	2,029	4.6%

242 "Education – College and University" Baltimore, MD full load cooling hours is an average of the hours for "Education – Community College" (713 hours/year) and "Education – University" (787 hours/year) in the Maryland/Mid-Atlantic TRM v.10, p.422

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Building type by weather station	Maryland	North Carolina		Virginia								Building weight used for midstream
	Baltimore	Elizabeth City	Rocky Mount	Char-lottesville	Sterling	Farmville	Norfolk	Arlington	Richmond	Roanoke	Fredericksburg	
and dormitory)												
Mercantile (mall)	887	1,268	983	783	788	923	1,168	1,092	1,051	798	983	0.5%
Mercantile (retail, not mall)	911	1,302	1,010	804	809	948	1,200	1,122	1,079	820	1,009	10.5%
Multifamily (common areas)	1,521	2,175	1,686	1,343	1,351	1,583	2,003	1,873	1,802	1,369	1,685	-
Office – small (<40,000 sq ft)	634	906	703	560	563	660	835	781	751	570	702	9.4%
Office – large (≥40,000 sq ft)	733	1,048	813	647	651	763	965	902	868	660	812	9.4%
Other243	245	350	272	216	218	255	323	302	290	220	271	19.3%
Public assembly	945	1,351	1,048	834	840	983	1,245	1,163	1,119	850	1,047	0.9%
Public order and safety (police and fire station)	245	350	272	216	218	255	323	302	290	220	271	0.4%
Religious worship	245	350	272	216	218	255	323	302	290	220	271	10.5%
Service (beauty, auto repair workshop)	923	1,320	1,023	815	820	960	1,216	1,136	1,093	831	1,023	6.1%
Warehouse and storage[244]	2,081	2,975	2,307	1,837	1,849	2,165	2,741	2,562	2,465	1,873	2,306	3.5%

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243 "Other" building type is mapped to the building type with the most conservative full load heating hours in the Mid-Atlantic TRM 2018, p.528 "Manufacturing – Bio Tech/High Tech."

244 "Warehouse and Storage" Baltimore, MD full load heating hours is an average of the hours for "Storage - Conditioned" (854 hours/year) and "Warehouse - Refrigerated" (342 hours/year) in the Maryland/Mid-Atlantic TRM v.10, p.423

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Building type by weather station	Maryland	North Carolina		Virginia								Building weight used for midstream
	Baltimore	Elizabeth City	Rocky Mount	Char-lottesville	Sterling	Farmville	Norfolk	Arlington	Richmond	Roanoke	Fredericksburg	
Midstream program default	714	1,021	792	630	634	743	940	879	846	642	791	-

17.2.2 Annual equivalent full-load heating hours for heat pumps, VRFs, and mini-split systems

Table 17-5. Heat pump, VRF, and mini-split equivalent full load heating hours for non-residential buildings

Building type by weather station	Maryland	North Carolina		Virginia								Building weights used for midstream
	Baltimore	Elizabeth City	Rocky Mount	Char-lottesville	Sterling	Farmville	Norfolk	Arlington	Richmond	Roanoke	Fredericksburg	
Education – elementary and middle school	668	393	428	535	696	591	492	618	558	613	662	1.5%
Education – high school	719	423	460	576	749	636	530	665	600	660	713	1.5%
Education – college and university245	622	366	398	498	648	550	458	576	519	571	617	1.5%
Food sales - grocery	980	576	627	785	1,021	867	722	907	818	899	972	1.8%
Food sales – convenience store	623	366	399	499	649	551	459	577	520	572	618	1.8%
Food sales – gas station convenience store	623	366	399	499	649	551	459	577	520	572	618	1.8%
Food service - full service	1,131	665	724	906	1,179	1,001	833	1,047	944	1,038	1,122	4.5%

[245] "Education – College and University" Baltimore, MD full load heating hours is an average of the hours for "Education – Community College"(713 hours/year) and "Education – University" (530 hours/year) in the Maryland/Mid-Atlantic TRM v.10, p.423

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Building type by weather station	Maryland	North Carolina		Virginia								Building weights used for midstream
	Baltimore	Elizabeth City	Rocky Mount	Char-lottesville	Sterling	Farmville	Norfolk	Arlington	Richmond	Roanoke	Fredericksburg	
Food service - fast food	1,226	721	785	982	1,278	1,085	903	1,135	1,023	1,125	1,216	4.5%
Health Care-inpatient	214	126	137	171	223	189	158	198	179	196	212	3.0%
Health Care-outpatient	932	548	596	747	971	825	687	863	778	855	924	3.0%
Lodging – (hotel, motel and dormitory)	2,242	1,319	1,435	1,797	2,337	1,984	1,652	2,075	1,871	2,058	2,223	4.6%
Mercantile (mall)	591	348	378	474	616	523	436	547	493	542	586	0.5%
Mercantile (retail, not mall)	739	435	473	592	770	654	545	684	617	678	733	10.5%
Multifamily (common areas)	256	151	164	205	267	227	189	237	214	235	254	-
Office – Small (<40,000 sq ft)	440	259	282	353	459	389	324	407	367	404	436	9.4%
Office – Large (≥40,000 sq ft)	221	130	141	177	230	196	163	205	184	203	219	9.4%
Other	146	86	93	117	152	129	108	135	122	134	145	19.3%
Public assembly[246]	1,114	655	713	893	1,161	986	821	1,031	930	1,022	1,105	0.9%
Public order and safety (police and fire station)[247]	146	86	93	117	152	129	108	135	122	134	145	0.4%
Religious worship	146	86	93	117	152	129	108	135	122	134	145	10.5%
Service (beauty, auto	623	366	399	499	649	551	459	577	520	572	618	6.1%

246 "Public Order and Safety (Police and Fire Station)" building type is mapped to the building type with the most conservative full load heating hours in the Maryland/Mid-Atlantic TRM v.10, p.423, "Manufacturing – Bio Tech/High Tech."

247 "Religious Worship" building type is mapped to the building type with the most conservative full load heating hours in the Maryland/Mid-Atlantic TRM v.10, p.423, p.529 "Manufacturing – Bio Tech/High Tech."

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Building type by weather station	Maryland	North Carolina		Virginia								Building weights used for midstream
	Baltimore	Elizabeth City	Rocky Mount	Char-lottesville	Sterling	Farmville	Norfolk	Arlington	Richmond	Roanoke	Fredericksburg	
repair workshop)												
Warehouse and storage	598	352	383	479	623	529	441	553	499	549	593	3.5%
Midstream program default	599	334	364	456	593	503	419	526	475	522	564	1.5%

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17.2.3 Annual hours of use for variable frequency drives

Table 17-6. Variable frequency drive annual hours of use by facility type[248]

Building type	Fan motor hours	Chilled water pumps[249]	Hot water pumps
Education – Elementary and middle school	2,187	1,205	3,229
Education – High school	2,187	1,205	3,229
Education – College and university	2,187	1,205	4,038
Food Sales - Grocery	4,055	1,877	5,376
Food Sales – Convenience store	6,376	2,713	5,376
Food Sales – Gas station convenience store	6,376	2,713	5,376
Food Service - Full service	4,182	1,923	5,376
Food Service - Fast food	6,456	2,742	5,376
Health Care - Inpatient	7,666	3,177	8,760
Health Care - Outpatient	3,748	1,767	5,376
Lodging – (Hotel, motel, and dormitory)	3,064	1,521	5,492
Mercantile (Mall)	4,833	2,157	5,376
Mercantile (Retail, not mall)	4,057	1,878	2,344
Office – Small (<40,000 sq ft)	3,748	1,767	3,038
Office – Large (≥ 40,000 sq ft)	3,748	1,767	3,038
Other	2,857	1,446	5,376
Public assembly	1,955	1,121	5,376
Public order and safety (police and fire station)	7,665	3,177	5,376
Religious worship	1,955	1,121	5,376
Service - (Beauty, auto repair workshop)	3,750	1,768	5,376
Warehouse and storage	2,602	1,354	5,376

17.2.4 Update summary

Updates made to this section are described in Table 17-7.

Table 17-7. Summary of update(s)

Version	Update type	Description
2022	Revised table	Revised full load cooling hours and full load heating hours for some of the building types in Elizabeth City and Rocky Mount due to errors. Added Midstream program default values for full load cooling hours and full load heating hours
2021	New weather stations	To the single weather station in Richmond, VA, seven weather stations were added for Virginia: Charlottesville, Dulles International Airport (Sterling), Farmville, Norfolk, Reagan International Airport (Arlington), Roanoke, and Shannon Airport. Also, divided the previously shared

248 Maryland/Mid-Atlantic TRM v.10, pp. 299 - 301. The facility hours have been mapped from a facility type list in the United Illuminating Company and Connecticut Light & Power Company. 2012. Connecticut Program Savings Document – 8th Edition for 2013 Program Year. Orange, CT.

249 For condenser water pumps, use the same operating hours as chilled water pumps

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Version	Update type	Description
		column—that contained the average of the two NC weather stations—into two separate columns (Elizabeth City, NC and Rocky Mount-Wilson, NC).
	Table	Updated building type for the Unitary Air Conditioners, Heat Pumps, Chiller, VRF, and Mini-split Systems
	Table	Removed the separate table for Chiller system cooling hours
2020	None	No change
v10	New weather stations	Replaced the Charlotte, NC weather station with the average results from two weather stations located within the Company's service territory: Elizabeth City, NC and Rocky Mount-Wilson, NC.
	Updated EFLHs	By-building hours of use values were updated and—in some cases, corrected—based upon revisions to HDD/CDD adjustments due to change of weather stations in NC.
	New table	A table was added for the HOU values for VFDs.

17.3 Sub-Appendix F2-III: Non-residential HVAC equipment efficiency ratings

This sub-appendix contains the minimum efficiency metrics that are required by building codes for four categories of equipment:

- Unitary air conditioners and condensing units, in Table 17-8
- Unitary and applied heat pumps, in Table 17-9
- Variable Refrigerant Flow (VRF) air conditioners and heat pumps, in Table 17-10
- Water chilling packages (a.k.a. chillers), in Table 17-11

17.3.1 Cooling efficiencies of unitary air conditioners and condensing units

Table 17-8. Unitary air conditioners and condensing units - minimum efficiency[250]

Equipment type	Size category (Btu/h)	Heating system type	Subcategory	Minimum annual efficiency	Minimum demand efficiency
Air conditioners, air cooled	< 65,000 Btu/h	All	Split system/ Single package	13.0 SEER	11.1 EER[251]
Through the wall, packaged terminal air conditioners (air cooled)	≤ 30,000 Btu/h	All	Split system/ Single package	12.0 SEER	10.5 EER[251]
Small-duct, high-velocity (air cooled)	< 65,000 Btu/h	All	Split system/ Single package	11.0 SEER	9.9 EER[251]
Air conditioners, air cooled	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric resistance (or none)	Split system/ Single package	12.9 IEER	11.2 EER

[250] ASHRAE 90.1 2013, Table 6.8.1-1 - Electrically Operated Unitary Air Conditioners and Condensing Units - Minimum Efficiency Requirement.

[251] This value was not provided in ASHRAE 90.1 2013, Table 6.8.1-1, SEER was converted to EER as an approximation.

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Equipment type	Size category (Btu/h)	Heating system type	Subcategory	Minimum annual efficiency	Minimum demand efficiency
		All other	Split system/ Single package	12.7 IEER	11.0 EER
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric resistance (or none)	Split system/ Single package	12.4 IEER	11.0 EER
		All other	Split system/ Single package	12.2 IEER	10.8 EER
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric resistance (or none)	Split system/ Single package	11.6 IEER	10.0 EER
		All other	Split system/ Single package	11.4 IEER	9.8 EER
	≥ 760,000 Btu/h	Electric resistance (or none)	Split system/ Single package	11.2 IEER	9.7 EER
		All other	Split system/ Single package	11.0 IEER	9.5 EER
Air conditioners, water cooled	< 65,000 Btu/h	All	Split system/ Single package	12.3 IEER	12.1 EER
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric resistance (or none)	Split system/ Single package	13.9 IEER	12.1 EER
		All other	Split system/ Single package	13.7 IEER	11.9 EER
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric resistance (or none)	Split system/ Single package	13.9 IEER	12.5 EER
		All other	Split system/ Single package	13.7 IEER	12.3 EER
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric resistance (or none)	Split system/ Single package	13.6 IEER	12.4 EER
		All other	Split system/ Single package	13.4 IEER	12.2 EER
	≥ 760,000 Btu/h	Electric resistance (or none)	Split system/ Single package	13.5 IEER	12.2 EER
		All other	Split system/ Single package	13.3 IEER	12.0 EER

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Equipment type	Size category (Btu/h)	Heating system type	Subcategory	Minimum annual efficiency	Minimum demand efficiency
Air conditioners, evaporatively cooled[252]	< 65,000 Btu/h	All	Split system/ Single package	12.3 IEER	12.1 EER
	≥ 65,000 Btu/h and < 135,000 Btu/h	All other	Split system/ Single package	12.3 IEER	12.1 EER
		Electric resistance (or none)	Split system/ Single package	12.1 IEER	11.9 EER
	≥ 135,000 Btu/h and < 240,000 Btu/h	All other	Split system/ Single package	12.2 IEER	12.0 EER
		Electric resistance (or none)	Split system/ Single package	12.0 IEER	11.8 EER
	≥ 240,000 Btu/h and < 760,000 Btu/h	All other	Split system/ Single package	12.1 IEER	11.9 EER
		Electric resistance (or none)	Split system/ Single package	11.9 IEER	11.7 EER
	≥ 760,000 Btu/h	All other	Split system/ Single package	11.9 IEER	11.7 EER
		Electric resistance (or none)	Split system/ Single package	11.7 IEER	11.5 EER
Condensing units, air cooled[252]	≥ 135,000 Btu/h	-	-	11.8 IEER	10.5 EER
Condensing units, water cooled[252]	≥ 135,000 Btu/h	-	-	14.0 IEER	13.5 EER
Condensing units, evaporatively cooled[252]	≥ 135,000 Btu/h	-	-	14.0 IEER	13.5 EER

17.3.2 Efficiencies of unitary and applied heat pumps

Table 17-9. Unitary and applied heat pumps - minimum efficiency[253]

Equipment type	Cooling capacity/ size category	Heating system type	Subcategory or rating conditions	Minimum annual efficiency	Minimum demand efficiency
Air cooled (cooling mode)	< 65,000 Btu/h	All	Split System/ Single package	14.0 SEER	11.8 EER[254]
Through-the-wall, packaged terminal heat pumps (air-cooled cooling mode)	≤ 30,000 Btu/h	All	Split System/ Single package	12.0 SEER	10.5 EER[254]

[252] These systems types were added in ASHRAE 90.1-2013. Therefore, these systems are not retroactively used for the Non-Residential Heating and Cooling Efficiency Program offered under the DSM Phase III program, due to data requirement constraints. However, these systems will be included in the DNV analysis for the Non-Residential Heating and Cooling Efficiency Program offered under the DSM Phase VII program.

