5 NON-RESIDENTIAL LIGHTING SYSTEMS AND CONTROLS PROGRAM

The Non-Residential Lighting Systems and Controls Program is offered in Virginia beginning August 1, 2014, and in North Carolina beginning January 1, 2015. 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 are shown in Table 5-1.

Table 5-1: 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 5.1.1
	Occupancy Sensors & Controls	Section 5.1.2
	Reach-in Unit Occupancy Sensor	Section 5.1.3

5.1.1 Lighting Fixtures, Lamps, and Delamping

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 install T8, T5, LED, or CFL lamps/ ballasts.

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 four lamp fixtures), or removal of the entire fixture itself, so that there is no longer a connected load. Similarly to lamp and fixture retrofit calculations, changes in load due to delamping are tracked through the difference between baseline and installed wattage.

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

This measure is offered in the Non-Residential Lighting Systems and Controls program and the Non-Residential Small Business Improvement program (Section 8).

Savings Estimation Approach

<u>*Retrofit:*</u>

Gross annual electric energy savings are calculated according to the following equation:

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

Gross coincident demand reduction is calculated according to the following equation:

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

<u>*New construction:*</u>

When developing STEP Manual 9.0.0 (year-end 2018), DNV GL used existing program data from Virginia and North Carolina Non-Residential Lighting Systems and Controls program participants to generate a list of ratios for each eligible measure type that is used as a multiplier to be applied to the customer provided installed quantity times installed wattage to estimate a baseline default wattage times quantity for new construction measures, where no baseline information is available. The default ratios were generated using the following variables from available lighting retrofit measure records for all program particiapnts through the end of 2018.

- installed energy-efficient (ee) wattage
- installed energy-efficient (ee) quantity
- baseline (base) wattage
- baseline (base) quantity

DNV GL collaborates with Dominion during program launch to specify the required data fields that implementers should collect for evaluation purposes. At the end of 2017, years after program launch, there were sufficient new construction records that it was necessary to identify a deemed savings method specific to those records. The Mid-Atlantic TRM deemed savings method for new construction projects could not be appropriately applied using the collected data (designed for retrofit projects). Therefore, DNV GL implemented the method described below.

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

$$\Delta kW = \frac{Qty_{ee} \times watts_{ee} \times (Ratio - 1) \times CF \times WHF_d \times ISR}{1{,}000\, W/kW}$$

$$Ratio = (Qty_{base} \times watts_{base})/(Qty_{ee} \times watts_{ee})$$

Where:

ΔkWh = gross annual electric energy savings
ΔkW = gross coincident demand reductions
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
Ratio = ratio of the installed condition to the baseline condition
HOU = annual operating hours of use for fixtures/lamps
WHF_e = waste heat factor for energy to account for cooling savings from efficient lighting
WHF_d = waste heat factor for demand to account for cooling savings from efficient lighting
CF = coincidence factor
ISR = in-service rate is the percentage of rebated measures actually installed

Input Variables

Table 5-2: Input Values for Lighting Fixtures and Lamps

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
Ratio	Variable	See Table 5-3	-	Dominion Energy non-residential lighting systems and controls participant data through year-end 2017

Component	Type	Value	Unit	Source(s)
CF	Fixed	Measure with "24/7" in fixture name, treat as "LED Exit Sign" in Table 12-6 in Sub-appendix III Measure with "exterior" in fixture name in Table 12-6 in Sub-appendix III Measure without "exterior" or "24/7" in fixture name in Table 12-7 in Sub-appendix III	percent	Mid-Atlantic 2018, pp. 311, 347, 364, and 387, [39]
HOU	Variable		hours (annual)	Mid-Atlantic 2018, pp. 311, 347, 363, 387
WHF_e	Variable		-	Mid-Atlantic TRM 2018 pp. 526-527[40]
WHF_d	Variable		-	Mid-Atlantic TRM2018 pp. 526-527[41]
ISR	Fixed	1.00	percent	Mid-Atlantic TRM 2018, p. 311

Table 5-3. Default Ratio for Calculating New Construction Baseline Lighting Wattage Multiplied with Baseline Quantity

Installed (ee) Fixture	Baseline (base) Fixture	Ratio
T8 - 2 - 2ft 17watt Lamps with Reflector & NB	2 Bi-ax Lamps in 2x2, 2U-bends	2.3
T8 - 3 - 2ft 17watt Lamps with Reflector & NB	2 Bi-ax Lamps in 2x2, 2U-bends	1.6
T8 Enclosed Fixture - 2 Lamp NB No Reflector 24/7	68W – 175W HID	2.6
T8 Enclosed Fixture - 3 Lamp NB No Reflector 24/7	23W – 308W HID	2.9
T8 Enclosed Fixture - 4 Lamp HB Miro Reflector[42]	T8 – 4ft 4 Lamp	N/A[43]
T8 High-Bay - 4ft 3 lamp	34W – 320W HID	2.4

[39] 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.

[40] Waste heat factor used to account for cooling energy savings from efficient lighting. For a cooled space, the value is 1.13 (calculated as 1 + (0.74*(0.45) / 2.5)). Based on 0.45 ASHRAE Lighting waste heat cooling factor for Washington DC and estimate that 74% of commercial floorspace in the Mid-Atlantic region is cooled (Delmarva Commercial Baseline Research Project, Final Report, SAIC, 1995) with 2.5 COP typical cooling system efficiency (methodology adopted from ASHRAE Journal, Calculating Lighting and HVAC Interactions, 1993).

[41] Waste heat factor to account for cooling demand savings from efficient lighting. For a cooled space, the value is 1.25 (calculated as 1 + (0.74*(0.85) / 2.5)). Based on 2.5 COP cooling system efficiency, estimate that 74% of commercial floorspace in the Mid-Atlantic region is cooled (Delmarva Commercial Baseline Research Project, Final Report, SAIC, 1995), and 85% of lighting heat that needs to be mechanically cooled at time of summer peak (methodology adopted from ASHRAE Journal, Calculating Lighting and HVAC Interactions, 1993).

[42] MIRO® is a registered trademark of Alanode. http://www.simkar.com/wp-content/uploads/2015/08/MIRO.pdf. Accessed 11/20/2018.

[43] Use the default New Fixture Type when there is no ratio available for the specific new fixture type.

Installed (ee) Fixture	Baseline (base) Fixture	Ratio
T8 High-Bay - 4ft 4 lamp	268W – 456W HID	2.3
T8 High-Bay - 4ft 6 lamp	156W – 465W HID	2.2
T8 High-Bay - 4ft 8 lamp	400W – 465W HID	1.6
T8 High-Bay - Double Fixture 4ft 6 lamp	240W – 1,160W HID	2.8
T8 High-Bay - Double Fixture 4ft 8 lamp	1,060W HID	1.8
LW HPT8 4ft 1 lamp	30W – 135W T8	3.8
LW HPT8 4ft 2 lamp	30W – 218W T8	2.3
LW HPT8 4ft 3 lamp	32W – 190W T8	1.4
LW HPT8 4ft 4 lamp	32W – 226W T8	1.5
HPT8 T8 4ft 2 lamp	T12HO – 8ft 1 Lamp	2.0
HPT8 T8 4ft 4 lamp	T12HO – 8ft 2 Lamp	2.0
T5 HO Enclosed - 1 lamp 24/7	75W – 100W HID	N/A[43]
T5 HO Enclosed - 2 lamp 24/7	150W – 175W HID	N/A[43]
T5 HO Enclosed - 3 lamp 24/7	250W HID	N/A[43]
2 Lamp T5 28W 24/7	75W – 150W HID	N/A[43]
T5 HO Enclosed - 2 lamp Miro Reflector 24/7	250W HID	N/A[43]
T5 2 - 2ft lamps 24 watts	116W HID	2.1
T5 3 - 2ft lamps 24 watts	150W HID	N/A[43]
T5 4 - 2ft lamps 24 watts	175W HID	N/A[43]
T5 3 - 4ft HO Lamps	250W – 296W HID	1.3
T5 HO - Highbay 2L	250WHID	2.2
T5 HO - Highbay 3L	295W HID	1.9
T5 HO - Highbay 4L	250W – 488W HID	2.2
T5 HO - Highbay 6L	324W 508W HID	1.5
T5HO - Double fixture Highbay 5L	1,000W HID	N/A[43]
T5HO - Double Fixture Highbay 6L	1,000W HID	1.5
CFL - Screw In (bulb only) - <30W	65W – 100W Incandescent (EISA Standard)	3.6
CFL - Screw In (bulb only) - 30W or greater	50W – 75W Incandescent (EISA Standard)	3.9
CFL - Fixture/Wallpack	178W – 452W HID	5.1
CFL - Hardwired fixture	Incandescent (EISA Standard)	
LED Exit Signs	Incandescent Standard Exit Sign	9.7
LED Downlight Fixture >=31W	53W – 100W Incandescent	3.5
LED Downlight 13-30W (excludes screw-in lamps)	12W – 1,000W Incandescent Downlight(EISA Standard)	6.1
LED 2X4 FIXTURE (39-80W)	2x4 T8 Fluorescent	3.0

