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

**Case No. PUR-2018-00168 (Virginia)**
**Docket No. E-22 Sub 577 (North Carolina)**
**VOLUME 4 OF 4**
**PUBLIC VERSION**

Date: May 15, 2020
Prepared by DNV GL Energy Insights USA, Inc. (DNV GL)

# Appendix F-2. Standard Tracking and Engineering Protocols (STEP) Manual for Non-residential Programs Version 10

# Appendix F2
# Standard Tracking and Engineering Protocols Manual for Non-residential Programs

## (Version 10.0.0)

Protocols to Track Demand-Side Management Programs (DSM) Resource Savings

Virginia Electric and Power Company

Prepared by DNV GL Energy Insights USA, Inc.

May 1, 2020

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

The Non-Residential Lighting Systems and Controls Program is for DSM Phase III. It has been offered in Virginia since its beginning in August 1, 2014 and in North Carolina since 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 (DSM III) are shown in Table 1-1.

**Table 1-1: Non-residential Lighting Systems and Controls Program DSM Phase III Measure List**

| End-Use | Measure | Related Program | 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 |
| | Reach-in Unit Occupancy Sensor | | Section 1.1.3 |

# 1.1 Lighting End Use

## 1.1.1 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 T8, T5, LED, or CFL lamps/ ballasts installations.

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, Non-residential Lighting Systems and Controls Program, DSM Phase VII and the Non-Residential Small Business Improvement program (Section 5).

### Savings Estimation Approach

*Retrofit:*

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 demand reduction is calculated according to the following equation:

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

*New construction:*

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 the Company 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.

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

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

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

Where:

$\Delta$kWh = per measure gross annual electric energy savings
$\Delta$kW = per measure 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 1-2: 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 |
| **Ratio** | Variable | For default values, see Table 1-3: | - | Dominion Energy non-residential lighting systems and controls participant data through year-end 2019 |
| **CF** | Variable | Measure with "24/7" or "exterior" in fixture name, treat as "LED Exit Sign" in Table 8-14 in Sub-appendix F2-IV: Non-residential Lighting Factors: Annual Equivalent Hours, Coincidence Factors and Waste Heat Factors<br>Measure without "exterior" or "24/7" in fixture name, treat as "interior" in Table 8-15 in Sub-appendix F2-IV: Non-residential Lighting Factors: Annual Equivalent Hours, Coincidence Factors and Waste Heat Factors | - | Mid-Atlantic 2019, pp. 315, 351, 369, and 391[1] |
| **HOU** | Variable | | hours, annual | Mid-Atlantic 2019, pp. 315, 351, 369, 391 |
| **WHF$_e$** | Variable | | - | Mid-Atlantic TRM 2019 pp. 587-588[2] |
| **WHF$_d$** | Variable | | - | Mid-Atlantic TRM2019 pp. 587-588[3] |
| **ISR** | Fixed | 1.00 | - | Mid-Atlantic TRM 2019, p. 319[4] |

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[1] 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.

[2] 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).

[3] 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).

[4] Mid-Atlantic TRM 2019, 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.

**Table 1-3: Default Ratio to be Multiplied with Baseline Quantity[5] to Calculate Baseline Lighting Wattage**

| Installed (ee) Fixture | Baseline (base) Fixture | Ratio |
|---|---|---|
| **T8 - 2 - 2ft 17watt Lamps with Reflector & NB** | 62W – 420W T8 2 Bi-ax Lamps in 2x2, 2U-bends | 2.3 |
| **T8 - 3 - 2ft 17watt Lamps with Reflector & NB** | 58W – 96W T8 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[6]** | T8 – 4ft 4 Lamp | N/A[7] |
| **T8 High-Bay - 4ft 3 lamp** | 34W – 320W HID | 2.4 |
| **T8 High-Bay - 4ft 4 lamp** | 117W – 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** | 47W – 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** | 80W – 207W T12HO – 8ft 1 Lamp | 2.0 |
| **HPT8 T8 4ft 4 lamp** | 30W – 516W T12HO – 8ft 2 Lamp | 2.0 |
| **T5 HO Enclosed - 1 lamp 24/7** | 75W – 100W HID | N/A7 |
| **T5 HO Enclosed - 2 lamp 24/7** | 150W – 175W HID | N/A7 |
| **T5 HO Enclosed - 3 lamp 24/7** | 250W HID | N/A7 |
| **2 Lamp T5 28W 24/7** | 75W – 150W HID | N/A7 |

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[5] Use the default New Fixture Type, if there is no ratio available for the specific new fixture type.

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

[7] Use the default ratio for the "Default" Installed (ee) Fixture Type when there is no ratio available for the specific new fixture type.

| Installed (ee) Fixture | Baseline (base) Fixture | Ratio |
|---|---|---|
| **T5 HO Enclosed - 2 lamp Miro Reflector 24/7** | 250W HID | N/A7 |
| **T5 2 - 2ft lamps 24 watts** | 116W HID | 2.1 |
| **T5 3 - 2ft lamps 24 watts** | 150W HID | N/A7 |
| **T5 4 - 2ft lamps 24 watts** | 175W HID | N/A7 |
| **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/A7 |
| **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** | 40W – 75W Incandescent (EISA Standard) | 4.0 |
| **CFL - Fixture/Wallpack** | 178W – 452W HID | 5.1 |
| **CFL - Hardwired fixture** | Incandescent (EISA Standard) | N/A[7] |
| **LED Exit Signs** | 3W – 150W Incandescent Standard Exit Sign | 9.5 |
| **LED Downlight Fixture >=31W** | 53W – 100W Incandescent | 3.5 |
| **LED Downlight 13-30W (excludes screw-in lamps)** | 12W – 500W Incandescent Downlight(EISA Standard) | 6.0 |
| **LED 2X4 FIXTURE (39-80W)** | 32W – 458W 2x4 T8 Fluorescent | 3.1 |
| **LED Fixture (2x2 or 1x4)** | 28W – 456W 2 2x2 Bi-ax Lamps, 2U-bends, 2L 4ft T8 | 2.5 |
| **LED Lamps (<= 7W)** | 5W – 167W Halogen, 25W – 252W Incandescent | 7.8 |
| **LED Lamps (>7W up to 12W) (excludes screw-in lamps)** | 14W – 240W Halogen | 5.3 |
| **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 |

| Installed (ee) Fixture | Baseline (base) Fixture | Ratio |
|---|---|---|
| **LED Exterior New Fixture** | 35W – 1,610 HID | 4.2 |
| **LED Interior New Fixture** | 775W – 1,190W HID | 4.0 |
| **LED Exterior** | 160W – 1,150W HID | 3.7 |
| **LED 24/7** | 12W – 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 | 2.1 |
| **LED Panels** | 34W – 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 – 300W Halogen, 14W – 400W Incandescent | 5.9 |
| **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** | 12W – 263W T8 – 4ft 4 Lamp | 2.9 |
| **LED – 3 linear 4ft Tube/Bar** | 47W – 175W T8 – 4ft 3 Lamp | 2.1 |
| **LED – 2 linear 4ft Tube/Bar** | 22W – 262W T8 – 4ft 2 Lamp | 2.3 |
| **LED – 1 linear 4ft Tube/Bar** | 18W – 172W LED – 1 Linear 4ft Tube/Bar T8 – 4ft 1 Lamp | 2.3 |
| **LED – 1 linear 4ft Tube/Bar – 1 T8 Delamp** | 30W – 150W LED – 1 Linear 4ft Tube/Bar T8 – 4ft 1 Lamp | 3.2 |
| **LED – 2 linear 4ft Tube/Bar – 1 T8 Delamp** | 58W – 149W T8 – 4ft 2 Lamp | 2.5 |
| **LED – 3 linear 4ft Tube/Bar – 1 T8 Delamp** | 93W – 172W T8 – 4ft 3 Lamp | 2.6 |
| **LED – 2 linear 4ft Tube/Bar – 2 T8 Delamp** | 60W – 277W T8 – 4ft 4 Lamp | 3.5 |
| **LED Linear/Bar** | 17W – 160W T8 | 2.2 |
| **Default**[8] | | 3.1 |

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[8] The default fixture type is based on a weighted average of the ratios for all fixture types in the table.

## 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 2019, pp. 314-325, 351, 369, 391, and 587-588.

## Update Summary

The changes to this section, compared with last year, are described in Table 1-4.

**Table 1-4: Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **Source** | • Updated page numbers / version of the Mid-Atlantic TRM |
| **Input Variable** | • Established default ratios to be used to calculate baseline wattage for 2019 measures by using 2018 tracking data |

## 1.1.2 Occupancy 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 DSM Phase II as well as the Non-Residential Small Business Improvement program, described in Section5.

### Savings Estimation Approach

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

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

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

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

Where:

ΔkWh = per measure gross annual electric energy savings
ΔkW = per measure 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 1-5: Input Values, Lighting Sensors and Controls**

| Component | Type | Value | Unit | Source(s) |
|---|---|---|---|---|
| **$watts_{connected}$** | Variable | See customer application | watt | Customer application |

| Component | Type | Value | Unit | Source(s) |
|---|---|---|---|---|
| **HOU** | Variable | See Table 8-14 or Table 8-15 in Sub-appendix F2-IV: Non-residential Lighting Factors: Annual Equivalent Hours, Coincidence Factors and Waste Heat Factors | hours/year | Mid-Atlantic TRM 2019, p. 582 |
| **$Qty_{sensors}$** | Variable | See customer application | - | Customer application |
| **$SVG_e$** | Fixed | 0.28 | - | Mid-Atlantic TRM 2019, p. 326 |
| **$SVG_d$** | Fixed | Occupancy sensor = 0.14 | - | Mid-Atlantic TRM 2019, p. 327 |
| **CF** | Variable | See Table 8-15 in Sub-appendix F2-IV: Non-residential Lighting Factors: Annual Equivalent Hours, Coincidence Factors and Waste Heat Factors | - | Mid-Atlantic TRM 2019, p. 586 |
| **$WHF_e$**[9] | Variable | See Table 8-15 in Sub-appendix F2-IV: Non-residential Lighting Factors: Annual Equivalent Hours, Coincidence Factors and Waste Heat Factors | - | Mid-Atlantic TRM 2019, pp. 587-588 |
| **$WHF_d$**[10] | Variable | See Table 8-15 in Sub-appendix F2-IV: Non-residential Lighting Factors: Annual Equivalent Hours, Coincidence Factors and Waste Heat Factors | - | Mid-Atlantic TRM 2019, pp. 587-588 |
| **ISR** | Fixed | 1.00 | - | Mid-Atlantic TRM 2019, p. 327 |

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[9] 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).

[10] 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).

### 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 2019, pp. 326-329 and pp. 586-588.

### Update Summary

The changes to this section, compared with last year, are described in Table 1-6.

**Table 1-6: Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **Source** | • Updated page numbers / version of the Mid-Atlantic TRM |

## 1.1.3 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

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

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

Per measure, 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 = per measure gross annual electric energy savings
ΔkW = per measure 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 1-7: 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 |
| **OSS** | Fixed | 0.307 | - | Efficiency Maine Commercial TRM 2019, p. 34[11] |
| **HOU** | Variable | See Table 8-15 in Sub-appendix F2-IV: Non-residential Lighting Factors: Annual Equivalent Hours, Coincidence Factors and Waste Heat Factorsfor grocery building type | hours (annual) | Mid-Atlantic TRM 2019, p. 525[12] |
| **$WHF_e$** | Fixed | Low Temp (-35°F - -1°F): 1.52<br>Med Temp (0°F - 30°F): 1.52<br>High Temp (31°F - 55°F): 1.41 | - | Mid-Atlantic TRM 2019, p. 388 |

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[11] 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.

[12] 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 2019.

| Component | Type | Value | Unit | Source(s) |
|---|---|---|---|---|
| **WHF<sub>d</sub>** | Fixed | Low Temp<br>(-35°F - -1°F): 1.51<br>Med Temp<br>(0°F - 30°F): 1.51<br>High Temp<br>(31°F - 55°F): 1.40 | - | Mid-Atlantic TRM 2019, p. 388 |
| **CF** | Fixed | 0.96 | - | Mid-Atlantic TRM 2019, p. 389[13] |

## 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:

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

$$= \frac{38\, watts}{1{,}000 \frac{W}{kW}} \times 0.307 \times 7{,}272\, hours \times 1.41$$

$$= 120\, kWh$$

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

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

$$= \frac{38\, watts}{1{,}000 \frac{W}{kW}} \times 0.307 \times 1.40 \times 0.96$$

$$= 0.016\, kW$$

## Source(s)

The primary sources for this deemed savings approach are the Efficiency Maine Commercial TRM 2019, pp. 34-35, and Mid-Atlantic TRM 2019, pp. 387-389 and 525.

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[13] $CF_{SSP}$ value for "grocery" building type.

## Update Summary

The changes to this section, compared with last year, are described in Table 1-8.

**Table 1-8: Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **Source** | • Updated page numbers / version of the Mid-Atlantic TRM and Maine Commercial TRM |

# 2 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 2-1.

**Table 2-1: Non-residential Lighting Systems and Controls Program (DSM VII) Measure List**

| End-Use | Measure | Legacy Program | Manual Section |
|---|---|---|---|
| **Lighting** | Lighting, Fixtures, Lamps, and Delamping including T8s, T5s, LEDs, and CFLs | Retrofits & Delamping: Non-residential Lighting Systems and Controls, DSM III | Section 2.1.1 |
| | | New Construction: none (new methodology for this program) | |
| | Occupancy Sensors & Controls | Non-residential Lighting Systems and Controls, DSM III | Section 2.1.2 |
| | Occupancy Sensors & Controls, Stairwell-integrated Occupancy Sensor | none | Section 2.1.3 |
| | Reach-in Unit Occupancy Sensor | Non-residential Lighting Systems and Controls, DSM III | Section 2.1.4 |

# 2.1 Lighting End Use

## 2.1.1 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 baseline is assumed to be a Bulged Reflector (BR) lamp of a standard BR30-type.

The measure also covers delamping of existing lighting systems. Delamping includes removal of one or more lamps in a fixture (e.g., removing two lamps out of four lamp fixtures), or removal of the entire fixture itself, so that there is no longer a 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 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 DSM Phase VII and the Non-Residential Small Business Improvement program (Section 5).

### Savings Estimation Approach

*Retrofit/Replace-on-burnout/Exit signs/Exterior:*

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

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

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

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

*New construction interior:*

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

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

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

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

Where:

ΔkWh = per measure gross annual electric energy savings
ΔkW = per measure gross coincident demand reductions
$LPD_{base}$ = 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
$WHF_d$ = waste heat factor for demand to account for cooling savings from efficient lighting
CF = coincidence factor
ISR = in-service rate

## Input Variables

**Table 2-2: Input Values for Lighting Fixtures, Lamps, and Delamping Savings Calculations**

| Component | Type | Value | Unit | Source(s) |
|---|---|---|---|---|
| **$Qty_{base}$** | Variable | See customer application | - | Customer application |
| **$Qty_{ee}$** | Variable | See customer application | - | Customer application |
| **$watts_{base}$** | Variable | See customer application | watts | Customer application |
| **$watts_{ee}$** | Variable | See customer application | watts | Customer application |
| **$LPD_{base}$** | Variable | See Table 2-3 | watt/ft$^2$ | 2015 Virginia Energy Conservation Code / IECC 2015 Section C405.4.2, Table C405.4.2(1) |
| | | Default: 16 W CFL | watts | Mid-Atlantic TRM 2019 p. 314,<br>ENERGY STAR®[14] |
| **$LPD_{ee}$** | Variable | See customer application | watt/ft$^2$ | Customer application |

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[14] LED exit sign default values come from an ENERGY STAR® report: Save Energy, Money and Prevent Pollution with Light-Emitting Diode (LED) Exit Signs:http://www.energystar.gov/ia/business/small_business/led_exitsigns_techsheet.pdf (accessed 7/13/2018).

| Component | Type | Value | Unit | Source(s) |
|---|---|---|---|---|
| **CF** | Variable | Measure with "24/7" or "exterior" in fixture name, treat as "LED Exit Sign" in Table 8-14 in Sub-appendix F2-IV: Non-residential Lighting Factors: Annual Equivalent Hours, Coincidence Factors and Waste Heat Factors<br>Measure without "exterior" or "24/7" in fixture name, treat as "Interior" in Table 8-15 in Sub-appendix F2-IV: Non-residential Lighting Factors: Annual Equivalent Hours, Coincidence Factors and Waste Heat Factors | - | Mid-Atlantic 2019, pp. 315, 351, 369, and 391 [15] |
| **HOU** | Variable | | hours, annual | Mid-Atlantic 2019, pp. 315, 351, 369, 391 |
| **$WHF_e$** | Variable | | - | Mid-Atlantic TRM 2019, pp. 587-588[16] |
| **$WHF_d$** | Variable | | - | Mid-Atlantic TRM 2019 pp. 587-588[17] |
| **ISR** | Fixed | 1.00 | - | Mid-Atlantic TRM 2019, p. 319[18] |

**Table 2-3: Interior Lighting Power Allowances**

| Customer building type | $LPD_{base}$[19] |
|---|---|
| **Education – Elementary and Middle School** | 0.87 |
| **Education – High School** | 0.87 |
| **Education – College and University** | 0.87 |
| **Food Sales - Grocery** | 1.26 |

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[15] 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.

[16] 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).

[17] 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).

[18] Mid-Atlantic TRM 2019, 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.

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

| Customer building type | $LPD_{base}$[19] |
|---|---|
| **Food Sales – Convenience Store** | 1.26 |
| **Food Sales – Gas Station Convenience Store** | 1.26 |
| **Food Service - Full Service** | 1.01 |
| **Food Service - Fast Food** | 0.90 |
| **Health Care - Inpatient** | 1.05 |
| **Health Care - Outpatient** | 0.90 |
| **Lodging – (Hotel, Motel and Dormitory)** | 0.87 |
| **Mercantile (Mall)** | 1.26 |
| **Mercantile (Retail, not mall)** | 1.26 |
| **Office – Small (<40,000 sq ft)** | 0.82 |
| **Office – Large (⩾ 40,000 sq ft)** | 0.82 |
| **Other** | 1.17 |
| **Public Assembly** | 1.01 |
| **Public Order and Safety (Police and Fire Station)** | 0.87 |
| **Religious Worship** | 1.00 |
| **Service (Beauty, Auto Repair Workshop)** | 1.19 |
| **Warehouse and Storage** | 0.66 |

## 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 2019, pp. 314–325, 351, 369, 391, and 587-588, and the IECC 2015 Section C405.4.2.

## Update Summary

The changes to this section, compared with last year, are described in Table 2-4.

**Table 2-4: Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **New Measure** | New section |

## 2.1.2 Occupancy Sensors and Controls

### Measure Description

This measure defines the savings associated with installing at wall-, fixture-, or remote-mounted occupancy sensors 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 DSM Phase VII as well as the Non-Residential Small Business Improvement program, described in Section 5. The baseline condition is lighting that is controlled with a manual switch.