[253] ASHRAE 90.1 2013, Table 6.8.1-2 - Electrically Operated Unitary and Applied Heat Pumps - Minimum Efficiency Requirement.

[254] This value was not provided in ASHRAE 90.1 2013, Table 6.8.1-2, so SEER was converted to EER as an approximation.

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Equipment type	Cooling capacity/ size category	Heating system type	Subcategory or rating conditions	Minimum annual efficiency	Minimum demand efficiency
Single-duct	< 65,000 Btu/h	All	Split System/ Single package	11.0 SEER	9.9 EER[254]
Air cooled (cooling mode)	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric resistance (or none)	Split system/ Single package	12.2 IEER	10.8 EER
		All other		12.0 IEER	10.6 EER
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric resistance (or none)	Split system/ Single package	11.6 IEER	10.6 EER
		All other		11.4 IEER	10.4 EER
	≥ 240,000 Btu/h	Electric resistance (or none)	Split system/ Single package	10.6 IEER	9.5 EER
		All other		10.4 IEER	9.3 EER
Water source[255] (cooling mode)	< 17,000 Btu/h	All	86°F entering water	Retrofits: 14.0 SEER[255]	Retrofits: 11.7 EER[254]
				RCx:[256] 13.1 $EER_{part-load}$	RCx: 11.2 EER
	≥ 17,000 Btu/h and < 65,000 Btu/h	All	86°F entering water	Retrofits: 14.0 SEER[255]	Retrofits: 11.7 EER[254]
				RCx: 14.5 $EER_{part-load}$	RCx: 12.0 EER
	≥ 65,000 Btu/h and < 135,000 Btu/h	All	86°F entering water	Retrofits: 12.2 IEER[255]	Retrofits: 10.9 EER[257]
				RCx: 13.4 $EER_{part-load}$	RCx: 12.0 EER
Ground source[255] (cooling mode)	< 65,000 Btu/h	All	77°F entering water	Retrofits: 14.0 SEER[255]	Retrofits: 11.7 EER[254]
				RCx: 17.4 $EER_{part-load}$	RCx: 13.4 EER
	≥ 65,000 Btu/h and < 135,000 Btu/h	All	77°F entering water	Retrofits: 12.2 IEER[255]	Retrofits: 10.9 EER[257]
				RCx: 14.9 $EER_{part-load}$	RCx: 13.4 EER
Air cooled (heating mode)	< 65,000 Btu/h	-	Split system/ Single system	7.7 HSPF	N/A
Through-the-wall, packaged terminal heat pump (air-cooled heating mode)	≤ 30,000 Btu/h	-	Split system/ Single system	7.4 HSPF	N/A

[255] Although ASHRAE values reflect the Building Code minimum, savings are calculated using the efficiencies shown. This is due to the Mid-Atlantic TRM 2019 assumption that the baseline technology—for residential ground source heat pump applications—is an air-cooled heat pump. (There is no corresponding commercial measure in the Mid-Atlantic TRM 2019.)

[256] Two types of measures are categorized as retro-commissioning (RCx) ones: Duct Testing & Sealing and AC/HP/Chiller Tune-ups.

[257] This value was not provided in ASHRAE 90.1 2013, Table 6.8.1-2, so IEER was converted to EER as an approximation.

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Equipment type	Cooling capacity/ size category	Heating system type	Subcategory or rating conditions	Minimum annual efficiency	Minimum demand efficiency
Air cooled (heating mode)	≥ 65,000 Btu/h and < 135,000 Btu/h	-	47°F DBT/ 43°F WBT outdoor air	3.3 COP	N/A
	≥ 135,000 Btu/h (cooling capacity)	-	47°F DBT/ 43°F WBT outdoor air	3.2 COP	N/A
Water source (heating mode)	< 135,000 Btu/h (cooling capacity)	-	68°F entering water	4.3 COP	N/A
Ground source (heating mode)	All Sizes[258] (cooling capacity)	-	32°F entering water	3.2 COP	N/A

[258] ASHRAE 90.1-2013 values only apply to equipment <135 kBtu/h. However, this value is used across all sizes as there is limited guidance for systems 135 kBtu/h and larger.

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17.3.3 Cooling efficiencies of variable refrigerant flow air conditioners and heat pumps

Table 17-10. Variable refrigerant flow air conditioners and heat pumps - minimum efficiency[259]

Equipment type	Size category	Heating section type	Subcategory or rating conditions	Minimum annual cooling efficiency	Minimum peak cooling efficiency	Minimum heating efficiency
VRF air conditioners, air cooled	< 65,000 Btu/h	All	VRF Multi-split system	13.0 SEER	11.1 EER[260]	N/A
	≥ 65,000 Btu/h and < 135,000 Btu/h	All[261]	VRF Multi-split system	13.1 IEER	11.2 EER[260]	N/A
	≥ 135,000 Btu/h and < 240,000 Btu/h	All[261]	VRF Multi-split system	12.9 IEER	11.0 EER[260]	N/A
	≥ 240,000 Btu/h	All[261]	VRF Multi-split system	11.6 IEER	10.0 EER[260]	N/A
VRF heat pumps, air cooled	< 65,000 Btu/h	All	VRF Multi-split system	13.0 SEER	11.1 EER[260]	7.7 HSPF
	≥ 65,000 Btu/h and < 135,000 Btu/h	All[261]	VRF Multi-split system	12.9 IEER	11.0 EER[260]	3.3 COP
	≥ 135,000 Btu/h and < 240,000 Btu/h	All[261]	VRF Multi-split system	12.3 IEER	10.6 EER[260]	3.2 COP
	≥ 240,000 Btu/h	All[261]	VRF Multi-split system	11.0 IEER	9.5 EER[260]	3.2 COP

[259] ASHRAE 90.1 2013, Tables 6.8.1-9 - Electrically Operated Variable Refrigerant Flow Air Conditioners- Minimum Efficiency Requirement and 6.8.1J - Electrically Operated Variable Refrigerant Flow Heat Pumps - Minimum Efficiency Requirement.

[260] This value was not provided in ASHRAE 90.1 2013, Table 6.8.1-9, so SEER was converted to EER as an approximation.

[261] ASHRAE 90.1 2013, only provides Electric resistance or none for Heating Section Type. This is used for all Heating Section Types to allow of other heating system types.

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17.3.4 Cooling efficiencies of water chilling packages

Table 17-11. Water chilling packages–minimum efficiency[262]

Equipment type	Size category	Units	Path A		Path B	
			Full load	IPLV	Full load	IPLV
Air cooled chillers	< 150 tons	EER	≥ 10.100	≥ 13.700	≥ 9.700	≥ 15.800
	≥ 150 tons	EER	≥ 10.100	≥ 14.000	≥ 9.700	≥ 16.100
Water-cooled, electrically operated, positive displacement	< 75 tons	kW/ton	≤ 0.750	≤ 0.600	≤ 0.780	≤ 0.500
	≥ 75 tons and < 150 tons	kW/ton	≤ 0.720	≤ 0.560	≤ 0.750	≤ 0.490
	≥ 150 tons and < 300 tons	kW/ton	≤ 0.660	≤ 0.540	≤ 0.680	≤ 0.440
	≥ 300 tons and < 600 tons	kW/ton	≤ 0.610	≤ 0.520	≤ 0.625	≤ 0.410
	≥ 600 tons	kW/ton	≤ 0.560	≤ 0.500	≤ 0.585	≤ 0.380
Water-cooled, electrically operated, centrifugal	<150 tons	kW/ton	≥ 0.610	≤ 0.550	≤ 0.695	≤ 0.440
	≥ 150 tons and < 300 tons	kW/ton	≤ 0.610	≤ 0.550	≤ 0.635	≤ 0.440
	≥ 300 tons and < 400 tons	kW/ton	≤ 0.560	≤ 0.520	≤ 0.595	≤ 0.390
	≥ 400 tons and < 600 tons	kW/ton	≤ 0.560	≤ 0.500	≤ 0.585	≤ 0.380
	≥ 600 tons	kW/ton	≤ 0.560	≤ 0.500	≤ 0.585	≤ 0.380
Water-cooled, unknown (default)	< 75 tons	kW/ton	≤ 0.750	≤ 0.600	≤ 0.780	≤ 0.500
	≥ 75 tons and < 150 tons (default)	kW/ton	≤ 0.720	≤ 0.560	≤ 0.750	≤ 0.490
	≥ 150 tons and < 300 tons	kW/ton	≤ 0.660	≤ 0.540	≤ 0.680	≤ 0.440
	≥ 300 tons and < 600 tons	kW/ton	≤ 0.610	≤ 0.520	≤ 0.625	≤ 0.410
	≥ 600 tons	kW/ton	≤ 0.560	≤ 0.500	≤ 0.585	≤ 0.380

17.3.5 Heating efficiency of electric resistance heating and systems with central chilled water plants

Table 17-12. Electric heating efficiency associated with central chilled water cooling systems[263]

Equipment type	Size category	HSPF (Btu/Wh)	COP
Air- or water-cooled chillers with unknown electric heating or electric resistance heat	Any	3.4	1.0

17.3.6 Update summary

Updates made to this section are described in Table 17-13.

262 ASHRAE 90.1-2013, Table 6.8.1-3 - Water Chilling Packages - Efficiency Requirements. Consistent with International Energy Conservation Code 2015, Table C403.2.3(7) Water Chilling Packages, Efficiency Requirements, used in the 2019 Mid-Atlantic TRM. Compliance with this standard can be obtained by meeting the minimum requirements of Path A or Path B. However, both the full load and IPLV must be met to fulfil the requirements of Path A or Path B. For new chiller installations, Path A is used for baselines when Path A requirements are met by new equipment. If new equipment not satisfied by Path A requirements, then Path B is used as the baseline.

263 For some measures applications indicate electric heating associated with chilled water cooling systems. For these systems we assume either central electric boilers or other electric resistance type heating with an efficiency.

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Table 17-13. Summary of update(s)

Version	Update type	Description
2022	Table	Expanded COP in table to include electric resistance heat
2021	Table	Added table for minimum COP for electric heating associated with central chilled water cooling systems.
2020	Standards application	Revised the VRF heating section type categories to accommodate more than just the electric resistance
v10	Standards update	Both VA and NC building codes were updated from ASHRAE 2010 to ASHRAE 2013 in 2019. This resulted in widespread increases to the minimum efficiency requirements of many equipment types.

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17.5 Sub-Appendix F2-IV: Non-residential lighting factors: annual equivalent hours, coincidence factors, and waste heat factors

For the purposes of this STEP Manual, Table 17-15 provides the annual lighting (interior CFL and non-CFL) hours of use, summer seasonal peak coincidence factors, and waste heat factors by building types for interior lighting fixtures that are designated for the Dominion territory. All of these are gathered from the Mid-Atlantic TRM, which pulls from a combination of the Connecticut Program Savings Document (PSD) and the EmPOWER Maryland 2014 Evaluation Report. Table 17-14 provides the same variables for exterior lights and LED exit signs.

Since the building types in the Mid-Atlantic TRM do not map directly to those used in this TRM, a separate mapping was conducted to arrive at the values. Under each TRM building type in Table 17-15 are listings of the Mid-Atlantic TRM building types that were mapped to this document.

For all non-residential lighting measures, DNV assigns these variables based on the measure characteristics in this descending order:

- Measure location (interior or exterior)
- Fixture name
- Building type

For example, when calculating savings for a specific non-residential lighting type (fixtures), variables (hours of use, coincidence factor, waste heat factors) are assigned based on if the fixture indicates it is for "exterior" use. All fixtures that contain the word "exterior" in the fixture name, from the tracking data provided to DNV, should assign parameters based on the lighting type in Table 17-14.

