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WHEN TRUST MATTERS

EVALUATION, MEASUREMENT, AND VERIFICATION REPORT

Developed for: Virginia Electric and Power Company (Dominion Energy Virginia/Dominion Energy North Carolina)

Case No. PUR-2022-00210 (Virginia)
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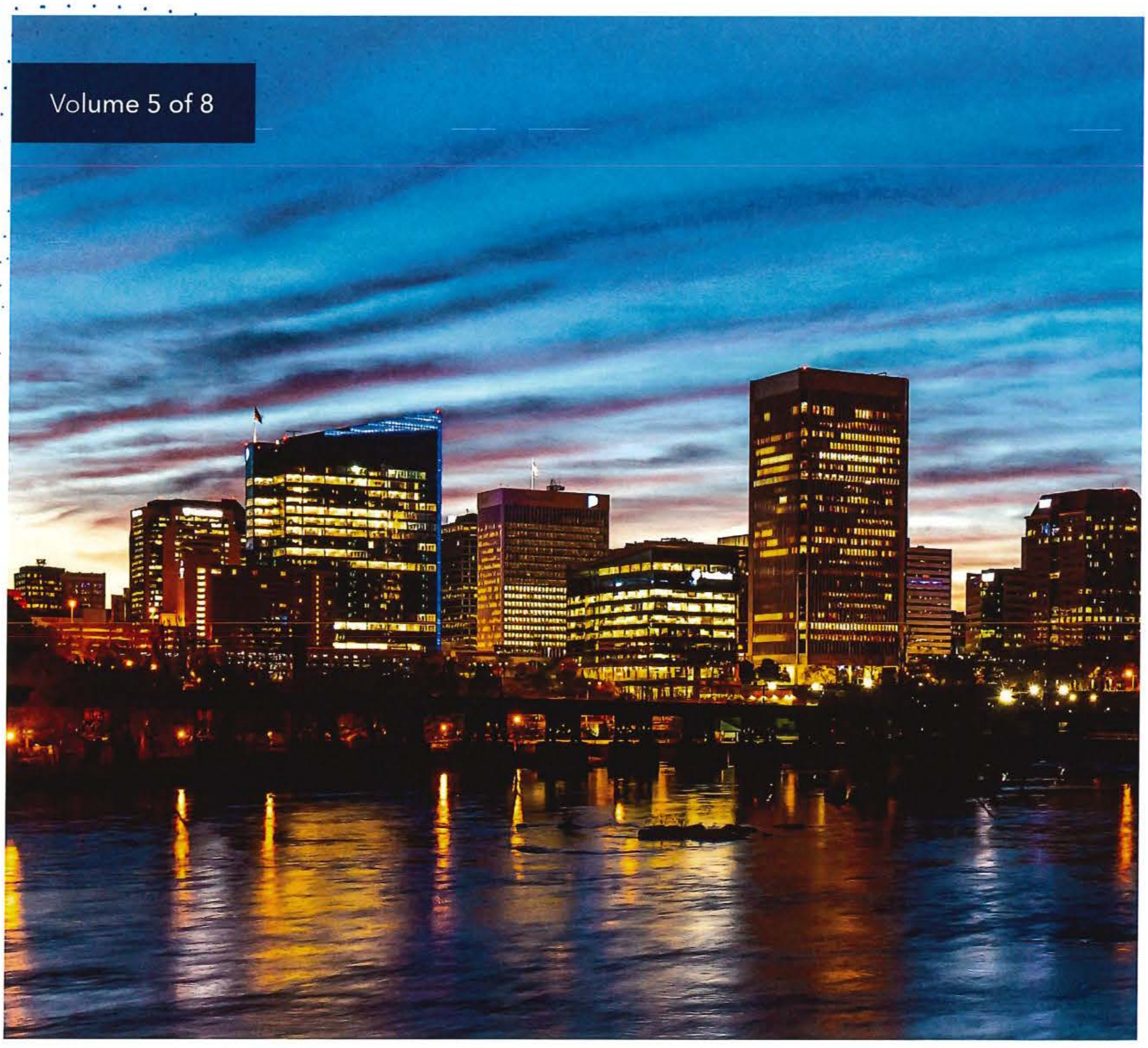
June 12, 2024

Prepared by DNV Energy Insights USA Inc. (DNV)

Volume 5 of 8



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Appendix F2
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 2023

Prepared by DNV Energy Insights USA Inc.

June 12, 2024

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Table of Contents

DNV

DNV

DNV

DNV

DNV

DNV

List of Tables

DNV

DNV

DNV

DNV

DNV

DNV

DNV

DNV

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 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 the existing equipment of code for new construction projects.

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

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Table 1-2. Programs that offer lighting fixtures, lamps, and delamping

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 7.3.1
Non-Residential Multifamily Program, DSM Phase VIII		Section 10.4.1
Non-Residential Agricultural Energy Efficiency Program, DSM Phase IX		Section 12.2.4
Non-Residential Health Care Program, DSM Phase X		Section 17.6.1
Non-Residential Data Center Program, DSM Phase X		Section 18.3.1
Non-Residential Hotel and Lodging Program, DSM Phase X		Section 19.6.1
Non-Residential Lighting Systems and Controls Program Extension, DSM Phase X	Retrofit, replace-on-burnout, exit signs, exterior, and new construction	Section 20.1.1
Non-Residential Income and Age Qualifying Program for Health Care and Rental Property Owners, DSM Phase X	Retrofit, replace-on-burnout, exit signs, and exterior	Section 21.5.1

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:

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

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

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Component	Type	Value	Unit	Source(s)
LPD_{base}	Variable	See Table 1-4 Default = Other building type	watt/sq.ft	2015 Virginia Energy Conservation Code/IECC 2015 Section C405.4.2, Table C405.4.2(1), Maryland/Mid-Atlantic TRM v. 10, p. 229, Non-Residential Lighting End Use Baseline, Gross and Net Impact, and Persistence Study, Appendix K, Dominion Energy, May 23, 2023, p. 23[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 22-17 in Sub-Appendix F2-V: Non-residential lighting factors: annual equivalent hours, coincidence factors, and waste heat factors 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 Data Center Program, DSM Phase X use Table 22-17 in Sub-Appendix F2-V: Non-residential lighting factors: annual equivalent hours, coincidence factors, and waste heat factors and the lighting type LED tube lighting – data center For the Non-Residential Agricultural Energy Efficiency Program, DSM Phase IX and other programs have the location of "Interior light except exit light" see Table 22-18 in Sub-Appendix F2-V: Non-residential lighting factors: annual equivalent hours,	-	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 and Non-Residential Lighting End Use Baseline, Gross and Net Impact, and Persistence Study, Appendix K, Dominion Energy, May 23, 2023, p. 5
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

1 The baseline for new construction is the industry standard practice LPD. This study found that the industry standard practice is 24% better than code. If the LPDee is higher than the LPD_{base} no savings are realized relative to the industry standard practice.

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.

Component	Type	Value	Unit	Source(s)
		coincidence factors, and waste heat factors.		
ISR	Fixed	1.00	-	Maryland/Mid-Atlantic TRM v.10, p. 2184

The following table provides the coded-based LPD by space type, and how those were adjusted to arrive at the baseline LPD to be used for non-residential new construction interior lighting projects.

Table 1-4 Interior lighting power allowances

Customer building type	Code LPD[5]	LPD_{base}[6]
Education – Elementary and middle school	0.87	0.66
Education – High school	0.87	0.66
Education – College and university	0.87	0.66
Food Sales – Grocery	1.26	0.96
Food Sales – Convenience store	1.26	0.96
Food Sales – Gas station convenience store	1.26	0.96
Food Service – Full service	1.01	0.77
Food Service – Fast food	0.90	0.68
Health Care – Inpatient	1.05	0.80
Health Care – Outpatient	0.90	0.68
Lodging – (Hotel, motel, and dormitory)	0.87	0.66
Mercantile (Mall)	1.26	0.96
Mercantile (Retail, not mall)	1.26	0.96
Office – Small (<40,000 sq ft)	0.82	0.62
Office – Large (≥ 40,000 sq ft)	0.82	0.62
Other	1.17	0.89
Public assembly	1.01	0.77
Public order and safety (police and fire station)	0.87	0.66
Religious worship	1.00	0.76
Service – (beauty, auto repair workshop)	1.19	0.90
Warehouse and storage	0.66	0.50

[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).

[6] Based on DNV's Non-Residential Lighting Baseline study results, issued in the Non-Residential Lighting End Use Baseline, Gross and Net Impact, and Persistence Study, Appendix K, Dominion Energy, May 23, 2023, p. 23. SCC Case No. PUR-2021-00247. The baseline for new construction is the industry standard practice LPD. This study found that the industry standard practice is 24% better than code. If the LPDee is higher than the LPDbase no savings are realized relative to the industry standard practice.

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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

<table>
<tr><th>DSM Phase</th><th>Program name</th><th>Value</th><th>Units</th><th>Source(s)</th></tr>
<tr><td rowspan="6">X</td><td>Non-Residential Income and Age Qualifying Program for Health Care and Rental Property Owners, DSM Phase X</td><td rowspan="5">10.10</td><td rowspan="9">years</td><td rowspan="5">Dominion Energy Non-Residential Lighting End-Use Baseline, Gross and Net Impact, and Persistence Study, DNV, 2023</td></tr>
<tr><td>Non-Residential Lighting Systems and Controls Program Extension, DSM Phase X</td></tr>
<tr><td>Non-Residential Hotel and Lodging Program, DSM Phase X</td></tr>
<tr><td>Non-Residential Data Center Program, DSM Phase X</td></tr>
<tr><td>Non-Residential Health Care Program, DSM Phase X</td></tr>
<tr><td>Non-Residential Agricultural Energy Efficiency Program, DSM Phase IX</td><td>10.65</td><td>Maryland/Mid-Atlantic TRM v.10, p. 219 and Wisconsin TRM 2022, p. 495[7]</td></tr>
<tr><td rowspan="2">VIII</td><td>Non-Residential Multifamily Program, DSM Phase VIII</td><td>8.40</td><td>Maryland/Mid-Atlantic TRM v.10, p. 219[8]</td></tr>
<tr><td>Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII</td><td rowspan="2">10.10</td><td rowspan="2">Dominion Energy Non-Residential Lighting End-Use Baseline, Gross and Net Impact, and Persistence Study, DNV, 2023</td></tr>
<tr><td>VII</td><td>Non-Residential Lighting Systems and Controls Program, DSM Phase VII</td></tr>
</table>

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 2018 Section C405.4.2. For some building types and the new construction industry standard practice, the Dominion Energy Non-Residential Lighting End-Use Baseline, Gross and Net Impact, and Persistence Study, 2023, is used.

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

8 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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1.1.1.7 Program design baseline

The program design baseline assumptions are shown in Table 1-6. These assumptions do not necessarily align with the assumptions used in the impact calculation in this TRM.

Table 1-6. Program design baseline assumptions

DSM Phase	Program name	Baseline description	Baseline type	Source(s)
X	Non-Residential Health Care Program, DSM Phase X	The previously installed lamp	Existing condition	Non-Residential STEP Manual v10, p. 17
	Non-Residential Data Center Program, DSM Phase X	Florescent light source	Retrofit: Existing condition Time of sale/New construction: Varies depending upon the specific characteristics of the fixtures installed, federal minimum standards, and applicable building energy codes	Maryland/Mid-Atlantic TRM v.10, p. 250
	Non-Residential Hotel and Lodging Program, DSM Phase X	The previously installed lamp	Existing condition	Non-Residential STEP Manual v10, p. 17
	Non-Residential Lighting Systems and Controls Program Extension, DSM Phase X	Retrofit: Existing lighting fixture Time of sale/New construction: Varies depending upon the specific characteristics of the fixtures installed, federal minimum standards, and applicable building energy codes	Retrofit: Existing condition Time of sale/New construction: Varies depending upon the specific characteristics of the fixtures installed, federal minimum standards, and applicable building energy codes	Mid-Atlantic TRM v5.0, p. 278
	Non-Residential Income and Age Qualifying Program for Health Care and Rental Property Owners, DSM Phase X	Incandescent lamp	Existing condition	Maryland/Mid-Atlantic TRM v.10, p. 250

1.1.1.8 Update summary

Updates made to this section are described in Table 1-7.

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Table 1-7. Summary of update(s)

Version	Update type	Description
2023	New subsection	Program design baseline assumptions
	Input table	• Updated HOU for some locations based on Non-Residential Lighting End-Use Baseline, Gross and Net Impact, and Persistence Study, DNV, 2023 • Updated new construction baseline LPD from code to industry standard practice.
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 1-8 and uses the impacts estimation approach described in this section.

Table 1-8. Programs that offer occupancy sensors and daylight controls

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 7.3.2
Non-Residential Multifamily Program, DSM Phase VIII	Section 10.4.2
Non-Residential Health Care Program, DSM Phase X	Section 17.6.2
Non-Residential Data Center Program, DSM Phase X	Section 18.3.2
Non-Residential Hotel and Lodging Program, DSM Phase X	Section 19.6.4
Non-Residential Lighting Systems and Controls Program Extension, DSM Phase X	Section 20.1.2

1.1.2.2 Impacts estimation approach

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

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

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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 1-9. Input values for occupancy sensors and controls savings calculations

Component	Type	Value	Unit	Source(s)
$watts_{connected}$	Variable	See customer application	watt	Customer application
HOU	Variable	For the For the Non-Residential Data Center Program, DSM Phase X use Table 22-17 in Sub-Appendix F2-V: Non-residential lighting factors: annual equivalent hours, coincidence factors, and waste heat factors and the lighting type LED tube lighting – data center For other programs see Table 22-18 in Sub-Appendix F2-V: Non-	hours/year	Maryland/Mid-Atlantic TRM v.10, pp. 215, 242, 254, 272, and 415-416 and Non-Residential Lighting End Use Baseline, Gross and Net Impact, and Persistence Study, Appendix K, Dominion Energy, May 23, 2023, p. 5

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Component	Type	Value	Unit	Source(s)
		residential lighting factors: annual equivalent hours, coincidence factors, and waste heat factors		
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	For the For the Non-Residential Data Center Program, DSM Phase X use Table 22-17 in Sub-Appendix F2-V: Non-residential lighting factors: annual equivalent hours, coincidence factors, and waste heat factors and the lighting type LED tube lighting – data center For other programs see Table 22-18 in Sub-Appendix F2-V: Non-residential lighting factors: annual equivalent hours, coincidence factors, and waste heat factors	-	Maryland/Mid-Atlantic TRM v.10, p. 223
CF_{winter}	Variable		-	Maryland/Mid-Atlantic TRM v.10, p. 223
WHF_e	Variable	See Table 22-18 in in Sub-Appendix F2-V: Non-residential lighting factors: annual equivalent hours, coincidence factors, and waste heat factors	-	Maryland/Mid-Atlantic TRM v.10, pp. 419-421
		Default: 0.94		Assumes "Small Office" building type
$WHF_{d,summer}$	Variable	See Table 22-18 in in Sub-Appendix F2-V: Non-residential lighting factors: annual equivalent hours, coincidence factors, and waste heat factors	-	Maryland/Mid-Atlantic TRM v.10, pp. 419-421
		Default: 1.35		Assumes "Other" building type
$WHF_{d,winter}$	Variable	See Table 22-18 in in Sub-Appendix F2-V: Non-residential lighting factors: annual equivalent hours, coincidence factors, and waste heat factors	-	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

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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 1-10.

Table 1-10. Effective useful life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
X	Non-Residential Lighting Systems and Controls Program Extension, DSM Phase X	10.10	years	Dominion Energy Non-Residential Lighting End-Use Baseline, Gross and Net Impact, and Persistence Study, DNV, 2023
	Non-Residential Hotel and Lodging Program, DSM Phase X			
	Non-Residential Data Center Program, DSM Phase X			
	Non-Residential Health Care Program, DSM Phase X			
VIII	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII			
	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 Program design baseline

The program design baseline assumptions are shown in Table 1-11. These assumptions do not necessarily align with the assumptions used in the impact calculation in this TRM.

Table 1-11. Program design baseline assumptions

DSM Phase	Program name	Baseline description	Baseline type	Source(s)
X	Non-Residential Health Care Program, DSM Phase X	Lighting without controls	Existing condition	Non-Residential STEP Manual v.10, p. 9
	Non-Residential Data Center Program, DSM Phase X	Lighting without controls	Existing condition	Maryland/Mid-Atlantic TRM v.10, p. 222
	Non-Residential Hotel and Lodging Program, DSM Phase X	Lighting without controls	Existing condition	Non-Residential STEP Manual v.10, p. 9

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DSM Phase	Program name	Baseline description	Baseline type	Source(s)
	Non-Residential Lighting Systems and Controls Program Extension, DSM Phase X	Lighting without controls	Existing condition	Mid-Atlantic TRM v.5.0, p. 300

1.1.2.8 Update summary

Updates made to this section are described in Table 1-12.

Table 1-12. Summary of update(s)

Version	Update type	Description
2023	New subsection	Program design baseline assumptions
	Inputs	Updated HOU for some locations based on the Non-Residential Lighting End-Use Baseline, Gross and Net Impact, and Persistence Study, DNV, 2023
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
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.

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.

This measure is offered through different programs listed in Table 1-13 and uses the impacts estimation approach described in this section.

Table 1-13. Programs that offer occupancy sensors and controls– stairwell integrated and bi-level lighting

Program name	Section
Non-Residential Lighting Systems and Controls Program, DSM Phase VII	Section 1.1.3
Non-Residential Health Care Program, DSM Phase X	Section 17.6.2

DNV

Program name	Section
Non-Residential Hotel and Lodging Program, DSM Phase X	Section 19.6.3
Non-Residential Lighting Systems and Controls Program Extension, DSM Phase X	Section 20.1.3

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
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

DNV

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 1-14. Input values for occupancy sensors and controls-stairwell integrated 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
$watts_{ee,low}$	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[9]

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 1-15.

Table 1-15. Effective useful life for lifecycle savings calculations

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

1.1.3.6 Source(s)

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

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

DNV

1.1.3.7 Program design baseline

The program design baseline assumptions are shown in Table 1-16. These assumptions do not necessarily align with the assumptions used in the impact calculation in this TRM.

Table 1-16. Program design baseline assumptions

DSM Phase	Program name	Baseline description	Baseline type	Source(s)
X	Non-Residential Health Care Program, DSM Phase X	Lighting without bi-level controls	Existing condition	NY TRM v.9, p. 832
	Non-Residential Hotel and Lodging Program, DSM Phase X			
	Non-Residential Lighting Systems and Controls Program Extension, DSM Phase X	Lighting that is controlled with a manual switch	Existing condition	Mid-Atlantic TRM v.7, p. 283

1.1.3.8 Update summary

Updates made to this section are described in Table 1-17.

Table 1-17. Summary of update(s)

Version	Update type	Description
2023	New subsection	Program design baseline assumptions
	Inputs	Updated HOU for some locations based on the Non-Residential Lighting End-Use Baseline, Gross and Net Impact, and Persistence Study, DNV, 2023
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

DNV

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.

This measure is offered through different programs listed in Table 1-18 and uses the impacts estimation approach described in this section.

Table 1-18. Programs that offer reach-in unit occupancy sensor

Program name	Section
Non-Residential Lighting Systems and Controls Program, DSM Phase VII	Section 1.1.2
Non-Residential Lighting Systems and Controls Program Extension, DSM Phase X	Section 20.1.4

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:

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

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

DNV

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 1-19. 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 4010, p. 173
ESF_d	Fixed	0.14	-	Maryland/Mid-Atlantic TRM v.10, p. 223
HOU	Variable	See Table 22-18 in	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 222
ISR	Fixed	1.00	-	Maryland/Mid-Atlantic TRM v.10, p. 222
WHFe[11]	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
$WHF_{d, summer}$[11]	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
$WHF_{d, winter}$[11]	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[12]
CF_{summer}	Fixed	0.96	-	Maryland/Mid-Atlantic TRM v.10, p. 270[13]

[10] 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.

[11] Low temp and medium temp categories are used for freezers and the high temperature category is used for refrigerated cases

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

[13] 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."

DNV

Component	Type	Value	Unit	Source(s)
CF_{winter}	Fixed	0.96	-	Maryland/Mid-Atlantic TRM v.10, p. 270[14]

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:

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

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

$$= 0.007\ kW$$

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

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

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

$$= 0.007\ kW$$

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

1.1.4.5 Effective useful life

The effective useful life of this measure is provided in Table 1-20.