### Savings Estimation Approach

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

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

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

$$\Delta kW \quad = watts \ \times Qty \times \frac{1\ kW}{1{,}000\ W} \ \times \ ESF_d \ \times \ ISR \ \times \ WHF_d \times CF$$

Where:

$\Delta$kWh = per measure gross annual electric energy savings
$\Delta$kW = per measure gross coincident demand reductions
Qty = number of occupancy sensors installed
watts = 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
$WHF_d$ = 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 2-5: Input Values for Occupancy Sensors and Controls Measure Savings**

| Component | Type | Value | Unit | Source(s) |
|---|---|---|---|---|
| **watts** | Variable | See customer application | watt | Customer application |

| Component | Type | Value | Unit | Source(s) |
|---|---|---|---|---|
| **HOU** | Variable | See Table 8-14 or Table 8-15 in Sub-appendix F2-IV: Non-residential Lighting Factors: Annual Equivalent Hours, Coincidence Factors and Waste Heat Factors | hours/year | Mid-Atlantic TRM 2019, p. 582 |
| **Qty** | Variable | See customer application | - | Customer application |
| **$ESF_e$** | Fixed | 0.28 | - | Mid-Atlantic TRM 2019, p. 326 |
| **$ESF_d$** | Fixed | 0.14 | - | Mid-Atlantic TRM 2019, p. 327 |
| **CF** | Fixed | See Table 8-15 in Sub-appendix F2-IV: Non-residential Lighting Factors: Annual Equivalent Hours, Coincidence Factors and Waste Heat Factors | - | Mid-Atlantic TRM 2019, p. 586 |
| **$WHF_e$**[20] | Variable | See Table 8-15 in Sub-appendix F2-IV: Non-residential Lighting Factors: Annual Equivalent Hours, Coincidence Factors and Waste Heat Factors<br>Default: 0.94 | - | Mid-Atlantic TRM 2019, pp. 587-588 |
| **$WHF_d$**[21] | Variable | See Table 8-15 in Sub-appendix F2-IV: Non-residential Lighting Factors: Annual Equivalent Hours, Coincidence Factors and Waste Heat Factors<br>Default: 1.36 | - | Mid-Atlantic TRM 2019, pp. 587-588 |

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[20] 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).

[21] 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).

| Component | Type | Value | Unit | Source(s) |
|---|---|---|---|---|
| **ISR** | Fixed | 1.00 | - | Mid-Atlantic TRM 2019, p. 327 |

## 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 2019, pp. 326-329 and pp. 586-588.

## Update Summary

The changes to this section, compared with last year, are described in Table 2-6.

**Table 2-6: Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **New Measure** | New section |

## 2.1.3 Occupancy Sensors and Controls – Stairwell Integrated

### Measure Description

This measure defines the savings associated with installing controls on existing features or installation of luminaires with integrated bi-level occupancy control in stairwells. The bi-level occupancy control technology allows for continuous lighting that maintains the code-mandated minimum illumination levels in unoccupied spaces while also and providinghigher light levels in occupied spaces. The baseline condition is lighting within interior spaces required to be illuminated at all times, such as stairwells.

### Savings Estimation Approach

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

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

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

$$\Delta kWh \quad = \Delta kW \times \left[1 - Pct_{low} \times \left(1 - \frac{watts_{ee,low}}{watts_{ee}}\right)\right] \times HOU$$

Where:

$\Delta$kW = per measure gross coincident demand reductions
$\Delta$kWh = per measure gross annual electric energy savings
$Qty_{base}$ = quantity of baseline fixtures equipped with bi-level occupancy control
$Qty_{ee}$ = quanity of installed fixures 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
$Pct_{low}$ = percentage of annual operating time that fixture operates at low-power
HOU = hours of use per year
CF = peak coincidence factor

### Input Variables

**Table 2-7: Input Values, Occupancy Sensors and Controls**

| Component | Type | Value | Unit | Source(s) |
|---|---|---|---|---|
| **$Qty_{base}$** | Variable | See customer application | - | Customer application |
| **$Qty_{ee}$** | Variable | See customer application | - | Customer application |

| Component | Type | Value | Unit | Source(s) |
|---|---|---|---|---|
| **$\text{watts}_{base}$** | Variable | See customer application | watts | Customer application |
| **$\text{watts}_{ee,low}$** | Variable | See customer application | watts | Customer application |
| **$\text{watts}_{ee}$** | Variable | See customer application | watts | Customer application |
| **$\text{Pct}_{low}$** | Fixed | 0.73 | - | New York TRM 2019, p. 445 |
| **HOU** | Fixed | 8,760 | Hours (annual) | New York TRM 2019, pp. 444-445 |
| **CF** | Fixed | 1.00 | - | Mid-Atlantic TRM 2019, p. 315 |

## 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 New York TRM 7, 2019, pp. 443-445, and Mid-Atlantic TRM, 2019, p. 315.

## Update Summary

The changes to this section, compared with last year, are described in Table 2-8.

**Table 2-8: Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **New Measure** | New section |

## 2.1.4 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. The baseline condition is lighting that is controlled with a manual switch.

### Savings Estimation Approach

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

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

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

$$\Delta kW \quad = Qty_{sensor} \times watts \times \frac{1\ kW}{1{,}000\ W} \times ESF_d \times ISR \times WHF_d \times CF$$

Where:

ΔkWh = per measure gross annual electric energy savings
ΔkW = per measure gross coincident demand reductions
Qty = number of occupancy sensors installed
watts = 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
$WHF_d$ = Waste Heat Factor for Demand; represents the increased savings due to reduced waste heat from lights that must be rejected by the refrigeration equipment
HOU = hours of use per year
CF = peak coincidence factor
ISR = in-service rate is the percentage of rebated measures actually installed

## Input Variables

**Table 2-9: 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 40[22], p.173 |
| **$ESF_d$** | Fixed | 0.14 | - | Mid-Atlantic TRM 2019, p.327 |
| **HOU** | Variable | See Table 8-15 in Sub-appendix F2-IV: Non-residential Lighting Factors: Annual Equivalent Hours, Coincidence Factors and Waste Heat Factors | hours, annual | Mid-Atlantic TRM 2019, p. 525[23] |
| **$WHF_e$** | Fixed | Low Temp (-35°F - -1°F): 1.52<br>Med Temp (0°F - 30°F): 1.52<br>High Temp (31°F - 55°F): 1.41 | - | Mid-Atlantic TRM 2019, p. 388 |
| **$WHF_d$** | Fixed | Low Temp (-35°F - -1°F): 1.51<br>Med Temp (0°F - 30°F): 1.51<br>High Temp (31°F - 55°F): 1.40 | - | Mid-Atlantic TRM 2019, p. 388 |
| **CF** | Fixed | 0.96 | - | Mid-Atlantic TRM 2019, p. 389[24] |

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[22] 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. We will assume that this value accounts for both reduction in operating hours and incremental reduction in power.

[23] 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 2019.

[24] Value for "grocery" building type from Mid-Atlantic TRM 2019, p. 389 footnote 873 "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."

## 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:

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

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

$$= 121\ kWh$$

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

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

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

$$= 0.007\ kW$$

## Source(s)

The primary sources for this deemed savings approach are the Efficiency Maine TRM 2019, p. 173, and Mid-Atlantic TRM 2019, pp. 327, 387-389, and 525.

## Update Summary

The changes to this section, compared with last year, are described in Table 2-10.

**Table 2-10: Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **New Measure** | New section |

# 3 NON-RESIDENTIAL HEATING AND COOLING EFFICIENCY PROGRAM, DSM PHASES III/VII

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 3-1.

**Table 3-1: Non-Residential Heating and Cooling Efficiency Program Measure List (DSM III/VII)**

| End-Use | Measure | Manual Section |
|---|---|---|
| **HVAC** | Unitary/Split Air Conditioning (AC) & Heat Pump (HP) Systems | Section 3.1.1 |
| | Variable Refrigerant Flow (VRF) & Mini-split Systems | Section 3.1.2 |
| | Water- and Air-cooled Chillers | Section 3.1.3 |
| | Variable Frequency Drive | Section 3.1.4 |
| | Dual Enthalpy Air-side Economizer | Section 3.1.5 |

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

# 3.1 Heating, Ventilation, and Air-Conditioning (HVAC) End Use

## 3.1.1 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 Table 8-9 and Table 8-10 in Sub-appendix F2-III: Non-residential HVAC Equipment Efficiency Ratings. 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 5.

### 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, per measure, gross annual electric cooling energy savings are calculated according to the following equation:

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

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

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

For ground-source heat pumps, the baseline efficiency is assumed to be that of an air-source heat pump.[25] See Equation 1 and Equation 2 in Sub-appendix F2-V: General Equations to convert between tons and Btu/h or kBtu/h, or vice versa.

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[25] Although ASHRAE values reflect the Building Code minimum, savings are calculated using the efficiencies provided in Sub-appendix F2-III: Non-residential HVAC Equipment Efficiency Ratings. This is due to the Mid-Atlantic TRM 2019 assumption that the baseline technology—for residential ground source heat pump

**Heating Energy Savings:**

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

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

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

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

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

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

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

$$\Delta kW = Size_{cool} \times \left[\frac{1}{EER_{base}} - \frac{1}{EER_{ee}}\right] \times CF$$

If necessary, see Equation 3 to convert between SEER and EER or Equation 4 in Sub-appendix F2-V: General Equations to convert between IEER and EER.

Where:

$\Delta$kWh = per measure gross annual electric energy savings
$\Delta kWh_{cool}$ = per measure gross annual electric cooling energy savings
$\Delta kWh_{heat}$ = per measure gross annual electric heating energy savings
$\Delta$kW = per measure gross coincident demand reductions
$Size_{cool}$ = 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

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applications—is an air-cooled heat pump. (There is no corresponding commercial measure in the Mid-Atlantic TRM 2019.)

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 = coincidence factor

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

## Input Variables

**Table 3-2: Input Values for Non-Residential HVAC Equipment**

| Component | Type | Value | Units | Source(s) |
|---|---|---|---|---|
| **$Size_{cool}$** | Fixed | See customer application | Btu/h | Customer application |
| **$Size_{heat}$** | Fixed | See customer application | Btu/h | Customer application |
| **$EFLH_{heat}$** | Variable | See Table 8-5 in Sub-appendix F2-II: Non-residential HVAC Equivalent Full Load Hours | hours (annual) | Mid-Atlantic TRM 2019, p. 590 |
| **$EFLH_{cool}$** | Variable | See Table 8-4 in Sub-appendix F2-II: Non-residential HVAC Equivalent Full Load Hours | hours (annual) | Mid-Atlantic TRM 2019, p. 589 |

| Component | Type | Value | Units | Source(s) |
|---|---|---|---|---|
| **HSPF/SEER/IEER / EER/COP$_{base}$** | Variable | See Table 8-9 and Table 8-10 in Sub-appendix F2-III: Non-residential HVAC Equipment Efficiency Ratings | kBtu/kW-hour (except COP is dimensionless) | ASHRAE 90.1 2013 |
| **HSPF/SEER/IEER /EER/COP$_{ee}$** | Variable | See customer application<br>Where IEER is not available, IEER = SEER. Or refer to Sub-appendix F2-V: General Equations to convert the available efficiency value to the required efficiency value. | kBtu/kW-hour (except COP is dimensionless) | 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:<br>< 135 kBtu/h = 0.588<br>≥ 135 kBtu/h = 0.874 | - | Mid-Atlantic TRM 2019, p. 415 |

## 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 2019 pp. 406-420 and 589-590, and ASHRAE 90.1 2013.

## Update Summary

The changes to this section, compared with last year, are described in Table 3-3.

**Table 3-3: Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **Source** | • Updated page numbers / version of the Mid-Atlantic TRM |

| Type of Change | Description of Change |
|---|---|
| **Input Variable** | • Update to weather stations in North Carolina resulted in revised EFLHs for weather-sensitive measures<br>• Baseline efficiency levels were revised per update to ASHRAE 2013 in VA and NC |

### 3.1.2 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. For baseline VRF air conditioner, and heat pump efficiencies refer to Table 8-11 in Sub-appendix F2-III: Non-residential HVAC Equipment Efficiency Ratings 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.

Mini split systems are also offered in the Non-Residential Small Business Improvement program, described in Section 5.

#### 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, per measure, gross annual electric cooling energy savings are calculated according to the following equation:

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

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:

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

To convert between EER and SEER see Equation 3 in Sub-appendix F2-V: General Equations.

**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:

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

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:

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

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

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

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

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

Where:

$\Delta kWh$ = per measure gross annual electric energy savings
$\Delta kWh_{cool}$ = per measure gross annual electric cooling energy savings for mini split heat pump systems
$\Delta kWh_{heat}$ = per measure gross annual electric heating energy savings for mini split heat pump systems
$\Delta kW$ = per measure gross coincident demand savings
$Size_{cool}$ = equipment cooling capacity
$Size_{heat}$ = equipment heating capacity
$SEER_{base}$ = 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
$HSPF_{ee}$ = 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 3-4: Input Values for VRF Systems and Mini Split Systems**

| Component | Type | Value | Units | Source(s) |
|---|---|---|---|---|
| **$EFLH_{heat}$** | Fixed | See Table 8-5 in Sub-appendix F2-II: Non-residential HVAC Equivalent Full Load Hours | hours (annual) | Mid-Atlantic TRM 2019, pp. 423, 466, and 590 |
| **$EFLH_{cool}$** | Fixed | See Table 8-4 in Sub-appendix F2-II: Non-residential HVAC Equivalent Full Load Hours | hours (annual) | Mid-Atlantic TRM 2019, pp. 423,465 & 589 |
| **$HSPF/SEER/EER/COP/IEER_{base}$** | Variable | See Table 8-11 in Sub-appendix F2-III: Non-residential HVAC Equipment Efficiency Ratings | kBtu/kW-hour (except COP is -) | ASHRAE 90.1 2013 |
| **$HSPF/SEER/EER/COP/IEER_{ee}$** | 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.<br>< 135 kBtu/h = 0.588<br>≥ 135 kBtu/h = 0.874 | - | Mid-Atlantic TRM 2019, pp. 424 and 466 |

## 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 2019 pp. 421-425, 462-468, and 589-590, and ASHRAE 90.1-2013.

## Update Summary

The changes to this section, compared with last year, are described in Table 3-5.

**Table 3-5: Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **Source** | - Updated page numbers / version of the Mid-Atlantic TRM |
| **Input Variable** | - Update to weather stations in North Carolina resulted in revised EFLHs for weather-sensitive measures<br>- Baseline efficiency levels were revised per update to ASHRAE 2013 in VA and NC |

## 3.1.3 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 8-12 of Sub-appendix F2-III: Non-residential HVAC Equipment Efficiency Ratings for the 2013 ASHRAE-90.1 specified minimum efficiencies. The installed chiller efficiency is taken from the customer application.

### Savings Estimation Approach

**Water-cooled Chillers**

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

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

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

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

**Air-cooled Chillers**

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

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

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

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

Where:

ΔkWh = per measure gross annual electric energy savings
ΔkW = per measure 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)
$EFLH_{cool}$ = equivalent full load hours of cooling
$EER_{base,full\ load}$, $kW/ton_{base,full\ load}$ = chiller system baseline efficiency at full load
$EER_{ee,full\ load}$, $kW/ton_{ee,full\ load}$ = chiller system installed efficiency at full load
CF = peak coincidence factor

## Input Variables

**Table 3-6: 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 | See Table 8-12 of Sub-appendix F2-III: Non-residential HVAC Equipment Efficiency Ratings | kW/ton | ASHRAE 90.1 2013, Table 6.8.1-3 |
| **$kW/ton_{base,IPLV}$** | Fixed | See Table 8-12 of Sub-appendix F2-III: Non-residential HVAC Equipment Efficiency Ratings | kW/ton | ASHRAE 90.1 2013, Table 6.8.1-3 |
| **$kW/ton_{ee,full\text{-}load}$** | Variable | See customer application[26] | kW/ton | Customer application |
| **$kW/ton_{ee,IPLV}$** | Variable | See customer application[26] | kW/ton | Customer application |
| **$EER_{base,\ full\ load}$** | Variable | See customer application[27] | kBtu/kW | Customer Application |
| | | Default: See Table 8-12 of Sub-appendix F2-III: Non-residential HVAC Equipment Efficiency Ratings | | ASHRAE 90.1-2013, Table 6.8.1-3 |
| **$EER_{base,\ IPLV}$** | Variable | See customer application[27] | kBtu/kW | Customer Application |
| | | Default: See Table 8-12 Sub-appendix F2-III: Non-residential HVAC Equipment Efficiency Ratings | | ASHRAE 90.1-2013, Table 6.8.1-3 |

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[26] When missing either the IPLV or the full load value, use Equation 8 in Sub-appendix F2-V: General Equations, as relevant.

| Component | Type | Value | Unit | Source(s) |
|---|---|---|---|---|
| **$EER_{ee,\ full\ load}$** | Variable | See customer application[27] | kBtu/kW | Customer application |
| **$EER_{ee,\ IPLV}$** | Variable | See customer application[27] | kBtu/kW | Customer application |
| **$EFLH_{cool}$** | Variable | See Table 8-6 of Sub-appendix F2-II: Non-residential HVAC Equivalent Full Load Hours | hours (annual) | Mid-Atlantic TRM 2019 p. 442, adjusted for Richmond, VA and Charlotte, NC based on TMY3 cooling degree days data. |
| **CF** | Fixed | 0.923 | - | Mid-Atlantic TRM 2019 p. 437 |

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 Mid Atlantic TRM in that the full load cooling hours of chillers are assigned by building type. As per Table 8-12 of Sub-appendix F2-III: Non-residential HVAC Equipment Efficiency Ratings, 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 2019 pp. 435-442, ASHRAE 90.1-2013, Table 6.8.1-3 - Water Chilling Packages - Efficiency Requirements.

## Update Summary

The changes to this section, compared with last year, are described in Table 3-7.

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[27] When missing either the IPLV or the full load value, use Equation 9 in Sub-appendix F2-V: General Equations, as relevant.

**Table 3-7: Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **Source** | • Updated page numbers / version of the Mid-Atlantic TRM |
| **Input Variable** | • Update to weather stations in North Carolina resulted in revised EFLHs for weather-sensitive measures<br>• Baseline efficiency levels were revised per update to ASHRAE 2013 in VA and NC |

## 3.1.4 Variable Frequency Drives, DSM Phase III

### 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. This measure is also delivered through the Non-residential Small Business Improvement Program, DSM Phase V, as indicated in Section 5.

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 5.

### Savings Estimation Approach

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

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

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

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

Where:

ΔkWh = per measure gross annual electric energy savings
ΔkW = per measure gross coincident demand reductions
HP = motor horse power
LF = motor load factor (%) at fan design airflow rate or pump design flowrate
$\eta$ = 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 3-8: Input Values for Non-Residential Variable Frequency Drives**

| Component | Type | Value | Unit | Source(s) |
|---|---|---|---|---|
| **HP** | Variable | See customer application | horsepower | Customer application |
| **LF** | Fixed | Default: 0.65 | - | Mid Atlantic TRM 2019, p. 428 |
| **$\eta$** | Variable | Default see Table 3-9 | - | NEMA Standards Publication Condensed MG 1-2007 |
| **ESF** | Fixed | Default see Table 3-10<br>Table 3-10 | - | Mid-Atlantic TRM 2015 p. 370; Mid-Atlantic TRM 2019 p. 433 |
| **DRF** | Fixed | Default see Table 3-10<br>Table 3-10 | - | Mid-Atlantic TRM 2015 p. 370; Mid-Atlantic TRM 2019 p. 433 |
| **HOU** | Variable | See Table 8-7 in Sub-appendix F2-II: Non-residential HVAC Equivalent Full Load Hours | hours (annual) | Mid-Atlantic TRM 2019 pp. 431-432 |
| **CF** | Fixed | 0.28 for fan applications<br>0.55 for pump applications | - | Mid-Atlantic TRM 2015 p. 370; Mid-Atlantic TRM 2019 p. 431 |

Table 3-9 provides the baseline motor efficiencies that are consistent with the minimum federal accepted motor efficiencies provided by the National Electrical Manufacturers Association (NEMA).[28]

**Table 3-9: Baseline Motor Efficiency[29]**

| Horsepower (hp) | $\eta$ |
|---|---|
| 1 | 0.855 |
| 1.5 | 0.865 |
| 2 | 0.865 |
| 3 | 0.895 |
| 5 | 0.895 |
| 7.5 | 0.917 |
| 10 | 0.917 |
| 15 | 0.924 |
| 20 | 0.930 |
| 25 | 0.936 |
| 30 | 0.936 |
| 40 | 0.941 |
| 50 | 0.945 |

| Horsepower (hp) | $\eta$ |
|---|---|
| 60 | 0.950 |
| 75 | 0.954 |
| 100 | 0.954 |
| 125 | 0.954 |
| 150 | 0.958 |
| 200 | 0.962 |
| 250 | 0.962 |
| 300 | 0.962 |
| 350 | 0.962 |
| 400 | 0.962 |
| 450 | 0.962 |
| 500 | 0.962 |

**Table 3-10: Energy Savings and Demand Reduction Factors by Application**

| VFD Applications | ESF | DRF |
|---|---|---|
| **Unknown VFD (Minimum)[30]** | 0.123 | 0.039 |
| **HVAC Fan VFD Savings Factors[31]** | | |
| **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 |

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[28] 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.