Installed (ee) Fixture	Baseline (base) Fixture	Ratio
LED Fixture (2x2 or 1x4)	2 2x2 Bi-ax Lamps, 2U-bends, 2L 4ft T8	2.5
LED Lamps (<= 7W)	5W – 167W Halogen, 25W – 252W Incandescent	7.4
LED Lamps (>7W up to 12W) (excludes screw-in lamps)	14W – 190W Halogen	5.8
LED or Induction HE	32W – 1,408W HID	3.0
LED or Induction HE Exterior	30W – 1,610W HID	3.2
LED or Induction HE Garage	150W – 1,123W HID	4.1
T8 to HPT8 Conver, reduce bulbs, add reflector	28W – 458W T8	3.8
LED Exterior New Fixture	35W – 1,610 HID	3.7
LED Interior New Fixture	775W – 1,190W HID	4.1
LED 24/7	36W – 352W T5, 44W – 244W T8	1.9
LED	9W – 360W CFL, 63W – 464W HID, 16W – 150W Incandescent, 13W – 256W T8	4.2
LED Highbay	196W – 456W T5, 107W – 363W T8	2.0
LED Panels	55W – 350W T8	2.1
LED Panels on Belly Pan	30W – 240W T8	2.2
LED Reach-in Refrigerated Case Lighting	15W – 565W T8	3.1
LED Screw In	30W – 200W Halogen, 14W – 400W Incandescent	5.8
LW HPT8 – 4ft 2 Lamp with Reflector and Delamp	59W – 190W T8	2.1
LW HPT8 – 4ft 3 Lamp with Reflector and Delamp	144W – 190W T8	3.1
LW HPT8 – 4ft 1 Lamp with Reflector and Delamp	48W – 80W T8	2.0
LED – 4 linear 4ft Tube/Bar	T8 – 4ft 4 Lamp	3.1
LED – 3 linear 4ft Tube/Bar	T8 – 4ft 3 Lamp	2.1
LED – 2 linear 4ft Tube/Bar	T8 – 4ft 2 Lamp	2.2
LED – 1 linear 4ft Tube/Bar	LED – 1 Linear 4ft Tube/Bar T8 – 4ft 1 Lamp	2.3
LED – 1 linear 4ft Tube/Bar – 1 T8 Delamp	LED – 1 Linear 4ft Tube/Bar T8 – 4ft 1 Lamp	3.3
LED – 2 linear 4ft Tube/Bar – 1 T8 Delamp	T8 – 4ft 2 Lamp	2.5
LED – 3 linear 4ft Tube/Bar – 1 T8 Delamp	T8 – 4ft 3 Lamp	2.6
LED – 2 linear 4ft Tube/Bar – 2 T8 Delamp	T8 – 4ft 4 Lamp	3.5

Installed (ee) Fixture	Baseline (base) Fixture	Ratio
LED Linear/Bar	17W - 160W T8	2.1
Default[44]		3.0

Default Savings

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

Source(s)

The primary source for this deemed savings approach is the Mid-Atlantic TRM 2017, p. 271 - 341 and p. 462 - 465.

[44] The default fixture type is based on the weighted average ratio for all fixture types in the table.

5.1.2 Sensors and Controls

Measure Description

This measure defines the savings associated with installing occupancy sensors at wall-, fixture-, or remote-mounted that switch lights off after a brief delay when they do not detect occupancy.

This measure is offered in both the Non-Residential Lighting Systems and Controls program as well as the Non-Residential Small Business Improvement program, described in Section 8.

Savings Estimation Approach

Gross annual electric energy savings are calculated according to the following equation:

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

Gross coincident demand reduction is calculated according to the following equation:

$$\Delta kW = Qty_{sensors} \times \frac{watts_{connected}}{1{,}000\ W/kW} \times SVG_d \times ISR \times WHF_d \times CF$$

Where:

ΔkWh = gross annual electric energy savings
ΔkW = gross coincident demand reductions
$Qty_{sensors}$ = number of occupancy sensors installed
watts = connected load on lighting sensor/control
HOU = hours of use per year
SVG_e = percentage of annual lighting energy saved by lighting control
SVG_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 = waste heat factor for demand to account for cooling savings from efficient lighting
CF = coincidence factor
ISR = in-service rate is the percentage of rebated measures actually installed

Input Variables

Table 5-4: Input Values, Lighting Sensors and Controls

Component	Type	Value	Unit	Source(s)
$watts_{connected}$	Variable	See customer application	watt	Customer application
HOU	Variable	Table 12-6 in Sub-appendix III	hours/year	Mid-Atlantic TRM 2018, p. 323
$Qty_{sensors}$	Variable	See customer application	-	Customer application
SVG_e	Fixed	0.28	percent	Mid-Atlantic TRM 2018, p. 323-324
SVG_d	Fixed	Occupancy sensor = 0.14	percent	Mid-Atlantic TRM 2018, p. 324
CF	Fixed		percent	Mid-Atlantic TRM 2018, p. 324
WHF_e[45]	Variable	See Table 12-6 in Sub-appendix III	percent	Mid-Atlantic TRM 2018, p. 324
WHF_d[46]	Variable	See Table 12-6 in Sub-appendix III	percent	Mid-Atlantic TRM 2018, p. 324
ISR	Fixed	1.00	percent	Mid-Atlantic TRM 2018, p. 324

Default Savings

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

Source(s)

The primary source for this deemed savings approach is the Mid-Atlantic 2018, p. 323-329.

[45] Waste heat factor to account for cooling energy savings from efficient lighting. For a cooled space, the value is 1.13 (calculated as 1 + (0.74*(0.45) / 2.5)). Based on 0.45 ASHRAE Lighting waste heat cooling factor for Washington DC and estimate that 74% of commercial floorspace in the Mid-Atlantic region is cooled (Delmarva Commercial Baseline Research Project, Final Report, SAIC, 1995) with 2.5 COP typical cooling system efficiency (methodology adopted from ASHRAE Journal, Calculating Lighting and HVAC Interactions, 1993).

[46] Waste heat factor to account for cooling demand savings from efficient lighting. For a cooled space, the value is 1.25 (calculated as 1 + (0.74*(0.85) / 2.5)). Based on 2.5 COP cooling system efficiency, estimate that 74% of commercial floorspace in the Mid-Atlantic region is cooled (Delmarva Commercial Baseline Research Project, Final Report, SAIC, 1995), and 85% of lighting heat that needs to be mechanically cooled at time of summer peak (methodology adopted from ASHRAE Journal, Calculating Lighting and HVAC Interactions, 1993).

5.1.3 Reach-In Unit Occupancy Sensor

Measure Description

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

Savings Estimation Approach

Gross annual electric energy savings are calculated according to the following equation:

$$\Delta kWh = Qty_{sensors} \times \frac{watts}{1{,}000\ W/kW} \times OSS \times HOU \times WHF_e$$

Gross coincident demand reduction is calculated according to the following equation:

$$\Delta kW = Qty_{sensors} \times \frac{watts}{1{,}000\ W/kW} \times OSS \times WHF_d \times CF$$

Where:

ΔkWh = gross annual electric energy savings
ΔkW = gross coincident demand reductions
$Qty_{sensors}$ = number of occupancy sensors installed
watts = connected lighting load controlled by occupancy sensor
OSS = occupancy sensor savings, resulting from a reduction in operating hours
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 = 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 = annual lighting hours of use
CF = peak coincidence factor

Input Variables

Table 5-5: 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

Component	Type	Value	Unit	Source(s)
$Qty_{sensors}$	Variable	See customer application	-	Customer application
OSS	Fixed	0.307	-	Efficiency Maine Commercial TRM 2018, p. 40[47]
HOU	Variable	See Table 12-7 in Sub-appendix III for grocery building type	hours (annual)	Mid-Atlantic TRM 2018, p. 521[48]
WHF_e	Fixed	Low Temp (-35°F - -1°F): 1.76 Med Temp (0°F - 30°F): 1.76 High Temp (31°F - 55°F): 1.38	-	Mid-Atlantic TRM 2018, p. 470
WHF_d	Fixed	Low Temp (-35°F - -1°F): 1.76 Med Temp (0°F - 30°F): 1.76 High Temp (31°F - 55°F): 1.38	-	Mid-Atlantic TRM 2018, p. 470
CF	Fixed	0.98	-	Mid-Atlantic TRM 2018, p. 522[49]

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 calculations:

$$\Delta kWh = \frac{watts}{1{,}000\ W/kW} \times OSS \times HOU \times WHF_e$$

$$= \frac{38\ watts}{1{,}000\ W/kW} \times 0.307 \times 7{,}134\ hours \times 1.38$$

[47] This value is consistent across all Maine TRM versions. It 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. We will assume that this value accounts for both reduction in operating hours and incremental reduction in power.

[48] No default HOU was provided in the Maine TRM 2016.2. It refers to data collected from the application. Since the STEP Manual does not use customer application HOU data, a default was assigned using annual hours from the Mid-Atlantic TRM 2017.

[49] CFS_{SP} value for "grocery" building type.

$$= 115\,kWh$$

The default gross coincident demand reductions will be assigned according to the following calculations:

$$\Delta kW = \frac{watts}{1{,}000\,W/kW} \times OSS \times WHF_d \times CF$$

$$= \frac{38\,watts}{1{,}000\,W/kW} \times 0.307 \times 1.38 \times 0.98$$

$$= 0.016\,kW$$

Source(s)

The primary sources for this deemed savings approach are the Efficiency Maine Commercial TRM 2018, p. 40-41 and Mid-Atlantic TRM 2018, p. 470 and p. 521-523.