All fixtures that contain the phrase "24/7" in the fixture name, from the tracking data provided to DNV, shall be assigned variables appropriate for "LED Exit Sign." All fixtures that do not specify "exterior" in the fixture name are assumed to be for interior use and should be assigned variables based on the building type as shown in Table 17-15.

Summary of terms used in this section:

- CFPJM – PJM summer peak coincidence factor is from June to August, weekdays between 2 p.m. and 6 p.m. EDT.
- CFSSP – Summer system peak coincidence factor refers to the hour ending 5 p.m. EDT on the hottest summer weekday.
- Interior CFL lighting refers to general-purpose CFL screw-based bulbs.
- Interior Non-CFL lighting type includes:
    - T5 Lighting
    - Pulse-start metal halide fixture – interior
    - Solid state lighting (LED) recessed downlight luminaire
    - Delamping
    - Occupancy sensor - wall box

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Table 17-14. Non-residential lighting parameters by exterior lighting type

Lighting type	Annual exterior lighting hours	CF_{summer}	CF_{winter}[264]	WHF_e[265]	$WHF_{d,summer}$	$WHF_{d,winter}$	Source
Pulse start metal halide - exterior	3,604[266]	0.11[267]	0.50	1.00	1.00	1.00	Maryland/Mid-Atlantic TRM v.10, p. 242
High pressure sodium	3,604[268]	0.11[269]	0.50	1.00	1.00	1.00	Maryland/Mid-Atlantic TRM v.10, p. 242
LED Exit Sign and "24/7" lights[270]	8,760	1.00	1.00	1.00	1.00	1.00	Maryland/Mid-Atlantic TRM v.10, p. 215; DNV judgement
LED parking garage	Canopy: 3,338 Parking garage: 8,678	Canopy: 0.00 Parking garage: 0.98	Canopy: 0.50 Parking garage: 0.98	1.00	1.00	1.00	Maryland/Mid-Atlantic TRM v.10, p. 254
Outdoor LED and roadway lighting	3,604	0.11[271]	0.50	1.00	1.00	1.00	Maryland/Mid-Atlantic TRM v.10, p. 242

The hours and coincident factors (CF) shown in Table 17-15 apply only to the Non-Residential Lighting Systems and Controls Programs (DSM Phases III and VII) and Non-Residential Cooling and Heating Programs (DSM Phases III and VII).

264 The source TRM does not provide winter CF. Therefore the winter CF is estimated based on sunrise and peak period. The winter peak period occurs for the hour ending at 8:00 A.M on non-holiday Mondays in January. The latest sunrise in the period is 7:17 A.M. Given the ambient light levels during the peak period, The winter CF is estimated to be 0.50. This estimate will be revised when better information becomes available.

265 "If cooling and heating equipment types are unknown or the space is unconditioned, assume WHFd = WHFe = 1.0." Maryland/Mid-Atlantic TRM 2020, p. 215.

266 Navigant Commercial and Industrial Long-Term Metering Study

267 Ibid.

268 Ibid.

269 Ibid.

270 DNV judgement that if non-residential lighting measure name contains "24/7" in the tracking data provided to DNV, treat it the same as "LED Exit Sign" when calculating savings.

271 Navigant Commercial and Industrial Long-Term Metering Study

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Table 17-15. Non-residential interior lighting parameters by facility type

Building types	Interior lighting annual hours[272]	CF_{summer}[273]	CF_{winter}[274]	$WHF_{d,summer}$[275]	$WHF_{d,winter}$[276]	WHF_e[277]
Agriculture	4,698[278]	0.670	0.670	1.00	1.00	1.00
Education – College and university	2,233	0.360	0.330	1.44	0.710	0.960
Education – High school	2,233	0.360	0.330	1.44	0.710	0.960
Education – Elementary and middle school	2,233	0.360	0.330	1.44	0.710	0.960
Food sales – convenience store	7,272	0.970	0.930	1.35	0.740	0.930
Food Sales – Gas station convenience store	7,272	0.970	0.930	1.35	0.740	0.930
Food Sales – Grocery	7,272	0.970	0.930	1.35	0.740	0.930
Food Service - Fast food	4,696	0.830	0.930	1.27	0.740	0.950
Food Service - Full service	4,696	0.830	0.930	1.27	0.740	0.950
Health Care – inpatient	3,817	0.680	0.510	1.35	0.740	0.930
Health Care – outpatient	3,817	0.680	0.510	1.35	0.740	0.930
Lodging – (Hotel, motel and dormitory)	4,058	0.610	0.460	1.35	0.740	0.930
Mercantile (Retail, not mall)	4,696	0.830	0.560	1.27	0.740	0.950
Mercantile (Mall)	4,696	0.830	0.560	1.27	0.740	0.950
Non-Residential Multifamily[279]	5,950	0.058	0.124	0.96	0.815	0.959
Office – Small (<40,000 sq ft)	3,044	0.690	0.490	1.36	0.750	0.940

272 Maryland/Mid-Atlantic TRM v.10, p. 418 Table D-3: C&I Interior Midstream Lighting Parameters by Building Type. Midstream lighting tables are referenced because downstream table parameters require knowledge of the location of the product installation—information that is unavailable for midstream programs.

273 Ibid.

274 Ibid.

275 Maryland/Mid-Atlantic TRM v.10, p. 419-421. Selected waste heat factors from "Washington, D.C. All utilities", AC (utility) WHF_d and heat pump WHF_e. Waste heat factors were provided for only five building types (1. Office, 2. Retail, 3. School, 4. Warehouse, 5. Other), therefore they were mapped to the full list of building types as appropriate. Original source of waste heat factor values are from the "EmPOWER Maryland DRAFT Final Impact Evaluation Report Evaluation Year 4 (June 1, 2012 – May 31, 2013) Commercial & Industrial Prescriptive & Small Business Programs, Navigant, March 31, 2014. Values for Washington D.C. and Delaware assume values from Maryland, Pepco and Maryland, DPL, respectively."

276 Maryland/Mid-Atlantic TRM v.10, p. 419-421. Selected waste heat factors from "Washington, D.C. All utilities", Waste heat factors were provided for only five building types (1. Office, 2. Retail, 3. School, 4. Warehouse, 5. Other), therefore they were mapped to the full list of building types as appropriate. Original source of waste heat factor values are from the "EmPOWER Maryland DRAFT Final Impact Evaluation Report Evaluation Year 4 (June 1, 2012 – May 31, 2013) Commercial & Industrial Prescriptive & Small Business Programs, Navigant, March 31, 2014. Values for Washington D.C. and Delaware assume values from Maryland, Pepco and Maryland, DPL, respectively." Winter peak WHF_d is not provided, therefore, the WHFe is used for no AC with electric resistance heating. This will yield the most conservative winter peak demand reduction estimate.

277 Ibid.

278 The Maryland/Mid-Atlantic TRM v.10 does not provide any values for agriculture building type; therefore the Interior Lighting Annual Hours and summer CF are from the Wisconsin TRM 2022, p. 495. The winter CF is assumed to be the same as the summer CF. Waster heat factors are assumed to be 1.00 with minimal space conditioning interactive effects.

279 Maryland/Mid-Atlantic TRM v.10, p.44, common areas

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Building types	Interior lighting annual hours[272]	CF_{summer}[273]	CF_{winter}[274]	$WHF_{d,summer}$[275]	$WHF_{d,winter}$[276]	WHF_{e}[277]
Office – Large (>= 40,000 sq ft)	3,044	0.690	0.490	1.36	0.750	0.940
Other (default)	4,058	0.610	0.460	1.35	0.740	0.930
Public assembly	4,058	0.610	0.460	1.35	0.740	0.930
Public order and safety (police and fire station)	4,058	0.610	0.460	1.35	0.740	0.930
Religious worship	4,058	0.610	0.460	1.350	0.740	0.930
Service - (Beauty, auto repair workshop)	4,696	0.830	0.460	1.270	0.560	0.950
Warehouse and storage	4,361	0.800	0.460	1.230	0.500	0.890

17.5.1.1 Update summary

Updates made to this section are described in Table 17-16.

Table 17-16. Summary of update(s)

Version	Update type	Description
2022	Inputs	Added agriculture building type to the interior lighting parameters table
2021	Inputs	Added winter CF_{winter} and $WHF_{d,winter}$
	Source	Updated page numbers / version of the Maryland/Mid-Atlantic TRM v.10
		Updated Exterior Lighting Annual Hours and CF values Added a new building type in the interior lighting parameter table
2020	None	No change
v10	Source	Updated page numbers / version of the Mid-Atlantic TRM v.9

17.6 Sub-Appendix F2-V: Non-residential commercial kitchen inputs

This sub-appendix contains the commercial kitchen inputs.

Table 17-17. Operational hours by building type[280]

Facility type	Hour/day	Day/year	Weight applied for unknown facility type[281]
Education - Elementary and middle school	8.0	214	0.09
Education - High school			

280 Maryland/Mid-Atlantic TRM v.10, p. 383, hours/day and days/year values are used for all facility types with the exception of Unknown, which uses Dominion Energy building weights. Maryland/Mid-Atlantic TRM v.10 cites the original source as California Energy Commission, Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Foodservice Equipment, Appendix E.

281 Unknown facility type is based on a weighted average of building types from Dominion Energy 2020 Commercial Energy Survey Results Appendix B, p. 4. Question 3. Building types that are in the source TRM are used when calculating weights to avoid overweighting building types that aren't typically associated with cooking equipment. Those buildings use the Other/Miscellaneous building category from the source TRM for hours/day and days/year.

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Facility type	Hour/day	Day/year	Weight applied for unknown facility type[281]
Education - College and university			
Food Sales - Grocery	12.0	365	0.10
Food Sales - Convenience store			
Food Sales - Gas station convenience store			
Food Service - Full service	13.0	342	0.17
Food Service - Fast food			
Health Care - Inpatient	11.0	365	0.11
Health Care - Outpatient			
Lodging - Hotel, motel and dormitory	20.0	365	0.17
Mercantile - Mall	9.0	325	0.00
Mercantile - Retail, non-mall			
Office - Small (<40,000 sq.ft.)	12.0	250	0.36
Office - Large (≥40,000 sq.ft.)			
Other	9.0	325	0.00
Public assembly			
Public order and safety (police and fire station)			
Religious worship			
Service (beauty, auto-repair, workshop)			
Warehouse and storage			
Unknown (default)[282]	13.1	307	0.00

17.6.1.1 Update summary

Updates made to this section are described in Table 17-16.

Table 17-18. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	New section	Moved tables shared by multiple measures from individual measure sections to this sub-appendix

[282] Unknown facility type is based on a weighted average of building types from DNV, Dominion Energy 2020 Commercial Energy Survey Results, Appendix B, p. 4, Question 3

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17.7 Sub-Appendix F2-V: Non-residential compressed air end use factors

This sub-appendix contains the compressed air end use factors of input variables based on type of control and coincidence factor based on operating schedule.

Table 17-19. Load proportion and HOU proportion defaults by load range bins

Bin	Load range	Default $Load_{bin}$ proportion	Default HOU_{bin} proportion
1	100% - 90%	0.95	0.00
2	90% - 80%	0.85	0.00
3	80% - 70%	0.75	0.00
4	70% - 60%	0.65	0.50
5	60% - 50%	0.55	0.50
6	50% - 40%	0.45	0.00
7	<40%	0.30	0.00

Table 17-20. Input variables based on type of control

Control type	η_{VFD}	X_2	X_1	C
Inlet modulation	1.00	0.007900	0.297000	0.695800
Load/no-load, 1 gal/cfm	1.00	-0.901260	1.555462	0.320416
Load/no-load, 2 gal/cfm	1.00	-0.708400	1.429375	0.284163
Load/no-load, 3 gal/cfm	1.00	-0.479030	1.213741	0.267587
Load/no-load, 4 gal/cfm	1.00	-0.383750	1.127370	0.263671
Load/no-load, 5 gal/cfm	1.00	-0.193200	0.954629	0.255839
Reciprocating	1.00	-0.000610	0.833885	0.166648
Geometric	1.00	0.227656	0.324240	0.436002
VFD	0.98	3.09E-16	0.950000	0.050000

Table 17-21. Coincidence factor (CF) based on operating schedule

Operating schedule	CF_{summer}[283]	$CF_{swinter}$[284]
Single shift (8/5) (default)	0.59	0.59
2-shift (16/5)	0.95	0.95
3-shift (24/5)	0.95	0.95
4-shift (24/7)	0.95	0.95

283 2019 IL TRM v 7.0 Volume 2

284 Source TRM does not provide a specific winter CF. Therefore, the summer CF is applied as the winter CF.

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Table 17-22. Dryer constant values, based on base dryer type and percent load

Dryer type	$Load_{dryer}$	R_1	K
Non-cycling, refrigerated	0%	0.000	0.00
	> 0%	0.250	0.75
Cycling, refrigerated	≤ 75%	1.133	0.10
	> 75%	0.200	0.80
VFD, refrigerated	≤ 50%	0.100	0.45
	> 50%	1.000	0.00
Digital scroll, refrigerated	0%	0.000	0.00
	> 0%	0.900	0.10

Table 17-23. $\%Purge_{base}$, based on dryer type

Dryer type	$\%Purge_{base}$
Non-cycling, refrigerated	0.00
Cycling, refrigerated	0.00
VFD, refrigerated	0.00
Digital scroll, refrigerated	0.00
Desiccant	0.15
Heated desiccant	0.70
Blower purge	0.00
Heated blower purge	0.00

17.7.1.1 Update summary

Updates made to this section are described in Table 17-24.