Table 1-20. Effective useful life for lifecycle savings calculations

<table>
<tr><th>DSM Phase</th><th>Program name</th><th>Value</th><th>Units</th><th>Source(s)</th></tr>
<tr><td>X</td><td>Non-Residential Lighting Systems and Controls Program Extension, DSM Phase X</td><td rowspan="2">10.10</td><td rowspan="2">years</td><td rowspan="2">Dominion Energy Non-Residential Lighting End-Use Baseline, Gross and Net Impact, and Persistence Study, DNV, 2023</td></tr>
<tr><td>VII</td><td>Non-Residential Lighting Systems and Controls Program, DSM Phase VII</td></tr>
</table>

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 Program design baseline

The program design baseline assumptions are shown in Table 1-21. These assumptions do not necessarily align with the assumptions used in the impact calculation in this TRM.

Table 1-21. Program design baseline assumptions

DSM Phase	Program name	Baseline description	Baseline type	Source(s)
X	Non-Residential Lighting Systems and Controls Program Extension, DSM Phase X	Lighting without controls	Existing condition	Mid-Atlantic TRM v.7, p. 283 and p.331

1.1.4.8 Update summary

Updates made to this section are described in Table 1-22.

Table 1-22. Summary of update(s)

<table>
<tr><th>Version</th><th>Update type</th><th>Description</th></tr>
<tr><td rowspan="2">2023</td><td>New subsection</td><td>Program design baseline assumption</td></tr>
<tr><td>Inputs</td><td>Updated HOU for some locations based on the Non-Residential Lighting End-Use Baseline, Gross and Net Impact, and Persistence Study, DNV, 2023</td></tr>
<tr><td>2022</td><td>EUL</td><td>Revised EUL</td></tr>
<tr><td rowspan="3">2021</td><td>Source</td><td>Updated page numbers / version of the Maryland/Mid-Atlantic TRM v.10</td></tr>
<tr><td>New table</td><td>Effective useful life (EUL) by program</td></tr>
<tr><td>Equation</td><td>Added gross winter peak demand reduction equation</td></tr>
<tr><td>2020</td><td>None</td><td>No change</td></tr>
</table>

Version	Update type	Description
v10	-	Initial release

DNV

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

End use	Measure	Manual section
Heating, ventilation, air-conditioning (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 HVAC 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 22-11 and Table 22-12 in Sub-Appendix F2-IV: 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 unitary/split air conditioning (ac) & heat pump (hp) systems HVAC upgrade

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 7.2.4
Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII	Section 8.2.1
Non-Residential Multifamily Program, DSM Phase VIII	Section 10.3.1
Non-Residential Health Care Program, DSM Phase X	Section 17.5.11
Non-Residential Hotel and Lodging Program, DSM Phase X	Section 19.5.12

DNV

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:

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

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

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

DNV

The per-measure, gross coincident summer peak demand reduction is calculated according to the following equation[15]:

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

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

[15] If the EER_{base} is greater than EER_{ee}, the peak demand reduction is set to zero.

DNV

CF_{winter} = winter coincidence factor

For ground-source heat pumps, the baseline efficiency is assumed to be that of an air-source heat pump.[16] See Equation 1 and Equation 2 in Sub-Appendix F2-IX: 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-IX: 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 HVAC equipment upgrade savings calculations

Component	Type	Value	Units	Source(s)
$Size_{cool}$	Variable	See customer application	Btu/h	Customer application
$Size_{heat}$	Variable	See customer application[17] Default = $Size_{cool}$	Btu/h	Customer application
$EFLH_{heat}$	Variable	See Table 22-8 in Sub-Appendix F2-V: Non-residential lighting factors: annual equivalent hours, coincidence factors, and waste heat factors	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 423
$EFLH_{cool}$	Variable	See Table 22-7 in Sub-Appendix F2-V: Non-residential lighting factors: annual equivalent hours, coincidence factors, and waste heat factors	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 422
HSPF/SEER/ IEER/EER/ COP_{base}	Variable	See Table 22-11 and Table 22-12 in Sub-Appendix F2-IV: Non-residential HVAC . If required efficiency value is not available, refer to Sub-Appendix F2-IX: 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-IX: 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	-	Maryland/Mid-Atlantic TRM v.10, p. 291

[16] Although ASHRAE values reflect the Building Code minimum, savings are calculated using the efficiencies provided in Sub-Appendix F2-IV: 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.)

[17] When customer-provided heating system size is <60% or >165% 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.

DNV

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		
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. 291[18]

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)
X	Non-Residential Hotel and Lodging Program, DSM Phase X	15.00	years	Maryland/Mid-Atlantic TRM v.10, p. 291
X	Non-Residential Health Care Program, DSM Phase X	15.00	years	Maryland/Mid-Atlantic TRM v.10, p. 291
VIII	Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII	15.00	years	Maryland/Mid-Atlantic TRM v.10, p. 291
VIII	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	15.00	years	Maryland/Mid-Atlantic TRM v.10, p. 291
VIII	Non-Residential Multifamily Program, DSM Phase VIII	15.00	years	Maryland/Mid-Atlantic TRM v.10, p. 291
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.

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

2.1.1.7 Program design baseline

The program design baseline assumptions are shown in Table 2-5. These assumptions do not necessarily align with the assumptions used in the impact calculation in this TRM.

Table 2-5. Program design baseline assumptions

DSM Phase	Program name	Baseline description	Baseline type	Source(s)
X	Non-Residential Health Care Program, DSM Phase X	HVAC system meeting ASHRAE 90.1 2013 efficiency standards	Codes and Standards	Non-Residential STEP Manual v10, p. 32
	Non-Residential Hotel and Lodging Program, DSM Phase X			

2.1.1.8 Update summary

Updates made to this section are described in Table 2-6.

Table 2-6. Summary of update(s)

Version	Update type	Description
2023	Input variable	Updated EFLH with TMYx weather data
	Equation	Corrected equation for kWh_{heat} equation ≥65,000 Btu/h, missing W/Btu conversion
	New subsection	Program design baseline assumptions
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
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

DNV

efficiencies refer to Table 22-13 in Sub-Appendix F2-IV: 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 2-7 and uses the impacts estimation approach described in this section.

Table 2-7. Programs that offer variable refrigerant flow systems and mini-split systems

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 8.2.2
Non-Residential Health Care Program, DSM Phase X	Section 17.5.12
Non-Residential Hotel and Lodging Program, DSM Phase X	Section 19.5.14

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:

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

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:

DNV

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

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[19]:

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

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 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

[19] If the EER_{base} is greater than EER_{ee}, the peak demand reduction is set to zero.

DNV

$HSPF_{ee}$	= 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-IX: 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 2-8. Input values for VRF systems and mini-split systems savings calculations

Component	Type	Value	Units	Source(s)
$Size_{cool}$	Variable	See customer application	Btu/h	Customer application
$Size_{heat}$	Variable	See customer application[20] Default = $Size_{cool}$	Btu/h	Customer application
$EFLH_{heat}$	Variable	See Table 22-8 in Sub-Appendix F2-V: Non-residential lighting factors: annual equivalent hours, coincidence factors, and waste heat factors	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 423
$EFLH_{cool}$	Variable	See Table 22-7 in Sub-Appendix F2-V: Non-residential lighting factors: annual equivalent hours, coincidence factors, and waste heat factors	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 422
HSPF/SEER/ EER/COP/ $IEER_{base}$	Variable	See Table 22-13 in Sub-Appendix F2-IV: Non-residential HVAC If required efficiency value is not available, refer to Sub-Appendix F2-IX: 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[21] If required efficiency value is not available, refer to Sub-Appendix F2-IX: 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

[20] When customer-provided heating system size is <60% or >165% 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.

[21] When missing an efficiency value, use the general equations to convert in Sub-Appendix F2-IX: General equations to convert to the appropriate value. If the heating COP is needed for heat pumps and the provided value equals the EER, assume an incorrect value was provided and convert EER to COP as an approximation

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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[22]

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 2-9.

Table 2-9. Effective useful life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
X	Non-Residential Hotel and Lodging Program, DSM Phase X	18.00	years	Maryland/Mid-Atlantic TRM v.10, p. 295
	Non-Residential Health Care Program, DSM Phase X			
VIII	Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII			
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 Program design baseline

The program design baseline assumptions are shown in Table 2-10. These assumptions do not necessarily align with the assumptions used in the impact calculation in this TRM.

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

Table 2-10. Program design baseline assumptions

DSM Phase	Program name	Baseline description	Baseline type	Source(s)
X	Non-Residential Health Care Program, DSM Phase X	HVAC system meeting ASHRAE 90.1 2013 efficiency standards	Codes and Standards	Non-Residential STEP Manual v.10, p. 32
	Non-Residential Hotel and Lodging Program, DSM Phase X			

2.1.2.8 Update summary

Updates made to this section are described in Table 2-11.

Table 2-11. Summary of update(s)

Version	Update type	Description
2023	Input Variable	Updated EFLH with TMYx weather data
	New subsection	Program design baseline assumptions
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
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 22-14 of Sub-Appendix F2-IV: Non-residential HVAC for the 2016 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 2-12 and uses the impacts estimation approach described in this section.

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Table 2-12. Programs that offer electric chillers

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 8.2.3
Non-Residential Health Care Program, DSM Phase X	Section 17.5.4
Non-Residential Hotel and Lodging Program, DSM Phase X	Section 19.5.4

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:

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

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
$EER_{base,IPLV}$,	= baseline chiller efficiency at integrated part load value (IPLV)
$kW/ton_{base,IPLV}$	= baseline chiller efficiency at integrated part load value (IPLV)
$EERe_{e,IPLV}$,	= efficient chiller efficiency at integrated part load value (IPLV)
$kW/ton_{ee,IPLV}$	= efficient chiller baseline efficiency at integrated part load value (IPLV)

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$EFLH_{cool}$	= equivalent full load hours of cooling
$EER_{base,full\ load}$	= baseline chiller efficiency at full load
$kW/ton_{base,full\ load}$	= baseline chiller efficiency at full load
$EER_{ee,full\ load}$	= efficient chiller efficiency at full load
$kW/ton_{ee,full\ load}$	= efficient chiller baseline 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 2-13. Input values for electric chillers savings calculations

Component	Type	Value	Unit	Source(s)
$Size_{ee}$	Variable	See customer application	ton, cooling capacity	Customer application
$kW/ton_{base,full\text{-}load}$	Variable	See Table 22-14 of Sub-Appendix F2-IV: Non-residential HVAC	kW/ton	ASHRAE 90.1 2013, Table 6.8.1-3
$kW/ton_{base,IPLV}$	Variable	See Table 22-14 of Sub-Appendix F2-IV: Non-residential HVAC	kW/ton	ASHRAE 90.1 2013, Table 6.8.1-3
$kW/ton_{ee,full\text{-}load}$	Variable	See customer application[23]	kW/ton	Customer application
$kW/ton_{ee,IPLV}$	Variable	See customer application[24]	kW/ton	Customer application
$EER_{base,\ full\ load}$	Variable	See customer application[25]	kBtu/kW	Customer Application
		Default: See Table 22-14 of Sub-Appendix F2-IV: Non-residential HVAC		ASHRAE 90.1-2013, Table 6.8.1-3
$EER_{base,\ IPLV}$	Variable	See customer application[26]	kBtu/kW	Customer Application
		Default: See Table 22-14 Sub-Appendix F2-IV: Non-residential HVAC		ASHRAE 90.1-2013, Table 6.8.1-3
$EER_{ee,\ full\ load}$	Variable	See customer application[27]	kBtu/kW	Customer application
$EER_{ee,\ IPLV}$	Variable	See customer application[28]	kBtu/kW	Customer application
$EFLH_{cool}$	Variable	See Table 22-7 in Sub-Appendix F2-V: Non-residential lighting factors: annual equivalent hours, coincidence factors, and waste heat factors	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

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

24 Ibid

25 Ibid

26 Ibid

27 Ibid

28 Ibid

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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 22-14 of Sub-Appendix F2-IV: Non-residential HVAC , the water chilling efficiency requirement from ASHRAE 90.1-2016, 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 2-14.

Table 2-14. Effective useful life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
X	Non-Residential Hotel and Lodging Program, DSM Phase X	23.00	years	Maryland/Mid-Atlantic v.10, p. 304
	Non-Residential Health Care Program, DSM Phase X			
VIII	Non-Residential Midstream Energy Efficiency Products 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)

2.1.3.6 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 90.1-2016, Table 6.8.1-3 - Water Chilling Packages - Efficiency Requirements.

2.1.3.7 Program design baseline

The program design baseline assumptions are shown in Table 2-15. These assumptions do not necessarily align with the assumptions used in the impact calculation in this TRM.

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Table 2-15. Program design baseline assumptions

DSM Phase	Program name	Baseline description	Baseline type	Source(s)
X	Non-Residential Health Care Program, DSM Phase X	Electric chiller meeting ASHRAE 90.1 2013 efficiency standards	Codes and Standards	Non-Residential STEP Manual v.10, p. 32
	Non-Residential Hotel and Lodging Program, DSM Phase X			

2.1.3.8 Update summary

Updates made to this section are described in Table 2-16.

Table 2-16. Summary of update(s)

Version	Update type	Description
2023	New subsection	Program design baseline assumptions
	Input variable	Updated EFLH with TMYx weather data
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

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Forward Curved (FC) Fan

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

Unknown (Default)

HVAC Pumps

Chilled Water Pump (CHW Pump)

Condenser Water Pump (CW Pump)

Hot Water Pump (HW Pump)

Unknown (Default)

This measure is offered through various programs that utilize different methodologies. The Non-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 7.2.7.

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:

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

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

HVAC Fans:

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

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 2-17. Input values for variable frequency drives savings calculations

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 2-18. Baseline motor efficiency		NEMA Standards Publication Condensed MG 1-2007
FF	Fixed	0.524 per Table 2-19	-	Maryland/Mid-Atlantic TRM v.10, p. 297
PLR_{base}	Variable	See customer application	-	Customer application

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Component	Type	Value	Unit	Source(s)
		Default = 0.53 per Table 2-21. forward-curved fan with outlet dampers at FF=0.524		Maryland/Mid-Atlantic TRM v.10, p. 298
$PLR_{base, peak}$	Fixed	1.00	-	DNV engineering judgement
PLR_{ee}	Variable	See customer application	-	Customer application
		Default: 0.30[29] per Table 2-21. 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 2-22	-	Maryland/Mid-Atlantic TRM v.10, p. 301
DSF	Variable	See Table 2-22	-	Maryland/Mid-Atlantic TRM v.10, p. 301
HOU	Variable	See Table 22-9 in Sub-Appendix F2-V: Non-residential lighting factors: annual equivalent hours, coincidence factors, and waste heat factors	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[30]

Table 2-18 provides the baseline motor efficiencies that are consistent with the minimum federal accepted motor efficiencies provided by the National Electrical Manufacturers Association (NEMA).[31]

Table 2-18. Baseline motor efficiency[32]

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

29 Corresponds to the approximate PLR for 'VFD with Duct Static Pressure Controls' from Table 2-20. at the average FF of 52.4% from Table 2-19.

30 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.

31 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.

32 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).

Horsepower (hp)	η		Horsepower (hp)	η
40	0.941		**500**	0.962
50	0.945			

Table 2-19 provides the assumed proportion of time that fans operate within ten ranges of airflow rates, relative to the design airflow rate (cfm).

Table 2-19. 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 2-20. provides the part-load ratios (PLRs) that vary with fan control types and air flow range.

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Table 2-20. 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 2-21 displays the average part-load ratios calculated using the flow fractions from Table 2-19, and the part-load values across flow ranges from Table 2-20.

Table 2-21. 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 2-22. Energy and demand savings factors by application

VFD Applications[33]	ESF	DSF
Chilled Water Pump	0.633	0.460
Hot Water Pump	0.652	0.000
Unknown/Other Pump (Average)[34]	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 2-23.

Table 2-23. 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)

[33] Mid-Atlantic TRM 2020, p. 301.
[34] Assigned for pumps not specifically in this table, such as condenser water pump.

DNV

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 2-24.

Table 2-24. Summary of update(s)

Version	Update type	Description
2023	None	No change
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 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 2-25 and uses the impacts estimation approach described in this section.

Table 2-25. Programs that offer dual enthalpy air-side economizers

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 6.3.7
Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 7.2.5

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Program name	Section
Non-Residential Health Care Program, DSM Phase X	Section 17.5.2
Non-Residential Hotel and Lodging Program, DSM Phase X	Section 19.5.2

2.1.5.2 Impacts estimation approach

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

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

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.[35] Hence,

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

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 2-26. 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 2-27	kWh/ton	Maryland/Mid-Atlantic TRM v.10, p. 314

35 Maryland/Mid-Atlantic TRM v.10, p. 313.

Table 2-27. Economizer energy savings factors by building type[36]

Building type	Energy savings factors (kWh/ton)										
	Baltimore, MD	Richmond, VA	Norfolk, VA	Roanoke, VA	Sterling, VA	Arlington, VA	Charlottes-ville, VA	Farmville, VA	Fredericks burg, VA	Elizabeth City, NC	Rocky Mount, NC
Education:[37] college and university, high school, elementary and middle school	39	55	61	42	42	56	43	46	48	59	53
Food sales:[38] grocery,[39] convenience store, gas station convenience store	57	80	90	61	61	82	63	68	70	86	77
Food service:[40] full service	29	41	46	31	31	42	32	35	36	44	39
Food service -fast food[41]	37	52	58	40	40	53	41	44	46	56	50
Mercantile (retail, not mall)[42]	57	80	90	61	61	82	63	68	70	86	77
Mercantile (mall)	57	80	90	61	61	82	63	68	70	86	77
Office: Small (<40,000 sq.	57	80	90	61	61	82	63	68	70	86	77

[36] 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 TMYx data.

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

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

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

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

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

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

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
ft.)[43] and Large (≥ 40,000 sq. ft.)											
Public assembly	25	35	39	27	27	36	28	30	31	38	34
Religious worship	6	8	9	6	6	9	7	7	7	9	8
Other[44]: lodging (hotel, motel and dormitory), health care (outpatient, inpatient) public order and safety (police and fire station)	57	80	90	61	61	82	63	68	70	86	77
Service (beauty, auto repair workshop)	57	80	90	61	61	82	63	68	70	86	77
Warehouse and storage	2	3	3	2	2	3	2	2	2	3	3

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

44 Other, lodging – (hotel, motel and dormitory), health care-outpatient, healthcare-inpatient, public order and safety (police and fire station) building types are 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 2-28.

Table 2-28. Effective useful life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
X	Non-Residential Hotel and Lodging Program, DSM Phase X	10.00	years	Mid-Atlantic TRM v.10, p. 313
	Non-Residential Health Care Program, DSM Phase X			
IX	Non-Residential Building Optimization Program, DSM Phase IX			
VIII	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII			
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)
	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 Program design baseline

The program design baseline assumptions are shown in Table 2-29. These assumptions do not necessarily align with the assumptions used in the impact calculation in this TRM.

Table 2-29. Program design baseline assumptions

DSM Phase	Program name	Baseline description	Baseline type	Source(s)
X	Non-Residential Health Care Program, DSM Phase X	HVAC system with no economizer	Existing condition	Mid-Atlantic TRM v.9, p. 451
	Non-Residential Hotel and Lodging Program, DSM Phase X			

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2.1.5.8 Update summary

Updates made to this section are described in Table 2-30.

Table 2-30. Summary of update(s)

Version	Update type	Description
2023	New subsection	Program design baseline assumptions
	Input variable	Updated the Energy Savings Factors (ESF)s with TMYx weather data
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

DNV

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.[45]

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. The Non-Residential Income and Age Qualifying Program for Health Care and Rental Property Owners, DSM Phase X window film measure leverages the methodology in Appendix F1 Residential TRM Section 22.2.2, which includes multifamily buildings.

Table 3-1. Programs that offer window film

Program name	Manual section
Non-Residential Window Film Program, DSM Phase VII	Section 3.1.1
Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 7.1.1
Non-Residential Health Care Program, DSM Phase X	Section 17.2.1
Non-Residential Hotel and Lodging Program, DSM Phase X	Section 19.2.1
Non-Residential Income and Age Qualifying Program for Health Care and Rental Property Owners, DSM Phase X	Section 21.2.4

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.