6 NON-RESIDENTIAL HEATING AND COOLING EFFICIENCY PROGRAM

The Non-Residential Heating and Cooling Efficiency (CHV2) program is offered in Virginia beginning August 1, 2014, and in North Carolina beginning January 1, 2015. 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 6-1.

Table 6-1: Non-Residential Heating and Cooling Efficiency Program Measure List

End-Use	Measure	Manual Section
HVAC	Unitary/Split Air Conditioning (AC) & Heat Pump (HP) Systems	Section 6.1.1
	Variable Refrigerant Flow (VRF) & Mini-split Systems	Section 6.1.2
	Water- and Air-cooled Chillers	Section 6.1.3
	Variable Frequency Drive	Section 6.1.4
	Dual Enthalpy Air-side Economizer	Section 6.1.5

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

6.1.1 Unitary/Split HVAC and Heat Pumps

Measure Description

This measure relates to the installation of new high-efficiency unitary/split HVAC units and heat pumps in place of a standard efficiency unitary/split HVAC units and heat pumps. For the standard (baseline) efficiencies, refer to 2010 ASHRAE 90.1 Table 6.8.1A for unitary air conditioners and condensing units and Table 6.8.1B for unitary and applied heat pumps. 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 in both the Non-Residential Heating and Cooling Efficiency program as well as the Non-Residential Small Business Improvement program, described in Section 8.

Savings Estimation Approach

Algorithms and inputs to calculate heating, cooling savings, and demand reductions for unitary/split HVAC and package terminal AC 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 air-source heat pumps and AC units <65,000 Btu/h, gross annual electric cooling energy savings are calculated according to the following equation:

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

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

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

For ground-source heat pumps, the baseline efficiency is assumed to be that of an air-source heat pump.[50] See Equation 1 and Equation 2 in 12.5 to convert between tons and Btu/h or kBtu/h, or vice versa.

[50] Although ASHRAE values reflect the Building Code minimum, savings are calculated using the efficiencies provided in Sub-appendix VII. This is due to the Mid-Atlantic TRM 2018 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 2018.)

Heating Energy Savings:

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

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

For air-source heat pumps ≥65,000 Btu/h and ground-source heat pumps, gross annual electric heating energy savings are calculated according to the following equation:

$$\Delta kWh_{heat} = \frac{Size_{ee} \times \left[\frac{1}{COP_{base}} - \frac{1}{COP_{ee}}\right] \times FLH_{heat}}{1{,}000\ Btuh/kBtuh\ \times 3.412\ Btuh/W}$$

Heating and cooling energy savings are added to calculate the gross annual electric energy savings are calculated according to the following equation:

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

The gross coincident demand reduction is calculated according to the following equation:

$$\Delta kW = \frac{Size_{ee} \times \left[\frac{1}{EER_{base}} - \frac{1}{EER_{ee}}\right] \times CF}{1{,}000\ Btuh/kBtuh}$$

If necessary, see Equation 3 in 12.5 to convert between SEER and EER or Equation 4 in 12.5 to convert between IEER and EER.

Where:

ΔkWh = gross annual electric energy savings
ΔkWh_{cool} = gross annual electric cooling energy savings
ΔkWh_{heat} = gross annual electric heating energy savings
ΔkW = gross coincident demand reductions
$Size_{ee}$ = equipment 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.

FLH_{cool} = annual full-load cooling hours

FLH_{heat} = annual 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 = coincidence factor

In the event of a missing efficiency metric from an application, the equations provided in Sub-appendix V may be used to estimate it using another application-provided efficiency metric.

Input Variables

Table 6-2: Input Values for Non-Residential HVAC Equipment

Component	Type	Value	Units	Source(s)
$Size_{ee}$	Fixed	See customer application	Btu/hour	Customer application
FLH_{heat}	Variable	See Table 12-3 in Sub-appendix II	hours (annual)	Mid-Atlantic TRM 2018 p. 418
FLH_{cool}	Variable	See Table 12-3 in Sub-appendix II	Hours (annual)	Mid-Atlantic TRM 2018 p. 417
HSPF/SEER/IEER/ EER/COP_{base}	Variable	See Table 12-10 and Table 12-11 in Sub-appendix VII	kBtu/kW-hour (except COP is -)	ASHRAE 90.1 2010 Table 6.8.1A and Table 6.8.1B

Component	Type	Value	Units	Source(s)
HSPF/SEER/IEER/EER /COP_{ee}	Variable	See customer application Where IEER is not available, IEER = SEER. Or refer to 12.5 to convert the available efficiency value to the required efficiency value.	kBtu/kW-hour (except COP is -)	Customer application
CF	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	-	Mid-Atlantic TRM 2018 p. 408

Default Savings

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

Source(s)

The primary sources for this deemed savings approach are the ENERGY STAR® Air Source Heat Pump Calculator (2002 EPA), Mid-Atlantic TRM 2018 p. 398 - 412 and ASHRAE 90.1 2010.

6.1.2 Variable Refrigerant Flow Systems and Mini-Split Systems

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. The baseline VRF air conditioner efficiencies are based on Table 6.8.1I of 2010 ASHRAE 90.1 and the baseline efficiencies of VRF heat pumps are based on Table 6.8.1J of 2010 ASHARE 90.1. The measure efficiency is based on the installed unit's efficiency. The measure approved savings applies only to the air cooled VRF air conditioners and air cooled VRF heat pumps and water source or ground source units are not included.

Minimum baseline requirements for VRF and mini-split systems are provided in this section. Since the baseline system could also be unitary/split HVAC and heat pumps, the minimum baseline efficiencies for those equipments should be referenced from Section 6.1.1.

These measures are offered in the Non-Residential Heating and Cooling Efficiency program; mini split systems are also offered in the Non-Residential Small Business Improvement program, described in Section 8.

Savings 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, gross annual electric cooling energy savings are calculated according to the following equation:

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

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

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

To convert between EER and SEER see Equation 3 in 12.5.

Heating Energy Savings:

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

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

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

$$\Delta kWh_{heat} = \frac{Size \times \left[\frac{1}{COP_{base}} - \frac{1}{COP_{ee}}\right] \times FLH_{heat}}{1{,}000\, Btuh/kBtuh \times 3.412\, Btuh/W}$$

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

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

Gross coincident demand reduction is calculated according to the following equation:

$$\Delta kW = \frac{Size \times \left[\frac{1}{EER_{base}} - \frac{1}{EER_{ee}}\right] \times CF}{1{,}000\, Btuh/kBtuh}$$

Where:

ΔkWh = gross annual electric energy savings
ΔkWh_{cool} = gross annual electric cooling energy savings for mini split heat pump systems
ΔkWh_{heat} = gross annual electric heating energy savings for mini split heat pump systems
ΔkW = gross coincident demand savings
Size = equipment cooling capacity, measured in Btu/h
$SEER_{base}$ = 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.
FLH_{cool} = annual full load cooling hours
FLH_{heat} = annual full load heating hours
EER_{base} = energy efficiency ratio (EER) of existing or baseline equipment
EER_{ee} = energy efficiency ratio (EER) of installed equipment
$HSPF_{base}$ = heating seasonal performance factor (HSPF) of existing or baseline system
$HSPF_{ee}$ = heating seasonal performance factor (HSPF) of installed equipment
COP_{base} = coefficient of performance (COP) of existing or baseline heating equipment
COP_{ee} = coefficient of performance (COP) of installed heating equipment

CF = coincidence

Input Variables

Table 6-3: Input Values for VRF Systems and Mini Split Systems

Component	Type	Value	Units	Source(s)
FLH_{heat}	Fixed	See Table 12-4 in Sub-appendix II	hours (annual)	Mid-Atlantic TRM 2018 p. 418
FLH_{cool}	Fixed	See Table 12-3 in Sub-appendix II	hours (annual)	Mid-Atlantic TRM 2018 p. 417
HSPF/SEER/ EER/COP/ $IEER_{base}$	Variable	See Table 12-12 in Sub-appendix VII	kBtu/kW-hour (except COP is -)	ASHRAE 90.1 2010, Tables 6.8.1I and 6.8.1J
HSPF/SEER/ EER/COP/ $IEER_{ee}$	Variable	See customer application	kBtu/kW-hour (except COP is -)	Customer application
CF	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	-	Mid-Atlantic TRM 2018 p. 419

Default Savings

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

Source(s)

The primary sources for this deemed savings approach are the Maine Commercial TRM 2018 p. 52-55, the Mid-Atlantic TRM 2018 p. 414-420, and ASHRAE 90.1-2010, Table 6.8.1I and J – Electrically Operated Variable Refrigerant Flow Air Conditioners – Minimum Efficiency Requirement.

6.1.3 Electric Chillers

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 12-13 of Sub-appendix VII for the 2010 ASHRAE-90.1 specified minimum efficiencies. The installed chiller efficiency is taken from the customer application.