[29] 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).

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

[31] Mid-Atlantic TRM 2015 p. 370

| VFD Applications | ESF | DRF |
|---|---|---|
| **HVAC Pump VFD Savings Factors**[32] | | |
| **Chilled Water Pump** | 0.633 | 0.460 |
| **Hot Water Pump** | 0.652 | 0.000 |
| **Unknown/Other Pump (Average)**[33] | 0.643 | 0.230 |

## 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, pp. 367-371 (for fans) and Mid-Atlantic TRM 2019, pp. 427-433 (for pumps).

## Update Summary

The changes to this section, compared with last year, are described in Table 3-11.

**Table 3-11: Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **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 |

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[32] Mid-Atlantic TRM 2019, p. 433.

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

### 3.1.5 Variable Frequency Drives, DSM Phase VII

#### 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 5.

#### Savings Estimation Approach

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

HVAC Fans:

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

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

HVAC Pumps:

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

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

HVAC Fans:

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

HVAC Pumps:

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

Where:

ΔkWh = per measure gross annual electric energy savings
ΔkW = per measure gross coincident demand reductions
hp = motor horse power
LF = motor load factor (%) at fan design airflow rate or pump design flowrate
$\eta$ = NEMA-rated efficiency of motor
RHRS = 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, default is 1.0
$PLR_{ee, peak}$ = summer peak efficient part-load ratio, default is 1.0
ESF = energy savings factor
DSF = demand savings factor
CF = peak coincidence factor

## Input Variables

**Table 3-12: Input Values for Non-Residential Variable Frequency Drives**

| Component | Type | Value | Unit | Source(s) |
|---|---|---|---|---|
| **hp** | Variable | See customer application | horsepower | Customer application |

| Component | Type | Value | Unit | Source(s) |
|---|---|---|---|---|
| **LF** | Variable | See customer application | - | Customer application |
| | | Default: 0.65 | - | Mid Atlantic TRM 2019, p. 428 |
| $\eta$ | Variable | Default see Table 3-13 | - | NEMA Standards Publication Condensed MG 1-2007 |
| **FF** | Variable | Default see Table 3-14 | - | Mid Atlantic TRM 2019, p. 428 |
| $\mathbf{PLR_{base}}$ | Variable | Default see Table 3-15 | | |
| $\mathbf{PLR_{ee}}$ | Variable | Default see Table 3-15 | | |
| **ESF** | Fixed | See Table 3-17 | - | Mid-Atlantic TRM 2019 p. 433 |
| **DSF** | Fixed | See Table 3-17 | - | Mid-Atlantic TRM 2019 p. 433 |
| **RHRS** | Variable | See Table 8-7 in Sub-appendix F2-II: Non-residential HVAC Equivalent Full Load Hours | hours (annual) | Mid-Atlantic TRM 2019 pp. 431-432 |
| **CF** | Fixed | 0.55 for pump applications | - | Mid-Atlantic TRM 2019, p. 431 |

Table 3-9 provides the baseline motor efficiencies that are consistent with the minimum federal accepted motor efficiencies provided by the National Electrical Manufacturers Association (NEMA).[34]

**Table 3-13: Baseline Motor Efficiency[35]**

| Horsepower (hp) | $\eta$ |
|---|---|
| 1 | 0.855 |
| 1.5 | 0.865 |
| 2 | 0.865 |
| 3 | 0.895 |
| 5 | 0.895 |
| 7.5 | 0.917 |
| 10 | 0.917 |
| 15 | 0.924 |

| Horsepower (hp) | $\eta$ |
|---|---|
| 60 | 0.950 |
| 75 | 0.954 |
| 100 | 0.954 |
| 125 | 0.954 |
| 150 | 0.958 |
| 200 | 0.962 |
| 250 | 0.962 |
| 300 | 0.962 |

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[34] 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 the above mentioned NEMA Standard.

[35] 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) | $\eta$ |
|---|---|
| 20 | 0.930 |
| 25 | 0.936 |
| 30 | 0.936 |
| 40 | 0.941 |
| 50 | 0.945 |
| 350 | 0.962 |
| 400 | 0.962 |
| 450 | 0.962 |
| 500 | 0.962 |

**Table 3-14: Default Fan Duty Cycle**

| Flow Range (% of design cfm) | Flow 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 3-15: Part Load Ratios by Control Type, Fan Type, and Flow Range**

| Control Type | Fan Type(s) | Flow Range | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 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 |

Table 3-16 displays the average part-load ratios calculated using the flow fractions from Table 3-14, and the part-load values across flow ranges from Table 3-15.

**Table 3-16: Average Part Load Ratios (PLRs) by Control Type, and Fan Type**

| Control Type | Control Type Description | Fan Type(s) | Average PLR |
|---|---|---|---|
| **Outlet Damper** | Dampers at FC, BI, AF fan types | Airfoil (AF) | 0.78 |
| | | Backward Inclined (BI) | |
| | | Forward Curved (FC) | 0.53 |
| **Discharge Dampers** | Dampers at other fan types | All | 0.81 |
| | Unknown fan type | | |
| **Inlet Damper Box** | Damper Box | All | 0.70 |
| | Other/Unknown | | |
| **Inlet Vane Dampers** | Inlet Vane Damper | All | 0.54 |
| **VFD with Duct Static Pressure Controls** | Static Pressure Controls, Med./High Pressure (⩾1.0 inch w.g.) | All | 0.30 |
| **VFD with Low/No Duct Static Pressure Controls (<1” w.g.)** | Static Pressure Controls, Low Pressure (<1.0 inch w.g.) | All | 0.28 |
| **Eddy Current Drives** | Eddy Current Drive | All | 0.50 |
| **No Control or Bypass Damper** | Unknown | All | 1.00 |
| **Inlet Guide Vane** | Inlet Guide Vanes at FC, BI, AF fan types | Airfoil (AF) | 0.64 |
| | | Backward Inclined (BI) | |
| | | Forward Curved (FC) | 0.40 |

**Table 3-17: Energy Savings and Demand Reduction Factors by Application**

| VFD Applications[36] | ESF | DRF |
|---|---|---|
| **Chilled Water Pump** | 0.633 | 0.460 |
| **Hot Water Pump** | 0.652 | 0.000 |
| **Unknown/Other Pump (Average)[37]** | 0.643 | 0.230 |

## 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 Mid-Atlantic TRM 2019, pp. 427-433.

## Update Summary

The changes to this section, compared with last year, are described in Table 3-18.

**Table 3-18: Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **New Savings Methodology** | New section |

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[36] Mid-Atlantic TRM 2019, p. 433.

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

## 3.1.6 Dual Enthalpy Air-side Economizers

This measure is offered under the Non-Residential Heating and Cooling Efficiency and Non-Residential Small Business Improvement (Section 5) programs as either a new installation of an economizer or a retrofit add-on project. Both programs use the protocol provided below.

### Measure Description

#### 3.1.6.1.1 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).

#### 3.1.6.1.2 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

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

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

Per measure, gross coincident demand reduction is assumed to be zero because an economizer will typically not operate during the peak period.[38] Hence,

$$\Delta kW \quad = 0$$

Where:

$\Delta$kWh = per measure gross annual electric energy savings
$\Delta$kW = per measure gross coincident demand reductions
$Size_{cool}$ = HVAC system cooling capacity

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[38] Mid Atlantic TRM 2019, p. 451.

ESF = annual energy savings factor for the installation of dual enthalpy economizer control

## Input Variables

**Table 3-19: 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 3-20 | - | Mid-Atlantic TRM 2019, p. 453 |

**Table 3-20: Economizer Energy Savings Factors by Building Type[39]**

| Building Type | Energy Savings Factors (kWh/ton) | | |
|---|---|---|---|
| | Baltimore, MD | Richmond, VA | Rocky Mount/ Elizabeth City, NC |
| **Education[40]** | 39 | 35 | 29 |
| **Education – College and University** | | | |
| **Education – High School** | | | |
| **Education – Elementary and Middle School** | | | |
| **Food Sales[41]** | 57 | 52 | 43 |
| **Food Sales - Grocery[42]** | | | |
| **Food Sales – Convenience Store** | | | |
| **Food Sales – Gas Station Convenience Store** | | | |
| **Food Service[43]** | 29 | 26 | 22 |
| **Food Service - Full Service** | 29 | 26 | 22 |

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[39] Mid Atlantic TRM 2019, p. 453 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 HDD and CDD provided in Sub-appendix F2-I: Cooling and Heating Degree Days and HoursFor example, VA and NC values are calculated from Baltimore,MD savings factors and degree days (DD-65°F = HDD + CDD) using TMY3 data.

[40] 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 2019, p. 453.

[41] All food sales, and service (beauty, auto repair workshop) building types in the STEP Manual were mapped to savings factors for the "Small Retail" building type listed in the Mid-Atlantic TRM 2019, p. 453.

[42] Food-sales-grocery and mercantile (mall) building types in the STEP Manual were mapped to the "Big Box Retail" building type listed in the Mid-Atlantic TRM 2019, p. 453.

[43] 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 2019, p. 453.

| Building Type | Energy Savings Factors (kWh/ton) | | |
|---|---|---|---|
| | Baltimore, MD | Richmond, VA | Rocky Mount/ Elizabeth City, NC |
| **Food Service - Fast Food**[44] | 37 | 34 | 28 |
| **Mercantile (Retail, not mall)**[45] | 57 | 52 | 43 |
| **Mercantile (mall)** | 57 | 52 | 43 |
| **Office – Small (<40,000 sq. ft.)**[46] | 57 | 52 | 43 |
| **Office – Large (≥ 40,000 sq. ft.)** | | | |
| **Public Assembly** | 25 | 23 | 19 |
| **Religious Worship** | 6 | 5 | 5 |
| **Other**[47] | 57 | 52 | 43 |
| **Lodging – (Hotel, Motel and Dormitory)** | | | |
| **Health Care - outpatient** | | | |
| **Health Care - inpatient** | | | |
| **Public Order and Safety (Police and Fire Station)** | | | |
| **Service (Beauty, Auto Repair Workshop)** | 57 | 52 | 43 |
| **Warehouse and Storage** | 2 | 2 | 2 |

## 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 2019, pp. 451-453.

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[44] 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 2019, p. 453.

[45] Mercantile (retail, not mall) building types in the STEP Manual were mapped to savings factors for the "Small Retail" building type in the Mid-Atlantic TRM 2019, p. 453.

[46] 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 2019, p. 447.

[47] 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 2019, p. 447.

## Update Summary

The changes to this section, compared with last year, are described in Table 3-21.

**Table 3-21: Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **Source** | - Updated page numbers / version of the Mid-Atlantic TRM |
| **Input Variable** | - Updated weather stations in North Carolina |

# 4 NON-RESIDENTIAL WINDOW FILM PROGRAM, DSM PHASES III/VII

## 4.1 Building Envelope End Use

### 4.1.1 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.

This section is applicable to both DSM Phase III and Phase VII. However note that the Annual Energy Savings Factor and the Annual Demand Reduction Factors differ between Phase III and Phase IV Because the program eligibility requirements differ.

To be eligible for a rebate under the DSM Phase III version of the program, the final Solar Heat Gain Coefficient (SHGC) of the window after application of window film must be equal to or less than 0.4.[48] Under the DSM Phase VII program, the final SHGC must be equal to or less than 0.5.[49]

#### 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 a blend of Elizabeth City and Rocky Mount-Wilson, NC weather using typical meteorological year 3 (TMY3) data and modification of a few key window parameters.[50] The assumed values for key parameters affected by addition of window film to single and double pane windows are provided in Table 4-1.

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

[49] DSM Phase VII Non-residential Window Film Program design assumptions.

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

**Table 4-1: Key Building Energy Modelling Parameters**

| Window Variable | Window Type | Baseline Value | Source(s) [51] | Post-Retrofit Value | Source(s)[51] |
|---|---|---|---|---|---|
| **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 4-5 and Table 4-4. 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). Similarly, gross coincident peak demand reduction factors are provided in Table 4-1.

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 demand reduction is calculated according to the following equation:

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

Where:

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

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

## Input Variables

**Table 4-2: Input Values for Solar Window Film**

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

**Table 4-3: Energy Savings Factors per Square Foot of Reflective Window Film per Building Type and Window Orientation for VA (DSM Phase III and VII)**

| Building Type[52] | Window Type | Heating System Type[53] | DSM Phase III | | | | DSM Phase VII | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $ESF_{North}$ (kWh/ft$^2$) | $ESF_{East}$ (kWh/ft$^2$) | $ESF_{South}$[54] (kWh/ft$^2$) | $ESF_{West}$ (kWh/ft$^2$) | $ESF_{North}$ (kWh/ft$^2$) | $ESF_{East}$ (kWh/ft$^2$) | $ESF_{South}$[55] (kWh/ft$^2$) | $ESF_{West}$ (kWh/ft$^2$) |
| Education – Elementary and Middle School | Single Pane | Electric | 4.34 | 8.20 | 6.66 | 10.02 | 3.37 | 6.38 | 5.20 | 7.82 |
| | | Non-electric | 4.20 | 9.07 | 9.51 | 9.31 | 3.28 | 6.67 | 7.39 | 7.15 |
| | Double Pane | Electric | 2.24 | 4.25 | 3.40 | 5.04 | 1.23 | 2.33 | 1.86 | 2.71 |
| | | Non-electric | 2.09 | 4.58 | 4.56 | 4.70 | 1.16 | 2.52 | 2.51 | 2.56 |
| Education – High School | Single Pane | Electric | 3.39 | 7.37 | 13.00 | 5.14 | 2.62 | 5.71 | 12.10 | 3.35 |
| | | Non-electric | 4.36 | 13.10 | 44.20 | 13.71 | 3.42 | 10.51 | 41.68 | 11.73 |
| | Double Pane | Electric | 1.74 | 3.70 | 2.76 | 3.92 | 0.94 | 2.06 | 1.59 | 2.18 |
| | | Non-electric | 2.01 | 6.66 | 6.98 | 8.45 | 1.03 | 3.68 | 3.82 | 3.91 |
| Education – College and University | Single Pane | Electric | 1.67 | 11.99 | 16.83 | 13.29 | 1.34 | 9.35 | 14.83 | 10.64 |
| | | Non-electric | 5.64 | 18.64 | 25.04 | 18.60 | 4.29 | 14.42 | 21.03 | 14.94 |
| | Double Pane | Electric | 1.62 | 7.99 | 12.97 | 8.84 | 1.01 | 4.49 | 4.39 | 4.95 |
| | | Non-electric | 3.01 | 9.79 | 15.96 | 9.67 | 1.71 | 5.33 | 5.79 | 5.24 |
| Food Sales - Grocery | Single Pane | Electric | 3.06 | 5.20 | -2.32 | 7.40 | 2.76 | 4.07 | -2.74 | 5.80 |
| | | Non-electric | 3.82 | 7.00 | 3.88 | 8.72 | 3.04 | 5.41 | 2.12 | 6.70 |
| | Double Pane | Electric | 1.63 | 2.79 | -3.57 | 3.84 | 0.71 | 1.49 | 1.13 | 2.05 |
| | | Non-electric | 1.84 | 3.55 | -0.09 | 4.43 | 0.98 | 1.97 | 2.37 | 2.39 |

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

[53] Non-electric heating systems were represented by gas heating in building energy models.

[54] 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.

[55] 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[52] | Window Type | Heating System Type[53] | DSM Phase III | | | | DSM Phase VII | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | ESF$_{North}$ (kWh/ft$^2$) | ESF$_{East}$ (kWh/ft$^2$) | ESF$_{South}$[54] (kWh/ft$^2$) | ESF$_{West}$ (kWh/ft$^2$) | ESF$_{North}$ (kWh/ft$^2$) | ESF$_{East}$ (kWh/ft$^2$) | ESF$_{South}$[55] (kWh/ft$^2$) | ESF$_{West}$ (kWh/ft$^2$) |
| Food Sales – Convenience Store | Single Pane | Electric | 1.50 | 4.24 | -2.42 | 6.58 | 1.25 | 3.35 | -2.52 | 5.13 |
| | | Non-electric | 3.23 | 6.44 | 4.33 | 8.20 | 2.74 | 4.92 | 2.74 | 6.26 |
| | Double Pane | Electric | 0.78 | 2.29 | -2.76 | 3.41 | 0.43 | 1.29 | -3.65 | 2.85 |
| | | Non-electric | 1.85 | 3.31 | 0.96 | 4.16 | 0.98 | 1.83 | -1.11 | 2.27 |
| Food Sales – Gas Station Convenience Store | Single Pane | Electric | 1.50 | 4.24 | -2.42 | 6.58 | 1.25 | 3.35 | -2.52 | 5.13 |
| | | Non-electric | 3.23 | 6.44 | 4.33 | 8.20 | 2.74 | 4.92 | 2.74 | 6.26 |
| | Double Pane | Electric | 0.78 | 2.29 | -2.76 | 3.41 | 0.43 | 1.29 | -3.65 | 2.85 |
| | | Non-electric | 1.85 | 3.31 | 0.96 | 4.16 | 0.98 | 1.83 | -1.11 | 2.27 |
| Food Service - Full Service | Single Pane | Electric | 5.03 | 9.59 | 6.29 | 9.57 | 3.63 | 7.23 | 4.79 | 7.39 |
| | | Non-electric | 4.57 | 10.18 | 9.44 | 9.89 | 3.53 | 7.74 | 7.30 | 7.73 |
| | Double Pane | Electric | 2.45 | 4.94 | 3.24 | 4.70 | 1.30 | 2.85 | 1.99 | 2.52 |
| | | Non-electric | 2.42 | 5.14 | 4.81 | 4.96 | 1.33 | 2.91 | 2.77 | 2.72 |
| Food Service - Fast Food | Single Pane | Electric | 3.48 | 8.64 | 5.72 | 7.09 | 2.68 | 6.35 | 4.97 | 5.55 |
| | | Non-electric | 3.68 | 9.23 | 9.79 | 7.34 | 2.87 | 6.87 | 7.95 | 5.71 |
| | Double Pane | Electric | 1.78 | 4.18 | 4.49 | 3.60 | 1.03 | 2.40 | 2.52 | 2.05 |
| | | Non-electric | 1.95 | 4.58 | 5.36 | 3.88 | 1.05 | 2.55 | 2.93 | 2.11 |
| Health Care-inpatient | Single Pane | Electric | 3.73 | 17.87 | -59.89 | 3.88 | 2.87 | 13.91 | -61.85 | 3.03 |
| | | Non-electric | 4.84 | 23.16 | -18.37 | 20.19 | 3.74 | 18.28 | -59.88 | 4.18 |
| | Double Pane | Electric | 1.98 | 8.61 | 4.96 | 1.99 | 1.12 | 4.82 | 2.92 | 1.10 |
| | | Non-electric | 3.13 | 11.92 | 6.47 | 10.16 | 1.87 | 6.35 | 3.97 | 1.55 |