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

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 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
Strip mall	22,500	1	Packaged AC w/ gas furnace	Packaged HP	Original model has only east-facing windows. Models were rotated to

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Building type	Total floor area (sq. ft.)	No. Floors	Gas heating HVAC system	Electric heating HVAC system	Note
					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 (TMYx) data—and modification of a few key window parameters.[46] 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 modeling parameters

Window variable	Window type	Baseline value	Source(s) [47]	Efficient value	Source(s)[47]
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 in Table 22-30 through Table 22-39 in the Sub-Appendix F2-VIII: Non-residential window film energy saving factors. Savings factors differ based on the number of panes within 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

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

[47] Building vintage ranges defined in DEER, http://www.deeresources.com

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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 window film savings calculations

Component	Type	Value	Unit	Source(s)
$SqFt_{orientation}$	Variable	See customer application	sq.ft.	Customer application
$ESF_{orientation}$	Variable	See Table 22-30 to Table 22-39 in Sub-Appendix F2-VIII: Non-residential window film energy saving factors 22.9	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)
X	Non-Residential Health Care Program, DSM Phase X	10.00	years	New York TRM 2021, v.9, p. 521[48]
X	Non-Residential Hotel and Lodging Program, DSM Phase X	10.00	years	New York TRM 2021, v.9, p. 521[48]
VIII	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	10.00	years	New York TRM 2021, v.9, p. 521[48]
VII	Non-Residential Window Film Program, DSM Phase VII	10.00	years	Program design assumptions (weighted average of measure lives of all measures offered by program and their planned uptake)

[48] 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)[49] 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 Program design baseline

The program design baseline assumptions are shown in Table 3-6. These assumptions do not necessarily align with the assumptions used in the impact calculation in this TRM.

Table 3-6. Program design baseline assumptions

DSM Phase	Program name	Baseline description	Baseline type	Source(s)
X	Non-Residential Health Care Program, DSM Phase X	Single or double pane window without window film	Existing condition	Mid-Atlantic TRM v.9, p. 427
	Non-Residential Hotel and Lodging Program, DSM Phase X			

3.1.1.8 Update summary

Updates made to this section are described in Table 3-7.

Table 3-7. Summary of update(s)

Version	Update type	Description
2023	New subsection	Program design baseline assumptions
	None	No change
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

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

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4 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.

4.1 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.

4.1.1 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 Table 4-1.

4.1.2 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.

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 4-1. Input values for non-residential distributed generation impact analysis

Variable	Value	Unit	Source
Measured generation	Metered site data	kW	Dominion Energy
Dispatched generation	Event-based resource requested by Dominion Energy	kW	Dominion Energy
Enrolled dispatchable generation	Per program terms, fixed per site	kW	Dominion Energy

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4.1.4 Default savings

Default savings will not be credited to a non-residential DG customer for unmeasured generation.

4.1.5 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.

4.1.6 Source(s)

DNV developed the non-residential DG evaluation methodology according to standard EM&V protocols.[50]

4.1.7 Update summary

Updates made to this section are described in Table 4-2.

Table 4-2. Summary of update(s)

Version	Update type	Description
2023	None	No change
2022	None	No change
2021	None	No change
2020	None	No change
v10	None	No change

[50] 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/sites/default/files/2020-04/napdr-mv.pdf

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5 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 5-1.

Table 5-1. Non-residential small manufacturing program measure list

End use	Measure	Legacy program	Manual section
Compressed air	Compressed air nozzles	-	Section 5.1.1
	Leak repair		Section 5.1.2
	No loss drains		Section 5.1.3
	Add storage (5 gal/cfm)		Section 5.1.4
	Heat of compression dryer		Section 5.1.5
	Low pressure-drop filter		Section 5.1.6
	VSD air compressor		Section 5.1.7
	Cycling refrigerant dryer		Section 5.1.8
	Dewpoint controls		Section 5.1.9
	Pressure reduction		Section 5.1.10
	Downsized VFD compressor		Section 5.1.11

5.1 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 align with the implementer calculations. Desk reviews are conducted for all projects that exceed 100,000 kWh savings and the first time any measure is implemented in the program.

5.1.1 Compressed air nozzle

5.1.1.1 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 5-2.

Table 5-2. 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

5.1.1.2 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:

DNV

$$\left(\frac{kW}{scfm}\right)_{base} = \frac{hp \times 1.1 \times 0.746}{0.945 \times \eta_{VFD}} \times \frac{\left(X_2 \times Load_{base}{}^2 + X_1 \times Load_{base} + C\right)}{scfm_{base}}$$

$$\left(\frac{kW}{scfm}\right)_{ee} = \frac{hp \times 1.1 \times 0.746}{0.945 \times \eta_{VFD}} \times \frac{\left(X_2 \times Load_{ee}{}^2 + X_1 \times Load_{ee} + C\right)}{scfm_{ee}}$$

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

5.1.1.3 Input variables

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

Table 5-3. 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 5-2	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 22-25 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Engineering estimate, only applicable if the control type is VFD
X_2	Variable	See Table 22-25 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
X_1	Variable	See Table 22-25 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
C	Variable	See Table 22-25 in Sub-Appendix F2-VII: 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, p. 451
HOU	Variable	See customer application	hours, annual	Customer application
		Default = 6,240		Minnesota TRM V3.1, 2020, p. 451
CF_{summer}	Variable	See Table 22-26 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Illinois TRM V8.0 Volume 2, 2020, p. 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 22-26 in Sub-Appendix F2-VII: Non-residential compressed air end use factors		Illionois TRM V8.0 Volume 2, 2020, pp. 575[51]
		Default =0.59		Default based on single shift (8/5) operating schedule from IL

[51] The source TRM does not differentiate between winter and summer peak periods. Therefore, DNV applied the same CF for summer and winter peak periods.

DNV

Component	Type	Value	Unit	Source(s)
				TRM V8.0 Volume 2, 2020, p. 575

5.1.1.4 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.

5.1.1.5 Effective useful life

The Effective useful life of this measure is provided in Table 5-4.

Table 5-4. 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)

5.1.1.6 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.

5.1.1.7 Update summary

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

Table 5-5. Summary of update(s)

Updates in Version	Update type	Description
2023	None	No change
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

DNV

5.1.2 Leak repair

5.1.2.1 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.

5.1.2.2 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:

$$\left(\frac{kW}{scfm}\right)_{base} = \frac{hp \times 1.1 \times 0.746}{0.945 \times \eta_{VFD}} \times \frac{(X_2 \times Load_{base}{}^2 + X_1 \times Load_{base} + C)}{scfm_{base}}$$

$$\left(\frac{kW}{scfm}\right)_{ee} = \frac{hp \times 1.1 \times 0.746}{0.945 \times \eta_{VFD}} \times \frac{(X_2 \times Load_{ee}{}^2 + X_1 \times Load_{ee} + C)}{scfm_{ee}}$$

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:

DNV

$$\Delta kW_{winter} = \left(scfm_{base} \times \left(\frac{kW}{cfm}\right)_{base} - scfm_{ee} \times \left(\frac{kW}{cfm}\right)_{ee}\right) \times CF_{winter}$$

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
$\Delta scfm$ = 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

5.1.2.3 Input variables

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

Table 5-6. Input values for leak repair 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
$\Delta scfm$	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 22-25 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Engineering estimate; only applicable for VFD-controlled compressors
X_2	Variable	See Table 22-25 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
X_1	Variable	See Table 22-25 in Sub-Appendix F2-VII: 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 22-25 in Sub-Appendix F2-VII: 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 22-26 in Sub-Appendix F2-VII: 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 22-26 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Illinois TRM v8.0 Volume 2, 2020, p. 575[52]
		Default =0.59		Default based on single shift (8/5) operating schedule from IL TRM V8.0 Volume 2, 2020, p. 575

5.1.2.4 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.

5.1.2.5 Effective useful life

The effective useful life of this measure is provided in Table 5-7.

Table 5-7. 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)

5.1.2.6 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.

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

DNV

5.1.2.7 Update summary

Updates made to this section are described in Table 5-8.

Table 5-8. Summary of update(s)

Version	Update type	Description
2023	None	No change
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

5.1.3 No-loss condensate drain

5.1.3.1 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.

5.1.3.2 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:

DNV

$$scfm_{ee} = scfm_{base} - \Delta scfm$$

$$Load_{ee} = \frac{scfm_{ee}}{scfm_{rated}}$$

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

DNV

CF_{winter} = winter coincidence factor

5.1.3.3 Input variables

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

Table 5-9. Input values 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 22-25 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Engineering estimate, only applicable for VFD-controlled compressors
X2	Variable	See Table 22-25 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
X1	Variable	See Table 22-25 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
C	Variable	See Table 22-25 in Sub-Appendix F2-VII: 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 22-26 in Sub-Appendix F2-VII: 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 22-26 in Sub-Appendix F2-VII: Non-residential compressed air end use factors		Illinois TRM v 8.0 Volume 2 2020, p. 575[53]
		Default =0.59		Default based on single shift (8/5) operating schedule from IL TRM v 8.0 Volume 2 2020, p. 575

[53] 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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5.1.3.4 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.

5.1.3.5 Effective useful life

The effective useful life of this measure is provided in Table 5-10.

Table 5-10. 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)

5.1.3.6 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.

5.1.3.7 Update summary

Updates made to this section are described in Table 5-11.

Table 5-11. Summary of update(s)

Version	Update type	Description
2023	None	No change
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

5.1.4 Add storage

5.1.4.1 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

DNV

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.

5.1.4.2 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:

$$\left(\frac{kW}{scfm}\right)_{base} = \frac{hp \times 1.1 \times 0.746}{0.945} \times \frac{(X_{2,base} \times Load^2 + X_{1,base} \times Load + C_{base})}{scfm}$$

$$\left(\frac{kW}{scfm}\right)_{ee} = \frac{hp \times 1.1 \times 0.746}{0.945} \times \frac{(X_{2,ee} \times Load^2 + X_{1,ee} \times Load + C_{ee})}{scfm}$$

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

DNV

$kW/scfm_{ee}$ = efficient trim compressor operating performance
$scfm_{rated}$ = trim compressor rated flow rate
$scfm_{rated}$ = trim compressor rated flow rate
hp = compressor rated horsepower[54]
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

5.1.4.3 Input variables

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

Table 5-12. Input values 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 22-25 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
$X_{1,base}$	Variable	See Table 22-25 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
C_{base}	Variable	See Table 22-25 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
$X_{2,ee}$	Variable	See Table 22-25 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
$X_{1,ee}$	Variable	See Table 22-25 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004

[54] 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
C_{ee}	Variable	See Table 22-25 in Sub-Appendix F2-VII: 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 22-26 in Sub-Appendix F2-VII: 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 22-26 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	IL TRM v 8.0 Volume 2 2020, p. 575[55]
		Default =0.59		Default based on single shift (8/5) operating schedule from IL TRM v 8.0 Volume 2 2020, p. 575

5.1.4.4 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.

5.1.4.5 Effective useful life

The effective useful life of this measure is provided in Table 5-13.

Table 5-13. 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)

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

DNV

5.1.4.6 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.

5.1.4.7 Update summary

Updates made to this section are described in Table 5-14.

Table 5-14. Summary of update(s)

Version	Update type	Description
2023	None	No change
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	Inputs	Added default operating hours and CF value
v10	-	Initial release

5.1.5 Heat-of-compression dryer

5.1.5.1 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.

5.1.5.2 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:

DNV

$$scfm_{reduced} = scfm_{dryer,rated,base} \times Purge_{base} - scfm_{dryer,rated,ee} \times Purge_{ee}$$

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:

$$scfm_{ee} = scfm_{base} - scfm_{reduced}$$

$$Load_{ee} = \frac{scfm_{ee}}{scfm_{rated}}$$

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:

DNV

$$\Delta kW_{summer} = \left[scfm_{base} \times \left(\frac{kW}{scfm}\right)_{base} + kW_{heater,base} + kW_{blower,base} + kW_{refrig,base} - (1 + PSF \times (p_{base} - p_{ee}))\left((scfm_{ee}) \times \left(\frac{kW}{scfm}\right)_{ee}\right)\right] \times CF_{summer}$$

Per dryer, the gross summer coincident demand reduction is calculated according to the following equation:

$$\Delta kW_{winter} = \left[scfm_{base} \times \left(\frac{kW}{scfm}\right)_{base} + kW_{heater,base} + kW_{blower,base} + kW_{refrig,base} - (1 + PSF \times (p_{base} - p_{ee}))\left((scfm_{ee}) \times \left(\frac{kW}{scfm}\right)_{ee}\right)\right] \times CF_{winter}$$

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

DNV

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

5.1.5.3 Input variables

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

Table 5-15. Input values for heat of compression dryer savings calculation

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 22-28 in Sub-Appendix F2-VII: 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 22-27 in Sub-Appendix F2-VII: Non-residential compressed air end use factors for refrigerated dryers, only	-	Compressed Air Challenge, Cycling Refrigerated Air Dryers - Are Savings Significant

DNV

Component	Type	Value	Units	Sources
K	Variable	See Table 22-27 in Sub-Appendix F2-VII: 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 22-25 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Engineering estimate; only applicable if the control type is a VFD
X_2	Variable	See Table 22-25 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
X_1	Variable	See Table 22-25 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
C	Variable	See Table 22-25 in Sub-Appendix F2-VII: 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 22-26 in Sub-Appendix F2-VII: 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 22-26 in Sub-Appendix F2-VII: Non-residential compressed air end use factors		Illinois TRM v 8.0 Volume 2 2020, p. 575[56]
		Default =0.59		Default based on single shift (8/5) operating schedule from IL TRM v 8.0 Volume 2 2020, p. 575

5.1.5.4 Default savings

There are no default savings for this measure as site-specific values are required to calculate savings.

5.1.5.5 Effective useful life

The Effective useful life of this measure is provided in Table 5-16.

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

DNV

Table 5-16. 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)

5.1.5.6 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 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.

5.1.5.7 Update summary

Updates made to this section are described in Table 5-17.

Table 5-17. Summary of update(s)

Version	Update type	Description
2023	None	No change
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

5.1.6 Low pressure-drop filter

5.1.6.1 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.[57] 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.

[57] "Fundamentals of Compressed Air Systems", Compressed Air Challenge, 2004

DNV

5.1.6.2 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:

$$\left(\frac{kW}{scfm}\right)_{base} = \frac{hp \times 1.1 \times 0.746}{0.945 \times \eta_{VFD}} \times \frac{\left(X_2 \times Load_{base}{}^2 + X_1 \times Load_{base} + C\right)}{scfm_{base}}$$

The change in pressure due to the new filter is calculated using the following equation:

$$\Delta p = MIN\ (p_{base} - p_{ee}, \Delta p_{max})$$

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

DNV

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

5.1.6.3 Input variables

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

Table 5-18. Input values 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 22-25 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Engineering estimate, only applicable if the control type is VFD
X_2	Variable	See Table 22-25 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
X_1	Variable	See Table 22-25 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
C	Variable	See Table 22-25 in Sub-Appendix F2-VII: 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

DNV

Component	Type	Value	Units	Sources
CF_{summer}	Variable	See Table 22-26 in Sub-Appendix F2-VII: 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 22-26 in Sub-Appendix F2-VII: Non-residential compressed air end use factors		Illinois TRM v 8.0 Volume 2 2020, p. 575[58]
		Default = 0.59		Default based on single shift (8/5) operating schedule from IL TRM v 8.0 Volume 2 2020, p. 575

5.1.6.4 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.

5.1.6.5 Effective useful life

The effective useful life of this measure is provided in Table 5-19.

Table 5-19. 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)

5.1.6.6 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.

5.1.6.7 Update summary

Updates made to this section are described in Table 5-20.

Table 5-20. Summary of update(s)

Version	Update type	Description
2023	None	No change
2022	None	No change

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

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 winter peak coincident demand reduction equation
2020	Inputs	Added default operating hours
v10	-	Initial release

5.1.7 VFD air compressor

5.1.7.1 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.

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.

5.1.7.2 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:

$$\left(\frac{kW}{scfm}\right)_{base,bin} = \frac{hp \times 1.1 \times 0.746}{0.945 \times \eta_{VFD}} \times \frac{\left(X_{2,base} \times {Load_{bin}}^{2} + X_{1,base} \times Load_{bin} + C_{base}\right)}{scfm_{bin}}$$

DNV

$$\left(\frac{kW}{scfm}\right)_{ee,\,bin} = \frac{hp \times 1.1 \times 0.746}{0.945 \times \eta_{VFD}} \times \frac{\left(X_{2,ee} \times Load_{bin}{}^{2} + X_{1,ee} \times Load_{bin} + C_{ee}\right)}{scfm_{bin}}$$

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
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

5.1.7.3 Input variables

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

Table 5-21. Input values VFD air compressor savings calculations

Component	Type	Value	Units	Sources
hp	Variable	See customer application	hp	Customer application

DNV

Component	Type	Value	Units	Sources
$scfm_{rated}$	Variable	See customer application	scfm	Customer application
$load_{bin}$	Variable	For default see Table 22-24 in Sub-Appendix F2-VII: 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 22-25 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
$X_{1, base}$	Variable	See Table 22-25 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
C_{base}	Variable	See Table 22-25 in Sub-Appendix F2-VII: 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
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 22-24 in Sub-Appendix F2-VII: 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 22-26 in Sub-Appendix F2-VII: 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

DNV

Component	Type	Value	Units	Sources
CF_{winter}	Variable	See Table 22-26 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Illinois TRM v 8.0 Volume 2 2020, p. 575[59]
		Default = 0.59		Default based on single shift (8/5) operating schedule from IL TRM v 8.0 Volume 2 2020, p. 575

5.1.7.4 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.

5.1.7.5 Effective useful life

The effective useful life of this measure is provided in Table 5-22.

Table 5-22. 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)

5.1.7.6 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.

5.1.7.7 Update summary

Updates made to this section are described in Table 5-23.

Table 5-23. Summary of update(s)

Version	Update type	Description
2023	None	No change
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

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

DNV

5.1.8 Cycling air dryer

5.1.8.1 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.

5.1.8.2 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:

$$scfm_{reduced} = scfm_{base\ dryer,rated} \times Purge_{base}$$

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:

$$scfm_{ee} = scfm_{base} - scfm_{reduced}$$

DNV

$$Load_{ee} = \frac{scfm_{ee}}{scfm_{rated}}$$

$$Load_{dryer,ee} = \frac{scfm_{ee}}{scfm_{ee\ dryer,\ rated}}$$

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:

$$kW_{blower} = \frac{hp_{blower} \times 0.8 \times 0.746}{0.957}$$

$$kW_{heater} = kW_{heater,rated} \times Utilization_{heater}$$

$$kW_{refrig} = kW_{refrig.,rated} \times \left(R_{1,base} \times Load_{dryer,base} + K_{base}\right)$$

$$kW_{dryer,ee} = kW_{dryer,rated,ee} \times \left(R_{1,ee} \times Load_{dryer,ee} + K_{ee}\right)$$

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:

$$\Delta kW_{winter} = \left[scfm_{base} \times \left(\frac{kW}{scfm}\right)_{base} + kW_{heater} + kW_{blower} + kW_{refrig} - scfm_{ee} \times \left(\frac{kW}{scfm}\right)_{ee} - kW_{dryer,\ ee}\right] \times CF_{winter}$$

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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
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
$R_{1,ee}$ = 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

5.1.8.3 Input variables

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

Table 5-24. Input values for cycling air dryer savings calculation

Component	Type	Value	Units	Sources
hp	Variable	Customer application	hp	See customer application
$scfm_{rated}$	Variable	Customer application	scfm	See customer application

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Component	Type	Value	Units	Sources
$scfm_{system,rated}$	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 22-28 in Sub-Appendix F2-VII: 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 22-27 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Compressed Air Challenge, Cycling Refrigerated Air Dryers - Are Savings Significant
K_{base}	Variable	See Table 22-27 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Compressed Air Challenge, Cycling Refrigerated Air Dryers - Are Savings Significant
$R_{1, ee}$	Variable	See Table 22-27 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Compressed Air Challenge, Cycling Refrigerated Air Dryers - Are Savings Significant
K_{ee}	Variable	See Table 22-27 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Compressed Air Challenge, Cycling Refrigerated Air Dryers - Are Savings Significant
X_2	Variable	See Table 22-25 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
X_1	Variable	See Table 22-25 in Sub-Appendix F2-VII: 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 22-25 in Sub-Appendix F2-VII: 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 22-26 in Sub-Appendix F2-VII: 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 22-26 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Illinois TRM v 8.0 Volume 2 2020, p. 575[60]
		Default = 0.59		Default based on single shift (8/5) operating schedule from IL TRM v 8.0 Volume 2 2020, p. 575

5.1.8.4 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.