Table 17-24. Summary of update(s)

Version	Update type	Description
2022	None	No change
2021	New section	Moved tables shared by multiple measures from individual measure sections to this sub-appendix

17.8 Sub-Appendix F2-V: Non-residential window film energy saving factors

This sub-appendix contains the Energy Saving Factor (ESF) per square foot of reflective window film by facility type, window pane type, heating system type, and window orientation. Each table is for a specific weather location.

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Table 17-25. Energy savings factors for reflective window film by facility type and window orientation for Charlottesville, VA

Facility type[285]	Window type	Heating System type[286]	ESF_{north} (kWh/ft^2)	ESF_{east} (kWh/ft^2)	ESF_{south}[287] (kWh/ft^2)	ESF_{west} (kWh/ft^2)
Education – Elementary and middle school	Single pane	Electric	1.86	4.09	6.83	6.05
		Non-electric	2.12	5.76	7.93	10.03
	Double pane	Electric	0.77	1.74	3.00	2.56
		Non-electric	0.89	2.45	3.62	4.48
Education – High school	Single pane	Electric	3.93	6.88	16.77	11.43
		Non-electric	3.62	6.25	10.94	13.41
	Double pane	Electric	1.73	2.77	6.62	4.59
		Non-electric	1.56	2.63	4.97	5.70
Education – College and university	Single pane	Electric	3.93	6.88	16.77	11.43
		Non-electric	3.62	6.25	10.94	13.41
	Double pane	Electric	1.73	2.77	6.62	4.59
		Non-electric	1.56	2.63	4.97	5.70
Food Sales - Grocery	Single pane	Electric	2.58	7.21	6.47	10.99
		Non-electric	3.00	8.20	7.58	12.53
	Double pane	Electric	13.06	4.66	5.03	3.03
		Non-electric	1.35	5.26	5.83	3.46
Food Sales – Convenience store	Single pane	Electric	2.58	7.21	6.47	10.99
		Non-electric	3.00	8.20	7.58	12.53
	Double pane	Electric	13.06	4.66	5.03	3.03
		Non-electric	1.35	5.26	5.83	3.46
Food Sales – Non-electric station convenience store	Single pane	Electric	2.58	7.21	6.47	10.99
		Non-electric	3.00	8.20	7.58	12.53
	Double pane	Electric	13.06	4.66	5.03	3.03
		Non-electric	1.35	5.26	5.83	3.46
Food Service - Full service	Single pane	Electric	0.00	6.56	8.37	11.69
		Non-electric	0.00	7.26	10.23	12.86
	Double pane	Electric	0.00	0.00	4.05	5.28
		Non-electric	0.00	3.01	4.71	5.66
Food Service - Fast food	Single pane	Electric	0.00	3.72	4.68	6.57
		Non-electric	0.00	5.00	7.14	8.12
	Double pane	Electric	0.00	1.60	2.38	3.00
		Non-electric	0.00	2.14	3.39	3.61
Health Care-inpatient	Single pane	Electric	7.11	33.18	15.87	29.91
		Non-electric	4.60	18.31	11.15	17.66
	Double pane	Electric	3.23	14.26	7.44	11.58
		Non-electric	2.03	7.66	4.91	6.68
Health Care-outpatient	Single pane	Electric	1.25	39.48	17.60	23.83
		Non-electric	1.74	30.28	16.98	23.10
	Double pane	Electric	0.55	16.95	7.12	9.45
		Non-electric	0.79	12.93	6.59	9.18
Lodging – (Hotel, Motel, and Dormitory)	Single pane	Electric	3.69	11.43	13.40	10.31
		Non-electric	4.30	13.43	15.02	11.13
	Double pane	Electric	1.52	4.70	5.62	4.10
		Non-electric	1.71	5.43	6.33	4.34

285 Warehouse and storage building type DEER models do not have windows. Tracking data with this building type will be flagged for on-site verification.

286 Non-electric heating systems were represented by gas heating in building energy models.

287 Negative demand reduction is observed in some building types for south window orientation, implying that installation of window film on the south side of the buildings leads to increased energy use due to increase heating load in the winter season.

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Facility type[285]	Window type	Heating System type[286]	ESF_{north} (kWh/ft^2)	ESF_{east} (kWh/ft^2)	ESF_{south}[287] (kWh/ft^2)	ESF_{west} (kWh/ft^2)
Mercantile (mall)	Single pane	Electric	2.68	7.46	5.48	8.41
		Non-electric	2.93	8.24	6.85	9.00
	Double pane	Electric	1.09	2.88	2.53	3.48
		Non-electric	1.22	3.21	3.10	3.72
Mercantile (Retail, not mall)	Single pane	Electric	2.58	7.21	6.47	10.99
		Non-electric	3.00	8.20	7.58	12.53
	Double pane	Electric	13.06	4.66	5.03	3.03
		Non-electric	1.35	5.26	5.83	3.46
Office – Small (<40,000 sq ft)	Single pane	Electric	1.58	5.03	2.73	4.91
		Non-electric	1.76	5.54	3.19	5.66
	Double pane	Electric	0.64	2.05	1.09	1.96
		Non-electric	0.72	2.22	1.25	2.21
Office –Large (≥ 40,000 sq ft)	Single pane	Electric	5.30	17.19	15.82	17.79
		Non-electric	2.23	6.08	7.07	8.17
	Double pane	Electric	2.15	6.83	6.06	6.70
		Non-electric	0.89	2.40	2.91	3.13
Other[288]	Single pane	Electric	0.07	2.28	0.02	0.43
		Non-electric	0.09	2.39	0.04	0.52
	Double pane	Electric	0.03	1.02	0.01	0.16
		Non-electric	0.03	1.06	0.02	0.20
Public assembly	Single pane	Electric	0.46	2.49	2.49	1.24
		Non-electric	0.75	2.38	2.83	1.74
	Double pane	Electric	0.22	1.03	1.06	0.71
		Non-electric	0.36	0.98	1.18	0.92
Public Order and safety (police and fire station)	Single pane	Electric	0.07	2.28	0.02	0.43
		Non-electric	0.09	2.39	0.04	0.52
	Double pane	Electric	0.03	1.02	0.01	0.16
		Non-electric	0.03	1.06	0.02	0.20
Religious worship	Single pane	Electric	0.46	2.49	2.49	1.24
		Non-electric	0.75	2.38	2.83	1.74
	Double pane	Electric	0.22	1.03	1.06	0.71
		Non-electric	0.36	0.98	1.18	0.92
Service (beauty, auto repair workshop)	Single pane	Electric	2.68	7.46	5.48	8.41
		Non-electric	2.93	8.24	6.85	9.00
	Double pane	Electric	1.09	2.88	2.53	3.48
		Non-electric	1.22	3.21	3.10	3.72

288 ESF for the “Other” building type is taken from the Convenience store building energy model because it represents a conservative savings estimate and common building characteristics.

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Table 17-26. Energy savings factors for reflective window film by facility type and window orientation for Farmville, VA

Building type[289]	Window type	Heating system type[290]	ESF_{north} (kWh/ft^2)	ESF_{east} (kWh/ft^2)	ESF_{south}[291] (kWh/ft^2)	ESF_{west} (kWh/ft^2)
Education – Elementary and middle school	Single pane	Electric	2.00	4.83	7.76	7.02
		Non-electric	2.04	5.98	7.95	9.92
	Double pane	Electric	0.91	1.85	3.41	3.11
		Non-electric	0.93	2.57	3.67	4.38
Education – High school	Single pane	Electric	4.02	7.20	17.71	12.10
		Non-electric	3.35	6.32	11.26	13.78
	Double pane	Electric	1.75	2.78	7.18	4.99
		Non-electric	1.47	2.73	5.24	5.89
Education – College and university	Single pane	Electric	4.02	7.20	17.71	12.10
		Non-electric	3.35	6.32	11.26	13.78
	Double pane	Electric	1.75	2.78	7.18	4.99
		Non-electric	1.47	2.73	5.24	5.89
Food Sales - Grocery	Single pane	Electric	2.60	7.16	6.43	10.26
		Non-electric	3.08	8.29	7.57	11.70
	Double pane	Electric	14.74	2.15	5.09	4.19
		Non-electric	1.28	2.56	5.93	4.92
Food Sales – Convenience store	Single pane	Electric	2.60	7.16	6.43	10.26
		Non-electric	3.08	8.29	7.57	11.70
	Double pane	Electric	14.74	2.15	5.09	4.19
		Non-electric	1.28	2.56	5.93	4.92
Food Sales – Non-electric station convenience store	Single pane	Electric	2.60	7.16	6.43	10.26
		Non-electric	3.08	8.29	7.57	11.70
	Double pane	Electric	14.74	2.15	5.09	4.19
		Non-electric	1.28	2.56	5.93	4.92
Food Service - Full service	Single pane	Electric	0.00	6.88	8.52	12.21
		Non-electric	0.00	7.51	10.09	13.04
	Double pane	Electric	0.00	0.00	4.19	5.58
		Non-electric	0.00	3.23	4.82	5.93
Food Service - Fast food	Single pane	Electric	0.00	3.93	4.80	6.76
		Non-electric	0.00	5.18	7.10	8.22
	Double pane	Electric	0.00	1.68	2.41	2.98
		Non-electric	0.00	2.23	3.38	3.66
Health Care-inpatient	Single pane	Electric	7.35	33.15	15.59	29.96
		Non-electric	4.68	18.31	10.88	17.71
	Double pane	Electric	3.23	14.21	7.39	11.62
		Non-electric	2.02	7.66	4.85	6.73
Health Care-outpatient	Single pane	Electric	1.32	38.88	16.62	23.90
		Non-electric	1.83	29.98	16.10	23.35
	Double pane	Electric	0.59	16.91	6.75	9.48
		Non-electric	0.83	13.02	6.31	9.29
Lodging – (Hotel, Motel, and Dormitory)	Single pane	Electric	3.62	11.58	12.80	10.34
		Non-electric	4.15	13.29	14.36	11.45
	Double pane	Electric	1.53	4.65	5.43	4.17
		Non-electric	1.75	5.27	6.12	4.53

289 Warehouse and storage building type DEER models do not have windows. Tracking data with this building type will be flagged for on-site verification.

290 Non-electric heating systems were represented by gas heating in building energy models.

291 Negative demand reduction is observed in some building types for south window orientation, implying that installation of window film on the south side of the buildings leads to increased energy use due to increase heating load in the winter season.

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Building type[289]	Window type	Heating system type[290]	ESF$_{north}$ (kWh/ft^2)	ESF$_{east}$ (kWh/ft^2)	ESF$_{south}$[291] (kWh/ft^2)	ESF$_{west}$ (kWh/ft^2)
Mercantile (mall)	Single pane	Electric	2.59	7.47	5.31	8.42
		Non-electric	2.90	8.38	6.75	9.11
	Double pane	Electric	1.09	2.89	2.43	3.49
		Non-electric	1.21	3.27	3.04	3.78
Mercantile (Retail, not mall)	Single pane	Electric	2.60	7.16	6.43	10.26
		Non-electric	3.08	8.29	7.57	11.70
	Double pane	Electric	14.74	2.15	5.09	4.19
		Non-electric	1.28	2.56	5.93	4.92
Office – Small (<40,000 sq ft)	Single pane	Electric	1.59	5.16	2.61	5.05
		Non-electric	1.74	5.81	3.00	5.83
	Double pane	Electric	0.66	2.08	1.05	2.05
		Non-electric	0.75	2.33	1.24	2.32
Office – Large (≥ 40,000 sq ft)	Single pane	Electric	5.34	17.71	15.70	18.27
		Non-electric	2.24	6.52	7.01	8.63
	Double pane	Electric	2.17	6.97	6.11	6.92
		Non-electric	0.90	2.61	2.78	3.17
Other[288]	Single pane	Electric	0.08	2.44	0.02	0.44
		Non-electric	0.10	2.55	0.04	0.54
	Double pane	Electric	0.03	1.10	0.01	0.18
		Non-electric	0.04	1.15	0.02	0.22
Public assembly	Single pane	Electric	0.44	2.94	2.66	1.46
		Non-electric	0.74	2.72	2.92	1.88
	Double pane	Electric	0.23	1.27	1.18	0.86
		Non-electric	0.37	1.13	1.29	1.03
Public order and safety (police and fire station)	Single pane	Electric	0.08	2.44	0.02	0.44
		Non-electric	0.10	2.55	0.04	0.54
	Double pane	Electric	0.03	1.10	0.01	0.18
		Non-electric	0.04	1.15	0.02	0.22
Religious worship	Single pane	Electric	0.44	2.94	2.66	1.46
		Non-electric	0.74	2.72	2.92	1.88
	Double pane	Electric	0.23	1.27	1.18	0.86
		Non-electric	0.37	1.13	1.29	1.03
Service (Beauty, auto repair workshop)	Single pane	Electric	2.59	7.47	5.31	8.42
		Non-electric	2.90	8.38	6.75	9.11
	Double Pane	Electric	1.09	2.89	2.43	3.49
		Non-electric	1.21	3.27	3.04	3.78

Table 17-27. Energy savings factors for reflective window film by facility type and window orientation for Fredericksburg, VA

Facility type[292]	Window type	Heating system type[293]	ESF$_{north}$ (kWh/ft^2)	ESF$_{east}$ (kWh/ft^2)	ESF$_{south}$[294] (kWh/ft^2)	ESF$_{west}$ (kWh/ft^2)
Education – Elementary and middle school	Single pane	Electric	1.96	4.67	8.26	7.09
		Non-electric	1.95	5.56	8.11	9.86
	Double pane	Electric	0.89	1.79	3.60	3.09
		Non-electric	0.91	2.35	3.74	4.50

292 Warehouse and storage building type DEER models do not have windows. Tracking data with this building type will be flagged for on-site verification.