| Building Type[52] | Window Type | Heating System Type[53] | DSM Phase III | | | | DSM Phase VII | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $ESF_{North}$ (kWh/ft$^2$) | $ESF_{East}$ (kWh/ft$^2$) | $ESF_{South}$[54] (kWh/ft$^2$) | $ESF_{West}$ (kWh/ft$^2$) | $ESF_{North}$ (kWh/ft$^2$) | $ESF_{East}$ (kWh/ft$^2$) | $ESF_{South}$[55] (kWh/ft$^2$) | $ESF_{West}$ (kWh/ft$^2$) |
| Health Care-outpatient | Single Pane | Electric | 1.70 | 4.85 | -3.63 | 4.62 | 1.35 | 3.77 | 2.18 | 3.59 |
| | | Non-electric | 2.63 | 7.18 | 1.63 | 6.86 | 2.04 | 5.50 | 5.53 | 5.28 |
| | Double Pane | Electric | 1.06 | 2.54 | -4.91 | 2.40 | 0.56 | 1.34 | 0.75 | 1.26 |
| | | Non-electric | 1.50 | 3.60 | -1.89 | 3.43 | 0.78 | 1.94 | 1.96 | 1.87 |
| Lodging – (Hotel, Motel, and Dormitory) | Single Pane | Electric | 2.81 | 5.57 | -0.02 | 6.11 | 2.25 | 4.60 | 1.45 | 4.77 |
| | | Non-electric | 5.04 | 11.31 | 9.21 | 9.28 | 3.89 | 9.00 | 8.73 | 7.17 |
| | Double Pane | Electric | 1.42 | 2.86 | -1.27 | 2.78 | 0.75 | 1.77 | -0.15 | 1.54 |
| | | Non-electric | 2.58 | 5.89 | 3.02 | 4.24 | 1.40 | 3.34 | 2.55 | 2.31 |
| Mercantile (mall) | Single Pane | Electric | 2.97 | 5.11 | 1.17 | 6.06 | 2.34 | 3.98 | 1.07 | 4.76 |
| | | Non-electric | 6.16 | 13.43 | 16.27 | 12.09 | 4.61 | 10.38 | 12.16 | 9.36 |
| | Double Pane | Electric | 1.85 | 3.24 | 2.11 | 3.96 | 1.01 | 1.98 | 1.34 | 2.22 |
| | | Non-electric | 2.95 | 6.95 | 7.45 | 5.67 | 1.80 | 3.59 | 4.16 | 3.38 |
| Mercantile (Retail, not mall) | Single Pane | Electric | 3.26 | 8.75 | 11.28 | 11.55 | 2.07 | 6.08 | 8.16 | 8.33 |
| | | Non-electric | 3.78 | 9.30 | 12.07 | 7.27 | 2.48 | 6.86 | 8.73 | 5.17 |
| | Double Pane | Electric | 1.34 | 4.10 | 5.18 | 5.55 | 0.79 | 2.27 | 2.75 | 2.91 |
| | | Non-electric | 1.85 | 4.32 | 5.66 | 4.40 | 1.09 | 2.45 | 3.13 | 2.28 |
| Office – Small (<40,000 sq ft) | Single Pane | Electric | 0.52 | 6.05 | 3.22 | 5.52 | 0.43 | 5.11 | 4.50 | 4.65 |
| | | Non-electric | 3.09 | 8.36 | 7.43 | 7.82 | 2.41 | 6.54 | 6.86 | 6.12 |
| | Double Pane | Electric | 0.36 | 3.25 | 2.86 | 2.99 | 0.24 | 1.80 | 1.71 | 1.73 |
| | | Non-electric | 1.57 | 4.24 | 4.46 | 3.93 | 0.87 | 2.31 | 2.48 | 2.18 |

| Building Type[52] | Window Type | Heating System Type[53] | DSM Phase III | | | | DSM Phase VII | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $ESF_{North}$ (kWh/ ft$^2$) | $ESF_{East}$ (kWh/ ft$^2$) | $ESF_{South}$[54] (kWh/ ft$^2$) | $ESF_{West}$ (kWh/ ft$^2$) | $ESF_{North}$ (kWh/ ft$^2$) | $ESF_{East}$ (kWh/ ft$^2$) | $ESF_{South}$[55] (kWh/ ft$^2$) | $ESF_{West}$ (kWh/ ft$^2$) |
| Office – Large (≥40,000 sq ft) | Single Pane | Electric | 5.93 | 30.29 | 41.28 | 29.71 | 4.65 | 23.92 | 32.84 | 23.37 |
| | | Non-electric | 12.77 | 44.15 | 55.42 | 40.59 | 9.87 | 34.15 | 42.99 | 31.42 |
| | Double Pane | Electric | 3.45 | 16.38 | 22.04 | 15.91 | 1.89 | 9.15 | 12.26 | 8.74 |
| | | Non-electric | 6.74 | 22.89 | 28.77 | 21.18 | 3.67 | 12.54 | 15.74 | 11.57 |
| Other[56] | Single Pane | Electric | 1.50 | 4.24 | -2.42 | 6.58 | 1.25 | 3.35 | -2.52 | 5.13 |
| | | Non-electric | 3.23 | 6.44 | 4.33 | 8.20 | 2.74 | 4.92 | 2.74 | 6.26 |
| | Double Pane | Electric | 0.78 | 2.29 | -2.76 | 3.41 | 0.43 | 1.29 | -3.65 | 2.85 |
| | | Non-electric | 1.85 | 3.31 | 0.96 | 4.16 | 0.98 | 1.83 | -1.11 | 2.27 |
| Public Assembly | Single Pane | Electric | 3.02 | 5.52 | 3.05 | 15.47 | 10.99 | 13.00 | 2.54 | 14.05 |
| | | Non-electric | 4.33 | 8.60 | 8.90 | 18.58 | 12.37 | 15.64 | 6.94 | 16.55 |
| | Double Pane | Electric | 1.52 | 2.97 | 1.73 | 12.01 | 0.85 | 1.65 | 0.99 | 2.01 |
| | | Non-electric | 2.21 | 4.44 | 4.64 | 13.93 | 1.20 | 2.43 | 2.57 | 2.70 |
| Public Order and Safety (Police and Fire Station) | Single Pane | Electric | 1.04 | 7.64 | -0.84 | 4.15 | 0.75 | 5.83 | 4.85 | 2.26 |
| | | Non-electric | 2.17 | 11.12 | 6.85 | 8.75 | 1.70 | 8.57 | 9.02 | 6.11 |
| | Double Pane | Electric | 0.55 | 3.79 | 2.74 | -0.07 | 0.32 | 2.10 | 1.59 | -1.95 |
| | | Non-electric | 1.12 | 5.60 | 5.60 | 2.95 | 0.68 | 3.03 | 3.05 | 0.26 |
| Religious Worship | Single Pane | Electric | 10.98 | 31.39 | 15.40 | 32.80 | 9.89 | 26.83 | 14.27 | 27.37 |
| | | Non-electric | 9.08 | 22.89 | 10.84 | 23.59 | 2.97 | 6.97 | 3.23 | 7.00 |
| | Double Pane | Electric | 6.84 | 17.56 | 8.29 | 17.97 | 4.07 | 9.94 | 4.83 | 10.20 |
| | | Non-electric | 5.35 | 12.68 | 5.87 | 12.76 | 2.97 | 6.97 | 3.23 | 7.00 |

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[56] 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[52] | Window Type | Heating System Type[53] | DSM Phase III | | | | DSM Phase VII | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $ESF_{North}$ (kWh/ $ft^2$) | $ESF_{East}$ (kWh/ $ft^2$) | $ESF_{South}$[54] (kWh/ $ft^2$) | $ESF_{West}$ (kWh/ $ft^2$) | $ESF_{North}$ (kWh/ $ft^2$) | $ESF_{East}$ (kWh/ $ft^2$) | $ESF_{South}$[55] (kWh/ $ft^2$) | $ESF_{West}$ (kWh/ $ft^2$) |
| Service (Beauty, Auto Repair Workshop) | Single Pane | Electric | 5.26 | 1.78 | 0.00 | 1.65 | 21.22 | 5.67 | 2.86 | 5.78 |
| | | Non-electric | 1.90 | 5.37 | 3.29 | 3.80 | 5.88 | 13.07 | 10.17 | 11.96 |
| | Double Pane | Electric | 0.20 | 0.79 | 0.42 | 0.99 | 0.73 | 1.66 | 0.90 | 2.37 |
| | | Non-electric | 0.95 | 1.87 | 1.64 | 1.91 | 2.04 | 4.21 | 3.61 | 4.19 |

**Table 4-4: Energy Savings Factors per Square Foot of Reflective Window Film per Building Type and Window Orientation for NC (DSM Phase III and VII)**

| Building Type[57] | Window Type | Heating System Type[58] | DSM III | | | | DSM VII | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $ESF_{North}$ (kWh/ ft$^2$) | $ESF_{East}$ (kWh/ ft$^2$) | $ESF_{South}$[59] (kWh/ ft$^2$) | $ESF_{West}$ (kWh/ ft$^2$) | $ESF_{North}$ (kWh/ ft$^2$) | $ESF_{East}$ (kWh/ ft$^2$) | $ESF_{South}$[60] (kWh/ ft$^2$) | $ESF_{West}$ (kWh/ ft$^2$) |
| Education – Elementary and Middle School | Single Pane | Electric | 5.39 | 10.33 | 10.29 | 12.53 | 3.94 | 7.57 | 3.27 | 8.96 |
| | | Non-electric | 2.36 | 5.23 | 5.60 | 5.30 | 3.27 | 7.35 | 6.13 | 7.58 |
| | Double Pane | Electric | 2.74 | 5.33 | 5.41 | 6.32 | 1.47 | 2.78 | 2.90 | 3.23 |
| | | Non-electric | 2.36 | 5.23 | 5.60 | 5.30 | 1.14 | 2.57 | 2.90 | 2.66 |
| Education – High School | Single Pane | Electric | 4.30 | 9.47 | 9.12 | 10.83 | 3.19 | 6.65 | 6.74 | 7.66 |
| | | Non-electric | 4.30 | 9.47 | 9.12 | 10.83 | 3.19 | 6.65 | 6.74 | 7.66 |
| | Double Pane | Electric | 2.17 | 4.76 | 4.62 | 5.44 | 1.14 | 2.35 | 2.38 | 2.70 |
| | | Non-electric | 2.17 | 4.76 | 4.62 | 5.44 | 1.14 | 2.35 | 2.38 | 2.70 |
| Education – College and University | Single Pane | Electric | 2.61 | 25.42 | 27.91 | 16.32 | 2.19 | 16.49 | 12.11 | 12.47 |
| | | Non-electric | 6.15 | 32.13 | 25.64 | 22.13 | 4.33 | 19.85 | 15.02 | 15.43 |
| | Double Pane | Electric | 1.55 | 8.25 | 9.95 | -1.49 | 0.82 | 4.44 | 5.12 | 4.98 |
| | | Non-electric | 2.75 | 10.04 | 11.97 | -0.06 | 1.46 | 5.28 | 6.20 | 5.56 |

| Building Type[57] | Window Type | Heating System Type[58] | DSM III | | | | DSM VII | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $ESF_{North}$ (kWh/ft$^2$) | $ESF_{East}$ (kWh/ft$^2$) | $ESF_{South}$[59] (kWh/ft$^2$) | $ESF_{West}$ (kWh/ft$^2$) | $ESF_{North}$ (kWh/ft$^2$) | $ESF_{East}$ (kWh/ft$^2$) | $ESF_{South}$[60] (kWh/ft$^2$) | $ESF_{West}$ (kWh/ft$^2$) |
| Food Sales - Grocery | Single Pane | Electric | 4.14 | 7.39 | -1.54 | 9.94 | 3.04 | 5.26 | 1.35 | 7.15 |
| | | Non-electric | 4.11 | 7.88 | 2.79 | 10.10 | 3.10 | 5.92 | 4.04 | 7.33 |
| | Double Pane | Electric | 2.14 | 3.78 | -3.75 | 5.09 | 1.09 | 1.93 | 2.07 | 2.59 |
| | | Non-electric | 2.01 | 3.99 | -1.34 | 5.08 | 1.09 | 2.11 | 2.73 | 2.58 |
| Food Sales – Convenience Store | Single Pane | Electric | 2.40 | 6.05 | -1.68 | 8.75 | 1.76 | 4.23 | 0.72 | 6.27 |
| | | Non-electric | 3.75 | 7.08 | 3.52 | 9.27 | 2.85 | 5.21 | 4.03 | 6.77 |
| | Double Pane | Electric | 1.22 | 3.04 | -3.30 | 4.42 | 0.72 | 1.55 | -1.43 | 2.24 |
| | | Non-electric | 1.89 | 3.58 | -0.19 | 4.67 | 1.05 | 1.84 | 0.04 | 2.39 |
| Food Sales – Gas Station Convenience Store | Single Pane | Electric | 2.40 | 6.05 | -1.68 | 8.75 | 1.76 | 4.23 | 0.72 | 6.27 |
| | | Non-electric | 3.75 | 7.08 | 3.52 | 9.27 | 2.85 | 5.21 | 4.03 | 6.77 |
| | Double Pane | Electric | 1.22 | 3.04 | -3.30 | 4.42 | 0.72 | 1.55 | -1.43 | 2.24 |
| | | Non-electric | 1.89 | 3.58 | -0.19 | 4.67 | 1.05 | 1.84 | 0.04 | 2.39 |
| Food Service - Full Service | Single Pane | Electric | 5.28 | 12.08 | 11.10 | 14.03 | 3.98 | 8.81 | 8.39 | 10.03 |
| | | Non-electric | 4.93 | 11.26 | 11.75 | 12.72 | 3.80 | 8.52 | 9.03 | 9.25 |
| | Double Pane | Electric | 2.80 | 6.01 | 5.76 | 6.72 | 1.30 | 3.08 | 2.97 | 3.38 |
| | | Non-electric | 2.59 | 5.75 | 6.01 | 6.16 | 1.43 | 2.95 | 3.18 | 3.13 |
| Food Service - Fast Food | Single Pane | Electric | 3.66 | 11.12 | 9.62 | 8.79 | 2.86 | 8.43 | 8.71 | 6.04 |
| | | Non-electric | 3.62 | 10.63 | 10.22 | 8.37 | 2.76 | 8.11 | 8.85 | 5.85 |
| | Double Pane | Electric | 1.95 | 5.97 | 5.90 | 4.53 | 1.04 | 2.94 | 3.22 | 2.20 |
| | | Non-electric | 1.89 | 5.68 | 5.93 | 4.30 | 1.03 | 2.87 | 3.24 | 2.13 |

| Building Type[57] | Window Type | Heating System Type[58] | DSM III | | | | DSM VII | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $ESF_{North}$ (kWh/ft$^2$) | $ESF_{East}$ (kWh/ft$^2$) | $ESF_{South}$[59] (kWh/ft$^2$) | $ESF_{West}$ (kWh/ft$^2$) | $ESF_{North}$ (kWh/ft$^2$) | $ESF_{East}$ (kWh/ft$^2$) | $ESF_{South}$[60] (kWh/ft$^2$) | $ESF_{West}$ (kWh/ft$^2$) |
| Health Care-inpatient | Single Pane | Electric | 4.54 | 21.98 | 14.75 | -23.53 | 3.53 | 16.49 | 11.25 | 4.10 |
| | | Non-electric | 6.29 | 26.17 | 15.16 | 24.57 | 5.17 | 19.17 | 13.12 | 5.50 |
| | Double Pane | Electric | -12.17 | 11.23 | 7.49 | -18.79 | 4.02 | 10.12 | 6.78 | 1.42 |
| | | Non-electric | 6.29 | 26.17 | 15.16 | 24.57 | 4.47 | 11.03 | 7.34 | 1.81 |
| Health Care-outpatient | Single Pane | Electric | 2.77 | 6.02 | 3.33 | 2.04 | 2.15 | 4.44 | 2.91 | 2.43 |
| | | Non-electric | 3.38 | 7.91 | 6.50 | 4.03 | 2.66 | 5.92 | 5.41 | 3.84 |
| | Double Pane | Electric | 1.39 | 3.07 | 2.69 | 3.16 | 0.78 | 1.61 | 1.45 | 1.67 |
| | | Non-electric | 1.73 | 4.03 | 4.28 | 4.06 | 0.95 | 2.10 | 2.28 | 2.11 |
| Lodging – (Hotel, Motel, and Dormitory) | Single Pane | Electric | 3.77 | 10.11 | 3.68 | 8.87 | 2.89 | 7.68 | 3.24 | 6.83 |
| | | Non-electric | 4.91 | 13.76 | 10.06 | 10.85 | 3.70 | 10.41 | 8.47 | 8.41 |
| | Double Pane | Electric | 1.85 | 5.02 | -0.76 | 4.41 | 1.03 | 2.73 | 0.01 | 2.45 |
| | | Non-electric | 2.50 | 7.10 | 2.00 | 5.48 | 1.35 | 3.77 | 1.74 | 3.04 |
| Mercantile (mall) | Single Pane | Electric | 4.11 | 8.85 | 7.00 | 9.50 | 3.17 | 5.87 | 4.82 | 6.81 |
| | | Non-electric | 6.68 | 18.30 | 23.16 | 21.06 | 5.13 | 14.07 | 18.13 | 15.57 |
| | Double Pane | Electric | 2.04 | 3.95 | 3.18 | 4.43 | 1.09 | 2.07 | 1.93 | 2.25 |
| | | Non-electric | 2.98 | 9.41 | 11.37 | 10.25 | 1.67 | 4.89 | 6.04 | 5.27 |
| Mercantile (Retail, not mall) | Single Pane | Electric | 3.38 | 9.45 | 13.99 | 14.03 | 2.37 | 7.21 | 10.78 | 10.26 |
| | | Non-electric | 3.51 | 8.96 | 13.00 | 8.29 | 2.61 | 6.77 | 9.91 | 5.89 |
| | Double Pane | Electric | 1.83 | 4.81 | 6.47 | 6.91 | 1.02 | 2.66 | 3.78 | 3.65 |
| | | Non-electric | 1.78 | 4.35 | 6.05 | 3.93 | 1.03 | 2.43 | 3.44 | 2.06 |