5.1.8.5 Effective useful life

The effective useful life of this measure is provided in Table 5-25.

Table 5-25. 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)

5.1.8.6 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

[60] 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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5.1.8.7 Update summary

Updates made to this section are described in Table 5-26.

Table 5-26. Summary of update(s)

Version	Update type	Description
2023	None	No change
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

5.1.9 Dew point controls

5.1.9.1 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.

5.1.9.2 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:

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$$scfm_{reduced} = scfm_{base\ dryer,rated} \times Purge_{base} - \left(scfm_{base,dryer,\ rated} \times Purge_{base} \times Load_{base,\ dryer}\right) \times (1 - Time)$$

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:

$$\left(\frac{kW}{scfm}\right)_{base} = \frac{hp \times 1.1 \times 0.746}{0.945 \times \eta_{VFD}} \times \frac{\left(X_2 \times Load_{base}{}^2 + X_1 \times Load_{base} + C\right)}{scfm_{base}}$$

$$\left(\frac{kW}{scfm}\right)_{ee} = \frac{hp \times 1.1 \times 0.746}{0.945 \times \eta_{VFD}} \times \frac{\left(X_2 \times Load_{ee}{}^2 + X_1 \times Load_{ee} + C\right)}{scfm_{ee}}$$

Where the kW load due to each component is calculated using the following equations:

$$kW_{blower,ee} = kW_{blower,base} \times Load_{ee}$$

$$kW_{blower,bas} = hp_{blower} \times 0.8 \times 0.746 \times 0.957 =$$

$$kW_{heater,bas\iota} = kW_{heater,rated,base} \times Utilization_{heater}$$

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$$kW_{heater,ee} = kW_{heater,base} \times Load_{ee}$$

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
$Load_{system,base}$ = 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

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X1 = coefficient
C = constant
HOU = annual hours of use
CF_{summer} = summer coincidence factor
CF_{winter} = winter coincidence factor

5.1.9.3 Input variables

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

Table 5-27. Input values for dew point controls savings calculation

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 22-28 in Sub-Appendix F2-VII: 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
η_{VFD}	Variable	See Table 22-25 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	engineering estimate, only applicable if the control type is VFD
X2	Variable	See Table 22-25 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
X1	Variable	See Table 22-25 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Fundamentals of Compressed Air Systems, Compressed Air Challenge, 2004
C	Variable	See Table 22-25 in Sub-Appendix F2-VII: 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
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 22-26 in Sub-Appendix F2-VII: 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 22-26 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Illinois TRM v 8.0 Volume 2 2020, p. 575[61]
		Default = 0.59		Default based on single shift (8/5) operating schedule from IL TRM v 8.0 Volume 2 2020, p. 575

5.1.9.4 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.

5.1.9.5 Effective useful life

The effective useful life of this measure is provided in Table 5-28.

Table 5-28. 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)

5.1.9.6 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.

5.1.9.7 Update summary

Updates made to this section are described in Table 5-29.

[61] 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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Table 5-29. Summary of update(s)

Version	Update Type	Description
2023	None	No change
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

5.1.10 Pressure reduction

5.1.10.1 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.

5.1.10.2 Impacts estimation approach

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

$$\Delta kWh = \Delta kWh_{artificial} + \Delta kWh_{pressure}$$

$$\Delta kWh_{artificial} = \left(scfm_{base} \times \left(\frac{kW}{scfm}\right)_{base} - (scfm_{ee}) \times \left(\frac{kW}{scfm}\right)_{ee}\right) \times HOU$$

$$\Delta kWh_{pressure} = \left(scfm_{ee} \times \left(\frac{kW}{scfm}\right)_{ee} \times PSF \times \Delta p\right) \times HOU$$

To determine the reduction in flow rate from the change to the pressure set-point, the following equation is used:

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$$scfm_{reduced} = (scfm_{base} \times \%scfm_{artificial}) - (scfm_{base} \times scfm_{artificial}) \times \left(\frac{(p_{ee} + 14.7)}{(p_{base} + 14.7)}\right)^n$$

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:

$$\Delta kW_{summer} = (\Delta kW_{artificial} + \Delta kW_{pressure}) \times CF_{summer}$$

$$\Delta kW_{artificial} = \left(scfm_{base} \times \left(\frac{kW}{scfm}\right)_{base} - (scfm_{ee}) \times \left(\frac{kW}{scfm}\right)_{ee}\right)$$

$$\Delta kW_{pressure} = \left(scfm_{ee} \times \left(\frac{kW}{scfm}\right)_{ee} \times PSF \times \Delta p\right)$$

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

$$\Delta kW_{winter} = (\Delta kW_{artificial} + \Delta kW_{pressure}) \times CF_{winter}$$

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
$\Delta kWh_{artificial}$= 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

5.1.10.3 Input variables

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

Table 5-30. Input values for pressure reduction savings calculation

Component	Type	Value	Units	Sources
p_{base}	Variable	See customer application	psig	Customer application
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

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Component	Type	Value	Units	Sources
$scfm_{artificial}$	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 22-25 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Engineering estimate, only applicable if the control type is VFD
X_2	Variable	See Table 22-25 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	"Fundamentals of Compressed Air Systems", Compressed Air Challenge, 2004
X_1	Variable	See Table 22-25 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	"Fundamentals of Compressed Air Systems", Compressed Air Challenge, 2004
C	Variable	See Table 22-25 in Sub-Appendix F2-VII: 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 22-26 in Sub-Appendix F2-VII: 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 22-26 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	Illinois TRM v 8.0 Volume 2 2020, p. 575[62]
		Default = 0.59		Default based on single shift (8/5) operating schedule from IL TRM v 8.0 Volume 2 2020, p. 575

5.1.10.4 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.

5.1.10.5 Effective useful life

The effective useful life of this measure is provided in Table 5-31.

Table 5-31. 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

62 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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DSM Phase	Program name	Value	Units	Source(s)
				of all measures offered by program and their planned uptake)

5.1.10.6 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.

5.1.10.7 Update summary

Updates made to this section are described in Table 5-32.

Table 5-32. Summary of update(s)

Version	Update type	Description
2023	None	No change
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

5.1.11 Downsized VFD compressor

5.1.11.1 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 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.

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5.1.11.2 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:

$$\left(\frac{kW}{scfm}\right)_{base,\,bin} = \frac{hp_{base} \times 1.1 \times 0.746}{0.945} \times \frac{\left(X_{2,base} \times Load_{base,\;bin}{}^{2} + X_{1,base} \times Load_{base,\;\;bin} + C_{base}\right)}{scfm_{bin}}$$

$$\left(\frac{kW}{scfm}\right)_{ee,\,bin} = \frac{hp_{ee} \times 1.1 \times 0.746}{0.945 * \times \eta_{VFD}} \times \frac{\left(X_{2,ee} \times Load_{ee,\,bin}{}^{2} + X_{1,ee} \times Load_{ee,\,bin} + C_{ee}\right)}{scfm_{bin}}$$

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:

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$$\Delta kW_{winter} = \sum_{bin=1}^{7} scfm_{bin} \times \left[\left(\frac{kW}{cfm}\right)_{base,bin} - \left(\frac{kW}{cfm}\right)_{ee,bin}\right] \times HOU_{bin} \times CF_{winter}$$

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

5.1.11.3 Input variables

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

Table 5-33. 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
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 22-24 in Sub-Appendix F2-VII: 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)

Component	Type	Value	Units	Sources
$X_{2,base}$	Variable	See Table 22-25 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	"Fundamentals of Compressed Air Systems", Compressed Air Challenge, 2004
$X_{1,base}$	Variable	See Table 22-25 in Sub-Appendix F2-VII: Non-residential compressed air end use factors	-	"Fundamentals of Compressed Air Systems", Compressed Air Challenge, 2004
C_{base}	Variable	See Table 22-25 in Sub-Appendix F2-VII: 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 22-24 in Sub-Appendix F2-VII: 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 22-26 in Sub-Appendix F2-VII: 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
CF_{winter}	Variable	See Table 22-26 in Sub-Appendix F2-VII: Non-residential compressed air end use factors		Illinois TRM v 8.0 Volume 2 2020, p. 575[63]
		Default = 0.59		Default based on single shift (8/5) operating schedule[51]

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

DNV

5.1.11.4 Default savings

This measure does not have default savings. The savings depend on the rated power. However, some variables have default values.

5.1.11.5 Effective useful life

The effective useful life of this measure is provided in Table 5-34.

Table 5-34. 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)

5.1.11.6 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.

5.1.11.7 Update summary

Updates made to this section are described in Table 5-35.

Table 5-35. Summary of update(s)

Version	Update type	Description
2023	None	No change
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

6 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 6-1.

Table 6-1. Non-residential office program measure list

End Use	Measure	Legacy program	Manual section
Lighting	Reduce lighting schedule	-	Section 6.2.1
Heating, ventilation, air-conditioning (HVAC)	HVAC unit scheduling	-	Section 6.3.1
	HVAC temperature setback		Section 6.3.2
	HVAC condensing		Section 6.3.3
	HVAC discharge air temperature reset		Section 6.3.4
	HVAC static pressure reset		Section 6.3.5
	HVAC VAV minimum flow reduction		Section 6.3.6
	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 6.3.7), analyses for all the measure savings are based on building model simulations.

6.1 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.[64] 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.[65] 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.

[64] 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

[65] 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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6.1.1 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.

6.1.1.1 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

6.1.1.2 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 6-2 and Table 6-3.

DNV

Table 6-2. Energy savings factor (ESF) by measure

Weather station	Measure								
	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	0.489	0.658	0.893	0.386	146.8	0.306	0.629	0.127	0.447
Farmville	0.477	0.635	0.936	0.509	142.1	0.474	0.615	0.152	0.528
Norfolk	0.486	0.642	0.893	0.421	146.2	0.337	0.650	0.115	0.449
Arlington	0.477	0.706	0.968	0.391	195.5	0.358	0.638	0.134	0.451
Richmond	0.475	0.686	0.979	0.500	165.3	0.453	0.632	0.149	0.533
Roanoke	0.486	0.679	0.952	0.439	170.8	0.366	0.649	0.132	0.459
Fredericksburg	0.482	0.639	0.911	0.401	140.3	0.410	0.633	0.135	0.481
Rocky Mount-Wilson	0.487	0.661	0.943	0.421	160.4	0.385	0.649	0.118	0.466
Elizabeth City	0.490	0.698	0.914	0.312	167.9	0.236	0.668	0.114	0.382

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Table 6-3. 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

6.1.1.3 Default savings

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

6.1.1.4 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)
XI	Non-Residential Building Optimization Program, DSM Phase IX	5.00	years	Wisconsin TRM 2022, p. 369[66]
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)

6.1.1.5 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.

[66] 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.

6.1.1.6 Update summary

Updates made to this section are described in Table 6-5.

Table 6-5. Summary of update(s)

Version	Update type	Description
2023	None	No change
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

6.2 Lighting end use

6.2.1 Reduce lighting schedule

6.2.1.1 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.

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

Table 6-6. Programs that offer reduce lighting schedule

Program Name	Section
Non-Residential Office Program, DSM Phase VII	Section 6.2.1
Non-Residential Building Optimization Program, DSM Phase IX	Section 14.2.1

6.2.1.2 Impact Estimation Approach

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

$$\Delta kWh = ESF \times SqFt \times MAF$$

$$MAF = \left(\frac{(HPD_{base} \times DPW_{base}) - (HPD_{ee} \times DPW_{ee})}{10 \frac{hrs}{week}} \right)$$

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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
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

6.2.1.3 Input variables

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

Table 6-7. Input values for reduce lighting schedule savings calculations

Component	Type	Value	Unit	Source(s)
ESF	Variable	See Table 6-2	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

6.2.1.4 Default savings

This measure does not have default savings.

6.2.1.5 Effective useful life

The effective useful life of this measure is provided in Table 6-12.

Table 6-8. Effective useful life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Building Optimization Program, DSM Phase IX	5.00	years	Wisconsin TRM 2022, p. 369[67]
VII	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)

6.2.1.6 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 (TMYx) data.

6.2.1.7 Update summary

Updates made to this section are described in Table 6-9.

Table 6-9. Summary of update(s)

Version	Update type	Description
2023	None	No change
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

6.3 Heating, Ventilation, and Air Conditioning (HVAC) end use

6.3.1 HVAC unit scheduling

6.3.1.1 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

[67] 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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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

This measure is offered through different programs listed in Table 6-10 and uses the Impacts estimation approach described in this section.

Table 6-10. Programs that offer HVAC unit schedule

Program Name	Section
Non-Residential Office Program, DSM Phase VII	Section 6.3.1
Non-Residential Building Optimization Program, DSM Phase IX	Section 14.3.1

6.3.1.2 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

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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

6.3.1.3 Input variables

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

Table 6-11. Input values for HVAC unit scheduling savings calculations

Component	Type	Value	Unit	Source(s)
ESF	Variable	See Table 6-2	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

6.3.1.4 Default savings

This measure does not have default savings.

6.3.1.5 Effective useful life

The effective useful life of this measure is provided in Table 6-12.

Table 6-12. Effective useful life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Building Optimization Program, DSM Phase IX	5.00	years	Wisconsin TRM 2022, p. 369[68]
VII	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)

[68] 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.

DNV

6.3.1.6 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.

6.3.1.7 Update summary

Updates made to this section are described in Table 6-13.

Table 6-13. Summary of update(s)

Version	Update type	Description
2023	None	No change
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

6.3.2 HVAC temperature setback

6.3.2.1 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 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

This measure is offered through different programs listed in Table 6-14. Programs that offer HVAC temperature setback and uses the Impacts estimation approach described in this section.

Table 6-14. Programs that offer HVAC temperature setback

Program Name	Section
Non-Residential Office Program, DSM Phase VII	Section 6.3.2
Non-Residential Building Optimization Program, DSM Phase IX	Section 14.3.2

DNV

6.3.2.2 Impact Estimation Approach

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

$$\Delta kWh = ESF \times scfm_{supply\,fan} \times MAF$$

$$MAF = \left(\frac{T_{unoccupied,base} - T_{unoccupied,ee}}{9°F}\right)$$

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

6.3.2.3 Input variables

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

Table 6-15. Input values for HVAC temperature setback savings calculations

Component	Type	Value	Unit	Source(s)
ESF	Variable	See Table 6-2	kWh/Unit	OpenStudio® energy modeling software outputs using EnergyPlus™ engine
$T_{unoccuiped,base}$	Variable	See customer application	°F	Customer application
$T_{unocculped,ee}$	Variable	See customer application	°F	Customer application
$scfm_{supply\,fan}$	Variable	See customer application	scfm	Customer application

DNV

6.3.2.4 Default savings

This measure does not have default savings.

6.3.2.5 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)
IX	Non-Residential Building Optimization Program, DSM Phase IX	5.00	years	Wisconsin TRM 2022, p. 369[69]
VII	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)

6.3.2.6 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.

6.3.2.7 Update summary

Updates made to this section are described in Table 6-17.

Table 6-17. Summary of update(s)

Version	Update type	Description
2023	None	No change
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

6.3.3 HVAC condensing water temperature reset

6.3.3.1 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

[69] 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.

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.

This measure is offered through different programs listed in Table 6-18 and uses the Impacts estimation approach described in this section.

Table 6-18. Programs that offer HVAC condensing water temperature reset

Program Name	Section
Non-Residential Office Program, DSM Phase VII	Section 6.3.3
Non-Residential Building Optimization Program, DSM Phase IX	Section 14.3.3

6.3.3.2 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

DNV

6.3.3.3 Input variables

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

Table 6-19. Input values for HVAC condensing water temperature reset savings calculations

Component	Type	Value	Unit	Source(s)
ESF	Variable	See Table 6-2	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

6.3.3.4 Default savings

This measure does not have default savings.

6.3.3.5 Effective useful life

The effective useful life of this measure is provided in Table 6-20.

Table 6-20. Effective useful life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Building Optimization Program, DSM Phase IX	5.00	years	Wisconsin TRM 2022, p. 369[70]
VII	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)

6.3.3.6 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.

6.3.3.7 Update summary

Updates made to this section are described in Table 6-21.

[70] 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.

DNV

Table 6-21. Summary of update(s)

Version	Update type	Description
2023	None	No change
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

6.3.4 HVAC discharge air temperature reset

6.3.4.1 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.

This measure is offered through different programs listed in Table 6-22. Programs that offer HVAC discharge air temperature reset and uses the Impacts estimation approach described in this section.

Table 6-22. Programs that offer HVAC discharge air temperature reset

Program Name	Section
Non-Residential Office Program, DSM Phase VII	Section 6.3.4
Non-Residential Building Optimization Program, DSM Phase IX	Section 14.3.4

6.3.4.2 Impact Estimation Approach

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

$$\Delta kWh = ESF \times scfm_{supply\ fan} \times MAF$$

$$MAF = \left(\frac{T_{discharge\ reset,ee} - T_{discharge,base}}{6°F}\right)$$

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:

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

DNV

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

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

6.3.4.3 Input variables

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

Table 6-23. Input values for HVAC discharge air temperature reset savings calculation

Component	Type	Value	Unit	Source(s)
ESF	Variable	See Table 6-2	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

6.3.4.4 Default savings

This measure does not have default savings.

6.3.4.5 Effective useful life

The effective useful life of this measure is provided in Table 6-24.

Table 6-24. Effective useful life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Building Optimization Program, DSM Phase IX	5.00	years	Wisconsin TRM 2022, p. 369[71]
VII	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)

71 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.

DNV

6.3.4.6 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.

6.3.4.7 Update summary

Updates made to this section are described in Table 6-25

Table 6-25. Summary of update(s)

Version	Update type	Description
2023	None	No change
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

6.3.5 HVAC static pressure reset

6.3.5.1 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 6-26.

Table 6-26. 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

DNV

Coefficient	Fixed static pressure (baseline)	Reset static pressure (efficient)
Coefficient 5	0.00000	0.00000
Minimum percent power	20%	10%

This measure is offered through different programs listed in Table 6-27. Programs that offer HVAC static pressure reset and uses the Impacts estimation approach described in this section.

Table 6-27. Programs that offer HVAC static pressure reset

Program Name	Section
Non-Residential Office Program, DSM Phase VII	Section 6.3.5
Non-Residential Building Optimization Program, DSM Phase IX	Section 14.3.5

6.3.5.2 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:

$$\Delta kW_{summer} = DRF_{summer} \times scfm_{supply\ fan}$$

$$\Delta kW_{winter} = DRF_{winter} \times scfm_{supply\ fan}$$

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

6.3.5.3 Input variables

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

Table 6-28. Input values for HVAC static pressure reset savings calculations

Component	Type	Value	Unit	Source(s)
ESF	Variable	See Table 6-2	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 6-3	kW/ scfm	EnergyPlus™ energy modeling software outputs
DRF_{winter}	Variable	See Table 6-3	kW/ scfm	EnergyPlus™ energy modeling software outputs

6.3.5.4 Default savings

This measure does not have default savings.

6.3.5.5 Effective useful life

The effective useful life of this measure is provided in Table 6-29.

Table 6-29. Effective useful life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Building Optimization Program, DSM Phase IX	5.00	years	Wisconsin TRM 2022, p. 369[72]
VII	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)

6.3.5.6 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.

6.3.5.7 Update summary

Updates made to this section are described in Table 6-30.

Table 6-30. Summary of update(s)

Version	Update Type	Description
2023	None	No change
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

[72] 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.

DNV

Version	Update Type	Description
v10	-	Initial release

6.3.6 HVAC VAV minimum flow reduction

6.3.6.1 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.

This measure is offered through different programs listed in Table 6-31. Programs that offer and uses the Impacts estimation approach described in this section.

Table 6-31. Programs that offer HVAC VAV minimum flow reduction

Program Name	Section
Non-Residential Office Program, DSM Phase VII	Section 6.3.6
Non-Residential Building Optimization Program, DSM Phase IX	Section 14.3.6

6.3.6.2 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:

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

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

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

DNV

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

6.3.6.3 Input variables

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

Table 6-32. Input values for HVAC VAV minimum flow reduction savings calculations

Component	Type	Value	Unit	Source(s)
ESF	Variable	See Table 6-2	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

6.3.6.4 Default savings

This measure does not have default savings.