293 Non-electric heating systems were represented by gas heating in building energy models.

294 Negative demand reduction is observed in some building types for south window orientation, implying that installation of window film on the south side of the buildings leads to increased energy use due to increase heating load in the winter season.

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Facility type[292]	Window type	Heating system type[293]	ESF_{north} (kWh/ft^2)	ESF_{east} (kWh/ft^2)	ESF_{south}[294] (kWh/ft^2)	ESF_{west} (kWh/ft^2)
Education – High school	Single pane	Electric	3.81	7.50	15.01	11.58
		Non-electric	3.52	6.47	11.47	14.11
	Double pane	Electric	1.77	2.29	5.86	4.63
		Non-electric	1.42	2.75	5.29	5.63
Education – College and university	Single pane	Electric	3.81	7.50	15.01	11.58
		Non-electric	3.52	6.47	11.47	14.11
	Double pane	Electric	1.77	2.29	5.86	4.63
		Non-electric	1.42	2.75	5.29	5.63
Food Sales - Grocery	Single pane	Electric	2.48	9.54	8.43	7.49
		Non-electric	3.01	11.17	10.14	8.64
	Double pane	Electric	16.37	5.27	3.52	3.00
		Non-electric	1.29	6.08	4.26	3.52
Food Sales – Convenience store	Single pane	Electric	2.48	9.54	8.43	7.49
		Non-electric	3.01	11.17	10.14	8.64
	Double pane	Electric	16.37	5.27	3.52	3.00
		Non-electric	1.29	6.08	4.26	3.52
Food Sales – Non-electric station convenience store	Single pane	Electric	2.48	9.54	8.43	7.49
		Non-electric	3.01	11.17	10.14	8.64
	Double pane	Electric	16.37	5.27	3.52	3.00
		Non-electric	1.29	6.08	4.26	3.52
Food Service - Full service	Single pane	Electric	0.00	6.44	8.55	11.97
		Non-electric	0.00	7.38	10.18	12.87
	Double pane	Electric	0.00	0.00	4.26	5.49
		Non-electric	0.00	3.11	4.77	5.71
Food Service - Fast food	Single pane	Electric	0.00	3.67	4.83	6.58
		Non-electric	0.00	4.98	7.14	8.04
	Double pane	Electric	0.00	1.64	2.41	2.98
		Non-electric	0.00	2.17	3.38	3.56
Health Care-inpatient	Single pane	Electric	6.66	32.82	15.88	29.55
		Non-electric	4.39	18.32	11.24	17.51
	Double pane	Electric	3.34	13.91	7.30	11.47
		Non-electric	2.08	7.55	4.89	6.64
Health Care-outpatient	Single pane	Electric	1.03	37.41	15.62	22.39
		Non-electric	1.61	29.19	15.53	22.23
	Double pane	Electric	0.51	16.11	6.46	9.10
		Non-electric	0.77	12.50	6.13	9.02
Lodging – (Hotel, motel, and dormitory)	Single pane	Electric	3.62	11.47	12.77	10.01
		Non-electric	3.97	12.71	14.23	10.46
	Double pane	Electric	1.41	4.10	5.22	3.81
		Non-electric	1.66	5.16	5.99	4.15
Mercantile (mall)	Single pane	Electric	2.54	5.78	5.37	8.12
		Non-electric	2.85	6.61	6.80	8.82
	Double pane	Electric	1.10	3.07	2.46	3.44
		Non-electric	1.22	3.50	3.06	3.72
Mercantile (Retail, not mall)	Single pane	Electric	2.48	9.54	8.43	7.49
		Non-electric	3.01	11.17	10.14	8.64
	Double pane	Electric	16.37	5.27	3.52	3.00
		Non-electric	1.29	6.08	4.26	3.52
Office – Small (<40,000 sq ft)	Single pane	Electric	1.54	4.88	2.39	4.74
		Non-electric	1.79	5.58	3.08	5.60
	Double pane	Electric	0.59	1.97	0.96	1.93
		Non-electric	0.72	2.37	1.24	2.28

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Facility type[292]	Window type	Heating system type[293]	ESF$_{north}$ (kWh/ft^2)	ESF$_{east}$ (kWh/ft^2)	ESF$_{south}$[294] (kWh/ft^2)	ESF$_{west}$ (kWh/ft^2)
Office – Large (≥ 40,000 sq ft)	Single pane	Electric	5.31	17.28	15.43	17.60
		Non-electric	2.19	6.61	7.45	8.35
	Double pane	Electric	2.16	6.33	6.16	6.61
		Non-electric	0.96	2.64	3.03	3.19
Other[288]	Single pane	Electric	0.06	2.37	0.02	0.42
		Non-electric	0.08	2.52	0.04	0.53
	Double pane	Electric	0.03	1.10	0.01	0.17
		Non-electric	0.03	1.16	0.02	0.22
Public assembly	Single pane	Electric	0.43	2.91	2.55	1.57
		Non-electric	0.78	2.65	3.01	1.95
	Double pane	Electric	0.23	1.25	1.14	0.80
		Non-electric	0.38	1.09	1.29	1.02
Public order and safety (police and fire station)	Single pane	Electric	0.06	2.37	0.02	0.42
		Non-electric	0.08	2.52	0.04	0.53
	Double pane	Electric	0.03	1.10	0.01	0.17
		Non-electric	0.03	1.16	0.02	0.22
Religious worship	Single pane	Electric	0.43	2.91	2.55	1.57
		Non-electric	0.78	2.65	3.01	1.95
	Double pane	Electric	0.23	1.25	1.14	0.80
		Non-electric	0.38	1.09	1.29	1.02
Service (Beauty, auto repair workshop)	Single pane	Electric	2.54	5.78	5.37	8.12
		Non-electric	2.85	6.61	6.80	8.82
	Double pane	Electric	1.10	3.07	2.46	3.44
		Non-electric	1.22	3.50	3.06	3.72

Table 17-28. Energy savings factors for reflective window film by facility type and window orientation for Norfolk, VA

Facility type[295]	Window type	Heating system type[296]	ESF$_{north}$ (kWh/ft^2)	ESF$_{east}$ (kWh/ft^2)	ESF$_{south}$[297] (kWh/ft^2)	ESF$_{west}$ (kWh/ft^2)
Education – Elementary and middle school	Single pane	Electric	2.00	4.60	7.20	6.75
		Non-electric	2.20	6.14	8.26	10.61
	Double pane	Electric	0.82	1.67	3.15	2.69
		Non-electric	0.87	2.23	3.67	4.32
Education – High school	Single pane	Electric	4.28	7.53	17.89	11.80
		Non-electric	3.92	6.53	11.41	15.09
	Double pane	Electric	1.84	2.86	6.91	4.59
		Non-electric	1.75	2.48	5.52	6.07
Education – College and university	Single pane	Electric	4.28	7.53	17.89	11.80
		Non-electric	3.92	6.53	11.41	15.09
	Double pane	Electric	1.84	2.86	6.91	4.59
		Non-electric	1.75	2.48	5.52	6.07
Food sales - grocery	Single pane	Electric	2.72	10.30	9.41	7.96
		Non-electric	3.23	11.58	10.99	8.88
	Double pane	Electric	12.62	5.66	2.79	3.24
		Non-electric	1.39	6.32	3.23	3.64

295 Warehouse and storage building type DEER models do not have windows. Tracking data with this building type will be flagged for on-site verification.

296 Non-electric heating systems were represented by gas heating in building energy models.

297 Negative demand reduction is observed in some building types for south window orientation, implying that installation of window film on the south side of the buildings leads to increased energy use due to increase heating load in the winter season.

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Facility type[295]	Window type	Heating system type[296]	ESF_{north} (kWh/ft^2)	ESF_{east} (kWh/ft^2)	ESF_{south}[297] (kWh/ft^2)	ESF_{west} (kWh/ft^2)
Food sales – convenience store	Single pane	Electric	2.72	10.30	9.41	7.96
		Non-electric	3.23	11.58	10.99	8.88
	Double pane	Electric	12.62	5.66	2.79	3.24
		Non-electric	1.39	6.32	3.23	3.64
Food sales – Non-electric station convenience store	Single pane	Electric	2.72	10.30	9.41	7.96
		Non-electric	3.23	11.58	10.99	8.88
	Double pane	Electric	12.62	5.66	2.79	3.24
		Non-electric	1.39	6.32	3.23	3.64
Food service - full service	Single pane	Electric	0.00	6.76	7.96	12.00
		Non-electric	0.00	7.50	9.69	13.03
	Double pane	Electric	0.00	0.00	3.89	5.51
		Non-electric	0.00	3.19	4.55	5.90
Food service - fast food	Single pane	Electric	0.00	4.07	4.67	6.76
		Non-electric	0.00	5.35	7.09	8.42
	Double pane	Electric	0.00	1.78	2.29	3.07
		Non-electric	0.00	2.33	3.34	3.79
Health care-inpatient	Single pane	Electric	6.65	32.75	14.84	29.52
		Non-electric	4.42	18.30	10.69	17.53
	Double pane	Electric	3.33	13.99	7.03	11.45
		Non-electric	2.10	7.64	4.78	6.67
Health care-outpatient	Single pane	Electric	1.24	38.50	14.45	23.37
		Non-electric	1.73	29.32	13.83	22.39
	Double pane	Electric	0.58	16.83	6.44	9.40
		Non-electric	0.81	12.75	5.92	8.99
Lodging – (Hotel, motel, and dormitory)	Single pane	Electric	4.01	12.26	13.03	10.62
		Non-electric	4.59	14.44	14.52	11.72
	Double pane	Electric	1.63	4.67	5.49	4.02
		Non-electric	1.82	5.67	6.13	4.68
Mercantile (mall)	Single pane	Electric	2.79	6.34	5.28	8.46
		Non-electric	3.09	7.09	6.77	9.12
	Double pane	Electric	1.18	3.31	2.46	3.58
		Non-electric	1.31	3.66	3.09	3.83
Mercantile (Retail, not mall)	Single pane	Electric	2.72	10.30	9.41	7.96
		Non-electric	3.23	11.58	10.99	8.88
	Double pane	Electric	12.62	5.66	2.79	3.24
		Non-electric	1.39	6.32	3.23	3.64
Office – Small (<40,000 sq ft)	Single pane	Electric	1.60	5.24	2.63	5.13
		Non-electric	1.78	5.69	3.05	5.71
	Double pane	Electric	0.66	2.08	1.00	2.04
		Non-electric	0.74	2.32	1.20	2.34
Office – Large (≥ 40,000 sq ft)	Single pane	Electric	5.49	16.69	14.64	17.03
		Non-electric	2.27	6.46	7.14	8.50
	Double pane	Electric	2.22	6.39	5.89	6.37
		Non-electric	1.06	2.77	2.91	3.32
Other[288]	Single pane	Electric	0.05	2.61	0.03	0.45
		Non-electric	0.07	2.72	0.03	0.55
	Double pane	Electric	0.01	1.11	0.02	0.18
		Non-electric	0.02	1.15	0.02	0.21
Public assembly	Single pane	Electric	0.55	2.94	2.56	1.69
		Non-electric	0.85	2.69	2.83	2.21
	Double pane	Electric	0.26	1.27	1.11	0.91
		Non-electric	0.38	1.05	1.16	1.07

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Facility type[295]	Window type	Heating system type[296]	ESF_{north} (kWh/ft^2)	ESF_{east} (kWh/ft^2)	ESF_{south}[297] (kWh/ft^2)	ESF_{west} (kWh/ft^2)
Public order and safety (police and fire station)	Single pane	Electric	0.05	2.61	0.03	0.45
		Non-electric	0.07	2.72	0.03	0.55
	Double pane	Electric	0.01	1.11	0.02	0.18
		Non-electric	0.02	1.15	0.02	0.21
Religious worship	Single pane	Electric	0.55	2.94	2.56	1.69
		Non-electric	0.85	2.69	2.83	2.21
	Double pane	Electric	0.26	1.27	1.11	0.91
		Non-electric	0.38	1.05	1.16	1.07
Service (Beauty, auto repair workshop)	Single pane	Electric	2.79	6.34	5.28	8.46
		Non-electric	3.09	7.09	6.77	9.12
	Double pane	Electric	1.18	3.31	2.46	3.58
		Non-electric	1.31	3.66	3.09	3.83

Table 17-29. Energy savings factors for reflective window film by facility type and window orientation for Arlington, VA

Facility type[298]	Window type	Heating system type[299]	ESF_{north} (kWh/ft^2)	ESF_{east} (kWh/ft^2)	ESF_{south}[300] (kWh/ft^2)	ESF_{west} (kWh/ft^2)
Education – Elementary and middle school	Single pane	Electric	1.91	4.43	7.63	7.09
		Non-electric	1.99	5.79	8.00	9.99
	Double pane	Electric	0.82	1.81	3.32	2.72
		Non-electric	0.86	2.09	3.58	4.00
Education – High school	Single pane	Electric	3.97	6.74	15.27	11.23
		Non-electric	3.62	6.42	11.51	13.85
	Double pane	Electric	1.70	2.40	6.09	4.40
		Non-electric	1.44	1.98	5.15	5.55
Education – College and university	Single pane	Electric	3.97	6.74	15.27	11.23
		Non-electric	3.62	6.42	11.51	13.85
	Double pane	Electric	1.70	2.40	6.09	4.40
		Non-electric	1.44	1.98	5.15	5.55
Food sales - Grocery	Single pane	Electric	2.46	9.86	8.82	7.40
		Non-electric	3.05	11.39	10.80	8.55
	Double pane	Electric	16.05	5.49	2.48	2.88
		Non-electric	1.33	6.27	3.03	3.35
Food Sales – Convenience store	Single pane	Electric	2.46	9.86	8.82	7.40
		Non-electric	3.05	11.39	10.80	8.55
	Double pane	Electric	16.05	5.49	2.48	2.88
		Non-electric	1.33	6.27	3.03	3.35
Food Sales – Non-electric station convenience store	Single pane	Electric	2.46	9.86	8.82	7.40
		Non-electric	3.05	11.39	10.80	8.55
	Double pane	Electric	16.05	5.49	2.48	2.88
		Non-electric	1.33	6.27	3.03	3.35

298 Warehouse and storage building type DEER models do not have windows. Tracking data with this building type will be flagged for on-site verification.