Savings Estimation Approach

Water-cooled Chillers

Gross annual electric energy savings are calculated according to the following equation:

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

Gross coincident demand reduction is calculated according to the following equation:

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

Air-cooled Chillers

Gross annual electric energy savings are calculated according to the following equation:

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

Gross coincident demand reduction is calculated according to the following equation:

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

Where:

ΔkWh = gross annual electric energy savings
ΔkW = gross coincident demand reductions
$Size_{ee}$ = cooling capacity of the installed chiller system
$EER_{base,IPLV}$, $kW/ton_{base,IPLV}$ = chiller system baseline efficiency at integrated part load value (IPLV), in kW/ton (for $kW/ton_{base,IPLV}$) assigned based on installed system capacity
$EER_{ee,IPLV}$, $kW/ton_{ee,IPLV}$ = chiller system installed efficiency at integrated part load value (IPLV)
FLH_{cool} = annual cooling full load hours
$EER_{base,full\ load}$, $kW/ton_{base,full\ load}$ = chiller system baseline efficiency at full load

$EER_{ee,full\ load}$, $kW/ton_{ee,full\ load}$ = chiller system installed efficiency at full load
CF = peak coincidence factor

Input Variables

Table 6-4: Input Values for Non-Residential Electric Chillers

Component	Type	Value	Unit	Source(s)
$Size_{ee}$	Variable	See customer application	ton, cooling capacity	Customer application
$kW/ton_{base,full\text{-}load}$	Fixed	Use installed system capacity to assign $kW/ton_{base,full\text{-}load}$ as per Table 12-13 of Sub-appendix VII	kW/ton	ASHRAE 90.1 2010, Table 6.8.1C
$kW/ton_{base,IPLV}$	Fixed	Use install system capacity to assign $kW/ton_{base,IPLV}$ as per Table 12-13 of Sub-appendix VII	kW/ton	ASHRAE 90.1 2010, Table 6.8.1C
$kW/ton_{ee,full\text{-}load}$	Variable	See customer application[51]	kW/ton	Customer application
$kW/ton_{ee,IPLV}$	Variable	See customer application[51]	kW/ton	Customer application
$EER_{base,\ full\ load}$	Variable	See customer application[52]	kBtu/kW	Customer Application
		Default: Table 12-13 of Sub-appendix VII		ASHRAE 90.1-2010, Table 6.8.1C
$EER_{base,\ IPLV}$	Variable	See customer application[52]	kBtu/kW	Customer Application
		Default: Table 12-13 of Sub-appendix VII		ASHRAE 90.1-2010, Table 6.8.1C
$EER_{ee,\ full\ load}$	Variable	See customer application[52]	kBtu/kW	Customer application
$EER_{ee,\ IPLV}$	Variable	See customer application	kBtu/kW	Customer application
FLH_{cool}	Variable	See Table 12-13 of Sub-appendix VII	hours (annual)	Mid-Atlantic TRM 2018 p. 437, adjusted for Richmond, VA and Charlotte, NC based on TMY3 cooling degree days data. See adjustment in Table 12-3 in Sub-appendix II
CF	Fixed	0.923	-	Mid-Atlantic TRM 2018 p. 432

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. STEP follows a similar approach as used in

[51] When missing either the IPLV or the full load value, use either Equation 7 in Sub-appendix V, as relevant.
[52] When missing either the IPLV or the full load value, use either Equation 8 in Sub-appendix V, as relevant.

Mid Atlantic TRM, i.e, assign the full load cooling hours of chiller by building type listed in Table 40.

In Table 12-13 in 12.7, the water chilling efficiency requirement from ASHRAE 90.1-2010, presents two paths of compliance for water-cooled chillers. Path A is intended for those project sites where the chiller application is primarily operating at full-load conditions during its annual operating period. Path B is intended for those project sites where the chiller application is primarily operating at part-load conditions during its annual operating period. Compliance with the code-specified minimum efficiency can be achieved by meeting the requirement of either Path A or Path B. However, both full-load and IPLV levels must be met to fulfill the requirements of Path A or Path B.

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

Default Savings

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

Source(s)

The primary sources for this deemed savings approach are the Mid-Atlantic TRM 2018 p. 430-437, ASHRAE 90.1-2010, Table 6.8.1C - Water Chilling Packages - Efficiency Requirements.

6.1.4 Variable Frequency Drives

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 reductions 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:

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 in both the Non-Residential Heating and Cooling Efficiency program as well as the Non-Residential Small Business Improvement program, described in Section 8.

Savings Estimation Approach

Gross annual electric energy savings are calculated according to the following equation:

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

Gross coincident demand reduction is calculated according to the following equation:

$$\Delta kW = \frac{hp\ x\ 0.746\ x\ LF}{\eta} \times\ CF\ \times\ DRF$$

Where:

ΔkWh	=	gross annual electric energy savings
ΔkW	=	gross coincident demand reductions
hp	=	motor horse power
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	=	peak coincidence factor

Input Variables

Table 6-5: Input Values for Non-Residential Variable Frequency Drives

Component	Type	Value	Unit	Source(s)
hp	Variable	See customer application	horsepower	Customer application
η	Variable	Default see Table 6-6	-	NEMA Standards Publication Condensed MG 1-2007
ESF	Fixed	See Table 6-7	-	Mid-Atlantic TRM 2015 p. 370; Mid-Atlantic TRM 2018 p. 424
DRF	Fixed	See Table 6-7	-	Mid-Atlantic TRM 2015 p. 370; Mid-Atlantic TRM 2018 p. 427
HOU	Variable	See Table 6-8. For condenser water pumps, use the same operating hours as chilled water pumps	hours (annual)	Mid-Atlantic TRM 2018 p. 425-427
CF	Fixed	0.28 for fan applications 0.55 for pump applications	-	Mid-Atlantic TRM 2015 p. 370; Mid-Atlantic TRM 2018 p. 425
LF	Variable	If actual motor load factor is unknown, use 0.65	-	Mid Atlantic TRM 2018, p. 424

Table 6-6 provides the baseline motor efficiencies that are consistent with the minimum federal accepted motor efficiencies provided by the National Electrical Manufacturers Association (NEMA).[53]

[53] 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.

Table 6-6: Baseline Motor Efficiency[54]

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 6-7: Energy Savings and Demand Reduction Factors by Application

VFD Applications	ESF	DRF
Unknown VFD (Minimum)[55]	0.123	0.039
HVAC Fan VFD Savings Factors[56]		
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[57]		
Chilled Water Pump	0.633	0.460
Hot Water Pump	0.652	0.000
Unknown/Other Pump (Average)[58]	0.643	0.230

[54] 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).

[55] Assigned for applications such as compressors, based on DNV GL research and judgement.

[56] Mid-Atlantic TRM 2015 p. 370

[57] Mid-Atlantic TRM 2018, p. 427.

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

Table 6-8: Variable Frequency Drive Annual Hours of Use by Facility Type[59]

Building Type	Fan Motor Hours	Chilled Water Pumps	Heating Pumps
Education – Elementary and Middle School	2,187	1,205	3,229
Education – High School	2,187	1,205	3,229
Education – College and University	2,187	1,205	4,038
Food Sales - Grocery	4,055	1,877	5,376
Food Sales – Convenience Store	6,376	2,713	5,376
Food Sales – Gas Station Convenience Store	6,376	2,713	5,376
Food Service - Full Service	4,182	1,923	5,376
Food Service - Fast Food	6,376	2,713	5,376
Health Care - Inpatient	7,666	3,177	8,760
Health Care - Outpatient	3,748	1,767	5,376
Lodging – (Hotel, Motel, and Dormitory)	3,064	1,521	5,376
Mercantile (Mall)	4,057	1,878	2,344
Mercantile (Retail, not Mall)	4,833	2,157	5,376
Office – Small (<40,000 sq ft)	3,748	1,767	3,038
Office – Large (≥ 40,000 sq ft)	3,748	1,767	3,038
Other	2,857	1,446	5,376
Public Assembly	1,952	1,120	5,376
Public Order and Safety (Police and Fire Station)	1,952	1,120	5,376
Religious Worship	1,955	1,121	5,376
Service (Beauty, Auto Repair Workshop)	1,949	1,119	5,376
Warehouse and Storage	2,602	1,354	-

Default Savings

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

Source(s)

The primary sources for this deemed savings approach are Mid-Atlantic TRM 2015, p. 367-371 (for fans) and Mid-Atlantic TRM 2018, p. 421-429 (for pumps).

[59] Mid-Atlantic TRM 2018, p. 421-429. The facility hours have been mapped from a facility type list in the United Illuminating Company and Connecticut Light & Power Company. 2012. Connecticut Program Savings Document – 8th Edition for 2013 Program Year. Orange, CT.

6.1.5 Dual Enthalpy Air-side Economizers

This measure is offered under the Non-Residential Heating and Cooling Efficiency and Non-Residential Small Business Improvement (Section 8) programs as either a new installation of an economizer or a retrofit add-on project. Both programs use the protocol provided below.

Measure Description

Non-Residential Heating and Cooling Efficiency Program

This measure involves the installation of a dual enthalpy economizer to provide free cooling during the appropriate ambient conditions. Dual enthalpy economizers are used to control a ventilation system's outside air intake in order to reduce a facility's total cooling load. The economizer operation controls the outside air and return air flow rate by monitoring the outside air temperature (sensible heat) and humidity (latent heat), and provides free cooling in place of mechanical cooling. This reduces the demand on the mechanical cooling system, lowering its usage hours, saving energy. This measure applies only to retrofits or newly installed cooling units with 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 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.