6.3.6.5 Effective useful life

The effective useful life of this measure is provided in Table 6-33.

Table 6-33. Effective useful life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Building Optimization Program, DSM Phase IX	5.00	years	Wisconsin TRM 2022, p. 369[73]
VII	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)

[73] 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.

DNV

6.3.6.6 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.

6.3.6.7 Update summary

Updates made to this section are described in Table 6-34.

Table 6-34. Summary of update(s)

Version	Update type	Description
2023	None	No change
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

6.3.7 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.

DNV

7 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.

The measures offered through the program and the sections that contain the savings algorithms for each measure are presented in Table 7-1.

Table 7-1. 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
Heating, ventilation, air-conditioning (HVAC)	Duct testing & sealing	-	Section 7.2.1
	Heat Pump tune-up	-	Section 7.2.2
	Refrigerant charge correction	-	Section 7.2.3
	Heat pump upgrade	Non-Residential Heating and Cooling Efficiency Program, DSM Phase VII	Section 2.1.1
	Dual enthalpy air-side economizer		Section 2.1.5
	Programmable thermostat	-	Section 7.2.6
	HVAC variable frequency drives	-	Section 7.2.7
Lighting	Lighting, fixtures, lamps, and delamping	Non-Residential Lighting Systems and Controls Program, DSM Phase VII	Section 1.1.1
	Sensors and controls		Section 1.1.2
	LED exit signs	-	Section 7.3.3
Appliance or Plug load	Vending machine miser	-	Section 7.4.1
Refrigeration	Refrigeration variable frequency drives	-	Section 7.5.1
	Night cover	-	Section 7.5.2
	Evaporator fan electronically commutated motor (ECM) retrofit	-	Section 7.5.3
	Evaporator fan motor controls	-	Section 7.5.4
	Door closer	-	Section 7.5.5
	Anti-sweat heater controls	-	Section 7.5.6
	Strip curtain (cooler and freezer)	-	Section 7.5.7

7.1 Building envelope end use

7.1.1 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.

DNV

7.2 Heating, Ventilation, and Air Conditioning (HVAC) end use

7.2.1 Duct testing and sealing

7.2.1.1 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 7-2 and uses the impacts estimation approach described in this section.

Table 7-2. Programs that offer duct testing and sealing

Program name	Section
Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 7.2.1
Non-Residential Multifamily Program, DSM Phase VIII	Section 10.3.3
Non-Residential Prescriptive Enhanced Program, DSM Phase IX	Section 16.3.2
Non-Residential Health Care Program, DSM Phase X	Section 17.5.3
Non-Residential Hotel and Lodging Program, DSM Phase X	Section 19.5.1

7.2.1.2 Impacts estimation approach

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

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

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:

DNV

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

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:

DNV

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

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 distribution system efficiency with cooling is used for summer demand impacts. 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:

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

Duct testing and sealing on air-cooled chiller systems:

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

Chiller systems with non-electric heating fuel will not have gross coincident winter peak demand reductions. For winter demand, the distribution system heating efficiency is used. For chiller systems with electric heating, impacts 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:

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

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
$EER_{full\text{-}load}$ = 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-IX: General may be used to estimate the missing efficiency using another application-provided efficiency metric.

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 7-3. 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[74]	kBtu/h (per unit)	Customer application
		Default = Size$_{cool}$ x 12 kBtu/ton		
SEER/IEER/EER/COP/HSPF	Variable	See customer application[75]	Btu/W-hr (COP is dimension-less)	Customer application
		Default: See Table 22-11 and Table 22-12 in Sub-Appendix F2-IV: Non-residential HVAC based on equipment type		ASHRAE 90.1-2016
kW/ton$_{full\ load}$	Variable	See customer application	kW/ton	Customer application
		Default: see Table 22-14 in Sub-Appendix F2-IV: Non-residential HVAC based on equipment type		ASHRAE 90.1-2016
kW/ton$_{IPLV}$	Variable	See customer application	kW/ton	Customer application
		Default: see Table 22-14 in Sub-Appendix F2-IV: Non-residential HVAC based on equipment type		ASHRAE 90.1-2016
EER$_{full\ load}$	Variable	See customer application[75]	Btu/W-h	Customer application
		Default: see Table 22-14 in Sub-Appendix F2-IV: Non-residential HVAC based on equipment type		ASHRAE 90.1-2016
EER$_{IPLV}$	Variable	See customer application[75]	kBtu/kW-h	Customer application
		Default: see Cooling efficiencies of water chilling packages Table 22-14 in Sub-Appendix F2-IV: Non-residential HVAC based on equipment type		ASHRAE 90.1-2016
$\bar{n}_{dist,base,cool}$	Variable	See customer application along with Table 7-4 and Table 7-5	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 7-4 and Table 7-5	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 7-4 and Table 7-5	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 7-4 and Table 7-5	percent	Customer application
		Default: No insulation, 15% leakage		New York TRM 2018, p. 242
EFLH$_{heat}$	Variable	See Table 22-8 in Sub-Appendix F2-V: Non-residential lighting factors: annual equivalent hours, coincidence factors, and waste heat factors	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 423

[74] When customer-provided heating system size is <60% or >165% 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.

[75] 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)
$EFLH_{cool}$	Variable	See Table 22-7 in Sub-Appendix F2-V: Non-residential lighting factors: annual equivalent hours, coincidence factors, and waste heat factors	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[76]
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[77]

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 7-4 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%.

[76] 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.

[77] 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 7-4. Duct system efficiency by broad building type categories[78]

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

78 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.

Table 7-5. Duct system efficiency mapping to building type[79]

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

7.2.1.4 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.

7.2.1.5 Effective useful life

The effective useful life of this measure is provided in Table 7-6.

Table 7-6. Effective useful life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
X	Non-Residential Health Care Program, DSM Phase X	18.00	years	New York TRM 2021, p. 656
	Non-Residential Hotel and Lodging Program, DSM Phase X			

[79] 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.

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX			
VIII	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII			
	Non-Residential Multifamily Program, DSM Phase VIII			

7.2.1.6 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.

7.2.1.7 Program design baseline

The program design baseline assumptions are shown in Table 7-7. These assumptions do not necessarily align with the assumptions used in the impact calculation in this TRM.

Table 7-7. Program design baseline assumptions

DSM Phase	Program name	Baseline description	Baseline type	Source(s)
X	Non-Residential Health Care Program, DSM Phase X	Ducts with leakage to unconditioned space	Existing condition	Non-Residential STEP Manual v10, p. 80
	Non-Residential Hotel and Lodging Program, DSM Phase X			

7.2.1.8 Update summary

Updates made to this section are described in Table 7-8.

Table 7-8. Summary of update(s)

Version	Update type	Description
2023	Inputs	Updated EFLHs with TMYx weather data
	Equation	Clarified summer and winter coincident peak impacts use the cooling and heating distribution system efficiencies, respectively.
	New subsection	Program design baseline
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

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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 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-IV: Non-residential HVAC

7.2.2 HVAC tune-up

7.2.2.1 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.

This measure is offered through different programs listed in Table 7-9, and uses the impacts estimation approach described in this section.

Table 7-9. Programs that offer HVAC tune-ups

Program name	Section
Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 7.2.2
Non-Residential Multifamily Program, DSM Phase VIII	Section 10.3.2
Non-Residential Prescriptive Enhanced Program, DSM Phase IX	Section 16.3.1
Non-Residential Health Care Program, DSM Phase X	Section 17.5.9
Non-Residential Hotel and Lodging Program, DSM Phase X	Section 19.5.919.5.4

7.2.2.2 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

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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 and ground source heat pumps[80] ≥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:

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

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 air-cooled 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 water-cooled chillers:

80 For ground source heat pumps use $EER_{part\text{-}load}$ in place of IEER in this equation.

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$$\Delta kW_{summer} = Size_{cool} \times kW/ton_{full\ load} \times CF_{summer} \times TUF$$

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.
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.
$kW/ton_{full\ load}$ = full load chiller performance of existing water-cooling chillers
CF_{summer} = summer coincidence factor
CF_{winter} = winter coincidence factor

7.2.2.3 Input variables

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

Table 7-10. Input values for AC/HP/chiller tune-up savings calculations

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

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Component	Type	Value	Units	Source(s)
$Size_{heat}$	Variable	See customer application[81]	kBtu/h	Customer application
		Default for HPs: 12 kBtuh/ton x $Size_{cool}$		
$EFLH_{cool}$	Variable	Refer to Sub-Appendix F2-V: Non-residential lighting factors: annual equivalent hours, coincidence factors, and waste heat factors ACs, HPs, & Chillers: Table 22-7	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 422
$EFLH_{heat}$	Variable	Refer to Sub-Appendix F2-V: Non-residential lighting factors: annual equivalent hours, coincidence factors, and waste heat factors HPs: Table 22-8	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 423
HSPF/ SEER/ IEER/ EER/ COP[82]	Variable	See customer application[83]	kBtu/kW-hour (except COP is dimensionless)	Customer application
		Refer to Sub-Appendix F2-IV: Non-residential HVAC ACs & HPs: Table 22-12 Chillers: Table 22-14		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-IV: Non-residential HVAC Chillers: Table 22-14		ASHRAE 90.1-2013
$kW/ton_{full\ load}$	Variable	See customer application	kW/ton	ASHRAE 90.1-2013
		Refer to Sub-Appendix F2-IV: Non-residential HVAC Chillers: Table 22-14		
TUF	Variable	If refrigerant charge adjustment (RCA) was not done: ACs: 0.023 HPs: 0.028 Chillers: 0.050 If RCA was done: ACs: 0.050 HPs: 0.050 Chillers: 0.050	-	Maryland/Mid-Atlantic TRM v.10, p. 316, California Impact Evaluation of 2013-14 Commercial Quality Maintenance Programs,[84] and Wisconsin Focus on 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

81 When customer-provided heating system size is <60% or >165% 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.

82 For the Non-Residential Midstream Program, if the reported COP is the same as the reported EER, the COP is assumed to be a data error, and the reported COP will be converted to COP using the equations in the Sub-Appendix F2-IX: General equations

83 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.

84 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.

DNV

Component	Type	Value	Units	Source(s)
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[85]

7.2.2.4 Default savings

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

7.2.2.5 Effective useful life

The effective useful life of this measure is provided in Table 7-11.

Table 7-11. Effective useful life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
X	Non-Residential Hotel and Lodging Program, DSM Phase X	5.00	years	Maryland/Mid-Atlantic TRM v.10, p. 316
X	Non-Residential Health Care Program, DSM Phase X	5.00	years	Maryland/Mid-Atlantic TRM v.10, p. 316
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	5.00	years	Maryland/Mid-Atlantic TRM v.10, p. 316
VIII	Non-Residential Multifamily Program, DSM Phase VIII	5.00	years	Maryland/Mid-Atlantic TRM v.10, p. 316

7.2.2.6 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.

7.2.2.7 Program design baseline

The program design baseline assumptions are shown in Table 7-12. These assumptions do not necessarily align with the assumptions used in the impact calculation in this TRM.

Table 7-12. Program design baseline assumptions

DSM Phase	Program name	Baseline description	Baseline type	Source(s)
X	Non-Residential Health Care Program, DSM Phase X	An HVAC system prior to being tuned-up	Existing condition	Mid-Atlantic TRM v9, p. 451

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

DNV

DSM Phase	Program name	Baseline description	Baseline type	Source(s)
	Non-Residential Hotel and Lodging Program, DSM Phase X			

7.2.2.8 Update summary

Updates made to this section are described in Table 7-13.

Table 7-13. Summary of update(s)

Version	Update Type	Description
2023	Inputs	Updated EFLHs with TMYx weather data
	Equation	Added summer peak reduction equation for water-cooled chillers using $kW/ton_{full\ load}$ to account for the Non-Residential Health Care Program, DSM Phase X and Non-Residential Hotel and Lodging Program, DSM Phase X offering this measure to water-cooled chillers
	New subsection	Program design baseline assumptions
2022	None	No change
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

7.2.3 Refrigerant charge correction

7.2.3.1 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.

DNV

This measure is offered through different programs listed in Table 1-18, and uses the impacts estimation approach described in this section.

Table 7-14. Programs that offer refrigerant charge correction

Program name	Section
Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 7.2.3
Non-Residential Hotel and Lodging Program, DSM Phase X	Section 19.5.10

7.2.3.2 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:

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

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:

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

DNV

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)
- $EFLH_{cool}$ = equivalent full load hours for cooling
- $EFLH_{heat}$ = equivalent full load hours for heating
- RCF = refrigerant charge factor
- CF = demand coincidence factor

7.2.3.3 Input variables

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

Table 7-15. Input values for refrigerant charge correction savings calculations

Component	Type	Value	Units	Source(s)
$Size_{cool}$	Variable	See customer application	tons (cooling capacity)	Customer application
$Size_{heat}$	Variable	See customer application[86]	kBtu/h	Customer application
		Default: = $Size_{cool}$ x 12 kBtu/h /ton		

[86] When customer-provided heating system size is <60% or >165% 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.

DNV

Component	Type	Value	Units	Source(s)
$EFLH_{cool}$	Variable	See Table 22-7 in Sub-Appendix F2-V: Non-residential lighting factors: annual equivalent hours, coincidence factors, and waste heat factors	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 422
$EFLH_{heat}$	Variable	See Table 22-8 in Sub-Appendix F2-V: Non-residential lighting factors: annual equivalent hours, coincidence factors, and waste heat factors	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 423
EER/SEER	Variable	See customer application[87]	Btu/W-hr	Customer application
		See Table 22-11 and Table 22-12 in Sub-Appendix F2-IV: Non-residential HVAC		ASHRAE 90.1 2013
HSPF/COP	Variable	See customer application[87]	Btu/W-hr (for HSPF); COP is -	Customer application
		See Table 22-12 in Sub-Appendix F2-IV: Non-residential HVAC		ASHRAE 90.1 2013
RCF[88]	Variable	AC units: 0.027 HP units: 0.022	-	Maryland/Mid-Atlantic TRM v.10, p. 315 and California 2013-2014 Evaluation Report[89]
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
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[90]

7.2.3.4 Default savings

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

7.2.3.5 Effective useful life

The effective useful life of this measure is provided in Table 7-16.

[87] 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.

[88] 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.

[89] 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.

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

DNV

Table 7-16. Effective useful life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
X	Non-Residential Hotel and Lodging Program, DSM Phase X	5.00	years	Maryland/Mid-Atlantic TRM v.10, p. 316
VIII	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII			

7.2.3.6 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.

7.2.3.7 Program design baseline

The program design baseline assumptions are shown in Table 7-17. These assumptions do not necessarily align with the assumptions used in the impact calculation in this TRM.

Table 7-17. Program design baseline assumptions

DSM Phase	Program name	Baseline description	Baseline type	Source(s)
X	Non-Residential Hotel and Lodging Program, DSM Phase X	System with low or high refrigerant charge	Existing equipment	Non-Residential STEP Manual v10, p. 95

7.2.3.8 Update summary

Updates made to this section are described in Table 7-18.

Table 7-18. Summary of update(s)

Version	Update type	Description
2023	Inputs	Updated EFLHs with TMYx weather data
	New subsection	Program design baseline assumptions
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

DNV

Version	Update type	Description
		Equipment efficiency levels were revised per update to ASHRAE 2013 in VA and NC

7.2.4 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.

7.2.5 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.

7.2.6 Programmable thermostat

7.2.6.1 Measure description

This measure involves the installation of programmable thermostats[91] 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.

7.2.6.2 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 zero since space conditioning equipment typically operates at maximum capacity during peak periods. There is no gross coincident winter peak demand reduction for AC units.

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

[91] Non-communicating thermostats are not eligible for the demand response programs.

DNV

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

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 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

DNV

7.2.6.3 Input variables

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

Table 7-19. Input values for programmable thermostat measure savings calculations

Component	Type	Value	Units	Source(s)
$Size_{cool}$	Variable	See customer application	tons of cooling capacity	Customer application
$Size_{heat}$	Variable	See customer application	kBtu/h	Customer application
		Default[92] = $Size_{cool}$ x 12 kBtu/h / ton		
$EFLH_{heat}$	Variable	See Table 22-8 in Sub-Appendix F2-V: Non-residential lighting factors: annual equivalent hours, coincidence factors, and waste heat factors	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 423
$EFLH_{cool}$	Variable	Refer to Table 22-7 in Sub-Appendix F2-V: Non-residential lighting factors: annual equivalent hours, coincidence factors, and waste heat factors	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 422
SEER/IEER	Variable	See customer application[93]	kBtu/kW-hour	Customer application
		See Table 22-11 and Table 22-12 in Sub-Appendix F2-IV: Non-residential HVAC		ASHRAE 90.1 2013, Table 6.8.1-1 and Table 6.8.1B
HSPF/COP	Variable	See customer application[93]	kBtu/kW-hour (except COP is dimensionless)	Customer application
		See Table 22-12 in Sub-Appendix F2-IV: Non-residential HVAC		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

7.2.6.4 Default savings

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

7.2.6.5 Effective useful life

The effective useful life of this measure is provided in Table 7-20.

92 When customer-provided heating system size is <60% or >165% 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.

93 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.

DNV

Table 7-20. 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

7.2.6.6 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.

7.2.6.7 Update summary

Updates made to this section are described in Table 7-21.

Table 7-21. Summary of update(s)

Version	Update type	Description
2023	Inputs	Updated EFLHs with TMYx weather data
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

7.2.7 Variable frequency drives

7.2.7.1 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:

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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)

This measure is offered through different programs listed in Table 7-22. The Non-Residential Heating and Cooling Efficiency Program, DSM Phase VII uses a different method than the impacts estimation approach described in this section.

Table 7-22. Programs that offer variable frequency drives

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 7.2.7
Non-Residential Health Care Program, DSM Phase X	Section 17.5.12
Non-Residential Data Center Program, DSM Phase X	Section 18.2.2
Non-Residential Hotel and Lodging Program, DSM Phase X	Section 19.5.13

7.2.7.2 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

7.2.7.3 Input variables

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

Table 7-23. Input values for variable frequency drives savings calculations

Component	Type	Value	Unit	Source(s)
hp	Variable	See customer application	horsepower	Customer application
LF	Fixed	0.65	-	Maryland/Mid-Atlantic TRM v.10, p. 297
η	Variable	For default see Table 7-24. Baseline motor efficiency	-	NEMA Standards Publication Condensed MG 1-2007
ESF	Variable	For default see Table 7-25	-	Mid-Atlantic TRM 2015 p. 370; Mid-Atlantic TRM v10, p. 301
DRF	Variable	For default see Table 7-25	-	Mid-Atlantic TRM 2015 p. 370; Mid-Atlantic TRM v10, p. 301
HOU	Variable	For the Non-Residential Data Center Program, DSM Phase X use 8,760 hours. Sor all other programs see Table 22-9 in Sub-Appendix F2-V: Non-residential lighting factors: annual equivalent hours, coincidence factors, and waste heat factors	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[94]

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

DNV

Table 7-24 provides the baseline motor efficiencies that are consistent with the minimum federal accepted motor efficiencies provided by the National Electrical Manufacturers Association (NEMA).[95]

Table 7-24. Baseline motor efficiency[96]

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		-	-

Table 7-25 provides the energy savings and demand reduction factors by the application and the baseline control types.

Table 7-25. Energy savings and demand reduction factors by application

VFD applications	ESF	DRF
Unknown VFD (Minimum)[97]	0.123	0.039
HVAC fan VFD savings factors[98]		
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[99]		
Chilled water pump	0.633	0.460
Hot water pump	0.652	0.000

95 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.

96 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).

97 Assigned for applications such as compressors, based on DNV research and judgement.

98 Mid-Atlantic TRM 2015, p. 370

99 Maryland/Mid-Atlantic TRM v.10, p. 301.

VFD applications	ESF	DRF
Unknown/other pump (Average)[100]	0.643	0.230

7.2.7.4 Default savings

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

7.2.7.5 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)
X	Non-Residential Hotel and Lodging Program, DSM Phase X	15.00	years	Maryland/Mid-Atlantic TRM v.10, p. 301
X	Non-Residential Data Center Program, DSM Phase X	15.00	years	Maryland/Mid-Atlantic TRM v.10, p. 301
X	Non-Residential Health Care Program, DSM Phase X	15.00	years	Maryland/Mid-Atlantic TRM v.10, p. 301
VIII	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	15.00	years	Maryland/Mid-Atlantic TRM v.10, p. 301
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)

7.2.7.6 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).