| Building Type[57] | Window Type | Heating System Type[58] | DSM III | | | | DSM VII | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $ESF_{North}$ (kWh/ft$^2$) | $ESF_{East}$ (kWh/ft$^2$) | $ESF_{South}$[59] (kWh/ft$^2$) | $ESF_{West}$ (kWh/ft$^2$) | $ESF_{North}$ (kWh/ft$^2$) | $ESF_{East}$ (kWh/ft$^2$) | $ESF_{South}$[60] (kWh/ft$^2$) | $ESF_{West}$ (kWh/ft$^2$) |
| Office – Small (<40,000 sq ft) | Single Pane | Electric | 1.40 | 7.28 | 8.01 | 7.82 | 1.29 | 5.29 | 6.20 | 5.60 |
| | | Non-electric | 3.15 | 8.58 | 9.81 | 8.87 | 2.38 | 6.41 | 7.56 | 6.47 |
| | Double Pane | Electric | 0.97 | 3.62 | 4.05 | 3.97 | 0.59 | 1.87 | 2.24 | 2.02 |
| | | Non-electric | 1.57 | 4.26 | 4.90 | 4.43 | 0.84 | 2.25 | 2.66 | 2.28 |
| Office – Large (≥40,000 sq ft) | Single Pane | Electric | 7.86 | 35.45 | 46.89 | 33.70 | 6.32 | 27.37 | 36.32 | 26.37 |
| | | Non-electric | 13.23 | 44.49 | 56.89 | 41.44 | 10.18 | 34.09 | 43.61 | 32.16 |
| | Double Pane | Electric | 4.50 | 18.99 | 24.48 | 17.94 | 2.57 | 10.27 | 13.28 | 10.08 |
| | | Non-electric | 6.77 | 22.83 | 29.08 | 21.31 | 3.79 | 12.22 | 15.63 | 11.82 |
| Other[61] | Single Pane | Electric | 2.40 | 6.05 | -1.68 | 8.75 | 1.76 | 4.23 | 0.72 | 6.27 |
| | | Non-electric | 3.75 | 7.08 | 3.52 | 9.27 | 2.85 | 5.21 | 4.03 | 6.77 |
| | Double Pane | Electric | 1.22 | 3.04 | -3.30 | 4.42 | 0.72 | 1.55 | -1.43 | 2.24 |
| | | Non-electric | 1.89 | 3.58 | -0.19 | 4.67 | 1.05 | 1.84 | 0.04 | 2.39 |
| Public Assembly | Single Pane | Electric | 3.71 | 7.46 | 5.46 | 12.53 | 2.71 | 5.44 | 4.34 | 7.62 |
| | | Non-electric | 4.56 | 9.58 | 9.94 | 14.91 | 3.54 | 7.26 | 7.91 | 9.72 |
| | Double Pane | Electric | 1.88 | 3.85 | 2.91 | 7.77 | 0.99 | 1.98 | 1.69 | 2.52 |
| | | Non-electric | 2.28 | 4.86 | 5.08 | 9.17 | 1.26 | 2.60 | 2.86 | 3.07 |
| Public Order and Safety (Police and Fire Station) | Single Pane | Electric | 3.59 | 9.59 | 9.65 | 8.83 | 2.78 | 6.85 | 7.26 | 5.56 |
| | | Non-electric | 4.60 | 12.59 | 14.30 | 12.20 | 3.65 | 9.26 | 10.81 | 8.20 |
| | Double Pane | Electric | 3.59 | 9.59 | 9.65 | 8.83 | 0.98 | 2.35 | 2.49 | 1.77 |
| | | Non-electric | 4.60 | 12.59 | 14.30 | 12.20 | 1.28 | 3.20 | 3.77 | 2.81 |

| Building Type[57] | Window Type | Heating System Type[58] | DSM III | | | | DSM VII | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | ESF$_{North}$ (kWh/ ft$^2$) | ESF$_{East}$ (kWh/ ft$^2$) | ESF$_{South}$[59] (kWh/ ft$^2$) | ESF$_{West}$ (kWh/ ft$^2$) | ESF$_{North}$ (kWh/ ft$^2$) | ESF$_{East}$ (kWh/ ft$^2$) | ESF$_{South}$[60] (kWh/ ft$^2$) | ESF$_{West}$ (kWh/ ft$^2$) |
| Religious Worship | Single Pane | Electric | 19.30 | 44.39 | 20.46 | 43.22 | 14.81 | 33.95 | 17.30 | 33.86 |
| | | Non-electric | 11.83 | 27.15 | 12.11 | 26.47 | 3.34 | 7.50 | 3.78 | 7.46 |
| | Double Pane | Electric | 10.46 | 20.33 | 12.52 | 22.13 | 5.50 | 12.29 | 6.61 | 12.17 |
| | | Non-electric | 6.37 | 12.90 | 7.24 | 26.47 | 3.34 | 7.50 | 3.78 | 7.46 |
| Service (Beauty, Auto Repair Workshop) | Single Pane | Electric | 4.52 | 2.56 | 7.29 | 3.00 | 3.58 | 7.28 | 22.03 | 16.65 |
| | | Non-electric | 2.04 | 4.25 | 7.57 | 4.35 | 6.50 | 12.65 | 22.50 | 19.25 |
| | Double Pane | Electric | 0.58 | 1.30 | 4.58 | 1.54 | 1.34 | 2.80 | 7.65 | 6.09 |
| | | Non-electric | 1.02 | 2.10 | 4.51 | 1.42 | 2.25 | 4.46 | 8.05 | 6.80 |

**Table 4-5: Demand Reduction Factors per Square Foot of Reflective Window Film per Building Type and Window Orientation for VA (DSM Phase III and VII)**

| Building Type[62] | Window Type | Heating System Type[63] | DSM III | | | | DSM VII | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | DRF$_{North}$ (kW/ft$^2$) | DRF$_{East}$ (kW/ft$^2$) | DRF$_{South}$[64] (kW/ft$^2$) | DRF$_{West}$ (kW/ft$^2$) | DRF$_{North}$ (kW/ft$^2$) | DRF$_{East}$ (kW/ft$^2$) | DRF$_{South}$[65] (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 | 1.01E-03 | 1.61E-03 | 1.89E-03 | 3.28E-03 |
| | | Non-electric | 1.72E-03 | 2.62E-03 | 2.90E-03 | 3.54E-03 | 2.61E-03 | 2.95E-03 | 3.12E-03 | 4.13E-03 |
| | Double Pane | Electric | 9.60E-04 | 1.33E-03 | 1.62E-03 | 2.01E-03 | 3.47E-04 | 5.27E-04 | 7.16E-04 | 1.10E-03 |
| | | Non-electric | 8.47E-04 | 1.47E-03 | 1.41E-03 | 1.89E-03 | 7.21E-04 | 1.00E-03 | 9.66E-04 | 1.52E-03 |
| Education – High School | Single Pane | Electric | 1.18E-03 | 2.03E-03 | 4.89E-03 | 1.97E-03 | 1.49E-03 | 2.28E-03 | 7.66E-03 | 2.03E-03 |
| | | Non-electric | 1.24E-03 | 2.42E-03 | 7.87E-03 | 3.10E-03 | 1.27E-03 | 2.36E-03 | 1.02E-02 | 3.11E-03 |
| | Double Pane | Electric | 6.16E-04 | 1.03E-03 | 1.18E-03 | 1.29E-03 | 5.38E-04 | 8.26E-04 | 8.58E-04 | 1.23E-03 |
| | | Non-electric | 6.99E-04 | 1.22E-03 | 1.42E-03 | 1.88E-03 | 5.03E-04 | 6.89E-04 | 7.54E-04 | 9.62E-04 |
| Education – College and University | Single Pane | Electric | 1.20E-03 | 2.67E-03 | 3.18E-03 | 3.21E-03 | 1.35E-03 | 2.73E-03 | 2.44E-03 | 3.20E-03 |
| | | Non-electric | 1.26E-03 | 2.79E-03 | 3.24E-03 | 3.21E-03 | 1.36E-03 | 2.76E-03 | 2.47E-03 | 3.24E-03 |
| | Double Pane | Electric | 6.32E-04 | 1.30E-03 | 1.85E-03 | 1.58E-03 | 4.79E-04 | 5.43E-04 | 5.51E-05 | 1.21E-03 |
| | | Non-electric | 6.61E-04 | 1.36E-03 | 1.95E-03 | 1.56E-03 | 4.79E-04 | 1.00E-03 | 9.30E-04 | 1.17E-03 |
| Food Sales - Grocery | Single Pane | Electric | 1.08E-03 | 1.68E-03 | 2.26E-04 | 2.57E-03 | 1.11E-03 | 1.61E-03 | -2.50E-03 | 3.11E-03 |
| | | Non-electric | 1.03E-03 | 1.47E-03 | -2.55E-04 | 2.30E-03 | 9.22E-04 | 1.32E-03 | -3.95E-03 | 2.57E-03 |
| | Double Pane | Electric | 5.45E-04 | 8.76E-04 | -8.30E-04 | 1.33E-03 | 4.15E-04 | 5.90E-04 | 7.83E-04 | 1.12E-03 |
| | | Non-electric | 4.73E-04 | 7.23E-04 | -1.20E-03 | 1.14E-03 | 3.36E-04 | 4.80E-04 | 7.29E-04 | 9.24E-04 |

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

[63] Non-electric heating systems were represented by gas heating in building energy models.

[64] 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.

[65] 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[62] | Window Type | Heating System Type[63] | DSM III | | | | DSM VII | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | DRF$_{North}$ (kW/ft$^2$) | DRF$_{East}$ (kW/ft$^2$) | DRF$_{South}$[64] (kW/ft$^2$) | DRF$_{West}$ (kW/ft$^2$) | DRF$_{North}$ (kW/ft$^2$) | DRF$_{East}$ (kW/ft$^2$) | DRF$_{South}$[65] (kW/ft$^2$) | DRF$_{West}$ (kW/ft$^2$) |
| Food Sales – Convenience Store | Single Pane | Electric | 8.76E-04 | 1.56E-03 | 7.02E-04 | 2.43E-03 | 8.92E-04 | 1.51E-03 | -8.74E-04 | 2.98E-03 |
| | | Non-electric | 8.34E-04 | 1.33E-03 | 2.23E-04 | 2.12E-03 | 9.54E-04 | 1.23E-03 | -2.12E-03 | 2.46E-03 |
| | Double Pane | Electric | 4.25E-04 | 8.15E-04 | -2.46E-04 | 1.25E-03 | 2.90E-04 | 5.21E-04 | -2.24E-03 | 1.82E-03 |
| | | Non-electric | 4.80E-04 | 6.75E-04 | -6.07E-04 | 1.08E-03 | 3.59E-04 | 4.46E-04 | -3.41E-03 | 8.83E-04 |
| Food Sales – Gas Station Convenience Store | Single Pane | Electric | 8.76E-04 | 1.56E-03 | 7.02E-04 | 2.43E-03 | 8.92E-04 | 1.51E-03 | -8.74E-04 | 2.98E-03 |
| | | Non-electric | 8.34E-04 | 1.33E-03 | 2.23E-04 | 2.12E-03 | 9.54E-04 | 1.23E-03 | -2.12E-03 | 2.46E-03 |
| | Double Pane | Electric | 4.25E-04 | 8.15E-04 | -2.46E-04 | 1.25E-03 | 2.90E-04 | 5.21E-04 | -2.24E-03 | 1.82E-03 |
| | | Non-electric | 4.80E-04 | 6.75E-04 | -6.07E-04 | 1.08E-03 | 3.59E-04 | 4.46E-04 | -3.41E-03 | 8.83E-04 |
| Food Service - Full Service | Single Pane | Electric | 1.16E-03 | 2.16E-03 | 2.18E-03 | 2.86E-03 | 1.18E-03 | 1.91E-03 | 1.78E-03 | 3.15E-03 |
| | | Non-electric | 1.05E-03 | 1.91E-03 | 1.93E-03 | 2.55E-03 | 9.52E-04 | 1.75E-03 | 1.59E-03 | 2.68E-03 |
| | Double Pane | Electric | 5.84E-04 | 1.07E-03 | 1.09E-03 | 1.43E-03 | 3.56E-04 | 6.82E-04 | 6.13E-04 | 1.11E-03 |
| | | Non-electric | 5.27E-04 | 9.64E-04 | 9.69E-04 | 1.27E-03 | 3.19E-04 | 6.16E-04 | 5.48E-04 | 9.44E-04 |
| Food Service - Fast Food | Single Pane | Electric | 1.01E-03 | 2.04E-03 | 1.29E-03 | 2.04E-03 | 1.02E-03 | 1.66E-03 | 1.08E-03 | 2.54E-03 |
| | | Non-electric | 8.82E-04 | 1.80E-03 | 1.83E-03 | 1.79E-03 | 8.78E-04 | 1.46E-03 | 1.56E-03 | 2.18E-03 |
| | Double Pane | Electric | 5.29E-04 | 9.72E-04 | 1.13E-03 | 1.05E-03 | 3.73E-04 | 6.15E-04 | 6.27E-04 | 9.12E-04 |
| | | Non-electric | 4.58E-04 | 8.46E-04 | 9.74E-04 | 9.19E-04 | 3.20E-04 | 5.47E-04 | 5.55E-04 | 7.83E-04 |
| Health Care-inpatient | Single Pane | Electric | 8.09E-04 | 3.14E-03 | -9.03E-03 | 1.28E-03 | 7.83E-04 | 2.91E-03 | -1.34E-02 | 1.52E-03 |
| | | Non-electric | 7.17E-04 | 2.76E-03 | -2.81E-03 | 3.22E-03 | 7.90E-04 | 2.96E-03 | -1.34E-02 | 1.52E-03 |
| | Double Pane | Electric | 4.25E-04 | 1.18E-03 | 7.57E-04 | 6.41E-04 | 2.74E-04 | 1.03E-03 | 6.08E-04 | 5.37E-04 |
| | | Non-electric | 5.55E-04 | 1.61E-03 | 9.14E-04 | 1.78E-03 | 3.73E-04 | 1.06E-03 | 6.23E-04 | 5.42E-04 |
| Health Care-outpatient | Single Pane | Electric | 8.09E-04 | 1.68E-03 | -3.34E-05 | 1.81E-03 | 7.67E-04 | 1.60E-03 | 1.49E-03 | 2.02E-03 |
| | | Non-electric | 8.06E-04 | 1.75E-03 | -4.43E-07 | 1.87E-03 | 7.67E-04 | 1.66E-03 | 1.57E-03 | 2.07E-03 |
| | Double Pane | Electric | 4.33E-04 | 8.48E-04 | -8.85E-04 | 9.14E-04 | 2.95E-04 | 5.75E-04 | 5.38E-04 | 7.17E-04 |
| | | Non-electric | 4.38E-04 | 8.81E-04 | -8.91E-04 | 9.45E-04 | 2.96E-04 | 5.96E-04 | 5.62E-04 | 7.36E-04 |

| Building Type[62] | Window Type | Heating System Type[63] | DSM III | | | | DSM VII | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | DRF$_{North}$ (kW/ft$^2$) | DRF$_{East}$ (kW/ft$^2$) | DRF$_{South}$[64] (kW/ft$^2$) | DRF$_{West}$ (kW/ft$^2$) | DRF$_{North}$ (kW/ft$^2$) | DRF$_{East}$ (kW/ft$^2$) | DRF$_{South}$[65] (kW/ft$^2$) | DRF$_{West}$ (kW/ft$^2$) |
| Lodging – (Hotel, Motel, and Dormitory) | Single Pane | Electric | 1.08E-03 | 1.60E-03 | 1.61E-03 | 2.31E-03 | 1.12E-03 | 1.45E-03 | 1.53E-03 | 3.00E-03 |
| | | Non-electric | 1.25E-03 | 2.14E-03 | 1.95E-03 | 2.57E-03 | 1.25E-03 | 1.93E-03 | 2.04E-03 | 3.19E-03 |
| | Double Pane | Electric | 5.56E-04 | 8.37E-04 | 6.35E-04 | 1.15E-03 | 3.82E-04 | 5.30E-04 | 4.86E-04 | 1.05E-03 |
| | | Non-electric | 6.40E-04 | 1.11E-03 | 6.73E-04 | 1.28E-03 | 4.50E-04 | 7.16E-04 | 6.48E-04 | 1.14E-03 |
| Mercantile (mall) | Single Pane | Electric | 1.45E-03 | 2.49E-03 | 2.47E-03 | 3.01E-03 | 1.77E-03 | 2.72E-03 | 2.41E-03 | 4.04E-03 |
| | | Non-electric | 1.27E-03 | 2.05E-03 | 2.12E-03 | 2.45E-03 | 1.53E-03 | 2.22E-03 | 2.01E-03 | 3.25E-03 |
| | Double Pane | Electric | 7.52E-04 | 1.21E-03 | 1.26E-03 | 1.52E-03 | 6.22E-04 | 9.59E-04 | 8.50E-04 | 1.43E-03 |
| | | Non-electric | 6.33E-04 | 1.02E-03 | 1.06E-03 | 1.22E-03 | 4.94E-04 | 7.79E-04 | 6.66E-04 | 1.10E-03 |
| Mercantile (Retail, not mall) | Single Pane | Electric | 1.03E-03 | 1.96E-03 | 2.35E-03 | 2.79E-03 | 1.11E-03 | 1.72E-03 | 1.82E-03 | 3.60E-03 |
| | | Non-electric | 1.01E-03 | 1.85E-03 | 2.01E-03 | 2.26E-03 | 8.12E-04 | 1.54E-03 | 1.57E-03 | 2.66E-03 |
| | Double Pane | Electric | 5.04E-04 | 9.78E-04 | 1.10E-03 | 1.64E-03 | 3.75E-04 | 6.06E-04 | 5.70E-04 | 1.26E-03 |
| | | Non-electric | 4.93E-04 | 8.39E-04 | 9.26E-04 | 1.34E-03 | 3.00E-04 | 4.92E-04 | 4.63E-04 | 1.09E-03 |
| Office – Small (<40,000 sq ft) | Single Pane | Electric | 6.43E-04 | 1.75E-03 | 1.59E-03 | 2.35E-03 | 9.36E-04 | 2.11E-03 | 2.14E-03 | 2.62E-03 |
| | | Non-electric | 8.41E-04 | 1.74E-03 | 1.47E-03 | 2.24E-03 | 1.15E-03 | 1.93E-03 | 2.00E-03 | 2.54E-03 |
| | Double Pane | Electric | 3.28E-04 | 9.10E-04 | 9.75E-04 | 1.18E-03 | 3.05E-04 | 8.13E-04 | 6.75E-04 | 9.36E-04 |
| | | Non-electric | 4.31E-04 | 8.79E-04 | 9.45E-04 | 1.12E-03 | 4.29E-04 | 6.87E-04 | 6.91E-04 | 9.07E-04 |
| Office – Large (≥40,000 sq ft) | Single Pane | Electric | 3.10E-03 | 8.52E-03 | 9.84E-03 | 9.20E-03 | 4.21E-03 | 1.09E-02 | 1.21E-02 | 1.29E-02 |
| | | Non-electric | 3.11E-03 | 8.62E-03 | 9.95E-03 | 9.28E-03 | 4.24E-03 | 1.11E-02 | 1.23E-02 | 1.30E-02 |
| | Double Pane | Electric | 1.58E-03 | 4.33E-03 | 5.04E-03 | 4.74E-03 | 1.57E-03 | 3.87E-03 | 4.28E-03 | 4.74E-03 |
| | | Non-electric | 1.61E-03 | 4.42E-03 | 5.11E-03 | 4.79E-03 | 1.59E-03 | 3.95E-03 | 4.37E-03 | 4.82E-03 |