Savings Estimation Approach

Gross annual electric energy savings are calculated according to the following equation:

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

Gross coincident demand reduction is assumed to be zero because an economizer will typically not operate during the peak period.[60] Hence,

$$\Delta kW = 0$$

Where:

ΔkWh	=	gross annual electric energy savings
ΔkW	=	gross coincident demand reductions
$Size_{cool}$	=	HVAC system cooling capacity
ESF	=	energy savings factor for the installation of dual enthalpy economizer control

[60] Mid Atlantic TRM 2018, p. 446.

Input Variables

Table 6-9: Input Values for Economizer Repair Savings Calculations

Component	Type	Value	Unit	Source(s)
$Size_{cool}$	Variable	See customer application	tons	Customer application
SF	Variable	See Table 6-10	-	Mid-Atlantic TRM 2018, p. 448

Table 6-10. Economizer Energy Savings Factors[61]

Savings Factors (kWh/ton)	Baltimore, MD	Richmond, VA	Charlotte, NC
Education[62]	39	35	32
Education – College and University			
Education – High School			
Education – Elementary and Middle School			
Food Sales[63]	57	52	46
Food Sales – Convenience Store			
Food Sales – Gas Station Convenience Store			
Service (Beauty, Auto Repair Workshop)			
Food Service[64]			
Food Service - Full Service	29	26	24
Food Service - Fast Food[65]	37	34	30
Food Sales - Grocery[66]	57	52	46
Mercantile (Retail, not mall)			
Mercantile (mall)	57	52	46

[61] Mid Atlantic TRM 2018, p. 448 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 used to calculate them.Richmond VA and Charlotte NC values are calculated from Baltimore,MD savings factors and degree days (DD-65°F = HDD + CDD) using TMY3 data for weather stations at Baltimore BLT-Washington International AP (Weather station number 724060; CDD = 1,233, HDD = 4,600), Richmond International AP (Weather station number 724010; CDD = 1,448, HDD = 3,849), and Charlotte Douglas International Airport (Weather station number 723140; CDD = 1,598, HDD = 3,140).

[62] All education building types in the STEP Manual were mapped to savings factors for the "Primary School" building type listed in the Mid-Atlantic TRM 2018, p. 448.

[63] All food sales, service (beauty, auto repair workshop) and mercantile (mall) building types in the STEP Manual were mapped to savings factors for the "Small Retail" building type listed in the Mid-Atlantic TRM 2018, p. 448.

[64] All general food service and food service-full service building types in the STEP Manual were mapped to savings factors for the "Full Service Restaurant" building type listed in the Mid-Atlantic TRM 2018, p. 448.

[65] Food service – fast food building types in the STEP Manual were mapped to savings factors for the "Fast Food" building type in the Mid-Atlantic TRM 2018, p. 448.

[66] Food-sales-grocery and mercantile (retail, not mall) building types in the STEP Manual were mapped to the "Big Box Retail" building type listed in the Mid-Atlantic TRM 2018, p. 448.

<table>
<tr><th>Savings Factors (kWh/ton)</th><th>Baltimore, MD</th><th>Richmond, VA</th><th>Charlotte, NC</th></tr>
<tr><td>Office – Small (<40,000 sq ft)[67]</td><td rowspan="2">57</td><td rowspan="2">52</td><td rowspan="2">46</td></tr>
<tr><td>Office – Large (>= 40,000 sq ft)</td></tr>
<tr><td>Public Assembly</td><td>25</td><td>23</td><td>20</td></tr>
<tr><td>Religious Worship</td><td>6</td><td>5</td><td>5</td></tr>
<tr><td>Warehouse and Storage</td><td>2</td><td>2</td><td>2</td></tr>
<tr><td>Other[68]</td><td rowspan="5">57</td><td rowspan="5">52</td><td rowspan="5">46</td></tr>
<tr><td>Lodging – (Hotel, Motel and Dormitory)</td></tr>
<tr><td>Health Care - outpatient</td></tr>
<tr><td>Health Care - inpatient</td></tr>
<tr><td>Public Order and Safety (Police and Fire Station)</td></tr>
</table>

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.

Source(s)

The primary source for this deemed savings approach is the Mid-Atlantic TRM 2018, p. 446-448.

[67] Office – small (< 40,000 sq ft) and office – large (>= 40,000 sq ft) building types in the STEP Manual were mapped to savings factors for the "Small Office" building types in the Mid-Atlantic TRM 2018, p. 448.

[68] Other, lodging – (hotel, motel and dormitory), health care-outpatient, healthcare-inpatient, public order and safety (police and fire station) building types in the STEP Manual were mapped to the "Other" building type in the Mid-Atlantic TRM 2018, p. 448.

7 NON-RESIDENTIAL WINDOW FILM

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 is offered in Virginia beginning August 1, 2014, and in North Carolina beginning January 1, 2015.

To be eligible for a rebate, the final Solar Heat Gain Coefficient (SHGC) of the window after application of window film must be equal to or less than 0.4[69]

Measure Description

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.

Savings Estimation Approach

The window film installation measure savings calculations utilize savings factors developed using DOE-2.2 energy modelling software simulations of prototypical building eQUEST models. Building models are based on the Database for Energy Efficient Resources (DEER) building data, modified for Richmond, VA and Elizabeth City, NC weather using typical meteorological year 3 (TMY3) data and modification of a few key window parameters. The assumed values for key parameters affected by addition of window film to single and double pane windows are provided in Table 7-1.

Table 7-1: Key Building Energy Modelling Parameters.

Window Variable	Window Type	Baseline Value	Source(s) [70]	Post-Retrofit Value	Source(s)[70]
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 7-3 and Table 7-4.. Savings factors differ based on the number of panes of affected windows (single or double) and the heating fuel type of the building (electric or non-electric). Similarly, gross coincident peak demand reduction factors are provided in Table 7-5 and Table 7-6.

Gross annual electric energy savings are calculated according to the following equation:

[69] Non-Residential Window Film Program website. Dominion. https://www.dominionenergy.com/large-business/energy-conservation-programs/window-film/non-residential-window-film-faqs. Accessed 10/10/2018

[70] Building vintage ranges defined in DEER, www.deeresources.com.

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

Gross coincident demand reduction is calculated according to the following equation:

$$\Delta kW = SqFt_{orientation} \times DRF_{orientation}$$

Where:

ΔkWh = gross annual electric energy savings
ΔkW = gross coincident demand reductions
$SqFt_{orientation}$ = area of window film for each window orientation of a retrofitted building
$ESF_{orientation}$ = annual energy savings factor
$DRF_{orientation}$ = annual demand reduction factor

Table 7-2: Input Values for Solar Window Film

Component	Type	Value	Unit	Source(s)
$SqFt_{orientation}$	Variable	See customer application	$feet^2$	Customer application
$ESF_{orientation}$	Fixed	See Table 7-3 and Table 7-4	$kWh/feet^2$	DOE 2.2 energy modelling software
$DRF_{orientation}$	Fixed	See Table 7-5 and Table 7-6	$kW/feet^2$	DOE 2.2 energy modelling software

Table 7-3: Annual Energy Savings Factors per Square Foot of Reflective Window Film per Building Type and Window Orientation for Richmond, VA

Building Type[71]	Window Type	Heating System Type[72]	ESF_{North} (kWh/ft^2)	ESF_{East} (kWh/ft^2)	ESF_{South}[73] (kWh/ft^2)	ESF_{West} (kWh/ft^2)
Education – Elementary and Middle School	Single Pane	Electric	4.34	8.20	6.66	10.02
		Non-electric	4.20	9.07	9.51	9.31
	Double Pane	Electric	2.24	4.25	3.40	5.04
		Non-electric	2.09	4.58	4.56	4.70
Education – High School	Single Pane	Electric	3.39	7.37	13.00	5.14
		Non-electric	4.36	13.10	44.20	13.71
	Double Pane	Electric	1.74	3.70	2.76	3.92
		Non-electric	2.01	6.66	6.98	8.45

[71] Warehouse and storage building type DEER models do not have windows. Tracking data with this building type will be flagged for on-site verification.
[72] Non-electric heating systems were represented by gas heating in building energy models.
[73] Negative demand reduction is observed in some building types for south window orientation, implying that installation of window film on the south side of the these buildings leads to increased energy use due to increase heating load in the winter season.