7.2.7.7 Program design baseline

The program design baseline assumptions are shown in Table 7-27. These assumptions do not necessarily align with the assumptions used in the impact calculation in this TRM.

Table 7-27. Program design baseline assumptions

DSM Phase	Program name	Baseline description	Baseline type	Source(s)
X	Non-Residential Health Care Program, DSM Phase X	A motor without a VFD	Existing condition	Non-Residential STEP Manual v.10, p. 46

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

DNV

DSM Phase	Program name	Baseline description	Baseline type	Source(s)
	Non-Residential Hotel and Lodging Program, DSM Phase X			
	Non-Residential Data Center Program, DSM Phase X			

7.2.7.8 Update summary

Updates made to this section are described in Table 7-28.

Table 7-28. Summary of update(s)

Version	Update Type	Description
2023	New subsection	Program design baseline assumptions
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

7.3 Lighting end use

7.3.1 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.

7.3.2 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.

7.3.3 LED exit signs

7.3.3.1 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.

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This measure is offered through different programs listed in Table 7-29 and uses the impacts estimation approach described in this section.

Table 7-29. Programs that offer LED exit signs

Program name	Section
Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 7.3.3
Non-Residential Multifamily Program, DSM Phase VIII	Section 10.4.3

7.3.3.2 Impacts estimation approach

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

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

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

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 7-30. Input values for LED exit sign savings 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		Maryland/Mid-Atlantic TRM v.10, p. 215, ENERGY STAR[101]
$watts_{ee}$	Variable	See customer application	watts	Customer application
		Default: 5		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 22-17 in Sub-Appendix F2-V: Non-residential lighting factors: annual equivalent hours, coincidence factors, and waste heat factors Default savings assumed as lighting condition as Unconditioned space, WHFe=1.0	-	Maryland/Mid-Atlantic TRM v.10, p. 215
$WHF_{d,summer}$	Variable		-	Maryland/Mid-Atlantic TRM v.10, p. 216
$WHF_{d,winter}$	Variable		-	Maryland/Mid-Atlantic TRM v.10, p. 216
CF_{summer}	Fixed	1.0	-	Maryland/Mid-Atlantic TRM v.10, p. 216[102]
CF_{winter}	Fixed		-	Maryland/Mid-Atlantic TRM v.10, p. 216[103]
ISR	Fixed		-	Maryland/Mid-Atlantic TRM v.10, p. 215[104]

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.

7.3.3.4 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:

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

[101] 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

[102] Efficiency Vermont Technical Reference Manual 2009-55, December 2008.

[103] Ibid.

[104] 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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$$= \frac{(1 \times 16\,W - 1 \times 5\,W)}{1{,}000\,W/kW} \times 8{,}760\,hour \times 1.0 \times 1.0$$

$$= 96.36\,kWh$$

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:

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

$$= \frac{(1 \times 16\,W - 1 \times 5\,W)}{1{,}000\,W/kW} \times 1.0 \times 1.0 \times 1.0$$

$$= 0.011\,kW$$

7.3.3.5 Effective useful life

The effective useful life of this measure is provided in Table 7-31.

Table 7-31. Effective useful life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
VIII	Non-Residential Multifamily Program, DSM Phase VIII	5.00	years	Maryland/Mid-Atlantic TRM v.10, p. 216
	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII			

7.3.3.6 Source(s)

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v.10, pp. 215-216.

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7.3.3.7 Update summary

Updates made to this section are described in Table 7-32.

Table 7-32. Summary of update(s)

Version	Update type	Description
2023	None	No change
2022	None	No change
2021	Source	Updated page numbers / version of the Mid-Atlantic TRM
	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

7.4 Appliance or plug load end use

7.4.1 Vending machine miser

7.4.1.1 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 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 7-33 and uses the impacts estimation approach described in this section.

Table 7-33. Programs that offer vending machine miser

Program name	Section
Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 7.4.1
Non-Residential Health Care Program, DSM Phase X	Section 17.1.2
Non-Residential Hotel and Lodging Program, DSM Phase X	Section 19.1.2

7.4.1.2 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:

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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 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

7.4.1.3 Input variables

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

Table 7-34. Input values for vending miser savings calculations

Component	Type	Value	Unit	Source(s)
kW_{rated}	Variable	See customer application	kW	Customer application
		See Table 7-35		Massachusetts e-TRM 2019-2021, p. 595
ESF	Variable	See Table 7-35	-	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[105]
CF_{winter}	Fixed	1.0		Wisconsin TRM 2019, p. 822[105]

Table 7-35. Vending miser rated kilowatts and energy savings factors[106]

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

[105] 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.

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

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7.4.1.4 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 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:

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

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

$$= 0.039\ kW$$

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

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

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

$$= 0.039\ kW$$

7.4.1.5 Effective useful life

The effective useful life of this measure is provided in Table 7-36.

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Table 7-36. Effective useful life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
X	Non-Residential Hotel and Lodging Program, DSM Phase X	5.00	years	Massachusetts e-TRM 2019-2021, p. 596
X	Non-Residential Health Care Program, DSM Phase X	5.00	years	Massachusetts e-TRM 2019-2021, p. 596
VIII	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	5.00	years	Massachusetts e-TRM 2019-2021, p. 596

7.4.1.6 Source(s)

The primary source for this deemed savings approach is the Massachusetts e-TRM I2019-2021, pp. 595-597.

7.4.1.7 Program design baseline

The program design baseline assumptions are shown in Table 7-37. These assumptions do not necessarily align with the assumptions used in the impact calculation in this TRM.

Table 7-37. Program design baseline assumptions

DSM Phase	Program name	Baseline description	Baseline type	Source(s)
X	Non-Residential Health Care Program, DSM Phase X	Vending machine without miser	Existing condition	Non-Residential STEP Manual v10, p. 179
X	Non-Residential Hotel and Lodging Program, DSM Phase X	Vending machine without miser	Existing condition	Non-Residential STEP Manual v10, p. 179

7.4.1.8 Update summary

Updates made to this section are described in Table 7-38.

Table 7-38. Summary of update(s)

Version	Update Type	Description
2023	New subsection	Program design baseline
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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7.5 Refrigeration end use

7.5.1 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.

7.5.1.1 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:

$$\Delta kW_{summer} = tons_{cool} \times DSF_{summer}$$

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

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7.5.1.2 Input variable

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

Table 7-39. Input variables for refrigeration variable frequency drives savings calculations

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

7.5.1.3 Default savings

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

7.5.1.4 Effective useful life

The effective useful life of this measure is provided in Table 7-40.

Table 7-40. 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	Pennsylvania TRM 2019, Vol. 3, p. 163

7.5.1.5 Source

The primary sources for this deemed savings approach Pennsylvania TRM 2019, Vol. 3, pp. 163-165.

7.5.1.6 Update summary

Updates made to this section are described in Table 7-41.

Table 7-41. Summary of update(s)

Version	Update Type	Description
2023	None	No change

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Version	Update Type	Description
2022	None	No change
2021	-	Initial release

7.5.2 Refrigeration night cover

7.5.2.1 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 7-42 and uses the impacts estimation approach described in this section.

Table 7-42. Programs that offer refrigeration night cover

Program name	Section
Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 7.5.2
Non-Residential Health Care Program, DSM Phase X	Section 17.7.9
Non-Residential Hotel and Lodging Program, DSM Phase X	Section 19.7.12

7.5.2.2 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,[107] 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

[107] Mid-Atlantic TRM 2020, p. 343. Assumed that continuous covers are deployed at night; therefore, no demand savings occur during the peak period.

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

7.5.2.3 Input variables

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

Table 7-43. 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[108]
L	Variable	See customer application	feet	Customer application
		Default = 6		DNV judgment
COP[109]	Fixed	2.20	-	Maryland/Mid-Atlantic TRM v.10, p. 342
ESF[110]	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

7.5.2.4 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:

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

[108] Mid-Atlantic 2020, p. 342. Original source: Davis Energy Group, Analysis of Standard Options for Open Case Refrigerators and Freezers.
[109] Kuiken et al, Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0, KEMA, March 22, 2010.
[110] 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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$$\Delta kW_{winter} = 0$$

7.5.2.5 Effective useful life

The effective useful life of this measure is provided in Table 7-44.

Table 7-44. Effective useful life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
X	Non-Residential Hotel and Lodging Program, DSM Phase X	5.00	years	Maryland/Mid-Atlantic TRM v.10, p. 343
X	Non-Residential Health Care Program, DSM Phase X			
VIII	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII			

7.5.2.6 Source(s)

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v10, pp. 342-343.

7.5.2.7 Program design baseline

The program design baseline assumptions are shown in Table 7-45. These assumptions do not necessarily align with the assumptions used in the impact calculation in this TRM.

Table 7-45. Program design baseline assumptions

DSM Phase	Program name	Baseline description	Baseline type	Source(s)
X	Non-Residential Health Care Program, DSM Phase X	Refrigerated case without a night cover	Existing condition	Non-Residential STEP Manual v10, p. 167
	Non-Residential Hotel and Lodging Program, DSM Phase X			

7.5.2.8 Update summary

Updates made to this section are described in Table 7-46.

Table 7-46. Summary of update(s)

Version	Update type	Description
2023	New subsection	Program design baseline
2022	None	No change
2021	Source	Updated page numbers / version of the Maryland/Mid-Atlantic TRM v10

Version	Update type	Description
	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

7.5.3 Evaporator Fan Electronically Commutated Motor (ECM) Retrofit (Reach-in and walk-in coolers and freezers)

7.5.3.1 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 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 7-47 and uses the impacts estimation approach described in this section.

Table 7-47. Programs that offer ECM retrofit

Program name	Section
Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 7.5.3
Non-Residential Prescriptive Enhanced Program, DSM Phase IX	Section 16.6.5
Non-Residential Health Care Program, DSM Phase X	Section 17.7.5
Non-Residential Hotel and Lodging Program, DSM Phase X	Section 19.7.8

7.5.3.2 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:

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

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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 provided in Table 7-48 are 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
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

7.5.3.3 Input variables

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

Table 7-48. Input values for ECM retrofit savings calculations

Component	Type	Value	Unit	Source(s)
$watts_{base}$	Variable	See customer application	watts	Customer application
		Defaults: See Table 7-49		Wisconsin TRM 2020, p. 795
$watts_{ee}$	Variable	See customer application	watts	Customer application
		Defaults: See Table 7-49		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		

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Component	Type	Value	Unit	Source(s)
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 Default: 1.38	-	Maryland/Mid-Atlantic TRM v.10, p. 347
CF_{summer}	Fixed	0.978	-	Maryland/Mid-Atlantic TRM v.10, p. 349[111]
CF_{winter}	Fixed	0.978	-	Maryland/Mid-Atlantic TRM v.10, p. 349[112]

Table 7-49. 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
Walk-in Cooler or Unknown (default)	Unknown (default)[113]	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)[114]	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

7.5.3.4 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:

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

$$= \frac{(151.19\, W - 50.74\, W)}{1{,}000\, W/kW} \times 0.692 \times 8{,}760\, hours \times 1.38$$

[111] 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.

[112] 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.

[113] 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.

[114] 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.

$$= 840.31\, kWh$$

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:

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

$$= \frac{(151.19\, W - 50.74\, W)}{1{,}000\, W/kW} \times 1.38 \times 0.978$$

$$= 0.136\, kW$$

7.5.3.5 Effective useful life

The effective useful life of this measure is provided in Table 7-50.

Table 7-50. Effective useful life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
X	Non-Residential Hotel and Lodging Program, DSM Phase X	15.00	years	Maryland/Mid-Atlantic TRM v.10, p. 347
X	Non-Residential Health Care Program, DSM Phase X	15.00	years	Maryland/Mid-Atlantic TRM v.10, p. 347
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	15.00	years	Maryland/Mid-Atlantic TRM v.10, p. 347

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7.5.3.6 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.

7.5.3.7 Program design baseline

The program design baseline assumptions are shown in Table 7-53. These assumptions do not necessarily align with the assumptions used in the impact calculation in this TRM.

Table 7-51. Program design baseline assumptions

DSM Phase	Program name	Baseline description	Baseline type	Source(s)
X	Non-Residential Health Care Program, DSM Phase X	Shaded-pole evaporator fan motor with no controls	Existing condition	Non-Residential STEP Manual v10, p. 157
	Non-Residential Hotel and Lodging Program, DSM Phase X			

7.5.3.8 Update summary

Updates made to this section are described in Table 7-52.

Table 7-52. Summary of update(s)

Version	Update type	Description
2023	New subsection	Program design baseline assumptions
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
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

7.5.4 Evaporator fan control (cooler and freezer)

7.5.4.1 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

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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 7-53 and uses the impacts estimation approach described in this section.

Table 7-53. Programs that offer evaporator fan control

Program name	Section
Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 7.5.4
Non-Residential Health Care Program, DSM Phase X	Section 17.7.4
Non-Residential Hotel and Lodging Program, DSM Phase X	Section 19.7.7

7.5.4.2 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:

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)

DNV

CF_{winter} = winter peak demand coincidence factor (CF)

7.5.4.3 Input variables

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

Table 7-54. 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[115]
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[116]
CF_{winter}	Variable	Single-speed (on/off controls): 0.12 Multi-speed: 0.31	-	Maryland/Mid-Atlantic TRM v.10, p. 349[117]

7.5.4.4 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 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

[115] 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

[116] 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.

[117] 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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$$\Delta kWh = hp \times \frac{kW}{hp} \times (\%On_{base} - \%On_{ee}) \times HOU \times WHF_e$$

$$= \frac{1}{15} hp \times 0.758 \frac{kW}{hp} \times (0.978 - 0.692) \times 8{,}760\ hours \times 1.38$$

$$= 174.14\ kWh$$

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

$$\Delta kW_{summer} = hp \times \frac{kW}{hp} \times WHF_d \times CF_{summer}$$

$$= \frac{1}{15} hp \times 0.758 \frac{kW}{hp} \times 1.38 \times 0.26$$

$$= 0.018\ kW$$

$$\Delta kW_{winter} = hp \times \frac{kW}{hp} \times WHF_d \times CF_{winter}$$

$$= \frac{1}{15} hp \times 0.758 \frac{kW}{hp} \times 1.38 \times 0.26$$

$$= 0.018\ kW$$

Reach-in

DNV

$$\Delta kW_{summer} = hp \times \frac{kW}{hp} \times WHF_d \times CF_{summer}$$

$$= \frac{1}{62} hp \times 0.758 \frac{kW}{hp} \times 1.38 \times 0.26$$

$$= 0.004\ kW$$

$$\Delta kW_{winter} = hp \times \frac{kW}{hp} \times WHF_d \times CF_{winter}$$

$$= \frac{1}{62} hp \times 0.758 \frac{kW}{hp} \times 1.38 \times 0.26$$

$$= 0.004\ kW$$

7.5.4.5 Effective useful life

The effective useful life of this measure is provided in Table 7-55.

Table 7-55. Effective useful life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
X	Non-Residential Hotel and Lodging Program, DSM Phase X	10.00	years	Maryland/Mid-Atlantic TRM v.10, p. 349
	Non-Residential Prescriptive Enhanced Program, DSM Phase IX			
VIII	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII			

7.5.4.6 Source(s)

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v.10, pp. 348-349.

7.5.4.7 Program design baseline

The program design baseline assumptions are shown in Table 7-56. These assumptions do not necessarily align with the assumptions used in the impact calculation in this TRM.

Table 7-56. Program design baseline assumptions

DSM Phase	Program name	Baseline description	Baseline type	Source(s)
X	Non-Residential Health Care Program, DSM Phase X	Evaporator fan with no controls	Existing condition	Non-Residential STEP Manual v10, p. 159
	Non-Residential Hotel and Lodging Program, DSM Phase X			

7.5.4.8 Update summary

Updates made to this section are described in Table 7-57.

Table 7-57: Summary of update(s)

Version	Update type	Description
2023	New subsection	Program design baseline
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

7.5.5 Door closer (cooler and freezer)

7.5.5.1 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.[118] 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.

[118] 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."

This measure is offered through different programs listed in Table 7-58, and uses the impacts estimation approach described in this section.

Table 7-58. Programs that offer cooler and freezer door closer

Program name	Section
Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 7.5.5
Non-Residential Prescriptive Enhanced Program, DSM Phase IX	Section 16.6.3
Non-Residential Health Care Program, DSM Phase X	Section 17.7.2
Non-Residential Hotel and Lodging Program, DSM Phase X	Section 19.7.3

7.5.5.2 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:

$$\Delta kW_{summer} = \Delta kW_{cooler}$$

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:

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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
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

7.5.5.3 Input variables

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

Table 7-59. Door closer electric energy savings and gross coincident demand reduction (per closer)[119]

Refrigeration unit type	Location	Walk-in		Reach-in	
		ΔkWh	ΔkW[120]	ΔkWh	ΔkW[120]
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 (-35°F to 30 °F)	Richmond, VA	172.7	0.0197	439	0.0501
	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

7.5.5.4 Default savings

In the event of incomplete data, make the following conservative assumptions:

119 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.

120 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.

- 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.

7.5.5.5 Effective useful life

The effective useful life of this measure is provided in Table 7-60.

Table 7-60. Effective useful life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
X	Non-Residential Hotel and Lodging Program, DSM Phase X	8.00	years	Tennessee Valley Authority TRM 2018, p. 128
	Non-Residential Health Care Program, DSM Phase X			
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX			
VIII	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII			

7.5.5.6 Source(s)

The primary source for this deemed savings approach is the Tennessee Valley Authority TRM 2018, pp. 127-129.

7.5.5.7 Program design baseline

The program design baseline assumptions are shown in Table 7-61. These assumptions do not necessarily align with the assumptions used in the impact calculation in this TRM.

Table 7-61. Program design baseline assumptions

DSM Phase	Program name	Baseline description	Baseline type	Source(s)
X	Non-Residential Health Care Program, DSM Phase X	Walk-in/Reach-in cool/freezer without an auto closer	Existing condition	Non-Residential STEP Manual v10, p. 141
	Non-Residential Hotel and Lodging Program, DSM Phase X			

7.5.5.8 Update summary

Updates made to this section are described in Table 7-62.

Table 7-62. Summary of update(s)

Version	Update type	Description
2023	New subsection	Program design baseline assumptions

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Version	Update type	Description
2022	None	None change
2021	New table	Effective useful life (EUL) by program
	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)

7.5.6 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.

7.5.6.1 Impacts estimation approach

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

$$\Delta kWh = kW_{load} \times (\%On_{base} - \%On_{ee}) \times HOU \times WHF_e$$

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

$$\Delta kW_{summer} = kW_{load} \times WHF_d \times CF_{summer}$$

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

$$\Delta kW_{winter} = kW_{load} \times WHF_d \times CF_{winter}$$

Where:

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

DNV

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

7.5.6.2 Input variable

Table 7-63. Input values for anti-sweat heater controls savings calculations

Component	Type	Value	Units	Source(s)
kW_{load}	Variable	See customer application	kW	Customer application
		Default: 0.13		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[121].
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

[121] 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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7.5.6.3 Default savings

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

7.5.6.4 Effective useful life

The effective useful life of this measure is provided in Table 7-64.

Table 7-64. 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

7.5.6.5 Source

The primary sources for this deemed savings approach Maryland/Mid-Atlantic TRM v.10, pp. 344-345.

7.5.6.6 Update summary

Updates made to this section are described in Table 7-65.

Table 7-65. Summary of update(s)

Version	Update type	Description
2023	Non	No change
2022	None	No change
2020	-	Initial release

7.5.7 Strip curtain (cooler and freezer)

7.5.7.1 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 7-66, and uses the impacts estimation approach described in this section.