| Building Type[62] | Window Type | Heating System Type[63] | DSM III | | | | DSM VII | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | DRF$_{North}$ (kW/ft$^2$) | DRF$_{East}$ (kW/ft$^2$) | DRF$_{South}$[64] (kW/ft$^2$) | DRF$_{West}$ (kW/ft$^2$) | DRF$_{North}$ (kW/ft$^2$) | DRF$_{East}$ (kW/ft$^2$) | DRF$_{South}$[65] (kW/ft$^2$) | DRF$_{West}$ (kW/ft$^2$) |
| Other[66] | Single Pane | Electric | 8.76E-04 | 1.56E-03 | 7.02E-04 | 2.43E-03 | 8.92E-04 | 1.51E-03 | -8.74E-04 | 2.98E-03 |
| | | Non-electric | 8.34E-04 | 1.33E-03 | 2.23E-04 | 2.12E-03 | 9.54E-04 | 1.23E-03 | -2.12E-03 | 2.46E-03 |
| | Double Pane | Electric | 4.25E-04 | 8.15E-04 | -2.46E-04 | 1.25E-03 | 2.90E-04 | 5.21E-04 | -2.24E-03 | 1.82E-03 |
| | | Non-electric | 4.80E-04 | 6.75E-04 | -6.07E-04 | 1.08E-03 | 3.59E-04 | 4.46E-04 | -3.41E-03 | 8.83E-04 |
| Public Assembly | Single Pane | Electric | 1.10E-03 | 1.82E-03 | 1.92E-03 | 5.63E-03 | 9.31E-03 | 9.94E-03 | 1.67E-03 | 1.11E-02 |
| | | Non-electric | 1.21E-03 | 1.99E-03 | 2.07E-03 | 7.11E-03 | 1.40E-02 | 1.48E-02 | 1.82E-03 | 1.58E-02 |
| | Double Pane | Electric | 5.68E-04 | 9.40E-04 | 9.83E-04 | 4.42E-03 | 4.01E-04 | 6.20E-04 | 5.86E-04 | 1.02E-03 |
| | | Non-electric | 6.17E-04 | 1.02E-03 | 1.05E-03 | 5.83E-03 | 4.20E-04 | 6.71E-04 | 6.42E-04 | 1.07E-03 |
| Public Order and Safety (Police and Fire Station) | Single Pane | Electric | 8.03E-04 | 1.95E-03 | 7.56E-04 | 1.64E-03 | 8.02E-04 | 1.67E-03 | 1.73E-03 | 1.54E-03 |
| | | Non-electric | 7.68E-04 | 2.10E-03 | 8.88E-04 | 1.75E-03 | 7.92E-04 | 1.79E-03 | 1.87E-03 | 1.65E-03 |
| | Double Pane | Electric | 3.97E-04 | 9.84E-04 | 1.07E-03 | 3.42E-04 | 2.77E-04 | 5.97E-04 | 6.00E-04 | -3.68E-04 |
| | | Non-electric | 3.91E-04 | 1.06E-03 | 1.14E-03 | 4.04E-04 | 2.74E-04 | 6.39E-04 | 6.43E-04 | -3.43E-04 |
| Religious Worship | Single Pane | Electric | 5.10E-03 | 1.20E-02 | 5.86E-03 | 1.26E-02 | 4.58E-03 | 1.12E-02 | 6.19E-03 | 1.19E-02 |
| | | Non-electric | 2.80E-03 | 6.93E-03 | 3.27E-03 | 7.09E-03 | 9.05E-04 | 2.13E-03 | 9.59E-04 | 1.88E-03 |
| | Double Pane | Electric | 2.91E-03 | 6.49E-03 | 3.11E-03 | 6.73E-03 | 1.83E-03 | 4.16E-03 | 1.85E-03 | 4.38E-03 |
| | | Non-electric | 1.63E-03 | 3.81E-03 | 1.77E-03 | 3.84E-03 | 9.05E-04 | 2.13E-03 | 9.59E-04 | 1.88E-03 |
| Service (Beauty, Auto Repair Workshop) | Single Pane | Electric | 9.90E-04 | 1.02E-03 | 0.00E+00 | 1.37E-03 | 4.96E-03 | 4.39E-03 | 3.55E-03 | 8.00E-03 |
| | | Non-electric | 6.19E-04 | 1.49E-03 | 1.07E-03 | 1.43E-03 | 2.81E-03 | 4.71E-03 | 3.77E-03 | 8.46E-03 |
| | Double Pane | Electric | 2.94E-04 | 4.34E-04 | 5.10E-04 | 6.89E-04 | 9.44E-04 | 1.18E-03 | 1.22E-03 | 2.82E-03 |
| | | Non-electric | 3.08E-04 | 4.76E-04 | 5.34E-04 | 7.13E-04 | 9.85E-04 | 1.32E-03 | 1.33E-03 | 2.97E-03 |

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[66] 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 4-6: Demand Reduction Factors per Square Foot of Reflective Window Film per Building Type and Window Orientation for NC (DSM Phase III and VII)**

| Building Type[67] | Window Type | Heating System Type[68] | DSM III | | | | DSM VII | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $DRF_{North}$ (kW/ft$^2$) | $DRF_{East}$ (kW/ft$^2$) | $DRF_{South}$[69] (kW/ft$^2$) | $DRF_{West}$ (kW/ft$^2$) | $DRF_{North}$ (kW/ft$^2$) | $DRF_{East}$ (kW/ft$^2$) | $DRF_{South}$[70] (kW/ft$^2$) | $DRF_{West}$ (kW/ft$^2$) |
| Education – Elementary and Middle School | Single Pane | Electric | 1.84E-03 | 2.55E-03 | 3.09E-03 | 4.07E-03 | 1.71E-03 | 2.30E-03 | 1.45E-03 | 3.44E-03 |
| | | Non-electric | 9.54E-04 | 1.41E-03 | 1.52E-03 | 2.02E-03 | 2.94E-03 | 3.37E-03 | 2.72E-03 | 4.93E-03 |
| | Double Pane | Electric | 9.97E-04 | 1.32E-03 | 1.58E-03 | 2.12E-03 | 7.14E-04 | 7.26E-04 | 8.49E-04 | 1.32E-03 |
| | | Non-electric | 9.54E-04 | 1.41E-03 | 1.52E-03 | 2.02E-03 | 1.25E-03 | 1.47E-03 | 1.37E-03 | 1.78E-03 |
| Education – High School | Single Pane | Electric | 1.26E-03 | 2.09E-03 | 2.37E-03 | 3.30E-03 | 1.48E-03 | 2.09E-03 | 2.19E-03 | 3.48E-03 |
| | | Non-electric | 1.26E-03 | 2.09E-03 | 2.37E-03 | 3.30E-03 | 1.48E-03 | 2.09E-03 | 2.19E-03 | 3.48E-03 |
| | Double Pane | Electric | 6.25E-04 | 1.04E-03 | 1.19E-03 | 1.62E-03 | 5.32E-04 | 7.51E-04 | 7.89E-04 | 1.24E-03 |
| | | Non-electric | 6.25E-04 | 1.04E-03 | 1.19E-03 | 1.62E-03 | 5.32E-04 | 7.51E-04 | 7.89E-04 | 1.24E-03 |
| Education – College and University | Single Pane | Electric | 1.26E-03 | 4.43E-03 | 4.51E-03 | 3.99E-03 | 1.27E-03 | 3.45E-03 | 2.57E-03 | 3.32E-03 |
| | | Non-electric | 1.49E-03 | 4.79E-03 | 3.42E-03 | 4.22E-03 | 1.27E-03 | 3.46E-03 | 2.43E-03 | 3.30E-03 |
| | Double Pane | Electric | 6.72E-04 | 1.46E-03 | 1.53E-03 | 5.12E-04 | 4.66E-04 | 9.09E-04 | 7.99E-04 | 1.16E-03 |
| | | Non-electric | 6.39E-04 | 1.42E-03 | 1.48E-03 | 4.61E-04 | 4.67E-04 | 9.19E-04 | 8.10E-04 | 1.16E-03 |
| Food Sales - Grocery | Single Pane | Electric | 1.02E-03 | 1.65E-03 | -6.42E-04 | 2.84E-03 | 1.08E-03 | 1.50E-03 | -8.38E-04 | 3.10E-03 |
| | | Non-electric | 8.59E-04 | 1.38E-03 | -1.12E-03 | 2.46E-03 | 9.49E-04 | 1.26E-03 | -1.68E-03 | 2.61E-03 |
| | Double Pane | Electric | 5.38E-04 | 8.52E-04 | -1.48E-03 | 1.44E-03 | 3.84E-04 | 5.34E-04 | 6.29E-04 | 1.10E-03 |
| | | Non-electric | 4.43E-04 | 7.00E-04 | -1.86E-03 | 1.25E-03 | 3.46E-04 | 4.53E-04 | 6.04E-04 | 9.31E-04 |

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[67] 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[67] | Window Type | Heating System Type[68] | DSM III |  |  |  | DSM VII |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  | $DRF_{North}$ ($kW/ft^2$) | $DRF_{East}$ ($kW/ft^2$) | $DRF_{South}$[69] ($kW/ft^2$) | $DRF_{West}$ ($kW/ft^2$) | $DRF_{North}$ ($kW/ft^2$) | $DRF_{East}$ ($kW/ft^2$) | $DRF_{South}$[70] ($kW/ft^2$) | $DRF_{West}$ ($kW/ft^2$) |
| Food Sales – Convenience Store | Single Pane | Electric | 9.15E-04 | 1.54E-03 | -5.66E-05 | 2.69E-03 | 9.12E-04 | 1.38E-03 | -1.09E-04 | 2.97E-03 |
|  |  | Non-electric | 9.24E-04 | 1.29E-03 | -4.56E-04 | 2.33E-03 | 9.52E-04 | 1.17E-03 | -7.69E-04 | 2.52E-03 |
|  | Double Pane | Electric | 4.63E-04 | 8.00E-04 | -8.48E-04 | 1.37E-03 | 3.21E-04 | 5.01E-04 | -1.05E-03 | 1.06E-03 |
|  |  | Non-electric | 4.74E-04 | 6.64E-04 | -1.15E-03 | 1.18E-03 | 3.39E-04 | 4.23E-04 | -1.62E-03 | 8.99E-04 |
| Food Sales – Gas Station Convenience Store | Single Pane | Electric | 9.15E-04 | 1.54E-03 | -5.66E-05 | 2.69E-03 | 9.12E-04 | 1.38E-03 | -1.09E-04 | 2.97E-03 |
|  |  | Non-electric | 9.24E-04 | 1.29E-03 | -4.56E-04 | 2.33E-03 | 9.52E-04 | 1.17E-03 | -7.69E-04 | 2.52E-03 |
|  | Double Pane | Electric | 4.63E-04 | 8.00E-04 | -8.48E-04 | 1.37E-03 | 3.21E-04 | 5.01E-04 | -1.05E-03 | 1.06E-03 |
|  |  | Non-electric | 4.74E-04 | 6.64E-04 | -1.15E-03 | 1.18E-03 | 3.39E-04 | 4.23E-04 | -1.62E-03 | 8.99E-04 |
| Food Service - Full Service | Single Pane | Electric | 1.18E-03 | 2.01E-03 | 2.19E-03 | 3.32E-03 | 1.13E-03 | 1.64E-03 | 1.61E-03 | 3.22E-03 |
|  |  | Non-electric | 1.02E-03 | 1.76E-03 | 1.94E-03 | 2.94E-03 | 9.39E-04 | 1.43E-03 | 1.44E-03 | 2.81E-03 |
|  | Double Pane | Electric | 5.93E-04 | 9.96E-04 | 1.10E-03 | 1.64E-03 | 4.01E-04 | 5.43E-04 | 5.34E-04 | 1.14E-03 |
|  |  | Non-electric | 5.04E-04 | 8.88E-04 | 9.83E-04 | 1.45E-03 | 3.31E-04 | 4.69E-04 | 4.78E-04 | 9.74E-04 |
| Food Service - Fast Food | Single Pane | Electric | 9.86E-04 | 2.06E-03 | 1.83E-03 | 2.35E-03 | 9.33E-04 | 1.61E-03 | 1.55E-03 | 2.39E-03 |
|  |  | Non-electric | 8.58E-04 | 1.80E-03 | 1.52E-03 | 2.07E-03 | 8.10E-04 | 1.42E-03 | 1.36E-03 | 2.10E-03 |
|  | Double Pane | Electric | 5.13E-04 | 1.09E-03 | 1.11E-03 | 1.21E-03 | 3.35E-04 | 5.52E-04 | 5.58E-04 | 8.56E-04 |
|  |  | Non-electric | 4.45E-04 | 9.56E-04 | 9.55E-04 | 1.06E-03 | 2.93E-04 | 4.83E-04 | 4.87E-04 | 7.52E-04 |
| Health Care-inpatient | Single Pane | Electric | 8.69E-04 | 3.44E-03 | 2.37E-03 | -3.25E-03 | 8.06E-04 | 2.87E-03 | 1.86E-03 | 1.53E-03 |
|  |  | Non-electric | 1.07E-03 | 3.52E-03 | 2.03E-03 | 4.36E-03 | 1.06E-03 | 2.90E-03 | 1.88E-03 | 1.53E-03 |
|  | Double Pane | Electric | -2.02E-03 | 1.83E-03 | 1.22E-03 | -2.91E-03 | 8.42E-04 | 1.95E-03 | 1.27E-03 | 5.38E-04 |
|  |  | Non-electric | 1.07E-03 | 3.52E-03 | 2.03E-03 | 4.36E-03 | 8.93E-04 | 1.95E-03 | 1.27E-03 | 5.37E-04 |
| Health Care-outpatient | Single Pane | Electric | 9.19E-04 | 1.75E-03 | 1.28E-03 | 9.88E-04 | 8.81E-04 | 1.42E-03 | 8.80E-04 | 1.16E-03 |
|  |  | Non-electric | 9.37E-04 | 1.82E-03 | 1.36E-03 | 1.02E-03 | 8.97E-04 | 1.48E-03 | 9.54E-04 | 1.19E-03 |
|  | Double Pane | Electric | 4.70E-04 | 8.82E-04 | 8.92E-04 | 1.01E-03 | 3.13E-04 | 5.03E-04 | 4.59E-04 | 7.03E-04 |
|  |  | Non-electric | 4.79E-04 | 9.16E-04 | 9.39E-04 | 1.05E-03 | 3.19E-04 | 5.24E-04 | 4.88E-04 | 7.22E-04 |

| Building Type[67] | Window Type | Heating System Type[68] | DSM III | | | | DSM VII | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $DRF_{North}$ (kW/ft$^2$) | $DRF_{East}$ (kW/ft$^2$) | $DRF_{South}$[69] (kW/ft$^2$) | $DRF_{West}$ (kW/ft$^2$) | $DRF_{North}$ (kW/ft$^2$) | $DRF_{East}$ (kW/ft$^2$) | $DRF_{South}$[70] (kW/ft$^2$) | $DRF_{West}$ (kW/ft$^2$) |
| Lodging – (Hotel, Motel, and Dormitory) | Single Pane | Electric | 1.05E-03 | 1.75E-03 | 1.17E-03 | 2.62E-03 | 1.02E-03 | 1.43E-03 | 7.56E-04 | 2.94E-03 |
| | | Non-electric | 1.20E-03 | 2.40E-03 | 1.67E-03 | 2.97E-03 | 1.15E-03 | 1.95E-03 | 1.26E-03 | 3.22E-03 |
| | Double Pane | Electric | 5.33E-04 | 8.90E-04 | 9.50E-05 | 1.34E-03 | 3.66E-04 | 5.26E-04 | -4.04E-05 | 1.05E-03 |
| | | Non-electric | 6.12E-04 | 1.25E-03 | 1.70E-04 | 1.50E-03 | 4.17E-04 | 7.21E-04 | 7.31E-05 | 1.14E-03 |
| Mercantile (mall) | Single Pane | Electric | 1.55E-03 | 2.69E-03 | 2.53E-03 | 3.49E-03 | 1.71E-03 | 2.48E-03 | 2.18E-03 | 3.98E-03 |
| | | Non-electric | 1.32E-03 | 2.93E-03 | 2.97E-03 | 4.13E-03 | 1.45E-03 | 2.56E-03 | 2.43E-03 | 4.12E-03 |
| | Double Pane | Electric | 7.74E-04 | 1.34E-03 | 1.27E-03 | 1.74E-03 | 5.98E-04 | 8.72E-04 | 7.63E-04 | 1.39E-03 |
| | | Non-electric | 6.51E-04 | 1.44E-03 | 1.46E-03 | 2.04E-03 | 5.03E-04 | 8.98E-04 | 8.47E-04 | 1.43E-03 |
| Mercantile (Retail, not mall) | Single Pane | Electric | 1.12E-03 | 1.96E-03 | 2.41E-03 | 3.76E-03 | 9.77E-04 | 1.53E-03 | 1.81E-03 | 3.60E-03 |
| | | Non-electric | 9.24E-04 | 1.60E-03 | 2.05E-03 | 2.58E-03 | 7.19E-04 | 1.22E-03 | 1.66E-03 | 2.52E-03 |
| | Double Pane | Electric | 6.28E-04 | 1.02E-03 | 1.15E-03 | 1.85E-03 | 3.75E-04 | 5.25E-04 | 4.98E-04 | 1.24E-03 |
| | | Non-electric | 4.85E-04 | 8.46E-04 | 9.94E-04 | 1.27E-03 | 2.62E-04 | 4.01E-04 | 3.72E-04 | 8.46E-04 |
| Office – Small (<40,000 sq ft) | Single Pane | Electric | 6.82E-04 | 1.77E-03 | 1.90E-03 | 2.83E-03 | 7.77E-04 | 1.68E-03 | 1.56E-03 | 2.60E-03 |
| | | Non-electric | 8.47E-04 | 1.71E-03 | 1.87E-03 | 2.64E-03 | 1.01E-03 | 1.61E-03 | 1.73E-03 | 2.49E-03 |
| | Double Pane | Electric | 3.70E-04 | 8.73E-04 | 9.07E-04 | 1.42E-03 | 2.91E-04 | 5.46E-04 | 5.44E-04 | 8.72E-04 |
| | | Non-electric | 4.14E-04 | 8.43E-04 | 9.04E-04 | 1.33E-03 | 3.73E-04 | 5.86E-04 | 5.63E-04 | 8.86E-04 |
| Office – Large (≥40,000 sq ft) | Single Pane | Electric | 3.21E-03 | 8.24E-03 | 9.91E-03 | 9.71E-03 | 4.69E-03 | 9.88E-03 | 1.13E-02 | 1.41E-02 |
| | | Non-electric | 3.20E-03 | 8.35E-03 | 1.00E-02 | 9.79E-03 | 4.72E-03 | 1.00E-02 | 1.14E-02 | 1.42E-02 |
| | Double Pane | Electric | 1.62E-03 | 4.20E-03 | 5.01E-03 | 4.99E-03 | 1.64E-03 | 3.52E-03 | 4.04E-03 | 5.12E-03 |
| | | Non-electric | 1.62E-03 | 4.22E-03 | 5.05E-03 | 4.98E-03 | 1.65E-03 | 3.52E-03 | 4.06E-03 | 5.12E-03 |