Building Type[71]	Window Type	Heating System Type[72]	ESF_{North} (kWh/ft^2)	ESF_{East} (kWh/ft^2)	ESF_{South}[73] (kWh/ft^2)	ESF_{West} (kWh/ft^2)
Education – College and University	Single Pane	Electric	1.67	11.99	16.83	13.29
		Non-electric	5.64	18.64	25.04	18.60
	Double Pane	Electric	1.62	7.99	12.97	8.84
		Non-electric	3.01	9.79	15.96	9.67
Food Sales - Grocery	Single Pane	Electric	3.06	5.20	-2.32	7.40
		Gas	3.82	7.00	3.88	8.72
	Double Pane	Electric	1.63	2.79	-3.57	3.84
		Gas	1.84	3.55	-0.09	4.43
Food Sales – Convenience Store	Single Pane	Electric	1.50	4.24	-2.42	6.58
		Non-electric	3.23	6.44	4.33	8.20
	Double Pane	Electric	0.78	2.29	-2.76	3.41
		Non-electric	1.85	3.31	0.96	4.16
Food Sales – Gas Station Convenience Store	Single Pane	Electric	1.50	4.24	-2.42	6.58
		Non-electric	3.23	6.44	4.33	8.20
	Double Pane	Electric	0.78	2.29	-2.76	3.41
		Non-electric	1.85	3.31	0.96	4.16
Food Service - Full Service	Single Pane	Electric	5.03	9.59	6.29	9.57
		Non-electric	4.57	10.18	9.44	9.89
	Double Pane	Electric	2.45	4.94	3.24	4.70
		Non-electric	2.42	5.14	4.81	4.96
Food Service - Fast Food	Single Pane	Electric	3.48	8.64	5.72	7.09
		Non-electric	3.68	9.23	9.79	7.34
	Double Pane	Electric	1.78	4.18	4.49	3.60
		Non-electric	1.95	4.58	5.36	3.88
Health Care-inpatient	Single Pane	Electric	3.73	17.87	-59.89	3.88
		Non-electric	4.84	23.16	-18.37	20.19
	Double Pane	Electric	1.98	8.61	4.96	1.99
		Non-electric	3.13	11.92	6.47	10.16
Health Care-outpatient	Single Pane	Electric	1.70	4.85	-3.63	4.62
		Non-electric	2.63	7.18	1.63	6.86
	Double Pane	Electric	1.06	2.54	-4.91	2.40
		Non-electric	1.50	3.60	-1.89	3.43

Building Type[71]	Window Type	Heating System Type[72]	ESF_{North} (kWh/ft^2)	ESF_{East} (kWh/ft^2)	ESF_{South}[73] (kWh/ft^2)	ESF_{West} (kWh/ft^2)
Lodging – (Hotel, Motel, and Dormitory)	Single Pane	Electric	2.81	5.57	-0.02	6.11
		Non-electric	5.04	11.31	9.21	9.28
	Double Pane	Electric	1.42	2.86	-1.27	2.78
		Non-electric	2.58	5.89	3.02	4.24
Mercantile (mall)	Single Pane	Electric	2.97	5.11	1.17	6.06
		Non-electric	6.16	13.43	16.27	12.09
	Double Pane	Electric	1.85	3.24	2.11	3.96
		Non-electric	2.95	6.95	7.45	5.67
Mercantile (Retail, not mall)	Single Pane	Electric	3.26	8.75	11.28	11.55
		Non-electric	3.78	9.30	12.07	7.27
	Double Pane	Electric	1.34	4.10	5.18	5.55
		Non-electric	1.85	4.32	5.66	4.40
Office – Small (<40,000 sq ft)	Single Pane	Electric	0.52	6.05	3.22	5.52
		Non-electric	3.09	8.36	7.43	7.82
	Double Pane	Electric	0.36	3.25	2.86	2.99
		Non-electric	1.57	4.24	4.46	3.93
Office – Large (≥ 40,000 sq ft)	Single Pane	Electric	5.93	30.29	41.28	29.71
		Non-electric	12.77	44.15	55.42	40.59
	Double Pane	Electric	3.45	16.38	22.04	15.91
		Non-electric	6.74	22.89	28.77	21.18
Other[74]	Single Pane	Electric	1.50	4.24	-2.42	6.58
		Gas	3.23	6.44	4.33	8.20
	Double Pane	Electric	0.78	2.29	-2.76	3.41
		Gas	1.85	3.31	0.96	4.16
Public Assembly	Single Pane	Electric	3.02	5.52	3.05	15.47
		Non-electric	4.33	8.60	8.90	18.58
	Double Pane	Electric	1.52	2.97	1.73	12.01
		Non-electric	2.21	4.44	4.64	13.93
Public Order and Safety (Police and Fire Station)	Single Pane	Electric	1.04	7.64	-0.84	4.15
		Non-electric	2.17	11.12	6.85	8.75
	Double Pane	Electric	0.55	3.79	2.74	-0.07
		Non-electric	1.12	5.60	5.60	2.95

[74] ESF for the "Other" building type is taken from the Convenience store building energy model because it represents a conservative savings estimate and common building characteristics.

Building Type[71]	Window Type	Heating System Type[72]	ESF_{North} (kWh/ft²)	ESF_{East} (kWh/ft²)	ESF_{South}[73] (kWh/ft²)	ESF_{West} (kWh/ft²)
Religious Worship	Single Pane	Electric	10.98	31.39	15.40	32.80
		Non-electric	9.08	22.89	10.84	23.59
	Double Pane	Electric	6.84	17.56	8.29	17.97
		Non-electric	5.35	12.68	5.87	12.76
Service (Beauty, Auto Repair Workshop)	Single Pane	Electric	5.26	1.78	0.00	1.65
		Non-electric	1.90	5.37	3.29	3.80
	Double Pane	Electric	0.20	0.79	0.42	0.99
		Non-electric	0.95	1.87	1.64	1.91

Table 7-4: Annual Energy Savings Factors per Square Foot of Reflective Window Film per Building Type and Window Orientation for Elizabeth City, NC

Building Type[75]	Window Type	Heating System Type[76]	ESF_{North} (kWh/ft²)	ESF_{East} (kWh/ft²)	ESF_{South}[77] (kWh/ft²)	ESF_{West} (kWh/ft²)
Education – Elementary and Middle School	Single Pane	Electric	5.39	10.33	10.29	12.53
		Non-electric	2.36	5.23	5.60	5.30
	Double Pane	Electric	2.74	5.33	5.41	6.32
		Non-electric	2.36	5.23	5.60	5.30
Education – High School	Single Pane	Electric	4.30	9.47	9.12	10.83
		Non-electric	4.30	9.47	9.12	10.83
	Double Pane	Electric	2.17	4.76	4.62	5.44
		Non-electric	2.17	4.76	4.62	5.44
Education – College and University	Single Pane	Electric	2.61	25.42	27.91	16.32
		Non-electric	6.15	32.13	25.64	22.13
	Double Pane	Electric	1.55	8.25	9.95	-1.49
		Non-electric	2.75	10.04	11.97	-0.06

Building Type[75]	Window Type	Heating System Type[76]	ESF_{North} (kWh/ft^2)	ESF_{East} (kWh/ft^2)	ESF_{South}[77] (kWh/ft^2)	ESF_{West} (kWh/ft^2)
Food Sales - Grocery	Single Pane	Electric	4.14	7.39	-1.54	9.94
		Gas	4.11	7.88	2.79	10.10
	Double Pane	Electric	2.14	3.78	-3.75	5.09
		Gas	2.01	3.99	-1.34	5.08
Food Sales – Convenience Store	Single Pane	Electric	2.40	6.05	-1.68	8.75
		Non-electric	3.75	7.08	3.52	9.27
	Double Pane	Electric	1.22	3.04	-3.30	4.42
		Non-electric	1.89	3.58	-0.19	4.67
Food Sales – Gas Station Convenience Store	Single Pane	Electric	2.40	6.05	-1.68	8.75
		Non-electric	3.75	7.08	3.52	9.27
	Double Pane	Electric	1.22	3.04	-3.30	4.42
		Non-electric	1.89	3.58	-0.19	4.67
Food Service - Full Service	Single Pane	Electric	5.28	12.08	11.10	14.03
		Non-electric	4.93	11.26	11.75	12.72
	Double Pane	Electric	2.80	6.01	5.76	6.72
		Non-electric	2.59	5.75	6.01	6.16
Food Service - Fast Food	Single Pane	Electric	3.66	11.12	9.62	8.79
		Non-electric	3.62	10.63	10.22	8.37
	Double Pane	Electric	1.95	5.97	5.90	4.53
		Non-electric	1.89	5.68	5.93	4.30
Health Care-inpatient	Single Pane	Electric	4.54	21.98	14.75	-23.53
		Non-electric	6.29	26.17	15.16	24.57
	Double Pane	Electric	-12.17	11.23	7.49	-18.79
		Non-electric	6.29	26.17	15.16	24.57
Health Care-outpatient	Single Pane	Electric	2.77	6.02	3.33	2.04
		Non-electric	3.38	7.91	6.50	4.03
	Double Pane	Electric	1.39	3.07	2.69	3.16
		Non-electric	1.73	4.03	4.28	4.06
Lodging – (Hotel, Motel, and Dormitory)	Single Pane	Electric	3.77	10.11	3.68	8.87
		Non-electric	4.91	13.76	10.06	10.85
	Double Pane	Electric	1.85	5.02	-0.76	4.41
		Non-electric	2.50	7.10	2.00	5.48