Table 7-66. Programs that offer cooler and freezer strip curtains

Program name	Section
Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 7.5.7
Non-Residential Prescriptive Enhanced Program, DSM Phase IX	Section 16.6.8
Non-Residential Health Care Program, DSM Phase X	Section 17.7.10

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Program name	Section
Non-Residential Hotel and Lodging Program, DSM Phase X	Section 19.7.13

7.5.7.2 Impacts estimation approach

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

$$\Delta kWh = kWh/ft^2 \times Area$$

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
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

7.5.7.3 Input variables

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

Table 7-67. Input values for strip curtain savings calculations

Component	Type	Value	Unit	Source(s)
ΔkWh/sq.ft	Variable	See Table 7-68	kWh/sq.ft	Pennsylvania TRM V3, 2019, p. 167
		Default = 19		Assume convenience store, Cooler
Area	Variable	See Table 7-69	sq.ft	Pennsylvania TRM V3, 2019, p. 168
		See customer application		Customer application
		Default = 21		Assume convenience store
HOU	Fixed	8,760	hours, annual	Wisconsin TRM 2019, p. 822

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Component	Type	Value	Unit	Source(s)
CF_{summer}	Fixed	1.0	-	Wisconsin TRM 2019, p. 822[122]
CF_{summer}	Fixed	1.0	-	Wisconsin TRM 2019, p. 822[122]

Table 7-68. 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
Restaurant	Cooler	24
	Freezer	129
Refrigerated Warehouse	Cooler	410

Table 7-69. 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
Refrigerated Warehouse	Cooler	120

7.5.7.4 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:

$$\Delta kWh = kWh/ft^2 \times Area$$

$$= 19\ kWh/ft^2 \times 21\ ft^2$$

[122] 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.

$$= 399\ kWh$$

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

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

$$= \frac{231\ kWh}{8{,}760\ hours} \times 1.0$$

$$= 0.026\ kW$$

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

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

$$= \frac{231\ kWh}{8{,}760\ hours} \times 1.0$$

$$= 0.026\ kW$$

7.5.7.5 Effective useful life

The effective useful life of this measure is provided in Table 7-70.

Table 7-70. Effective useful life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
X	Non-Residential Hotel and Lodging Program, DSM Phase X	4.00	years	Wisconsin TRM 2022, p. 831
X	Non-Residential Health Care Program, DSM Phase X	4.00	years	Wisconsin TRM 2022, p. 831
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	4.00	years	Wisconsin TRM 2022, p. 831
VIII	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	4.00	years	Wisconsin TRM 2022, p. 831

DNV

7.5.7.6 Source(s)

The primary source for this deemed savings approach is the Pennsylvania TRM V3, 2019, pp. 166-168 and Wisconsin TRM 2022, p. 831.

7.5.7.7 Program design baseline

The program design baseline assumptions are shown in Table 7-45. These assumptions do not necessarily align with the assumptions used in the impact calculation in this TRM.

Table 7-71. Program design baseline assumptions

DSM Phase	Program name	Baseline description	Baseline type	Source(s)
X	Non-Residential Health Care Program, DSM Phase X	Walk-in cooler with no strip curtain or an ineffective strip curtain installed	Existing condition	Non-Residential STEP Manual v10, p. 177
	Non-Residential Hotel and Lodging Program, DSM Phase X			

7.5.7.8 Update summary

Updates made to this section are described in Table 7-72.

Table 7-72. Summary of update(s)

Version	Update type	Description
2023	New subsection	Program design baseline
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
	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

DNV

8 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 8-1.

Table 8-1. Non-residential midstream energy efficiency products improvement enhanced program measure list

End use	Measure	Legacy program	Manual section
Cooking	Commercial combination oven	-	Section 8.1.1
	Commercial convection oven	-	Section 8.1.2
	Commercial fryer	-	Section 8.1.3
	Commercial griddle	-	Section 8.1.4
	Commercial hot food holding cabinet	-	Section 8.1.5
	Commercial steam cooker	-	Section 8.1.5
Heating, ventilation, air-conditioning (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	-	Section 8.3.1

DNV

8.1 Cooking end use

8.1.1 Commercial combination oven

8.1.1.1 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 8-2 and uses the impacts estimation approach described in this section.

Table 8-2. Programs that commercial combination oven

Program name	Section
Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII	Section 8.1.1
Non-Residential Prescriptive Enhanced Program, DSM Phase IX	Section 16.1.1
Non-Residential Health Care Program, DSM Phase X	Section 17.3.2
Non-Residential Hotel and Lodging Program, DSM Phase X	Section 19.3.1

8.1.1.2 Impacts estimation approach

The baseline annual electric energy consumption is calculated as follows:

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

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

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

The efficient annual electric energy consumption is calculated as follows:

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

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

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

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:

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

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

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$Hours_{daily}$ = 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

8.1.1.3 Input variables

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

Table 8-3. Input values for commercial electric combination ovens savings calculations

Component	Type	Value	Units	Source(s)
$Hours_{daily}$	Variable	See customer application	hours, daily	Customer application
		For defaults see Table 22-20 in Sub-Appendix F2-VI: Non-residential commercial kitchen inputs		Maryland/Mid-Atlantic TRM v.10, p. 387
Days	Variable	See customer application	days, annual	Customer application
		For defaults see Table 22-20 in Sub-Appendix F2-VI: 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

DNV

Component	Type	Value	Units	Source(s)
$PC_{base,conv}$	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
$kW_{ee,conv,idle}$[123]	Variable	<15 pans: 1.299 ≥15 pans: 2.099	kW	Maryland/Mid-Atlantic TRM v.10, p. 387
$kW_{ee,steam,idle}$[124]	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[125]
$Water_{ee}$	Fixed	20.0	gal/ hr	Ohio TRM 2010, p. 260[126]
CF_{summer}	Fixed	1.0	-	Maryland/Mid-Atlantic TRM v.10, p. 387[127]
CF_{winter}	Fixed	1.0	-	Maryland/Mid-Atlantic TRM v.10, p. 387[127]

8.1.1.4 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:

123 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.

124 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.

125 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.

126 Ibid

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

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

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

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

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

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

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

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

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

The efficient annual electric energy consumption is calculated as follows:

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

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

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

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

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

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

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

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

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

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:

DNV

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

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

$$= 1.47\ kW$$

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

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

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

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

8.1.1.5 Effective useful life

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

Table 8-4. Effective useful life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
X	Non-Residential Hotel and Lodging Program, DSM Phase X	12.00	years	Maryland/Mid-Atlantic TRM v.10, p. 389
X	Non-Residential Health Care Program, DSM Phase X	12.00	years	Maryland/Mid-Atlantic TRM v.10, p. 389
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	12.00	years	Maryland/Mid-Atlantic TRM v.10, p. 389

8.1.1.6 Source(s)

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

8.1.1.7 Program design baseline

The program design baseline assumptions are shown in Table 8-5. These assumptions do not necessarily align with the assumptions used in the impact calculation in this TRM.

Table 8-5. Program design baseline assumptions

DSM Phase	Program name	Baseline description	Baseline type	Source(s)
X	Non-Residential Health Care Program, DSM Phase X Non-Residential Hotel and Lodging Program, DSM Phase X	Typical standard efficiency electric combination oven	Existing condition	Non-Residential STEP Manual v10, p. 114

8.1.1.8 Update summary

Updates made to this section are described in Table 8-6.

Table 8-6. Summary of update(s)

Version	Update type	Description
2023	New subsection	Program design baseline assumptions
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

8.1.2 Commercial convection oven

8.1.2.1 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).

DNV

This measure is offered through different programs listed in Table 8-7 and uses the impacts estimation approach described in this section.

Table 8-7. Programs that offer commercial convection oven

Program name	Section
Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII	Section 8.1.2
Non-Residential Prescriptive Enhanced Program, DSM Phase IX	Section 16.1.1
Non-Residential Health Care Program, DSM Phase X	Section 17.3.1
Non-Residential Hotel and Lodging Program, DSM Phase X	Section 19.3.2

8.1.2.2 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:

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

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

DNV

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

8.1.2.3 Input variables

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

Table 8-8. Input values for convection oven savings calculations

Component	Type	Value	Units	Source(s)
$Hours_{daily}$	Variable	See customer application	hours, daily	Customer application
		For defaults see Table 22-20 in Sub-Appendix F2-VI: 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 22-20 in Sub-Appendix F2-VI: 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
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[128]
CF_{winter}	Fixed	1.0	-	Maryland/Mid-Atlantic TRM v.10, p. 384[128]

[128] 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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8.1.2.4 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 for a half size convection oven will be assigned as follows:

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

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

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

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

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

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

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

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

$$= 171.60\ kWh$$

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:

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

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

$$= 0.043\ kW$$

8.1.2.5 Effective useful life

The effective useful life of this measure is provided in Table 8-9.

Table 8-9. Effective useful life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
X	Non-Residential Hotel and Lodging Program, DSM Phase X	12.00	years	Maryland/Mid-Atlantic TRM v.10, p. 385
X	Non-Residential Health Care Program, DSM Phase X	12.00	years	Maryland/Mid-Atlantic TRM v.10, p. 385
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	12.00	years	Maryland/Mid-Atlantic TRM v.10, p. 385

8.1.2.6 Source(s)

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

8.1.2.7 Program design baseline

The program design baseline assumptions are shown in Table 8-17. These assumptions do not necessarily align with the assumptions used in the impact calculation in this TRM.

Table 8-10. Program design baseline assumptions

DSM Phase	Program name	Baseline description	Baseline type	Source(s)
X	Non-Residential Health Care Program, DSM Phase X	Standard efficiency convection oven with a heavy-load efficiency of 65% for full-size electric ovens and 68% for half-size electric ovens	Industry standard practice (ISP)	Non-Residential STEP Manual v10, p. 110
X	Non-Residential Hotel and Lodging Program, DSM Phase X	Standard efficiency convection oven with a heavy-load efficiency of 65% for full-size electric ovens and 68% for half-size electric ovens	Industry standard practice (ISP)	Non-Residential STEP Manual v10, p. 110

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8.1.2.8 Update summary

Updates made to this section are described in Table 8-11.

Table 8-11. Summary of update(s)

Version	Update type	Description
2023	New subsection	Program design baseline assumptions
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

8.1.3 Commercial fryer

8.1.3.1 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 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.[129]

This measure is offered through different programs listed in Table 8-12, and uses the impacts estimation approach described in this section.

Table 8-12. Programs that offer commercial fryer

Program name	Section
Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII	Section 8.1.3
Non-Residential Prescriptive Enhanced Program, DSM Phase IX	Section 16.1.3
Non-Residential Health Care Program, DSM Phase X	Section 17.3.3
Non-Residential Hotel and Lodging Program, DSM Phase X	Section 19.3.3

8.1.3.2 Impacts estimation approach

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

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

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:

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

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

8.1.3.3 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 8-13. Input values for electric commercial fryer savings calculations

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
CF_{summer}	Fixed	1.0	-	Maryland/Mid-Atlantic TRM v.10, p. 371[130]
CF_{winter}	Fixed	1.0	-	Maryland/Mid-Atlantic TRM v.10, p. 371[130]

8.1.3.4 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):

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

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

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

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

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

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

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

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

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

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:

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

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

$$= 0.407\ kW$$

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8.1.3.5 Effective useful life

The effective useful life of this measure is provided in Table 8-14.

Table 8-14. Effective useful life for lifecycle savings calculations

<table>
<tr><th>DSM Phase</th><th>Program name</th><th>Value</th><th>Units</th><th>Source(s)</th></tr>
<tr><td rowspan="2">X</td><td>Non-Residential Hotel and Lodging Program, DSM Phase X</td><td rowspan="4">12.00</td><td rowspan="4">years</td><td rowspan="4">Maryland/Mid-Atlantic TRM v.10, p. 372</td></tr>
<tr><td>Non-Residential Health Care Program, DSM Phase X</td></tr>
<tr><td>IX</td><td>Non-Residential Prescriptive Enhanced Program, DSM Phase IX</td></tr>
<tr><td>VIII</td><td>Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII</td></tr>
</table>

8.1.3.6 Source(s)

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

8.1.3.7 Program design baseline

The program design baseline assumptions are shown in Table 8-15. These assumptions do not necessarily align with the assumptions used in the impact calculation in this TRM.

Table 8-15. Program design baseline assumptions

<table>
<tr><th>DSM Phase</th><th>Program name</th><th>Baseline description</th><th>Baseline type</th><th>Source(s)</th></tr>
<tr><td rowspan="2">X</td><td>Non-Residential Health Care Program, DSM Phase X</td><td rowspan="2">Standard efficiency electric fryer with a heavy load efficiency of 75% for standard sized equipment and 70% for large vat equipment</td><td rowspan="2">Industry Standard Practice (ISP)</td><td rowspan="2">Non-Residential STEP Manual v10, p. 110 and Maryland/Mid-Atlantic TRM v10, p. 177</td></tr>
<tr><td>Non-Residential Hotel and Lodging Program, DSM Phase X</td></tr>
</table>

8.1.3.8 Update summary

Updates made to this section are described in Table 8-16.

Table 8-16. Summary of update(s)

Version	Update type	Description
2023	New subsection	Program design baseline assumptions
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 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

8.1.4 Commercial griddle

8.1.4.1 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 8-17 and uses the impacts estimation approach described in this section.

Table 8-17. Programs that offer commercial griddle

Program name	Section
Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII	Section 8.1.3
Non-Residential Prescriptive Enhanced Program, DSM Phase IX	Section 16.1.4

8.1.4.2 Impacts estimation approach

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

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

where,

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

and

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

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

8.1.4.3 Input variables

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

Table 8-18. Input values for commercial griddle savings calculations

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		Customer application

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Component	Type	Value	Units	Source(s)
		For defaults see Table 22-20 in Sub-Appendix F2-VI: Non-residential commercial kitchen inputs	hours, daily	Maryland/Mid-Atlantic TRM v.10, p. 380[131], 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 22-20 in Sub-Appendix F2-VI: Non-residential commercial kitchen inputs		Maryland/Mid-Atlantic TRM v.10, p. 380131, 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[132]
CF_{winter}	Fixed	1.0	-	Maryland/Mid-Atlantic TRM v.10, p. 380[132]

8.1.4.4 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.

8.1.4.5 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

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

[131] 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.

[132] 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.

DSM Phase	Program name	Value	Units	Source(s)
VIII	Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII			

8.1.4.6 Source(s)

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

8.1.4.7 Update summary

Updates made to this section are described in Table 8-20.

Table 8-20. Summary of update(s)

Version	Update type	Description
2023	None	No change
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

8.1.5 Commercial hot food holding cabinet

8.1.5.1 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 8-21, and uses the impacts estimation approach described in this section.

Table 8-21. Programs that offer commercial hot food holding cabinet

Program name	Section
Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII	Section 8.1.5
Non-Residential Prescriptive Enhanced Program, DSM Phase IX	Section 16.1.5

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8.1.5.2 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

8.1.5.3 Input variables

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

Table 8-22. Input values for hot food holding cabinet savings calculations

Component	Type	Value	Units	Source(s)
$watts_{base,idle}$	Variable	40 x Vol[133]	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 22-20 in Sub-Appendix F2-VI: Non-residential commercial kitchen inputs		Maryland/Mid-Atlantic TRM v.10, p. 380[134], for default the Dominion Energy 2020

133 Vol is the internal volume of the holding cabinet (ft3) = volume of installed unit

134 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.

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Component	Type	Value	Units	Source(s)
				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 22-20 in Sub-Appendix F2-VI: Non-residential commercial kitchen inputs		Maryland/Mid-Atlantic TRM v.10, p. 380[134], 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[135]
CF$_{winter}$	Fixed	1.0	-	Maryland/Mid-Atlantic TRM v.10, p. 377[135]

8.1.5.4 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.

8.1.5.5 Effective useful life

The effective useful life of this measure is provided in Table 8-23.

Table 8-23. 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			

8.1.5.6 Source(s)

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

8.1.5.7 Update summary

Updates made to this section are described in Table 8-24.

135 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 8-24. Summary of update(s)

Version	Update type	Description
2023	None	No change
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

8.1.6 Commercial steam cooker

8.1.6.1 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 8-25 and uses the impacts estimation approach described in this section.

Table 8-25. Programs that offer commercial steam cooker

Program name	Section
Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII	Section 8.1.3
Non-Residential Prescriptive Enhanced Program, DSM Phase IX	Section 16.1.6
Non-Residential Health Care Program, DSM Phase X	Section 17.3.4
Non-Residential Hotel and Lodging Program, DSM Phase X	Section 19.3.4

8.1.6.2 Savings estimation

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

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

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

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

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

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

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

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

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:

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

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

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

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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} = 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

8.1.6.3 Input variables

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

Table 8-26. Input values for commercial steam cooker savings calculations

Component	Type	Value	Units	Source(s)
$Hours_{daily}$	Variable	See customer application	hours, daily	Customer application
		For defaults see Table 22-20 in Sub-Appendix F2-VI: Non-residential commercial kitchen inputs		Maryland/Mid-Atlantic TRM v.10, p. 380[136], 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 22-20 in Sub-Appendix F2-VI: Non-residential commercial kitchen inputs		Maryland/Mid-Atlantic TRM v.10, p. 380[137], for default the Dominion Energy 2020 Commercial Energy Survey Appendix B, p.3 weighted average of building types is used

136 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.

137 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)
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[138]		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 8-27	gal/hr	Maryland/Mid-Atlantic TRM v.10, p. 376
GPH_{ee}	Variable	See Table 8-27	gal/hr	Maryland/Mid-Atlantic TRM v.10, p. 376
CF_{summer}	Fixed	1.0	-	Maryland/Mid-Atlantic TRM v.10, p. 374[139]
CF_{winter}	Fixed	1.0	-	Maryland/Mid-Atlantic TRM v.10, p. 374[139]

Table 8-27. 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

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

[139] 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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8.1.6.4 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:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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:

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

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

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

8.1.6.5 Effective useful life

The effective useful life of this measure is provided in Table 8-28.

Table 8-28. Effective useful life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
X	Non-Residential Hotel and Lodging Program, DSM Phase X	12.00	years	Maryland/Mid-Atlantic TRM v.10, p. 376
	Non-Residential Health Care Program, DSM Phase X			
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX			
VIII	Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII			

8.1.6.6 Source(s)

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

8.1.6.7 Program design baseline

The program design baseline assumptions are shown in Table 8-29. These assumptions do not necessarily align with the assumptions used in the impact calculation in this TRM.

Table 8-29. Program design baseline assumptions

DSM Phase	Program name	Baseline description	Baseline type	Source(s)
X	Non-Residential Health Care Program, DSM Phase X	Standard efficiency electric boiler-style steam cooker	Industry Standard Practice (ISP)	Non-Residential STEP Manual v10, p. 110 and Maryland/Mid-Atlantic TRM v10, p. 177
	Non-Residential Hotel and Lodging Program, DSM Phase X			

8.1.6.8 Update summary

Updates made to this section are described in Table 8-30.

Table 8-30. Summary of update(s)

Version	Update type	Description
2023	New subsection	Program baseline design assumptions
2022	None	No change

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Version	Update type	Description
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

8.2 Heating, Ventilation, and Air Conditioning (HVAC) end use

8.2.1 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.

8.2.2 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.

8.2.3 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.

8.3 Refrigeration end use

8.3.1 Commercial freezers and refrigerators

8.3.1.1 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 8-31 and uses the impacts estimation approach described in this section.

Table 8-31. Programs that offer commercial freezer and refrigerators

Program name	Section
Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII	Section 8.3.1

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Program name	Section
Non-Residential Prescriptive Enhanced Program, DSM Phase IX	Section 16.6.1
Non-Residential Health Care Program, DSM Phase X	Section 17.7.1
Non-Residential Health Care Program, DSM Phase X	Section 17.7.1
Non-Residential Hotel and Lodging Program, DSM Phase X	Section 19.7.1

8.3.1.2 Impacts estimation approach

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

$$\Delta kWh \quad = (kWh_{base} - kWh_{ee}) \times Days$$

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

$$\Delta kW_{summer} \quad = \left(\frac{\Delta kWh}{EFLH}\right) \times CF_{summer}$$

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

$$\Delta kW_{winter} \quad = \left(\frac{\Delta kWh}{EFLH}\right) \times CF_{winter}$$

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

8.3.1.3 Input variables

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

Table 8-32. Input values for commercial freezers and refrigerator savings calculations

Component	Type	Value	Units	Source(s)
kWh_{base}	Variable	See Table 8-33	kWh	Federal Standards, Energy Efficiency Program for Certain Commercial and Industrial

Component	Type	Value	Units	Source(s)
				Equipment, title 10, sec. 431.66 (2013)[140]
kWh_{ee}	Variable	See Table 8-34	kWh	ENERGY STAR® Certified-commercial-refrigerators-and-freezers[141]
Days	Fixed	365	days, annual	Constant
EFLH	Fixed	5,858	hours, annual	Maryland/Mid-Atlantic TRM v.10, pp. 335 and 339[142]
CF_{summer}	Fixed	0.77	-	Maryland/Mid-Atlantic TRM v.10, pp. 335 and 339[143]
CF_{winter}	Fixed	0.77	-	Maryland/Mid-Atlantic TRM v.10, pp. 335 and 339[144]
Volume	Variable	See customer application	cubic feet	Customer application

Table 8-33. 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 8-34. Calculated efficient unit daily energy consumption from volume, V

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

140 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.