299 Non-electric heating systems were represented by gas heating in building energy models.

300 Negative demand reduction is observed in some building types for south window orientation, implying that installation of window film on the south side of the buildings leads to increased energy use due to increase heating load in the winter season.

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Facility type[298]	Window type	Heating system type[299]	ESF_{north} (kWh/ft^2)	ESF_{east} (kWh/ft^2)	ESF_{south}[300] (kWh/ft^2)	ESF_{west} (kWh/ft^2)
Food service - Full service	Single pane	Electric	0.00	6.20	8.10	11.37
		Non-electric	0.00	7.15	10.04	12.54
	Double pane	Electric	0.00	0.00	3.90	5.15
		Non-electric	0.00	2.99	4.69	5.64
Food service - Fast food	Single pane	Electric	0.00	3.35	4.27	6.14
		Non-electric	0.00	4.84	6.99	7.92
	Double pane	Electric	0.00	1.55	2.23	2.85
		Non-electric	0.00	2.13	3.32	3.55
Health care-Inpatient	Single pane	Electric	6.54	33.20	16.51	29.69
		Non-electric	4.33	18.36	11.38	17.54
	Double pane	Electric	3.34	13.97	7.50	11.46
		Non-electric	2.08	7.56	4.94	6.64
Health care-Outpatient	Single pane	Electric	1.21	38.50	16.83	23.07
		Non-electric	1.79	29.72	16.37	22.63
	Double pane	Electric	0.45	16.60	6.86	9.08
		Non-electric	0.71	12.74	6.39	8.92
Lodging – (Hotel, motel, and dormitory)	Single pane	Electric	3.51	11.22	12.71	9.41
		Non-electric	4.03	12.75	14.26	10.41
	Double pane	Electric	1.43	4.37	5.31	3.81
		Non-electric	1.59	5.07	5.94	3.88
Mercantile (mall)	Single pane	Electric	2.53	5.84	4.97	7.91
		Non-electric	2.92	6.71	6.75	8.74
	Double pane	Electric	1.10	3.04	2.32	3.35
		Non-electric	1.25	3.56	3.04	3.72
Mercantile (Retail, not mall)	Single pane	Electric	2.46	9.86	8.82	7.40
		Non-electric	3.05	11.39	10.80	8.55
	Double pane	Electric	16.05	5.49	2.48	2.88
		Non-electric	1.33	6.27	3.03	3.35
Office – Small (<40,000 sq ft)	Single pane	Electric	1.44	4.84	2.27	4.70
		Non-electric	1.80	5.69	3.09	5.68
	Double pane	Electric	0.61	1.93	0.96	1.93
		Non-electric	0.71	2.28	1.24	2.24
Office – Large (≥ 40,000 sq ft)	Single pane	Electric	5.45	16.35	15.31	17.15
		Non-electric	2.09	6.47	7.19	8.56
	Double pane	Electric	2.19	6.14	6.07	6.43
		Non-electric	0.93	2.48	2.98	3.26
Other[288]	Single pane	Electric	0.04	2.34	0.01	0.40
		Non-electric	0.06	2.49	0.04	0.52
	Double pane	Electric	0.01	1.03	0.01	0.15
		Non-electric	0.02	1.08	0.02	0.20
Public assembly	Single pane	Electric	0.49	2.81	2.32	1.53
		Non-electric	0.81	2.54	2.77	1.85
	Double pane	Electric	0.22	1.17	1.01	0.84
		Non-electric	0.37	1.03	1.15	0.90

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Facility type[298]	Window type	Heating system type[299]	ESF$_{north}$ (kWh/ft^2)	ESF$_{east}$ (kWh/ft^2)	ESF$_{south}$[300] (kWh/ft^2)	ESF$_{west}$ (kWh/ft^2)
Public order and safety (police and fire station)	Single pane	Electric	0.04	2.34	0.01	0.40
		Non-electric	0.06	2.49	0.04	0.52
	Double pane	Electric	0.01	1.03	0.01	0.15
		Non-electric	0.02	1.08	0.02	0.20
Religious worship	Single pane	Electric	0.49	2.81	2.32	1.53
		Non-electric	0.81	2.54	2.77	1.85
	Double pane	Electric	0.22	1.17	1.01	0.84
		Non-electric	0.37	1.03	1.15	0.90
Service (Beauty, auto repair workshop)	Single pane	Electric	2.53	5.84	4.97	7.91
		Non-electric	2.92	6.71	6.75	8.74
	Double pane	Electric	1.10	3.04	2.32	3.35
		Non-electric	1.25	3.56	3.04	3.72

Table 17-30. Energy savings factors for reflective window film by facility type and window orientation for roanoke, VA

Facility type[301]	Window type	Heating system type[302]	ESF$_{north}$ (kWh/ft^2)	ESF$_{east}$ (kWh/ft^2)	ESF$_{south}$[303] (kWh/ft^2)	ESF$_{west}$ (kWh/ft^2)
Education – Elementary and middle school	Single pane	Electric	1.80	4.39	7.28	5.99
		Non-electric	1.90	5.83	7.76	9.74
	Double pane	Electric	0.82	1.77	3.21	2.50
		Non-electric	0.82	2.24	3.47	3.86
Education – High school	Single pane	Electric	3.91	7.10	14.39	10.93
		Non-electric	3.36	7.57	11.09	14.03
	Double pane	Electric	1.66	2.85	6.35	4.32
		Non-electric	1.60	2.82	4.94	6.15
Education – College and university	Single pane	Electric	3.91	7.10	14.39	10.93
		Non-electric	3.36	7.57	11.09	14.03
	Double pane	Electric	1.66	2.85	6.35	4.32
		Non-electric	1.60	2.82	4.94	6.15
Food sales - Grocery	Single pane	Electric	4.72	7.40	6.12	8.18
		Non-electric	5.67	8.55	7.50	9.28
	Double pane	Electric	15.20	5.16	2.82	3.28
		Non-electric	1.30	5.86	3.41	3.76
Food sales – Convenience store	Single pane	Electric	4.72	7.40	6.12	8.18
		Non-electric	5.67	8.55	7.50	9.28
	Double pane	Electric	15.20	5.16	2.82	3.28
		Non-electric	1.30	5.86	3.41	3.76
Food sales – Non-electric station convenience store	Single pane	Electric	4.72	7.40	6.12	8.18
		Non-electric	5.67	8.55	7.50	9.28
	Double pane	Electric	15.20	5.16	2.82	3.28
		Non-electric	1.30	5.86	3.41	3.76
Food Service - Full service	Single pane	Electric	0.00	6.65	8.27	11.94
		Non-electric	0.00	7.47	10.04	13.01
	Double pane	Electric	0.00	0.00	3.93	5.39

[301] Warehouse and storage building type DEER models do not have windows. Tracking data with this building type will be flagged for on-site verification.
[302] Non-electric heating systems were represented by gas heating in building energy models.
[303] Negative demand reduction is observed in some building types for south window orientation, implying that installation of window film on the south side of the buildings leads to increased energy use due to increase heating load in the winter season.

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Facility type[301]	Window type	Heating system type[302]	ESF_{north} (kWh/ft^2)	ESF_{east} (kWh/ft^2)	ESF_{south}[303] (kWh/ft^2)	ESF_{west} (kWh/ft^2)
		Non-electric	0.00	3.15	4.67	5.86
Food service - Fast food	Single pane	Electric	0.00	3.67	4.61	6.39
		Non-electric	0.00	5.12	7.10	8.04
	Double pane	Electric	0.00	1.57	2.28	2.96
		Non-electric	0.00	2.19	3.35	3.63
Health Care-inpatient	Single pane	Electric	7.47	33.28	15.45	29.99
		Non-electric	4.93	18.79	11.14	18.06
	Double pane	Electric	3.08	14.18	7.16	11.60
		Non-electric	2.00	7.83	4.89	6.83
Health Care-outpatient	Single pane	Electric	1.08	38.81	16.61	23.40
		Non-electric	1.68	30.34	16.53	23.14
	Double pane	Electric	0.38	16.38	7.03	9.13
		Non-electric	0.66	12.63	6.73	9.02
Lodging – (Hotel, motel, and dormitory)	Single pane	Electric	3.68	11.79	12.87	10.12
		Non-electric	4.25	13.72	14.48	11.12
	Double pane	Electric	1.50	4.96	5.45	4.09
		Non-electric	1.67	5.42	6.13	4.17
Mercantile (mall)	Single pane	Electric	2.55	7.21	5.28	8.45
		Non-electric	2.93	8.10	6.79	9.21
	Double pane	Electric	1.13	5.04	2.48	3.52
		Non-electric	1.27	5.57	3.09	3.85
Mercantile (Retail, not mall)	Single pane	Electric	4.72	7.40	6.12	8.18
		Non-electric	5.67	8.55	7.50	9.28
	Double pane	Electric	15.20	5.16	2.82	3.28
		Non-electric	1.30	5.86	3.41	3.76
Office – Small (<40,000 sq ft)	Single pane	Electric	1.55	5.26	2.32	5.04
		Non-electric	1.79	5.80	3.00	5.89
	Double pane	Electric	0.67	2.13	0.93	2.04
		Non-electric	0.74	2.31	1.16	2.35
Office – Large (≥ 40,000 sq ft)	Single pane	Electric	5.65	17.39	15.96	17.77
		Non-electric	2.27	6.71	7.37	8.80
	Double pane	Electric	2.25	6.81	6.16	6.67
		Non-electric	1.03	2.70	3.05	3.50
Other[288]	Single pane	Electric	0.05	2.48	0.01	0.40
		Non-electric	0.08	2.62	0.04	0.52
	Double pane	Electric	0.03	1.09	0.01	0.16
		Non-electric	0.04	1.15	0.02	0.21
Public assembly	Single pane	Electric	0.45	2.73	2.42	1.40
		Non-electric	0.80	2.63	2.85	1.84
	Double pane	Electric	0.16	1.10	1.01	0.60
		Non-electric	0.37	1.07	1.18	0.94
Public order and safety (police and fire station)	Single pane	Electric	0.05	2.48	0.01	0.40
		Non-electric	0.08	2.62	0.04	0.52
	Double pane	Electric	0.03	1.09	0.01	0.16
		Non-electric	0.04	1.15	0.02	0.21
Religious worship	Single pane	Electric	0.45	2.73	2.42	1.40
		Non-electric	0.80	2.63	2.85	1.84
	Double pane	Electric	0.16	1.10	1.01	0.60
		Non-electric	0.37	1.07	1.18	0.94

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Facility type[301]	Window type	Heating system type[302]	ESF_{north} (kWh/ft^2)	ESF_{east} (kWh/ft^2)	ESF_{south}[303] (kWh/ft^2)	ESF_{west} (kWh/ft^2)
Service (Beauty, Auto Repair Workshop)	Single Pane	Electric	2.55	7.21	5.28	8.45
		Non-electric	2.93	8.10	6.79	9.21
	Double Pane	Electric	1.13	5.04	2.48	3.52
		Non-electric	1.27	5.57	3.09	3.85

Table 17-31. Energy savings factors for reflective window film by facility type and window orientation for Sterling, VA