Building Type[75]	Window Type	Heating System Type[76]	ESF_{North} (kWh/ft^2)	ESF_{East} (kWh/ft^2)	ESF_{South}[77] (kWh/ft^2)	ESF_{West} (kWh/ft^2)
Mercantile (mall)	Single Pane	Electric	4.11	8.85	7.00	9.50
		Non-electric	6.68	18.30	23.16	21.06
	Double Pane	Electric	2.04	3.95	3.18	4.43
		Non-electric	2.98	9.41	11.37	10.25
Mercantile (Retail, not mall)	Single Pane	Electric	3.38	9.45	13.99	14.03
		Non-electric	3.51	8.96	13.00	8.29
	Double Pane	Electric	1.83	4.81	6.47	6.91
		Non-electric	1.78	4.35	6.05	3.93
Office – Small (<40,000 sq ft)	Single Pane	Electric	1.40	7.28	8.01	7.82
		Non-electric	3.15	8.58	9.81	8.87
	Double Pane	Electric	0.97	3.62	4.05	3.97
		Non-electric	1.57	4.26	4.90	4.43
Office – Large (≥ 40,000 sq ft)	Single Pane	Electric	7.86	35.45	46.89	33.70
		Non-electric	13.23	44.49	56.89	41.44
	Double Pane	Electric	4.50	18.99	24.48	17.94
		Non-electric	6.77	22.83	29.08	21.31
Other[78]	Single Pane	Electric	2.40	6.05	-1.68	8.75
		Gas	3.75	7.08	3.52	9.27
	Double Pane	Electric	1.22	3.04	-3.30	4.42
		Gas	1.89	3.58	-0.19	4.67
Public Assembly	Single Pane	Electric	3.71	7.46	5.46	12.53
		Non-electric	4.56	9.58	9.94	14.91
	Double Pane	Electric	1.88	3.85	2.91	7.77
		Non-electric	2.28	4.86	5.08	9.17
Public Order and Safety (Police and Fire Station)	Single Pane	Electric	3.59	9.59	9.65	8.83
		Non-electric	4.60	12.59	14.30	12.20
	Double Pane	Electric	3.59	9.59	9.65	8.83
		Non-electric	4.60	12.59	14.30	12.20
Religious Worship	Single Pane	Electric	19.30	44.39	20.46	43.22
		Non-electric	11.83	27.15	12.11	26.47
	Double Pane	Electric	10.46	20.33	12.52	22.13
		Non-electric	6.37	12.90	7.24	26.47

Building Type[75]	Window Type	Heating System Type[76]	ESF_{North} (kWh/ft^2)	ESF_{East} (kWh/ft^2)	ESF_{South}[77] (kWh/ft^2)	ESF_{West} (kWh/ft^2)
Service (Beauty, Auto Repair Workshop)	Single Pane	Electric	4.52	2.56	7.29	3.00
		Non-electric	2.04	4.25	7.57	4.35
	Double Pane	Electric	0.58	1.30	4.58	1.54
		Non-electric	1.02	2.10	4.51	1.42

Table 7-5: Annual Demand Reduction Factors per Square Foot of Reflective Window Film per Building Type and Window Orientation for Richmond, VA

Building Type[79]	Window Type	Heating System Type[80]	DRF_{North} (kW/ft^2)	DRF_{East} (kW/ft^2)	DRF_{South}[81] (kW/ft^2)	DRF_{West} (kW/ft^2)
Education – Elementary and Middle School	Single Pane	Electric	1.74E-03	2.52E-03	3.02E-03	3.83E-03
		Non-electric	1.72E-03	2.62E-03	2.90E-03	3.54E-03
	Double Pane	Electric	9.60E-04	1.33E-03	1.62E-03	2.01E-03
		Non-electric	8.47E-04	1.47E-03	1.41E-03	1.89E-03
Education – High School	Single Pane	Electric	1.18E-03	2.03E-03	4.89E-03	1.97E-03
		Non-electric	1.24E-03	2.42E-03	7.87E-03	3.10E-03
	Double Pane	Electric	6.16E-04	1.03E-03	1.18E-03	1.29E-03
		Non-electric	6.99E-04	1.22E-03	1.42E-03	1.88E-03
Education – College and University	Single Pane	Electric	1.20E-03	2.67E-03	3.18E-03	3.21E-03
		Non-electric	1.26E-03	2.79E-03	3.24E-03	3.21E-03
	Double Pane	Electric	6.32E-04	1.30E-03	1.85E-03	1.58E-03
		Non-electric	6.61E-04	1.36E-03	1.95E-03	1.56E-03
Food Sales - Grocery	Single Pane	Electric	1.08E-03	1.68E-03	2.26E-04	2.57E-03
		Gas	1.03E-03	1.47E-03	-2.55E-04	2.30E-03
	Double Pane	Electric	5.45E-04	8.76E-04	-8.30E-04	1.33E-03
		Gas	4.73E-04	7.23E-04	-1.20E-03	1.14E-03
Food Sales – Convenience Store	Single Pane	Electric	8.76E-04	1.56E-03	7.02E-04	2.43E-03
		Non-electric	8.34E-04	1.33E-03	2.23E-04	2.12E-03
	Double Pane	Electric	4.25E-04	8.15E-04	-2.46E-04	1.25E-03
		Non-electric	4.80E-04	6.75E-04	-6.07E-04	1.08E-03

79 Warehouse and storage building type DEER models do not have windows. Tracking data with this building type will be flagged for on-site verification.
80 Non-electric heating systems were represented by gas heating in building energy models.
81 Negative demand reduction is observed in some building types for south window orientation, implying that installation of window film on the south side of the these buildings leads to increased energy use due to increase heating load in the winter season.

Building Type[79]	Window Type	Heating System Type[80]	DRF_{North} (kW/ft^2)	DRF_{East} (kW/ft^2)	DRF_{South}[81] (kW/ft^2)	DRF_{West} (kW/ft^2)
Food Sales – Gas Station Convenience Store	Single Pane	Electric	8.76E-04	1.56E-03	7.02E-04	2.43E-03
		Non-electric	8.34E-04	1.33E-03	2.23E-04	2.12E-03
	Double Pane	Electric	4.25E-04	8.15E-04	-2.46E-04	1.25E-03
		Non-electric	4.80E-04	6.75E-04	-6.07E-04	1.08E-03
Food Service - Full Service	Single Pane	Electric	1.16E-03	2.16E-03	2.18E-03	2.86E-03
		Non-electric	1.05E-03	1.91E-03	1.93E-03	2.55E-03
	Double Pane	Electric	5.84E-04	1.07E-03	1.09E-03	1.43E-03
		Non-electric	5.27E-04	9.64E-04	9.69E-04	1.27E-03
Food Service - Fast Food	Single Pane	Electric	1.01E-03	2.04E-03	1.29E-03	2.04E-03
		Non-electric	8.82E-04	1.80E-03	1.83E-03	1.79E-03
	Double Pane	Electric	5.29E-04	9.72E-04	1.13E-03	1.05E-03
		Non-electric	4.58E-04	8.46E-04	9.74E-04	9.19E-04
Health Care-inpatient	Single Pane	Electric	8.09E-04	3.14E-03	-9.03E-03	1.28E-03
		Non-electric	7.17E-04	2.76E-03	-2.81E-03	3.22E-03
	Double Pane	Electric	4.25E-04	1.18E-03	7.57E-04	6.41E-04
		Non-electric	5.55E-04	1.61E-03	9.14E-04	1.78E-03
Health Care-outpatient	Single Pane	Electric	8.09E-04	1.68E-03	-3.34E-05	1.81E-03
		Non-electric	8.06E-04	1.75E-03	-4.43E-07	1.87E-03
	Double Pane	Electric	4.33E-04	8.48E-04	-8.85E-04	9.14E-04
		Non-electric	4.38E-04	8.81E-04	-8.91E-04	9.45E-04
Lodging – (Hotel, Motel, and Dormitory)	Single Pane	Electric	1.08E-03	1.60E-03	1.61E-03	2.31E-03
		Non-electric	1.25E-03	2.14E-03	1.95E-03	2.57E-03
	Double Pane	Electric	5.56E-04	8.37E-04	6.35E-04	1.15E-03
		Non-electric	6.40E-04	1.11E-03	6.73E-04	1.28E-03
Mercantile (mall)	Single Pane	Electric	1.45E-03	2.49E-03	2.47E-03	3.01E-03
		Non-electric	1.27E-03	2.05E-03	2.12E-03	2.45E-03
	Double Pane	Electric	7.52E-04	1.21E-03	1.26E-03	1.52E-03
		Non-electric	6.33E-04	1.02E-03	1.06E-03	1.22E-03
Mercantile (Retail, not mall)	Single Pane	Electric	1.03E-03	1.96E-03	2.35E-03	2.79E-03
		Non-electric	1.01E-03	1.85E-03	2.01E-03	2.26E-03
	Double Pane	Electric	5.04E-04	9.78E-04	1.10E-03	1.64E-03
		Non-electric	4.93E-04	8.39E-04	9.26E-04	1.34E-03
Office – Small (<40,000 sq ft)	Single Pane	Electric	6.43E-04	1.75E-03	1.59E-03	2.35E-03
		Non-electric	8.41E-04	1.74E-03	1.47E-03	2.24E-03
	Double Pane	Electric	3.28E-04	9.10E-04	9.75E-04	1.18E-03
		Non-electric	4.31E-04	8.79E-04	9.45E-04	1.12E-03