141 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

142 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.

143 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.

144 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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Equipment type and volume (ft^3)	Refrigerator energy, kWh	Freezer energy, kWh
15 ≤ V < 30 ft^3	=0.050 x V + 1.120	=0.232 x V + 2.360
30 ≤ V < 50 ft^3	=0.076 x V + 0.340	=0.232 x V + 2.360
V ≥ 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

8.3.1.4 Default savings

This measure does not have default savings.

8.3.1.5 Effective useful life

The effective useful life of this measure is provided in Table 8-35.

Table 8-35. Effective useful life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
X	Non-Residential Hotel and Lodging Program, DSM Phase X	12.00	years	Mid-Atlantic TRM 2020, p. 335
X	Non-Residential Health Care Program, DSM Phase X			
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX			
VIII	Non-Residential Midstream Energy Efficiency Products Program, DSM Phase VIII			

8.3.1.6 Source(s)

The primary source for this deemed savings approach is the Maryland/Mid-Atlantic TRM v.10, pp. 334–341.

8.3.1.7 Program design baseline

The program design baseline assumptions are shown in Table 8-36. These assumptions do not necessarily align with the assumptions used in the impact calculation in this TRM.

Table 8-36. Program design baseline assumptions

DSM Phase	Program name	Baseline description	Baseline type	Source(s)
X	Non-Residential Health Care Program, DSM Phase X			Non-Residential STEP Manual v10, p. 147

DSM Phase	Program name	Baseline description	Baseline type	Source(s)
	Non-Residential Hotel and Lodging Program, DSM Phase X	Refrigerator or freezer meeting minimum federal standards[145]	Codes and Standards	

8.3.1.8 Update summary

Updates made to this section are described in Table 8-37.

Table 8-37. Summary of update(s)

Version	Update type	Description
2023	New subsection	Program design baseline assumptions
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

[145] Federal Standards, Energy Efficiency Program for Certain Commercial and Industrial Equipment, title 10, sec. 431.66 (2013). The Mid-Atlantic TRM 2019 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.

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9 NON-RESIDENTIAL HVAC HEALTH AND SAFETY PROGRAM, DSM PHASE VIII

This program offers incentives for the installation of measures that reduce residential heating and cooling costs. It also offers measures that enhance the health and safety of residents including repairs and improvements to home heating and cooling systems and installation of energy-saving measures in the house, such as air sealing.

This program is for income qualifying, elderly, and disabled individuals. The Program conforms to the Virginia Department of Housing and Community Development qualification guidelines, which is currently set at 60% State Median Income. It is also available to customers who are 60 years or older with a household income of 120% of the State Median Income. The Program is available to customers residing in single-family homes, multifamily homes, and mobile homes.

Table 9-1. Non-residential HVAC health and safety program measure list

<table>
<tr><th>End use</th><th>Measure</th><th>Legacy program</th><th>Manual section</th></tr>
<tr><td rowspan="2">Building envelope</td><td>Air sealing</td><td>Residential Manufactured Housing Program, DSM Phase VIII</td><td>Appendix F1 Section 9.1.1</td></tr>
<tr><td>Building insulation</td><td>Residential Manufactured Housing Program, DSM Phase VIII</td><td>Appendix F1 Section 9.1.2</td></tr>
<tr><td>Health & safety</td><td>Various health & safety measures</td><td>-</td><td>Section 9.2</td></tr>
<tr><td rowspan="5">Heating, ventilation, air-conditioning (HVAC)</td><td>Heat pump upgrade</td><td rowspan="3">Residential Home Energy Assessment Program, DSM Phase VII</td><td>Appendix F1 Section 3.3.1</td></tr>
<tr><td>Duct testing and sealing</td><td>Appendix F1 Section 3.3.5</td></tr>
<tr><td>HVAC tune-up</td><td>Appendix F1 Section 3.3.2</td></tr>
<tr><td>Programmable thermostat</td><td>Residential Thermostat Purchase and Weather Smart Program, DSM Phase VIII</td><td>Appendix F1 Section 5.1.1</td></tr>
<tr><td>Home ventilation improvement</td><td>Residential HVAC Health and Safety Program, DSM Phase VIII</td><td>Appendix F1 Section 14.3.5</td></tr>
</table>

9.1 Building envelope

9.1.1 Air sealing

This measure is also provided by the Residential Manufactured Housing Program, DSM Phase VIII. The savings approach is described in Appendix F1: Technical Reference Manual for Residential Programs Section 9.1.1.

9.1.2 Building insulation

This measure is also provided by the Residential Manufactured Housing Program, DSM Phase VIII. The savings approach is described in Appendix F1: Technical Reference Manual for Residential Programs Section 9.1.2.

9.2 Health & safety

Health & Safety measures are offered through this program. These measures do not have energy savings. Measures include dehumidifier, air quality control, assess indoor air quality, carbon monoxide detector and source, combustion appliance safety check and enhance, fire and fall safety check and enhance, mold and mildew removal, re-wiring and roof repair.

9.3 Heating, ventilation, air-conditioning end use

9.3.1 Heat pump upgrade

This measure is also provided by the Residential Home Energy Assessment Program, DSM Phase VII. The savings approach is described in Appendix F1: Technical Reference Manual for Residential Programs Section 3.3.1.

9.3.2 Duct testing & sealing

This measure is also provided by the Residential Home Energy Assessment Program, DSM Phase VII. The savings approach is described in Appendix F1: Technical Reference Manual for Residential Programs Section 3.3.5.

9.3.3 Heat pump tune-up

This measure is also provided by the Residential Home Energy Assessment Program, DSM Phase VII. The savings approach is described in Appendix F1: Technical Reference Manual for Residential Programs Section 3.3.2.

9.3.4 Programmable thermostat

This measure is also provided by the Residential Home Energy Assessment Program, DSM Phase VII. The savings approach is described in Appendix F1: Technical Reference Manual for Residential Programs Section 5.1.1.

9.3.5 Home ventilation improvement

This measure is also provided by the Residential HVAC Health and Safety Program, DSM Phase VIII. The savings approach is described in Appendix F1: Technical Reference Manual for Residential Programs Section 14.3.5.

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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 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	Appendix F1 section 9.1.1
	Building insulation/ drill & fill wall insulation		Appendix F1 section 9.1.2
Domestic hot water	Domestic hot water pipe insulation	Residential Home Energy Assessment Program, DSM Phase VII	Appendix F1 section 3.2.1
	Water heater temperature setback/turndown		Appendix F1 section 3.2.5
Heating, ventilation, air-	HVAC upgrade/ unitary AC	Non-Residential Heating and Cooling Efficiency Program, DSM Phase VII	Section 2.1.1

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End use	Measure	Legacy program	Non-Residential manual section
conditioning (HVAC)	HVAC tune-up	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 7.2.2
	Duct sealing		Section 7.2.1
	Energy star room/wall AC units	Residential Home Energy Assessment Program, DSM Phase VII	Appendix F1 section 3.3.1
	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
	Sensors and controls		Section 1.1.2
	LED exit signs	Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII	Section 7.3.3
Appliance or Plug load	ENERGY STAR clothes washer	Residential Efficient Products Marketplace Program, DSM Phase VII	Appendix F1 section 4.1.2
	ENERGY STAR clothes dryer		Appendix F1 section 4.1.3
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, Section 9.1.1.

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, Section 9.1.2.

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, Section 3.2.1.

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, Section 3.2.5.

DNV

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 Small Business Improvement Enhanced Program, DSM Phase VIII. The savings approach is described in Section 7.2.2.

10.3.3 Duct sealing

This measure is also offered through the Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII. The savings approach is described in Section 7.2.1.

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.2023, Section 3.3.1.

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.[146] 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.

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

Table 10-2. Programs that offer smart thermostat installation

Program name	Section
Non-Residential Multifamily Program, DSM Phase VIII	Section 10.3.5
Non-Residential Health Care Program, DSM Phase X	Section 17.5.10
Non-Residential Hotel and Lodging Program, DSM Phase X	Section 19.5.11

[146] The key product criteria for Smart thermostats can be found at https://www.energystar.gov/products/heating_cooling/smart_thermostats/key_product_criteria

DNV

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.

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

DNV

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 10-3. Input values 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[147] Default = $Size_{cool}$	Btu/h	Customer application
$EFLH_{cool}$	Variable	See Sub-Appendix F2-V: Non-residential lighting factors: annual equivalent hours, coincidence factors, and waste heat factors, Table 22-7 and Table 22-8 use multifamily (common area)	hours, annual	Maryland/Mid-Atlantic TRM v.10, p. 423, scaled using CDD
$EFLH_{heat}$	Variable	See Sub-Appendix F2-V: Non-residential lighting factors: annual equivalent hours, coincidence factors, and waste heat factors, Table 22-8 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-IV: Non-residential HVAC , Table 22-11 and Table 22-12	Btu/Wh (COP is unitless)	ASHRAE 90.1-2016
ESF_{cool}	Variable	Manual thermostat existing: 0.050 Programmable thermostat existing: 0.030	-	Maryland/Mid-Atlantic TRM v10, p. 319
		Default = 0.030		DNV, Dominion Energy 2020 Commercial Energy Survey, Appendix B, p.60 (Q25)[148]
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)[148]

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 10-4.

[147] When customer-provided heating system size is <60% or >165% 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.

[148] Used weighted average of programmable thermostat and manual thermostat responses to determine the ESF.

Table 10-4. Effective useful life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
X	Non-Residential Hotel and Lodging Program, DSM Phase X	7.50	years	Maryland/Mid-Atlantic TRM v10, pp. 317-320
	Non-Residential Health Care Program, DSM Phase X			
VIII	Non-Residential Multifamily Program, DSM Phase VIII			

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 Program design baseline

The program design baseline assumptions are shown in Table 10-5. These assumptions do not necessarily align with the assumptions used in the impact calculation in this TRM.

Table 10-5. Program design baseline assumptions

DSM Phase	Program name	Baseline description	Baseline type	Source(s)
X	Non-Residential Health Care Program, DSM Phase X	Retrofit/direct install: In-situ manually operated or properly programmed thermostat that was replaced. New Construction/Time of Sale: A programmable thermostat meeting minimum efficiency standards as presented in the 2012 International Energy Conservation Code (IECC 2012) and the 2015 International Energy Conservation Code (IECC 2015).	Retrofit: Existing Condition New Construction/Time of Sale: Codes and Standards	Maryland/Mid-Atlantic TRM v10, p. 317
	Non-Residential Hotel and Lodging Program, DSM Phase X			

10.3.5.8 Update summary

Updates to this section are described in Table 10-6.

Table 10-6. Summary of update(s)

Version	Update type	Description
2023	New subsection	Program design baseline assumptions
	Inputs	Updated EFLHs with TMYx weather data
		Corrected the ESF for programmable thermostat to 0.03
2022	None	No change

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Version	Update type	Description
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 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.

10.4.3 LED exit signs

This measure is also offered through the Non-Residential Small Business Improvement Enhanced Program, DSM Phase VIII. The savings approach is described in Section 7.3.3.

10.5 Appliance or Plug Load end use

10.5.1 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 Appendix F1: Technical Reference Manual for Residential Programs v.2023, in Section 4.1.2.

10.5.2 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 Appendix F1: Technical Reference Manual for Residential Programs v.2023, Section 4.1.3.

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.

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This measure is offered through different programs listed in Table 10-7 and uses the impacts estimation approach described in this section.

Table 10-7. Programs that offer two-speed & variable-speed pool pump

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:

$$\Delta kW_{summer} = \left[\left(\frac{kWh_{daily,base}}{Hours_{daily,base}}\right) \times CF_{base,summer}\right] - \left[\left(\frac{kWh_{daily,e}}{Hours_{daily,ee}}\right) \times CF_{ee,summer}\right]$$

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.

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Table 10-8. Input values for two speed & variable speed pool pump savings calculations

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 10-9 based on $Type_{base}$ and $Bin_{size,base}$ Commercial: see Table 10-10 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 10-9 based on $Type_{base}$ and $Bin_{size,base}$ Commercial: see Table 10-10 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	days, annual	Customer application
		Default: 100		Maryland/Mid-Atlantic TRM v.10, p.195
$Bin_{size,base}$	Variable	See Table 10-9 and Table 10-10	-	Hawaii TRM 2021, p.191 and p.321
$Bin_{size,ee}$	Variable	See Table 10-9 and Table 10-10	-	Hawaii TRM 2021, p.191 and p.321
$Hours_{daily,base}$	Variable	Residential: see Table 10-9 based on $Type_{base}$ and $Bin_{size,base}$ Commercial: see Table 10-10 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 10-9 based on $Type_{base}$ and $Bin_{size,base}$ Commercial: see Table 10-10 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 10-9 based on $Type_{base}$ and $Bin_{size,base}$ Commercial: see Table 10-10 based on $Type_{base}$ and $Bin_{size,base}$	-	Hawaii TRM 2021, p.191 and p.321
$CF_{ee,summer}$	Variable	Residential: see Table 10-9 based on $Type_{base}$ and $Bin_{size,base}$ Commercial: see Table 10-10 based on $Type_{base}$ and $Bin_{size,base}$	-	Hawaii TRM 2021, p.191 and p.321

DNV

Component	Type	Value	Units	Source(s)
$CF_{base,winter}$	Variable	If Days < 365: 0.00 If Days = 365: Residential: see Table 10-9 based on $Type_{base}$ and $Bin_{size,base}$ Commercial: see Table 10-10 based on $Type_{base}$ and $Bin_{size,base}$	-	Hawaii TRM 2021, p.192 and p.322[149]
$CF_{ee,winter}$	Variable	If Days < 365: 0.00 If Days = 365: Residential: see Table 10-9 based on $Type_{base}$ and $Bin_{size,base}$ Commercial: see Table 10-10 based on $Type_{base}$ and $Bin_{size,base}$	-	Hawaii TRM 2021, p.192 and p.322[149]

Table 10-9. Typical residential pool pump input variables by pump size and pump type

$Type_{pump}$	Inputs variables	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 10-10. Typical commercial pool pump input variables by pump size and pump type

$Type_{pump}$	Input variables	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

[149] 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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$Type_{pump}$	Input variables	Bin, based on pump size (hp)			
		> 0 and ≤ 1	> 1 and ≤ 2	> 2 and ≤ 3	> 3 and ≤ 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.

10.6.1.5 Effective useful life

The effective useful life of this measure is provided in Table 10-11.

Table 10-11. Effective useful life for lifecycle savings calculations

DSM Phase	Program name	Value	Units	Source(s)
IX	Non-Residential Prescriptive Enhanced Program, DSM Phase IX	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 10-12.

Table 10-12. Summary of update(s)

Version	Update type	Description
2023	None	No change
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

DNV

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
Heating, ventilation, air-conditioning (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	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 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. If the review identifies discrepancies that result in more than a 10% change from the tracking savings, the savings estimate is revised.

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 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
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[150]
	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	15.00		Measure Life Study, the Massachusetts Joint Utilities, Energy
	VAV dual-max controls			
	VAV supply air temperature reset			

[150] 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.

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DSM Phase	Measure	Value	Units	Source(s)
	Chiller controls			& Resource Solutions, p. 1-5
	Supervisory plug load management systems			
	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
2023	EUL value	Updated measure EUL table of Demand controlled ventilation, and HVAC controls measures
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 90.1-2016 efficiency values.

11.3.5 Demand controlled ventilation

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.

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.

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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.

DNV

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
Heating, ventilation, air-conditioning (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 12.3.1
	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 12.3.5
	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[151] with fan diameters of at least 36 inches

[151] University of Illinois, Department of Agricultural and Biological Engineering. http://bess.illinois.edu/

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 values for circulation fans savings calculations

Component	Type	Value	Units	Source(s)
$watts_{base}$	Variable	See Table 12-4	watts	BESS Database[152]
$Watts_{ee}$	Variable	See customer application	watts	BESS Database[153]
		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[154]

Table 12-4. Default base and efficient fan power

Fan diameter (in)	$watts_{base}$ (W)	$Watts_{ee}$ (W)
36-47 (default)[155]	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:

$$\Delta kWh = \left(\frac{watts_{base} - watts_{ee}}{1{,}000}\right) \times HOU$$

[152] BESS fan database downloaded on 2/22/2023. Average watts from models below standard (minimum efficiency requirement detailed in the efficient equipment definition).
[153] BESS fan database downloaded on 2/22/2023. Average watts from models above standard (minimum efficiency requirement detailed in the efficient equipment definition).
[154] 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.
[155] If fan diameter is not provided in the customer application, then smallest range is assigned as default with the most conservative savings.

DNV

$$= \left(\frac{599\ watts - 458\ watts}{1{,}000}\right) \times 3{,}249\ hours$$

$$= 458.11\ kWh$$

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
2023	None	No change
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 values for high volume low speed fan savings calculations

Component	Type	Value	Units	Source(s)
$watts_{base}$	Variable	See Table 12-9	watts	Iowa TRM v5.0, Vol.3.0, 2020, p. 14
$Watts_{ee}$	Variable	See customer application	watts	Customer application
		For defaults see Table 12-9		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[156]
CF_{winter}	Fixed	0.00	-	Iowa TRM v5.0, Vol.3.0, 2020, p. 15[157]

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) [158]	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

[156] Iowa TRM v5.0, Vol.3.0, 2020, p. 14. Industrial Ventilation CF from eQuest

[157] 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.

[158] If fan diameter is not provided in the customer application, then smallest range is assigned as default with the most conservative savings.

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
2023	None	No change
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[159] 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:

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

[159] University of Illinois, Department of Agricultural and Biological Engineering. http://bess.illinois.edu/

DNV

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

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 values for ventilation fans savings calculations

Component	Type	Value	Units	Source(s)
$Watts_{base}$	Variable	See Table 12-4	watts	BESS database[160]
$Watts_{ee}$	Variable	See customer application	watts	Customer application
		For defaults see Table 12-4		BESS database[161]
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[162]

Table 12-14. Default base and efficient fan power

Fan Diameter (in)	$watts_{base}$ (W)	$Watts_{ee}$ (W)
36-47 (default)[163]	762	542
48-52	1,321	994
52+	1,478	1,203

[160] BESS fan database downloaded on 2/22/2023. Average watts from models below standard (minimum efficiency requirement detailed in the efficient equipment definition).

[161] BESS fan database downloaded on 2/22/2023. Average watts from models above standard (minimum efficiency requirement detailed in the efficient equipment definition).

[162] 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.

[163] 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
2023	None	No change
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
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 values for horticultural LED savings calculations

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
2023	None	No change
2022	-	Initial release

DNV

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.

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:

DNV

$$\Delta kW_{summer} = \frac{Qty_{ee} \times watts_{ee}}{1{,}000\ W/kW} \times ESF \times CF_{summer}$$

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

$$\Delta kW_{winter} = \frac{Qty_{ee} \times watts_{ee}}{1{,}000\ W/kW} \times ESF \times CF_{winter}$$

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 dairy lighting controls 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
$watts_{ee,low}$	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[164]
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[165]

[164] 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".

[165] 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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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.

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 P[166]

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
2023	None	No change
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:

[166] ComEd Luminaire Level Lighting Control IPA Program Impact Evaluation Report prepared by Navigant, 2018-06-05

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

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.

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 values for horticultural LED savings calculations

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[167]
$Watts_{ee}$	Variable	See customer application	watts	Customer application
HOU	Variable	See customer application[168]	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

[167] 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

[168] 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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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)	$= Watts_{ee} \times 1.10$
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 (default) 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.

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Table 12-28. Summary of update(s)

Version	Update type	Description
2023	EUL	Added Non-Stacked Indoor lighting type as the default EUL
2022	-	Initial release

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.

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Table 12-29. Input values for Poultry LED savings calculations

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
		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[169]
CF_{winter}	Fixed	1.0	-	Minnesota TRM v3.2, p.568[169]

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.

[169] 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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Table 12-31. Summary of update(s)

Version	Update type	Description
2023	None	No change
2022	-	Initial release

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