Facility type[304]	Window type	Heating system type[305]	ESF_{north} (kWh/ft^2)	ESF_{east} (kWh/ft^2)	ESF_{south}[306] (kWh/ft^2)	ESF_{west} (kWh/ft^2)
Education – Elementary and middle school	Single pane	Electric	1.98	4.27	7.63	6.48
		Non-electric	2.01	5.59	7.64	9.59
	Double pane	Electric	0.93	1.73	3.40	2.90
		Non-electric	0.91	2.15	3.35	4.18
Education – High school	Single pane	Electric	3.86	6.56	13.59	10.24
		Non-electric	3.37	6.73	10.97	13.29
	Double pane	Electric	1.64	2.37	6.34	4.24
		Non-electric	1.38	2.70	4.64	5.45
Education – College and university	Single pane	Electric	3.86	6.56	13.59	10.24
		Non-electric	3.37	6.73	10.97	13.29
	Double pane	Electric	1.64	2.37	6.34	4.24
		Non-electric	1.38	2.70	4.64	5.45
Food sales - Grocery	Single pane	Electric	2.39	9.43	8.46	7.22
		Non-electric	2.99	11.00	10.72	8.45
	Double pane	Electric	17.37	5.32	2.36	2.87
		Non-electric	1.29	6.11	2.99	3.40
Food sales – Convenience store	Single pane	Electric	2.39	9.43	8.46	7.22
		Non-electric	2.99	11.00	10.72	8.45
	Double pane	Electric	17.37	5.32	2.36	2.87
		Non-electric	1.29	6.11	2.99	3.40
Food Sales – Non-electric station convenience store	Single pane	Electric	2.39	9.43	8.46	7.22
		Non-electric	2.99	11.00	10.72	8.45
	Double pane	Electric	17.37	5.32	2.36	2.87
		Non-electric	1.29	6.11	2.99	3.40
Food service - Full Service	Single pane	Electric	0.00	6.35	8.25	11.54
		Non-electric	0.00	7.31	10.24	12.72
	Double pane	Electric	0.00	0.00	4.06	5.23
		Non-electric	0.00	3.06	4.77	5.64
Food service - Fast Food	Single pane	Electric	0.00	3.43	4.31	6.22
		Non-electric	0.00	4.88	7.00	7.91
	Double pane	Electric	0.00	1.45	2.21	2.73
		Non-electric	0.00	2.11	3.30	3.47
Health Care-inpatient	Single pane	Electric	6.44	33.03	16.28	29.64
		Non-electric	4.34	18.41	11.38	17.56
	Double pane	Electric	3.32	13.83	7.45	11.51
		Non-electric	2.08	7.52	4.90	6.66

304 Warehouse and storage building type DEER models do not have windows. Tracking data with this building type will be flagged for on-site verification.

305 Non-electric heating systems were represented by gas heating in building energy models.

306 Negative demand reduction is observed in some building types for south window orientation, implying that installation of window film on the south side of the buildings leads to increased energy use due to increase heating load in the winter season.

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Facility type[304]	Window type	Heating system type[305]	ESF_{north} (kWh/ft^2)	ESF_{east} (kWh/ft^2)	ESF_{south}[306] (kWh/ft^2)	ESF_{west} (kWh/ft^2)
Health Care-outpatient	Single pane	Electric	1.04	37.91	16.28	22.83
		Non-electric	1.66	29.45	16.06	22.62
	Double pane	Electric	0.37	16.33	6.66	8.89
		Non-electric	0.64	12.60	6.26	8.80
Lodging – (Hotel, motel, and dormitory)	Single pane	Electric	3.43	10.46	12.34	9.39
		Non-electric	4.02	12.44	13.93	10.15
	Double pane	Electric	1.40	4.14	5.09	3.48
		Non-electric	1.62	5.05	5.78	3.86
Mercantile (mall)	Single pane	Electric	2.41	5.59	4.81	7.64
		Non-electric	2.86	6.62	6.69	8.63
	Double pane	Electric	1.06	3.00	2.17	3.20
		Non-electric	1.23	3.52	2.95	3.60
Mercantile (Retail, not mall)	Single pane	Electric	2.39	9.43	8.46	7.22
		Non-electric	2.99	11.00	10.72	8.45
	Double pane	Electric	17.37	5.32	2.36	2.87
		Non-electric	1.29	6.11	2.99	3.40
Office – Small (<40,000 sq ft)	Single pane	Electric	1.54	4.85	2.11	4.50
		Non-electric	1.70	5.36	2.89	5.48
	Double pane	Electric	0.65	1.96	0.83	1.78
		Non-electric	0.70	2.15	1.12	2.13
Office – Large (≥ 40,000 sq ft)	Single pane	Electric	5.54	16.64	15.44	16.95
		Non-electric	2.07	6.66	7.45	8.65
	Double pane	Electric	2.23	6.07	6.10	6.35
		Non-electric	0.97	2.76	3.10	3.44
Other[288]	Single pane	Electric	0.08	2.35	0.02	0.38
		Non-electric	0.10	2.53	0.04	0.51
	Double pane	Electric	0.03	1.02	0.01	0.13
		Non-electric	0.03	1.09	0.02	0.19
Public assembly	Single pane	Electric	0.33	2.63	2.07	1.38
		Non-electric	0.76	2.44	2.58	1.75
	Double pane	Electric	0.15	1.07	0.85	0.70
		Non-electric	0.35	0.96	1.05	0.90
Public order and safety (police and fire station)	Single pane	Electric	0.08	2.35	0.02	0.38
		Non-electric	0.10	2.53	0.04	0.51
	Double pane	Electric	0.03	1.02	0.01	0.13
		Non-electric	0.03	1.09	0.02	0.19
Religious worship	Single pane	Electric	0.33	2.63	2.07	1.38
		Non-electric	0.76	2.44	2.58	1.75
	Double pane	Electric	0.15	1.07	0.85	0.70
		Non-electric	0.35	0.96	1.05	0.90
Service (Beauty, Auto Repair Workshop)	Single pane	Electric	2.41	5.59	4.81	7.64
		Non-electric	2.86	6.62	6.69	8.63
	Double pane	Electric	1.06	3.00	2.17	3.20
		Non-electric	1.23	3.52	2.95	3.60

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Table 17-32. Energy savings factors for reflective window film by facility type and window orientation for Richmond, VA

Facility type[307]	Window type	Heating system type[308]	ESF_{north} (kWh/ft²)	ESF_{east} (kWh/ft²)	ESF_{south}[309] (kWh/ft²)	ESF_{west} (kWh/ft²)
Education – Elementary and middle school	Single pane	Electric	1.90	4.53	7.56	6.30
		Non-electric	2.07	6.11	8.28	9.97
	Double pane	Electric	0.85	1.82	3.26	2.73
		Non-electric	0.91	2.35	3.82	4.33
Education – High school	Single pane	Electric	4.27	7.43	17.99	11.96
		Non-electric	3.76	7.72	11.71	14.84
	Double pane	Electric	1.97	2.87	7.06	4.83
		Non-electric	1.67	2.70	5.17	5.94
Education – College and university	Single pane	Electric	4.27	7.43	17.99	11.96
		Non-electric	3.76	7.72	11.71	14.84
	Double pane	Electric	1.97	2.87	7.06	4.83
		Non-electric	1.67	2.70	5.17	5.94
Food sales - Grocery	Single pane	Electric	2.67	10.12	8.56	8.94
		Non-electric	3.16	11.47	10.14	10.16
	Double pane	Electric	14.39	4.81	3.68	3.19
		Non-electric	1.38	5.41	4.39	3.63
Food sales – Convenience store	Single pane	Electric	2.67	10.12	8.56	8.94
		Non-electric	3.16	11.47	10.14	10.16
	Double pane	Electric	14.39	4.81	3.68	3.19
		Non-electric	1.38	5.41	4.39	3.63
Food Sales – Non-electric station convenience store	Single pane	Electric	2.67	10.12	8.56	8.94
		Non-electric	3.16	11.47	10.14	10.16
	Double pane	Electric	14.39	4.81	3.68	3.19
		Non-electric	1.38	5.41	4.39	3.63
Food service - Full service	Single pane	Electric	0.00	6.99	8.48	12.30
		Non-electric	0.00	7.64	10.09	13.05
	Double pane	Electric	0.00	0.00	4.06	5.58
		Non-electric	0.00	3.24	4.73	5.92
Food service - Fast food	Single pane	Electric	0.00	4.02	4.63	6.64
		Non-electric	0.00	5.32	7.16	8.31
	Double pane	Electric	0.00	1.73	2.34	2.97
		Non-electric	0.00	2.27	3.39	3.65
Health Care-inpatient	Single pane	Electric	6.70	33.01	15.30	29.63
		Non-electric	4.44	18.38	10.95	17.56
	Double pane	Electric	3.33	13.92	7.09	11.48
		Non-electric	2.08	7.60	4.81	6.67
Health Care-outpatient	Single pane	Electric	1.31	38.66	15.40	23.69
		Non-electric	1.82	29.61	14.79	22.83
	Double pane	Electric	0.48	16.47	6.46	9.44
		Non-electric	0.72	12.44	5.93	9.04
Lodging – (Hotel, motel, and dormitory)	Single pane	Electric	3.89	12.04	13.14	10.57
		Non-electric	4.44	13.90	14.71	11.55
	Double pane	Electric	1.60	5.08	5.48	4.23
		Non-electric	1.84	5.55	6.18	4.34

[307] Warehouse and storage building type DEER models do not have windows. Tracking data with this building type will be flagged for on-site verification.

[308] Non-electric heating systems were represented by gas heating in building energy models.

[309] Negative demand reduction is observed in some building types for south window orientation, implying that installation of window film on the south side of the buildings leads to increased energy use due to increase heating load in the winter season.

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Facility type[307]	Window type	Heating system type[308]	ESF_{north} (kWh/ft²)	ESF_{east} (kWh/ft²)	ESF_{south}[309] (kWh/ft²)	ESF_{west} (kWh/ft²)
Mercantile (mall)	Single pane	Electric	2.70	6.08	5.22	8.25
		Non-electric	3.03	6.93	6.84	8.99
	Double pane	Electric	1.14	3.24	2.42	3.48
		Non-electric	1.29	3.62	3.07	3.79
Mercantile (Retail, not mall)	Single pane	Electric	2.67	10.12	8.56	8.94
		Non-electric	3.16	11.47	10.14	10.16
	Double pane	Electric	14.39	4.81	3.68	3.19
		Non-electric	1.38	5.41	4.39	3.63
Office – Small (<40,000 sq ft)	Single pane	Electric	1.58	5.22	2.62	5.11
		Non-electric	1.82	5.84	3.13	5.86
	Double pane	Electric	0.69	2.15	1.06	2.07
		Non-electric	0.73	2.32	1.22	2.34
Office – Large (≥ 40,000 sq ft)	Single pane	Electric	5.58	17.52	15.45	17.57
		Non-electric	2.28	6.37	7.24	8.60
	Double pane	Electric	2.24	6.42	6.15	6.60
		Non-electric	1.04	2.59	2.97	3.12
Other[288]	Single pane	Electric	0.07	2.58	0.03	0.46
		Non-electric	0.08	2.70	0.04	0.56
	Double pane	Electric	0.03	1.12	0.01	0.17
		Non-electric	0.03	1.17	0.02	0.21
Public assembly	Single pane	Electric	0.58	3.12	2.70	1.43
		Non-electric	0.86	2.77	2.97	1.98
	Double pane	Electric	0.28	1.21	1.16	0.83
		Non-electric	0.40	1.11	1.24	0.99
Public order and safety (police and fire station)	Single pane	Electric	0.07	2.58	0.03	0.46
		Non-electric	0.08	2.70	0.04	0.56
	Double pane	Electric	0.03	1.12	0.01	0.17
		Non-electric	0.03	1.17	0.02	0.21
Religious worship	Single pane	Electric	0.58	3.12	2.70	1.43
		Non-electric	0.86	2.77	2.97	1.98
	Double pane	Electric	0.28	1.21	1.16	0.83
		Non-electric	0.40	1.11	1.24	0.99
Service (Beauty, auto repair workshop)	Single pane	Electric	2.70	6.08	5.22	8.25
		Non-electric	3.03	6.93	6.84	8.99
	Double pane	Electric	1.14	3.24	2.42	3.48
		Non-electric	1.29	3.62	3.07	3.79

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Table 17-33. Energy savings factors for reflective window film by facility type and window orientation for Rocky Mount, NC

Facility type[310]	Window type	Heating system type[311]	ESF_{north} (kWh/ft^2)	ESF_{east} (kWh/ft^2)	ESF_{south}[312] (kWh/ft^2)	ESF_{west} (kWh/ft^2)
Education – Elementary and middle school	Single pane	Electric	2.03	4.55	6.75	6.10
		Non-electric	2.27	6.24	8.35	10.70
	Double pane	Electric	0.87	1.95	2.90	2.48
		Non-electric	1.00	2.59	3.76	4.55
Education – High school	Single pane	Electric	4.47	8.10	20.13	12.97
		Non-electric	3.90	7.03	11.34	14.85
	Double pane	Electric	1.91	3.15	7.81	5.23
		Non-electric	1.82	3.30	5.63	6.82
Education – College and university	Single pane	Electric	4.47	8.10	20.13	12.97
		Non-electric	3.90	7.03	11.34	14.85
	Double pane	Electric	1.91	3.15	7.81	5.23
		Non-electric	1.82	3.30	5.63	6.82
Food sales - Grocery	Single pane	Electric	3.64	7.79	6.90	10.81
		Non-electric	4.16	8.62	7.74	11.86
	Double pane	Electric	10.34	2.28	5.32	3.53
		Non-electric	1.34	2.63	5.94	3.90
Food sales – Convenience store	Single pane	Electric	3.64	7.79	6.90	10.81
		Non-electric	4.16	8.62	7.74	11.86
	Double pane	Electric	10.34	2.28	5.32	3.53
		Non-electric	1.34	2.63	5.94	3.90
Food Sales – Non-electric station convenience store	Single pane	Electric	3.64	7.79	6.90	10.81
		Non-electric	4.16	8.62	7.74	11.86
	Double pane	Electric	10.34	2.28	5.32	3.53
		Non-electric	1.34	2.63	5.94	3.90
Food service - Full service	Single pane	Electric	0.00	7.00	8.51	12.74
		Non-electric	0.00	7.61	9.80	13.31
	Double pane	Electric	0.00	0.00	3.93	5.83
		Non-electric	0.00	3.24	4.49	6.11
Food service - Fast food	Single pane	Electric	0.00	4.00	4.83	6.96
		Non-electric	0.00	5.27	7.11	8.43
	Double pane	Electric	0.00	1.70	2.37	3.16
		Non-electric	0.00	2.26	3.35	3.80
Health care-inpatient	Single pane	Electric	7.19	32.81	14.02	29.48
		Non-electric	4.67	18.14	10.38	17.45
	Double pane	Electric	3.20	13.82	6.70	11.43
		Non-electric	2.02	7.51	4.64	6.62

[310] Warehouse and storage building type DEER models do not have windows. Tracking data with this building type will be flagged for on-site verification.