| Building Type[67] | Window Type | Heating System Type[68] | DSM III | | | | DSM VII | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $DRF_{North}$ (kW/ft$^2$) | $DRF_{East}$ (kW/ft$^2$) | $DRF_{South}$[69] (kW/ft$^2$) | $DRF_{West}$ (kW/ft$^2$) | $DRF_{North}$ (kW/ft$^2$) | $DRF_{East}$ (kW/ft$^2$) | $DRF_{South}$[70] (kW/ft$^2$) | $DRF_{West}$ (kW/ft$^2$) |
| Other[71] | Single Pane | Electric | 9.15E-04 | 1.54E-03 | -5.66E-05 | 2.69E-03 | 9.12E-04 | 1.38E-03 | -1.09E-04 | 2.97E-03 |
| | | Non-electric | 9.24E-04 | 1.29E-03 | -4.56E-04 | 2.33E-03 | 9.52E-04 | 1.17E-03 | -7.69E-04 | 2.52E-03 |
| | Double Pane | Electric | 4.63E-04 | 8.00E-04 | -8.48E-04 | 1.37E-03 | 3.21E-04 | 5.01E-04 | -1.05E-03 | 1.06E-03 |
| | | Non-electric | 4.74E-04 | 6.64E-04 | -1.15E-03 | 1.18E-03 | 3.39E-04 | 4.23E-04 | -1.62E-03 | 8.99E-04 |
| Public Assembly | Single Pane | Electric | 1.10E-03 | 1.84E-03 | 1.83E-03 | 3.88E-03 | 1.09E-03 | 1.57E-03 | 1.42E-03 | 3.83E-03 |
| | | Non-electric | 1.21E-03 | 2.04E-03 | 1.97E-03 | 4.69E-03 | 1.19E-03 | 1.75E-03 | 1.54E-03 | 4.66E-03 |
| | Double Pane | Electric | 5.61E-04 | 9.44E-04 | 9.38E-04 | 2.48E-03 | 3.80E-04 | 5.61E-04 | 5.02E-04 | 1.04E-03 |
| | | Non-electric | 6.10E-04 | 1.04E-03 | 1.01E-03 | 3.19E-03 | 4.19E-04 | 6.24E-04 | 5.53E-04 | 1.13E-03 |
| Public Order and Safety (Police and Fire Station) | Single Pane | Electric | 1.04E-03 | 2.03E-03 | 2.34E-03 | 2.36E-03 | 9.86E-04 | 1.55E-03 | 1.66E-03 | 2.25E-03 |
| | | Non-electric | 1.07E-03 | 2.19E-03 | 2.54E-03 | 2.53E-03 | 1.02E-03 | 1.67E-03 | 1.82E-03 | 2.36E-03 |
| | Double Pane | Electric | 1.04E-03 | 2.03E-03 | 2.34E-03 | 2.36E-03 | 3.47E-04 | 5.40E-04 | 5.79E-04 | 7.80E-04 |
| | | Non-electric | 1.07E-03 | 2.19E-03 | 2.54E-03 | 2.53E-03 | 3.59E-04 | 5.82E-04 | 6.34E-04 | 8.19E-04 |
| Religious Worship | Single Pane | Electric | 5.90E-03 | 1.32E-02 | 5.95E-03 | 1.32E-02 | 4.94E-03 | 1.13E-02 | 5.29E-03 | 1.19E-02 |
| | | Non-electric | 3.38E-03 | 7.84E-03 | 3.33E-03 | 7.55E-03 | 1.03E-03 | 2.38E-03 | 1.22E-03 | 2.25E-03 |
| | Double Pane | Electric | 3.13E-03 | 6.11E-03 | 3.55E-03 | 6.75E-03 | 1.80E-03 | 4.04E-03 | 2.03E-03 | 4.21E-03 |
| | | Non-electric | 1.81E-03 | 3.45E-03 | 2.14E-03 | 7.55E-03 | 1.03E-03 | 2.38E-03 | 1.22E-03 | 2.25E-03 |
| Service (Beauty, Auto Repair Workshop) | Single Pane | Electric | 9.37E-04 | 9.53E-04 | 1.88E-03 | 1.70E-03 | 2.39E-03 | 2.87E-03 | 5.40E-03 | 8.70E-03 |
| | | Non-electric | 6.39E-04 | 1.07E-03 | 1.96E-03 | 1.69E-03 | 2.56E-03 | 3.16E-03 | 5.64E-03 | 9.17E-03 |
| | Double Pane | Electric | 2.99E-04 | 4.94E-04 | 1.10E-03 | 8.64E-04 | 8.42E-04 | 1.01E-03 | 1.94E-03 | 3.03E-03 |
| | | Non-electric | 3.19E-04 | 1.15E-03 | 1.15E-03 | 5.78E-04 | 8.95E-04 | 1.11E-03 | 2.02E-03 | 3.19E-03 |

## 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 prototypical building energy models defined by the 2008 Database for Energy Efficient Resources (DEER),[72] modified to represent Richmond, VA and a blend of Elizabeth City, NC and Rocky Mount-Wilson, NC weather along with program-specific window characteristics.

## Update Summary

The changes to this section, compared with last year, are described in Table 4-7.

**Table 4-7: Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **Input Variable** | • Updated per-square-foot savings for buildings in North Carolina based on revised weather stations |

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[72] http://www.energy.ca.gov/deer/

# 5 NON-RESIDENTIAL SMALL BUSINESS IMPROVEMENT PROGRAM, DSM PHASE V

Dominion’s Non-Residential Small Business Improvement Program provides small business owners incentives to use Dominion-approved contractors to provide many of the measures already provided through existing legacy programs that typically target non-residential building owners: Non-Residential Heating and Cooling Efficiency program and the Non-residential Lighting Systems and Controls program. In addition, four retrocommissioning measures are provided. Program measures are summarized in Table 5-1.

According to the program terms and conditions, as of June 2017, to be eligible to participate in this program, Dominion Energy Virginia non-residential customers must be of a privately-owned business with five or fewer locations that has not exceeded monthly demand threshold of 100 kW three or more times in the past 12 months, has not opted out of participation, is responsible for the electric bill and is the owner of the facility or reasonably able to secure permission to complete measures. Once a customer participates in the program and receive a rebate, they cannot opt out for three years following the year of participation.

Prior to June 1, 2017, the Small Business Improvement Program delivered refrigeration measures to Virginia customers, but stopped per an SCC ruling.[73]

**Table 5-1: Non-residential Small Business Improvement Program Measure List**

| End-Use | Measure | Manual Section |
|---|---|---|
| **HVAC** | Duct Testing & Sealing | Section 5.1.1 |
| | Unitary/Split AC, HP, and Chiller Tune-up | Section 5.1.2 |
| | Refrigerant Charge Correction | Section 5.1.3 |
| | Unitary/Split AC & HP Upgrade | Section 3.1 |
| | Mini-split Heat Pump | Section 3.1.2 |
| | Dual Enthalpy Air-side Economizer | Section 3.1.5 |
| | Variable Frequency Drive | Section 3.1.4 |
| | Programmable Thermostat | Section 5.1.8 |
| **Lighting** | Lighting, Fixtures, Lamps, and Delamping | Section 1.1 |
| | Sensors & Controls | Section 1.1.2 |
| | LED Exit Signs | Section 5.2.3 |
| **Other** | Compressed Air Leak Repair | Section 5.3.1 |

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[73] As of June 1, 2017, refrigeration measures ceased to be offered through this program as a result of the ruling in Virginia SCC Case No. PUE-2016-00111 issued and effective on the same date.

# 5.1 Heating, Ventilation, and Air-Conditioning (HVAC) End Use

## 5.1.1 Duct Testing and Sealing

### Measure Description

This measures 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, and then 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 GL's judgment, this measure is applicable to ductwork at unitary and chiller-cooled systems.

This measure is offered in Non-Residential Prescriptive program DSM Phase VI, described in Section 1346.

### Savings Estimation Approach

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

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

**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.

*Unitary systems, for air-source heat pumps and AC units, Size$_{cool}$ < 65,000 Btu/h:*

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

*Unitary systems, for air-source heat pumps and AC units, Size$_{heat}$ < 65,000 Btu/h:*

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

*Unitary systems, for air-source heat pumps and AC units, Size$_{cool}$ ≥ 65,000Btu/h, and all ground-*

*source heat pumps:*

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

*Unitary systems, for air-source heat pumps and AC units, $Size_{heat}$ ≥ 65,000 Btu/h and all ground-source heat pumps:*

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

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

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

## Chiller Systems

*Water-cooled chiller systems, cooling savings:*

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

*Air-cooled chiller systems, cooling savings:*

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

*Chiller system heating savings for systems <65,000 Btu/h:*

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

*Chiller system heating savings for systems ≥65,000 Btu/h:*

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

For all system types, heating systems with non-electric primary heat will receive zero heating savings.

Per measure gross coincident demand reduction is calculated according to the following equations:

*Water-cooled chiller systems:*

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

*Air-cooled chiller systems:*

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

Where:

ΔkWh = per measure gross annual electric energy savings
ΔkW = per measure gross coincident demand reductions
$\text{Size}_{\text{cool}}$ = system cooling capacity in tons, based on nameplate data
$\text{Size}_{\text{heat}}$ = nominal rating of the unitary systems (heat pumps or AC units)
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.
EER = energy efficiency ratio (EER) of heat pump and air-conditioning systems at full-load conditions. (See Equation 3 in Sub-appendix F2-V: General Equations to convert SEER to EER, if EER is not provided.)
HSPF = heating seasonal performance factor (HSPF). It is used for heat pumps. (See Equation 6 in Sub-appendix F2-V: General Equations to convert COP to HSPF, if HSPF is not provided.)
COP = coefficient of performance (heating)
$\bar{n}_{dist,base,cool}$ = duct system average seasonal efficiency of baseline (pre-sealing) cooling system
$\bar{n}_{dist,base,heat}$ = duct system average seasonal efficiency of baseline (pre-sealing) heating system
$\bar{n}_{dist,ee,cool}$ = duct system average seasonal efficiency of efficient (post-sealing) cooling system
$\bar{n}_{dist,ee,heat}$ = duct system average seasonal efficiency of efficient (post-sealing) heating system
$n_{dist,peak,base}$ = duct system efficiency of baseline system, under peak conditions (equal to $\bar{n}_{dist,base,cool}$)
$n_{dist,peak,ee}$ = duct system efficiency of efficient system, under peak conditions (equal to $\bar{n}_{dist,ee,cool}$)

$EER_{full\text{-}load}$ = energy efficiency ratio (EER) of air-cooled chillers at full-load conditions.
$EER_{IPLV}$ = energy efficiency ratio (EER) of air-cooled chillers at integrated part load value (IPLV).
$\frac{kW}{ton_{IPLV}}$ = energy efficiency of water-cooled chiller system at integrated part load value (IPLV)
$\frac{kW}{ton_{full\ load}}$ = energy efficiency of water-cooled chiller system at full load
$EFLH_{cool}$ = cooling equivalent full load hours (EFLH)
$EFLH_{heat}$ = heating equivalent full load hours (EFLH)
CF = peak coincidence factor
TRF = Thermal regain factor

## Input Variables

**Table 5-2: 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 |
| $Size_{heat}$ | Variable | See customer application | kBtu/h (per unit) | Customer application |
| SEER | Variable | See customer application | Btu/W-hr | Customer application |
| | | Default: See Table 8-9 and Table 8-10 in Sub-appendix F2-III: Non-residential HVAC Equipment Efficiency Ratings based on equipment type | | ASHRAE 90.1-2013 |
| IEER | Variable | See customer application | Btu/W-hr | Customer application |
| | | Default: See Table 8-9 and Table 8-10 in Sub-appendix F2-III: Non-residential HVAC Equipment Efficiency Ratings based on equipment type | | ASHRAE 90.1-2013 |
| EER | Variable | See customer application | Btu/W-hr | Customer application |
| | | Default: See Table 8-9 and Table 8-10 Sub-appendix F2-III: Non-residential HVAC Equipment Efficiency Ratingsbased on equipment type | | ASHRAE 90.1-2013 |
| HSPF | Variable | See customer application | Btu/W-hr | Customer application |

| Component | Type | Value | Unit | Source(s) |
|---|---|---|---|---|
| | | Default: See Table 8-9 and Table 8-10 in Sub-appendix F2-III: Non-residential HVAC Equipment Efficiency Ratings based on equipment type | | ASHRAE 90.1-2013 |
| COP | Variable | See customer application | - | Customer application |
| | | Default: See Table 8-9 and Table 8-10 in Sub-appendix F2-III: Non-residential HVAC Equipment Efficiency Ratings based on equipment type | | ASHRAE 90.1-2013 |
| $\text{kW/ton}_{\text{full load}}$ | Variable | See customer application[74] | kW/ton | Customer application |
| | | Default: see Table 8-12 in Sub-appendix F2-III: Non-residential HVAC Equipment Efficiency Ratings based on equipment type | | ASHRAE 90.1-2013 |
| $\text{kW/ton}_{\text{IPLV}}$ | Variable | See customer application | kW/ton | Customer application |
| | | Default: see Table 8-12 in Sub-appendix F2-III: Non-residential HVAC Equipment Efficiency Ratings based on equipment type | | ASHRAE 90.1-2013 |
| $\text{EER}_{\text{full load}}$ | Variable | See customer application[75] | Btu/W-h | Customer application |
| | | Default: see Table 8-12 in Sub-appendix F2-III: Non-residential HVAC Equipment Efficiency Ratings based on equipment type | | ASHRAE 90.1-2013 |
| $\text{EER}_{\text{IPLV}}$ | Variable | See customer application | kBtu/kW-h | Customer application |

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[74] When missing either the IPLV or the full load value, use Equation 8 in Sub-appendix F2-V: General Equations, as relevant.

[75] When missing either the IPLV or the full load value, use Equation 9 in Sub-appendix F2-V: General Equations, as relevant.

| Component | Type | Value | Unit | Source(s) |
|---|---|---|---|---|
| | | Default: see Cooling Efficiencies of Water Chilling Packages Table 8-12 in Sub-appendix F2-III: Non-residential HVAC Equipment Efficiency Ratings based on equipment type | | ASHRAE 90.1-2013 |
| $\bar{n}_{dist,base,cool}$ | Variable | See customer application | 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 5-3 and Table 5-4 | 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 5-3 and Table 5-4 | 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 5-3 and Table 5-4 | percent | Customer application |
| | | Default: No insulation, 15% leakage | | New York TRM 2018, p. 242 |
| $n_{dist,peak,base}$ | Variable | See customer application along with Table 5-3 and Table 5-4 | percent | Customer application |
| | | Default: No insulation, 30% leakage | | New York TRM 2018, p. 242 |
| $n_{dist,peak,ee}$ | Variable | See customer application along with Table 5-3 and Table 5-4 | percent | Customer application |
| | | Default: No insulation, 15% leakage | | New York TRM 2018, p. 242 |
| **$\mathbf{EFLH_{heat}}$** | Fixed | See Table 8-5 in Sub-appendix F2-II: Non-residential HVAC Equivalent Full Load Hours | hours (annual) | Mid-Atlantic TRM 2019 p. 590 |
| **$\mathbf{EFLH_{cool}}$** | Fixed | For chiller systems, see Table 8-6; for all other system types, see Table 8-4 in Sub-appendix F2-II: Non-residential HVAC Equivalent Full Load Hours | hours (annual) | Mid-Atlantic TRM 2019 p. 442, p. 589 |

| Component | Type | Value | Unit | Source(s) |
|---|---|---|---|---|
| **CF** | Fixed | 0.68 | - | Calculated CF from Dominion's DSM Phase I program. April 1, 2012 EM&V Report, Sub-appendix C-1, p. F-176 |

The New York TRM provides values for duct system efficiency for uninsulated ducts and ducts with R-6 insulation for four building types: assembly building, fast food restaurant, full service restaurant, and small retail. The average column in Table 5-3 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 GL 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%.

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[76] Appendix C-1, Commercial HVAC Program: Load Shape and Net Savings Analysis Evaluation Report; Evaluation, Measurement and Verification Report for Dominion Virginia Power, Case PUE-2010-00084, Apr. 1, 2012, p. F-1.

**Table 5-3: Duct System Efficiency by Broad Building Type Categories**[77]

| 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 |

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[77] 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 5-4: Duct System Efficiency Mapping to Building Type**[78]

| Building Type | Associated Duct System Efficiency Building Type |
|---|---|
| **Education**<br>**Education – College and University**<br>**Education – High School**<br>**Education – Elementary and Middle School**<br>**Health Care – inpatient**<br>**Health Care – outpatient**<br>**Lodging – (Hotel, Motel, and Dormitory)**<br>**Office – Small (< 40,000 sq ft)**<br>**Office – Large (≥ 40,000 sq ft)**<br>**Other**<br>**Warehouse and Storage** | Average |
| **Food Sales**<br>**Food Sales – Gas Station Convenience Store**<br>**Food Sales – Convenience Store**<br>**Food Sales – Grocery**<br>**Mercantile (Retail, not Mall)**<br>**Mercantile (Mall)**<br>**Service (Beauty, Auto Repair Workshop)** | Small Retail |
| **Food Service**<br>**Food Service – Fast Food**<br>**Food Service – Other** | Fast Food Restaurant |
| **Food Service – Restaurant**<br>**Food Service – Full Service** | Full Service Restaurant |
| **Public Assembly**<br>**Public Order and Safety (Police and Fire Station)**<br>**Religious Worship** | Assembly Building |

## 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.

## Source(s)

The primary sources for this deemed savings approach is the New York TRM 2018, pp. 241-244, Mid-Atlantic TRM 2019, pp. 442 and 589-590, and ASHRAE 90.1-2013.

## Update Summary

The changes to this section, compared with last year, are described in Table 5-5.

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[78] 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 Mid-Atlantic TRM. Original sources: Connecticut Program Savings Document for 2012 Program Year (September, 2011), p. 219-220. http://www.ctenergyinfo.com/2012%20CT%20Program%20Savings%20Documentation%20FINAL.pdf. 2003 US DOE CBECS building type definitions. http://www.eia.gov/emeu/cbecs/building_types.html.

**Table 5-5**: **Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **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<br>- Equipment efficiency levels were revised per update to ASHRAE 2013 in VA and NC |
| **Default Savings** | - Default savings modified due to changes to Sub-appendix F2-III: Non-residential HVAC Equipment Efficiency Ratings |

## 5.1.2 Unitary/Split Air Conditioning, Heat Pump, and Chiller Tune-up

### Measure Description

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

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

### Savings Estimation Approach

Algorithms and inputs to calculate heating, cooling savings, and demand reductions 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.

**Cooling Energy Savings**

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

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

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

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

For air- and water-cooled chillers:

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

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

$$\Delta kW = Size_{cool} \times \frac{12\frac{kBtuh}{ton}}{EER} \times CF \times TUF$$

## Heating Energy Savings

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

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

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

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

Where:

$\Delta kWh$ = per measure gross annual electric energy savings
$\Delta kW$ = per measure gross coincident demand reductions
$\Delta kWh_{cool}$ = per measure gross annual electric cooling energy savings
$\Delta kWh_{heat}$ = 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.

CF = coincidence factor

## Input Variables

**Table 5-6: Input Variables for AC/HP/Chiller Tune-up Measure**

| Component | Type | Value | Units | Source(s) |
|---|---|---|---|---|
| **$\text{Size}_{\text{cool}}$** | Variable | See customer application | tons of cooling capacity | Customer application |
| **$\text{Size}_{\text{heat}}$** | Variable | See customer application<br>Default for HPs: 12 x $\text{Size}_{\text{cool}}$ | kBtu/h | Customer application |
| **$\text{EFLH}_{\text{cool}}$** | Fixed | Refer to Sub-appendix F2-II: Non-residential HVAC Equivalent Full Load Hours<br>ACs & HPs: Table 8-4<br>Chillers: Table 8-6 | hours (annual) | Mid-Atlantic TRM 2019, p. 589 |
| **$\text{EFLH}_{\text{heat}}$** | Fixed | Refer to Sub-appendix F2-II: Non-residential HVAC Equivalent Full Load Hours<br>HPs: Table 8-5 | hours (annual) | Mid-Atlantic TRM 2019, p. 590 |
| **HSPF/SEER/ IEER/ EER/COP** | Variable | Refer to Sub-appendix F2-III: Non-residential HVAC Equipment Efficiency Ratings<br>ACs & HPs: Table 8-10<br>Chillers: Table 8-12 | k/kW-hour (except COP is dimensionless) | ASHRAE 90.1-2013 |
| **IPLV** | Variable | See customer application<br>Refer to Sub-appendix F2-III: Non-residential HVAC Equipment Efficiency Ratings<br>Chillers: Table 8-12 | Btu/W for air-cooled chillers; kW/ton for water-cooled chillers | Customer application<br>ASHRAE 90.1-2013 |
| **RCA_Done[79]** | Boolean | See customer application | True/False | Customer application |

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

| Component | Type | Value | Units | Source(s) |
|---|---|---|---|---|
| **TUF** | Fixed | If RCA was not done:<br>ACs: 0.023<br>HPs: 0.028<br>Chillers: 0.050<br>If RCA was also done (only for Commercial Non-Residential Prescriptive Program):<br>ACs: 0.050<br>HPs: 0.050<br>Chillers: 0.050 | - | Mid-Atlantic TRM 2019 p. 455, California Impact Evaluation of 2013-14 Commercial Quality Maintenance Programs,[80] and Wisconsin Focus on Energy 2019 TRM, pp. 285-288. |
| **CF** | Fixed | Use system capacity to assign CF:<br>$< 11.5$ tons = 0.588<br>$\geq 11.5$ tons = 0.874 | - | Mid-Atlantic TRM 2019 p. 455 |

## 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 include the ASHRAE 90.1-2013, Mid-Atlantic TRM 2019, pp. 454-456, pp. 589-590, the California Impact Evaluation of 2013-14 Commercial Quality Maintenance Programs,[80] and the Wisconsin Focus on Energy TRM 2019, pp. 285-288.