Building Type[79]	Window Type	Heating System Type[80]	DRF_{North} (kW/ft²)	DRF_{East} (kW/ft²)	DRF_{South}[81] (kW/ft²)	DRF_{West} (kW/ft²)
Office – Large (≥ 40,000 sq ft)	Single Pane	Electric	3.10E-03	8.52E-03	9.84E-03	9.20E-03
		Non-electric	3.11E-03	8.62E-03	9.95E-03	9.28E-03
	Double Pane	Electric	1.58E-03	4.33E-03	5.04E-03	4.74E-03
		Non-electric	1.61E-03	4.42E-03	5.11E-03	4.79E-03
Other[82]	Single Pane	Electric	8.76E-04	1.56E-03	7.02E-04	2.43E-03
		Gas	8.34E-04	1.33E-03	2.23E-04	2.12E-03
	Double Pane	Electric	4.25E-04	8.15E-04	-2.46E-04	1.25E-03
		Gas	4.80E-04	6.75E-04	-6.07E-04	1.08E-03
Public Assembly	Single Pane	Electric	1.10E-03	1.82E-03	1.92E-03	5.63E-03
		Non-electric	1.21E-03	1.99E-03	2.07E-03	7.11E-03
	Double Pane	Electric	5.68E-04	9.40E-04	9.83E-04	4.42E-03
		Non-electric	6.17E-04	1.02E-03	1.05E-03	5.83E-03
Public Order and Safety (Police and Fire Station)	Single Pane	Electric	8.03E-04	1.95E-03	7.56E-04	1.64E-03
		Non-electric	7.68E-04	2.10E-03	8.88E-04	1.75E-03
	Double Pane	Electric	3.97E-04	9.84E-04	1.07E-03	3.42E-04
		Non-electric	3.91E-04	1.06E-03	1.14E-03	4.04E-04
Religious Worship	Single Pane	Electric	5.10E-03	1.20E-02	5.86E-03	1.26E-02
		Non-electric	2.80E-03	6.93E-03	3.27E-03	7.09E-03
	Double Pane	Electric	2.91E-03	6.49E-03	3.11E-03	6.73E-03
		Non-electric	1.63E-03	3.81E-03	1.77E-03	3.84E-03
Service (Beauty, Auto Repair Workshop)	Single Pane	Electric	9.90E-04	1.02E-03	0.00E+00	1.37E-03
		Non-electric	6.19E-04	1.49E-03	1.07E-03	1.43E-03
	Double Pane	Electric	2.94E-04	4.34E-04	5.10E-04	6.89E-04
		Non-electric	3.08E-04	4.76E-04	5.34E-04	7.13E-04

[82] DRF for the "Other" building type is taken from the Convenience store building energy model because it represents a conservative savings estimate and common building characteristics.

Table 7-6: Annual Demand Reduction Factors per Square Foot of Reflective Window Film per Building Type and Window Orientation for Elizabeth City, NC

Building Type[83]	Window Type	Heating System Type[84]	DRF_{North} (kW/ft²)	DRF_{East} (kW/ft²)	DRF_{South}[85] (kW/ft²)	DRF_{West} (kW/ft²)
Education – Elementary and Middle School	Single Pane	Electric	1.84E-03	2.55E-03	3.09E-03	4.07E-03
		Non-electric	9.54E-04	1.41E-03	1.52E-03	2.02E-03
	Double Pane	Electric	9.97E-04	1.32E-03	1.58E-03	2.12E-03
		Non-electric	9.54E-04	1.41E-03	1.52E-03	2.02E-03
Education – High School	Single Pane	Electric	1.26E-03	2.09E-03	2.37E-03	3.30E-03
		Non-electric	1.26E-03	2.09E-03	2.37E-03	3.30E-03
	Double Pane	Electric	6.25E-04	1.04E-03	1.19E-03	1.62E-03
		Non-electric	6.25E-04	1.04E-03	1.19E-03	1.62E-03
Education – College and University	Single Pane	Electric	1.26E-03	4.43E-03	4.51E-03	3.99E-03
		Non-electric	1.49E-03	4.79E-03	3.42E-03	4.22E-03
	Double Pane	Electric	6.72E-04	1.46E-03	1.53E-03	5.12E-04
		Non-electric	6.39E-04	1.42E-03	1.48E-03	4.61E-04
Food Sales - Grocery	Single Pane	Electric	1.02E-03	1.65E-03	-6.42E-04	2.84E-03
		Gas	8.59E-04	1.38E-03	-1.12E-03	2.46E-03
	Double Pane	Electric	5.38E-04	8.52E-04	-1.48E-03	1.44E-03
		Gas	4.43E-04	7.00E-04	-1.86E-03	1.25E-03
Food Sales – Convenience Store	Single Pane	Electric	9.15E-04	1.54E-03	-5.66E-05	2.69E-03
		Non-electric	9.24E-04	1.29E-03	-4.56E-04	2.33E-03
	Double Pane	Electric	4.63E-04	8.00E-04	-8.48E-04	1.37E-03
		Non-electric	4.74E-04	6.64E-04	-1.15E-03	1.18E-03
Food Sales – Gas Station Convenience Store	Single Pane	Electric	9.15E-04	1.54E-03	-5.66E-05	2.69E-03
		Non-electric	9.24E-04	1.29E-03	-4.56E-04	2.33E-03
	Double Pane	Electric	4.63E-04	8.00E-04	-8.48E-04	1.37E-03
		Non-electric	4.74E-04	6.64E-04	-1.15E-03	1.18E-03
Food Service - Full Service	Single Pane	Electric	1.18E-03	2.01E-03	2.19E-03	3.32E-03
		Non-electric	1.02E-03	1.76E-03	1.94E-03	2.94E-03
	Double Pane	Electric	5.93E-04	9.96E-04	1.10E-03	1.64E-03
		Non-electric	5.04E-04	8.88E-04	9.83E-04	1.45E-03

[83] Warehouse and storage building type DEER models do not have windows. Tracking data with this building type will be flagged for on-site verification.

Building Type[83]	Window Type	Heating System Type[84]	DRF_{North} (kW/ft^2)	DRF_{East} (kW/ft^2)	DRF_{South}[85] (kW/ft^2)	DRF_{West} (kW/ft^2)
Food Service - Fast Food	Single Pane	Electric	9.86E-04	2.06E-03	1.83E-03	2.35E-03
		Non-electric	8.58E-04	1.80E-03	1.52E-03	2.07E-03
	Double Pane	Electric	5.13E-04	1.09E-03	1.11E-03	1.21E-03
		Non-electric	4.45E-04	9.56E-04	9.55E-04	1.06E-03
Health Care-inpatient	Single Pane	Electric	8.69E-04	3.44E-03	2.37E-03	-3.25E-03
		Non-electric	1.07E-03	3.52E-03	2.03E-03	4.36E-03
	Double Pane	Electric	-2.02E-03	1.83E-03	1.22E-03	-2.91E-03
		Non-electric	1.07E-03	3.52E-03	2.03E-03	4.36E-03
Health Care-outpatient	Single Pane	Electric	9.19E-04	1.75E-03	1.28E-03	9.88E-04
		Non-electric	9.37E-04	1.82E-03	1.36E-03	1.02E-03
	Double Pane	Electric	4.70E-04	8.82E-04	8.92E-04	1.01E-03
		Non-electric	4.79E-04	9.16E-04	9.39E-04	1.05E-03
Lodging – (Hotel, Motel, and Dormitory)	Single Pane	Electric	1.05E-03	1.75E-03	1.17E-03	2.62E-03
		Non-electric	1.20E-03	2.40E-03	1.67E-03	2.97E-03
	Double Pane	Electric	5.33E-04	8.90E-04	9.50E-05	1.34E-03
		Non-electric	6.12E-04	1.25E-03	1.70E-04	1.50E-03
Mercantile (mall)	Single Pane	Electric	1.55E-03	2.69E-03	2.53E-03	3.49E-03
		Non-electric	1.32E-03	2.93E-03	2.97E-03	4.13E-03
	Double Pane	Electric	7.74E-04	1.34E-03	1.27E-03	1.74E-03
		Non-electric	6.51E-04	1.44E-03	1.46E-03	2.04E-03
Mercantile (Retail, not mall)	Single Pane	Electric	1.12E-03	1.96E-03	2.41E-03	3.76E-03
		Non-electric	9.24E-04	1.60E-03	2.05E-03	2.58E-03
	Double Pane	Electric	6.28E-04	1.02E-03	1.15E-03	1.85E-03
		Non-electric	4.85E-04	8.46E-04	9.94E-04	1.27E-03
Office – Small (<40,000 sq ft)	Single Pane	Electric	6.82E-04	1.77E-03	1.90E-03	2.83E-03
		Non-electric	8.47E-04	1.71E-03	1.87E-03	2.64E-03
	Double Pane	Electric	3.70E-04	8.73E-04	9.07E-04	1.42E-03
		Non-electric	4.14E-04	8.43E-04	9.04E-04	1.33E-03
Office – Large (≥ 40,000 sq ft)	Single Pane	Electric	3.21E-03	8.24E-03	9.91E-03	9.71E-03
		Non-electric	3.20E-03	8.35E-03	1.00E-02	9.79E-03
	Double Pane	Electric	1.62E-03	4.20E-03	5.01E-03	4.99E-03
		Non-electric	1.62E-03	4.22E-03	5.05E-03	4.98E-03