[311] Non-electric heating systems were represented by gas heating in building energy models.

[312] Negative demand reduction is observed in some building types for south window orientation, implying that installation of window film on the south side of the buildings leads to increased energy use due to increase heating load in the winter season.

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Facility type[310]	Window type	Heating system type[311]	ESF_{north} (kWh/ft²)	ESF_{east} (kWh/ft²)	ESF_{south}[312] (kWh/ft²)	ESF_{west} (kWh/ft²)
Health Care-outpatient	Single pane	Electric	1.16	38.33	13.54	23.36
		Non-electric	1.65	28.95	13.08	22.33
	Double pane	Electric	0.40	16.43	6.00	9.16
		Non-electric	0.62	12.28	5.59	8.72
Lodging – (Hotel, motel, and dormitory)	Single pane	Electric	4.29	13.30	13.93	12.22
		Non-electric	4.89	15.27	15.50	13.04
	Double pane	Electric	1.79	5.71	5.97	4.97
		Non-electric	2.05	6.16	6.64	5.21
Mercantile (mall)	Single pane	Electric	2.88	7.99	5.73	8.84
		Non-electric	3.05	8.60	6.79	9.15
	Double pane	Electric	1.20	3.07	2.64	3.68
		Non-electric	1.27	3.32	3.10	3.84
Mercantile (Retail, not mall)	Single pane	Electric	3.64	7.79	6.90	10.81
		Non-electric	4.16	8.62	7.74	11.86
	Double pane	Electric	10.34	2.28	5.32	3.53
		Non-electric	1.34	2.63	5.94	3.90
Office – Small (<40,000 sq ft)	Single pane	Electric	1.75	5.48	3.32	5.40
		Non-electric	1.86	5.70	3.49	5.91
	Double pane	Electric	0.74	2.26	1.33	2.18
		Non-electric	0.75	2.29	1.36	2.29
Office – Large (≥ 40,000 sq ft)	Single pane	Electric	5.44	17.77	15.93	18.02
		Non-electric	2.41	6.22	7.13	8.49
	Double pane	Electric	2.21	7.05	6.45	6.77
		Non-electric	1.07	2.46	2.89	3.21
Other[288]	Single pane	Electric	0.11	2.61	0.03	0.51
		Non-electric	0.11	2.69	0.04	0.58
	Double pane	Electric	0.05	1.14	0.02	0.19
		Non-electric	0.05	1.17	0.03	0.21
Public assembly	Single pane	Electric	0.53	2.69	2.92	1.45
		Non-electric	0.85	2.63	3.27	1.90
	Double pane	Electric	0.26	1.16	1.25	0.84
		Non-electric	0.40	1.13	1.38	1.00
Public order and safety (police and fire station)	Single pane	Electric	0.11	2.61	0.03	0.51
		Non-electric	0.11	2.69	0.04	0.58
	Double pane	Electric	0.05	1.14	0.02	0.19
		Non-electric	0.05	1.17	0.03	0.21
Religious worship	Single pane	Electric	0.53	2.69	2.92	1.45
		Non-electric	0.85	2.63	3.27	1.90
	Double pane	Electric	0.26	1.16	1.25	0.84
		Non-electric	0.40	1.13	1.38	1.00
Service (Beauty, auto repair workshop)	Single pane	Electric	2.88	7.99	5.73	8.84
		Non-electric	3.05	8.60	6.79	9.15
	Double pane	Electric	1.20	3.07	2.64	3.68
		Non-electric	1.27	3.32	3.10	3.84

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Table 17-34. Energy savings factors for reflective window film by facility type and window orientation for Elizabeth City, NC

Facility type[313]	Window type	Heating system type[314]	ESF_{north} (kWh/ft²)	ESF_{east} (kWh/ft²)	ESF_{south}[315] (kWh/ft²)	ESF_{west} (kWh/ft²)
Education – Elementary and middle school	Single pane	Electric	1.97	5.26	7.38	6.86
		Non-electric	2.35	6.78	9.05	11.31
	Double pane	Electric	0.87	1.98	3.24	3.04
		Non-electric	1.00	2.50	4.12	4.64
Education – High school	Single pane	Electric	4.77	9.14	20.46	14.20
		Non-electric	4.50	8.42	12.67	17.47
	Double pane	Electric	2.07	3.27	7.93	5.56
		Non-electric	1.98	3.03	5.78	7.32
Education – College and university	Single pane	Electric	4.77	9.14	20.46	14.20
		Non-electric	4.50	8.42	12.67	17.47
	Double pane	Electric	2.07	3.27	7.93	5.56
		Non-electric	1.98	3.03	5.78	7.32
Food sales - Grocery	Single pane	Electric	3.05	11.06	10.22	8.97
		Non-electric	3.44	11.99	11.43	9.66
	Double pane	Electric	9.07	5.28	3.11	3.56
		Non-electric	1.39	5.72	3.45	3.86
Food sales – Convenience store	Single pane	Electric	3.05	11.06	10.22	8.97
		Non-electric	3.44	11.99	11.43	9.66
	Double pane	Electric	9.07	5.28	3.11	3.56
		Non-electric	1.39	5.72	3.45	3.86
Food Sales – Non-electric station convenience store	Single pane	Electric	3.05	11.06	10.22	8.97
		Non-electric	3.44	11.99	11.43	9.66
	Double pane	Electric	9.07	5.28	3.11	3.56
		Non-electric	1.39	5.72	3.45	3.86
Food service - full service	Single pane	Electric	0.00	7.76	8.92	13.31
		Non-electric	0.00	8.23	10.24	13.96
	Double pane	Electric	0.00	0.00	4.24	6.03
		Non-electric	0.00	3.50	4.77	6.31
Food service - Fast food	Single pane	Electric	0.00	4.70	5.32	7.63
		Non-electric	0.00	5.84	7.52	9.14
	Double pane	Electric	0.00	2.00	2.55	3.35
		Non-electric	0.00	2.50	3.52	4.03
Health care-inpatient	Single pane	Electric	6.84	32.68	14.58	29.43
		Non-electric	4.49	18.27	10.64	17.62
	Double pane	Electric	3.34	13.81	6.87	11.41
		Non-electric	2.10	7.57	4.75	6.71

313 Warehouse and storage building type DEER models do not have windows. Tracking data with this building type will be flagged for on-site verification.

314 Non-electric heating systems were represented by gas heating in building energy models.

315 Negative demand reduction is observed in some building types for south window orientation, implying that installation of window film on the south side of the buildings leads to increased energy use due to increase heating load in the winter season.

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Facility type[313]	Window type	Heating system type[314]	ESF_{north} (kWh/ft²)	ESF_{east} (kWh/ft²)	ESF_{south}[315] (kWh/ft²)	ESF_{west} (kWh/ft²)
Health care-outpatient	Single pane	Electric	1.33	38.81	14.37	23.70
		Non-electric	1.79	29.62	13.78	22.67
	Double pane	Electric	0.65	18.01	6.99	9.61
		Non-electric	0.87	12.69	5.89	9.17
Lodging – (hotel, motel, and dormitory)	Single pane	Electric	4.47	13.85	14.09	12.75
		Non-electric	5.03	15.70	15.59	13.63
	Double pane	Electric	1.87	5.62	6.05	5.13
		Non-electric	2.06	6.11	6.63	5.34
Mercantile (mall)	Single pane	Electric	3.12	7.06	6.21	9.43
		Non-electric	3.25	7.50	7.17	9.76
	Double pane	Electric	1.31	3.58	2.88	3.97
		Non-electric	1.37	3.83	3.28	4.10
Mercantile (retail, not mall)	Single pane	Electric	3.05	11.06	10.22	8.97
		Non-electric	3.44	11.99	11.43	9.66
	Double pane	Electric	9.07	5.28	3.11	3.56
		Non-electric	1.39	5.72	3.45	3.86
Office – Small (<40,000 sq ft)	Single pane	Electric	1.81	5.82	3.27	5.74
		Non-electric	1.88	6.24	3.47	6.26
	Double pane	Electric	0.74	2.37	1.30	2.30
		Non-electric	0.79	2.52	1.38	2.47
Office – Large (≥ 40,000 sq ft)	Single pane	Electric	5.59	17.97	15.44	18.46
		Non-electric	2.37	6.58	7.21	8.91
	Double pane	Electric	2.29	6.93	6.27	6.89
		Non-electric	1.03	2.58	2.92	3.16
Other[288]	Single pane	Electric	0.06	2.83	0.03	0.56
		Non-electric	0.07	2.88	0.04	0.61
	Double pane	Electric	0.02	1.23	0.02	0.21
		Non-electric	0.03	1.25	0.03	0.23
Public assembly	Single pane	Electric	0.73	3.44	3.56	1.75
		Non-electric	0.96	3.03	3.72	2.36
	Double pane	Electric	0.35	1.47	1.55	1.01
		Non-electric	0.43	1.23	1.55	1.11
Public order and safety (police and fire station)	Single pane	Electric	0.06	2.83	0.03	0.56
		Non-electric	0.07	2.88	0.04	0.61
	Double pane	Electric	0.02	1.23	0.02	0.21
		Non-electric	0.03	1.25	0.03	0.23
Religious worship	Single pane	Electric	0.73	3.44	3.56	1.75
		Non-electric	0.96	3.03	3.72	2.36
	Double pane	Electric	0.35	1.47	1.55	1.01
		Non-electric	0.43	1.23	1.55	1.11
Service (beauty, auto repair workshop)	Single pane	Electric	3.12	7.06	6.21	9.43
		Non-electric	3.25	7.50	7.17	9.76
	Double pane	Electric	1.31	3.58	2.88	3.97
		Non-electric	1.37	3.83	3.28	4.10

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17.8.1.1 Update summary

Updates made to this section are described in Table 17-35.

Table 17-35. Summary of update(s)

Version	Update type	Description
2022	None	No Change
2021	New section	Moved ESF tables from the program section to this sub-appendix-

17.9 Sub-Appendix F2-VI: General equations

This section appears in Appendix F1 as Sub-appendix F1-II: General Equations (a.k.a. Section 24.2).

Equation 1: Cooling Capacities – Btu/h to tons

This equation appears in Appendix F1 as Sub-appendix F1-II: General Equations (a.k.a. Section 24.2).

Equation 2: Cooling Capacities – tons to Btu/h

This equation appears in Appendix F1 as Sub-appendix F1-II: General Equations (a.k.a. Section 24.2).

Equation 3: Energy Efficiencies - SEER to EER, for systems < 65,000 Btu/h

This equation appears in Appendix F1 as Sub-appendix F1-II: General Equations (a.k.a. Section 24.2).

Equation 4: Energy Efficiencies - EER to IEER, for systems ≥ 65,000 Btu/h

This equation appears in Appendix F1 as Sub-appendix F1-II: General Equations (a.k.a. Section 24.2).

Equation 5: Energy Efficiencies - HSPF to COP

This equation appears in Appendix F1 as Sub-appendix F1-II: General Equations (a.k.a. Section 24.2).

Equation 6: Energy Efficiencies - COP to HSPF

This equation appears in Appendix F1 as Sub-appendix F1-II: General Equations (a.k.a. Section 24.2).

Equation 7: Energy Efficiencies - COP to EER

This equation appears in Appendix F1 as Sub-appendix F1-II: General Equations (a.k.a. Section 24.2).

Equation 8: Energy Efficiencies – $kW/ton_{full\text{-}load}$ to kW/ton_{IPLV}

This equation appears in Appendix F1 as Sub-appendix F1-II: General Equations (a.k.a. Section 24.2).

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Equation 9: Energy Efficiencies – $EER_{full\text{-}load}$ to EER_{IPLV}

This equation appears in Appendix F1 as Sub-appendix F1-II: General Equations (a.k.a. Section 24.2).

Equation 10: Heat to electric energy – Btu/h to kW

This equation appears in Appendix F1 as Sub-appendix F1-II: General Equations (a.k.a. Section 24.2).