## Update Summary

The changes to this section, compared with last year, are described in Table 5-7.

**Table 5-7: Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **Source** | • Updated page numbers and versions of references to:<br>○ Mid-Atlantic TRM<br>○ Wisconsin Focus on Energy TRM<br>• Clarified citation and footnote of CPUC's Impact Evaluation for 2013-14 (HVAC3) |

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[80] California Public Utilities Commission (2016). Impact Evaluation of 2013-14 Commercial Quality Maintenance Programs (HVAC3), www.calmac.org/publications/HVAC3ImpactReport_0401.pdf. While these proportions were not provided in the report, DNV GL 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 GL 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.

| Type of Change | Description of Change |
|---|---|
| **Input Variable** | • For HPs at which RCA was not performed, revised Tune-up Factor (TUF) value from 0.027 to 0.028<br>• Update to weather stations in North Carolina resulted in revised EFLHs for weather-sensitive measures<br>• Baseline efficienty levels were revised per update to ASHRAE 2013 in VA and NC |

## 5.1.3 Refrigerant Charge Adjustment

### 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.

### Savings Estimation Approach

Algorithms and inputs to calculate cooling, heating and demand reductions 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 air-source 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:

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

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

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

#### Heating Energy Savings

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

$$\Delta kWh_{heat} = Size_{heat} \times \frac{12\frac{kBtuh}{ton}}{HSPF} \times EFLH_{heat} \times RCF$$

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

$$\Delta kWh_{heat} \quad = Size_{heat} \times \left( \frac{12 \frac{kBtuh}{ton}}{COP \ \times 3.412\, Btuh/W} \right) \times EFLH_{heat} \times RCF$$

Cooling and heating savings are added to calculate the per measure gross annual electric energy savings as follows:

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

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

$$\Delta kW \quad = Size_{cool} \times \frac{12}{EER} \times \ RCF \times \ CF$$

Where,

$\Delta$kWh = per measure gross annual electric energy savings
$\Delta$kW = per measure gross coincident demand reductions
$\Delta kWh_{cool}$ = per measure gross annual electric cooling energy savings
$\Delta kWh_{heat}$ = 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

## Input Variables

**Table 5-8: Input Variables for Refrigerant Charge Adjustment**

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

| Component | Type | Value | Units | Source(s) |
|---|---|---|---|---|
| | | Default: = $\text{Size}_{cool}$ | | |
| **$\text{EFLH}_{cool}$** | Fixed | See Table 8-4 in Sub-appendix F2-II: Non-residential HVAC Equivalent Full Load Hours | hours (annual) | Mid-Atlantic TRM 2019, p. 589 |
| **$\text{EFLH}_{heat}$** | Fixed | See Table 8-5 in Sub-appendix F2-II: Non-residential HVAC Equivalent Full Load Hours | hours (annual) | Mid-Atlantic TRM 2019 p. 590 |
| **EER/SEER** | Variable | See customer application | Btu/W-hr | Customer application |
| | | See Table 8-9 and Table 8-10 in Sub-appendix F2-III: Non-residential HVAC Equipment Efficiency Ratings | | ASHRAE 90.1 2013 |
| **HSPF/COP** | Variable | See customer application | Btu/W-hr (for HSPF); COP is - | Customer application |
| | | See Table 8-10 in Sub-appendix F2-III: Non-residential HVAC Equipment Efficiency Ratings | | ASHRAE 90.1 2013 |
| **RCF**[81] | Fixed | AC units: 0.027<br>HP units: 0.022 | - | Mid-Atlantic TRM 2019 p. 455 and California 2013-2014 Evaluation Report[82] |
| **CF** | Fixed | Use system capacity to assign CF as follows:<br>$< 11.25$ tons = 0.588<br>$\geq 11.25$ tons = 0.874 | - | Mid-Atlantic TRM 2019 p. 455 |

## Default Savings

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

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[81] RCF values were calculated utilizing the AC Tune-Up measure in the Mid-Atlantic TRM and electric savings due to coil cleaning and refrigerant charge adjustments found via extensive literature review.

[82] California Public Utilities Commission (2016). Impact Evaluation of 2013-14 Commercial Quality Maintenance Programs (HVAC3), www.calmac.org/publications/HVAC3ImpactReport_0401.pdf. While these proportions were not provided in the report, DNV GL 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 GL 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.

## Source(s)

The primary sources for this deemed savings approach include the ASHRAE 90.1-2013, Mid-Atlantic TRM 2019, pp. 454 - 456 and 589-590, and the California 2013-14 Impact Evaluation Report, pp. BB-2 to BB-3.

## Update Summary

The changes to this section, compared with last year, are described in Table 5-9.

**Table 5-9: Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **Source** | • Updated page number(s)/version of Mid-Atlantic TRM<br>• Clarified citation footnote of CPUC report |
| **Input Variable** | • Update to weather stations in North Carolina resulted in revised EFLHs for weather-sensitive measures<br>• Equipment efficiency levels were revised per update to ASHRAE 2013 in VA and NC |

### 5.1.4 Unitary/Split AC & HP Upgrade

This measure is also offered through the Non-Residential Heating and Cooling Efficiency program. The savings approach is described in Section 3.1.

### 5.1.5 Mini-split Heat Pump

This measure is also offered through the Non-Residential Heating and Cooling Efficiency program. The savings approach is described in Section 3.1.2.

### 5.1.6 Dual Enthalpy Air-side Economizer

This measure is also offered through the Non-Residential Heating and Cooling Efficiency program. The savings approach is described in Section 3.1.5.

### 5.1.7 Variable Frequency Drive

This measure is also offered through the Non-Residential Heating and Cooling Efficiency program. The savings approach is described in Section 3.1.4.

## 5.1.8 Programmable Thermostats

### Measure Description

This measure involves the installation of programmable thermostats[83] for cooling and/or heating systems in spaces with no existing setback control. The programmable thermostat shall setback 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 are assumed to be in continuous ON mode during the unoccupied period with fans cycling to maintain the occupied period temperature setpoints.

### Savings Estimation Approach

#### AC Units

Per measure, gross annual electric energy savings are calculated according to the following equation for units <65,000 Btu/h:

$$\Delta kWh \quad = \left[Size_{cool} \times \left(\frac{12}{SEER}\right) \times EFLH_{cool} \times ESF_{cool}\right]$$

Per measure, gross annual electric energy savings are calculated according to the following equation for units ≥65,000 Btu/h:

$$\Delta kWh \quad = \left[Size_{cool} \times \left(\frac{12}{IEER}\right) \times EFLH_{cool} \times ESF_{cool}\right]$$

Per measure, gross coincident demand reduction is considered to be zero since space conditioning equipment typically operates at maximum capacity during peak periods.

$$\Delta kW \quad = 0$$

#### Heat Pumps

Per measure, gross annual electric energy savings are calculated according to the following equation for units <65,000 Btu/h:

$$\begin{aligned}\Delta kWh \quad &= \left[Size_{cool} \times \left(\frac{12}{SEER}\right) \times EFLH_{cool} \times ESF_{cool}\right] \\ &\quad + \left[Size_{heat} \times EFLH_{heat} \times \left(\frac{1}{HSPF}\right) \times ESF_{heat}\right]\end{aligned}$$

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

Per measure, gross annual electric energy savings are calculated according to the following equation for units ≥65,000 Btu/h:

$$\Delta kWh = \left[Size_{cool} \times \left(\frac{12}{IEER}\right) \times EFLH_{cool} \times ESF_{cool}\right] + \left[Size_{heat} \times EFLH_{heat} \times \left(\frac{12}{3.412 \times COP}\right) \times ESF_{heat}\right]$$

Per measure, gross coincident demand reduction is considered to be zero since space conditioning equipment typically operates at maximum capacity during peak periods.

$$\Delta kW = 0$$

## Input Variables

**Table 5-10: Input Parameters for Programmable Thermostat Measure**

| Component | Type | Value | Units | Source(s) |
|---|---|---|---|---|
| **$Size_{cool}$** | Variable | See customer application | tons of cooling capacity | Customer application |
| **$Size_{heat}$** | Variable | See customer application | kBtu/h | Customer application |
| **$EFLH_{heat}$** | Fixed | See Table 8-5 in Sub-appendix F2-II: Non-residential HVAC Equivalent Full Load Hours | hours (annual) | Mid-Atlantic TRM 2019, p. 589 |
| **$EFLH_{cool}$** | Fixed | Refer to Table 8-4 in Sub-appendix F2-II: Non-residential HVAC Equivalent Full Load Hours | hours (annual) | Mid-Atlantic TRM 2019, p. 590 |
| **SEER/IEER** | Variable | See customer application | kBtu/kW-hour | Customer application |
| | | See Table 8-9 and Table 8-10 in Sub-appendix F2-III: Non-residential HVAC Equipment Efficiency Ratings | | ASHRAE 90.1 2013, Table 6.8.1A and Table 6.8.1B |
| **HSPF/COP** | Variable | See customer application | kBtu/kW-hour (except COP is dimensionless) | Customer application |
| | | See Table 8-10 in Sub-appendix F2-III: Non-residential HVAC Equipment Efficiency Ratings | | ASHRAE 90.1 2010 Table 6.8.1A and Table 6.8.1B |

| Component | Type | Value | Units | Source(s) |
|---|---|---|---|---|
| **$ESF_{cool}$** | Fixed | 0.090 | - | NY TRM 2018, p. 275 |
| **$ESF_{heat}$** | Fixed | 0.068 | - | NY TRM 2018, p. 275 |

## 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 ASHRAE 90.1-2010, New York TRM 2019, p. 275, and Mid-Atlantic TRM 2019, pp. 589-590.

## Update Summary

The changes to this section, compared with last year, are described in Table 5-11.

**Table 5-11: Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **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<br>• Equipment efficiency levels were revised per update to ASHRAE 2013 in VA and NC |

## 5.2 Lighting End Use

### 5.2.1 Lighting, Fixtures, Lamps, and Delamping

This measure is also offered through the Non-Residential Lighting Systems and Controls program. The savings approach is described in Section 1.1.1.

### 5.2.2 Sensors and Controls

This measure is also offered through the Non-Residential Lighting Systems and Controls program. The savings approach is described in Section 1.1.2.

## 5.2.3 LED Exit Signs

### 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.

### Savings Estimation Approach

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

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

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

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

Where:

$\Delta$kWh = per measure gross annual electric energy savings
$\Delta$kW = per measure gross coincident 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
$WHF_d$ = waste heat factor for demand to account for cooling savings from efficient lighting
CF = coincidence factor
ISR = in-service rate, the percentage of rebated measures actually installed

### Input Variables

**Table 5-12: Input Values for LED Exit Sign Calculations**

| Component | Type | Value | Unit | Source(s) |
|---|---|---|---|---|
| **$Qty_{base}$** | Variable | See customer application | - | Customer application |
| **$Qty_{ee}$** | Variable | Default: equal to $Qty_{base}$ | - | Customer application |

| Component | Type | Value | Unit | Source(s) |
|---|---|---|---|---|
| **$\text{watts}_{\text{base}}$** | Variable | See customer application | watts | Customer application |
| | | Default: 16 W CFL | | Mid-Atlantic TRM 2019 p. 314, ENERGY STAR®[84] |
| **$\text{watts}_{\text{ee}}$** | Variable | See customer application<br>Default: 5 W LED | watts | Mid-Atlantic TRM 2019 p. 314, ENERGY STAR® |
| **HOU** | Fixed | 8,760 | hours (annual) | Mid-Atlantic TRM 2019, p. 314 |
| **$\text{WHF}_{\text{e}}$** | Variable | See Table 8-15 in Sub-appendix F2-IV: Non-residential Lighting Factors: Annual Equivalent Hours, Coincidence Factors and Waste Heat Factors | - | Mid-Atlantic TRM 2019, p. 315 |
| **$\text{WHF}_{\text{d}}$** | Variable | See Table 8-15 in Sub-appendix F2-IV: Non-residential Lighting Factors: Annual Equivalent Hours, Coincidence Factors and Waste Heat Factors | - | Mid-Atlantic TRM 2019, p. 315 |
| **CF** | Fixed | 1.0 | - | Mid-Atlantic TRM 2019, p. 314[85] |
| **ISR** | Fixed | 1.0 | - | Mid-Atlantic TRM 2019, p. 315[86] |

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.

## 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:

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

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[84] LED exit sign default values come from an ENERGY STAR® report: Save Energy, Money and Prevent Pollution with Light-Emitting Diode (LED) Exit Signs:http://www.energystar.gov/ia/business/small_business/led_exitsigns_techsheet.pdf (accessed 7/13/2018).

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

[86] 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.

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

$$= 96.4\,kWh$$

The default per measure gross coincident demand reduction are calculated using the following calculation:

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

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

$$= 0.011\,kW$$

## Source(s)

The primary source for this deemed savings approach is the Mid-Atlantic TRM 2019, pp. 314-317.

## Update Summary

The changes to this section, compared with last year, are described in Table 5-13.

**Table 5-13: Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **Source** | • Updated page numbers / version of the Mid-Atlantic TRM |

## 5.3 Other End Use

### 5.3.1 Air Compressor Leak Repair

#### Measure Description

This measure involves improving the performance of an existing air compressor by repairing air leaks.

#### Savings Estimation Approach

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

$$\Delta kWh \quad = hp \times LF \times \frac{cfm}{hp} \times (Leak_{base} - Leak_{ee}) \times \frac{kW}{cfm} \times HOU$$

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

$$\Delta kW \quad = \frac{\Delta kWh \times CF}{HOU}$$

Where:

ΔkWh = per measure gross annual electric energy savings
ΔkW = per measure gross coincident demand reduction
hp = rated horsepower
LF = load factor of air compressor
cfm/hp = compressed airflow rate per air compressor motor horsepower
$Leak_{base}$ = baseline percentage of compressed air produced that is leaked
$Leak_{ee}$ = energy-efficient percentage of compressed air produced that is leaked
kW/cfm = energy consumed for each cubic foot of compressed air per minute produced
HOU = annual hours of operation
CF = coincidence factor of air compressor

#### Input Variables

**Table 5-14: Input Variables for Air Compressor Leak Repair Measure**

| Component | Type | Value | Units | Source(s) |
|---|---|---|---|---|
| **hp** | Variable | See customer application | hp | Customer application |
| **LF** | Variable | See customer application | percent | Customer application |
| **cfm/hp** | Variable | See customer application | cfm/hp | Customer application |
| **$Leak_{base}$** | Variable | See customer application | percent | Customer application |
| **$Leak_{ee}$** | Variable | See customer application | percent | Customer application |

| Component | Type | Value | Units | Source(s) |
|---|---|---|---|---|
| **kW/cfm** | Fixed | 0.17 | kW/cfm | Michigan Energy Measure Database[87] |
| **HOU** | Fixed | 6,240 | hours (annual) | Michigan Energy Measure Database[88] |
| **CF** | Fixed | 0.865 | - | Michigan Energy Measure Database[89] |

## Default Savings

There are no default savings for this measure because the savings are dependent on the change in the percent air leaked, the system capacity and load factor.

## Source(s)

The primary source for this deemed savings approach is the Michigan Energy Measure Database 2018, at http://www.michigan.gov/mpsc, Document "FES-I20 Compressed Air Leak Survey and Repair Michigan 11282017.doc," July 2017.

## Update Summary

The changes to this section, compared with last year, are described in Table 5-15.

**Table 5-15**: **Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **None** | |

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[87] Michigan Energy Measure Database 2018, at http://www.michigan.gov/mpsc, Document "FES-I20 Compressed Air Leak Survey and Repair Michigan 11282017.doc," July 2017, p. 1.

[88] Ibid.

[89] Ibid.

# 6 NON-RESIDENTIAL PRESCRIPTIVE PROGRAM, DSM PHASE VI

Dominion’s Non-Residential Prescriptive Program provides qualifying business owners incentives to use pursue one or more of the qualified energy efficiency measures through a local, participating contractor in Dominion’s contractor network. To qualify for this program, the customer must be responsible for the electric bill and must be the owner of the facility or reasonably able to secure permission to complete the measures. All program measures are summarized in Table 6-1.

**Table 6-1: Non-residential Prescriptive Program Measure List**

| End-Use | Measure | Manual Section |
|---|---|---|
| **Cooking** | Commercial Convection Oven | Section 6.1.1 |
| | Commercial Electric Combination Oven | Section 6.1.2 |
| | Commercial Electric Fryer | Section 6.1.3 |
| | Commercial Griddle | Section 6.1.4 |
| | Commercial Hot Food Holding Cabinet | Section 6.1.5 |
| | Commercial Steam Cooker | Section 6.1.6 |
| **HVAC** | Duct Testing & Sealing | Section 5.1.1 |
| | Unitary/Split AC/HP Tune-up | Section 5.1.2 |
| | Variable Speed Drives on Kitchen Fan | Section 6.2.3 |
| **Plug Load** | Smart Strip | Section 6.3.1 |
| **Refrigeration** | Door Closer | Section 6.4.1 |
| | Door Gasket | Section 6.4.2 |
| | Commercial Freezers and Refrigerators – Solid Door | Section 6.4.3 |
| | Commercial Ice Maker | Section 6.4.4 |
| | Evaporator Fan ECM Retrofit | Section 6.4.5 |
| | Evaporator Fan Control | Section 6.4.6 |
| | Floating Head Pressure Control | Section 6.4.7 |
| | Low/No-sweat Door Film | Section 6.4.8 |
| | Refrigeration Night Cover | Section 6.4.9 |
| | Refrigerator Coil Cleaning | Section 6.4.10 |
| | Suction Pipe Insulation (Cooler & Freezer) | Section 6.4.11 |
| | Strip Curtain (Cooler & Freezer) | Section 6.4.12 |
| | Vending Machine Miser | Section 6.4.13 |

# 6.1 Cooking End Use

## 6.1.1 Commercial Convection Oven

### 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).

### Savings Estimation Approach

The baseline annual electric energy consumption is calculated as follows:

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

The efficient annual electric energy consumption is calculated as follows:

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

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

$$\Delta kW\mathrm{h} \quad = kWh_{base} - \ kWh_{ee}$$

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

$$\Delta kW \quad = \frac{\Delta kWh}{(Hours_{daily} \times Days)}$$

where:

ΔkWh = per measure gross annual electric energy savings
ΔkW = per measure gross coincident demand reduction
$\mathrm{Hours}_{\mathrm{daily}}$ = average daily operating hours
$\mathrm{E}_{\mathrm{conv.}}$ = ASTM Energy to Food; the amount of energy absorbed by food during convection cooking
$\mathrm{lb}_{\mathrm{daily}}$ = pounds of food cooked per day
Days = annual days of operation

$\eta_{base}$ = baseline equipment cooking energy efficiency
$\eta_{ee}$ = 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

## Input Variables

**Table 6-2: Input Parameters for Convection Oven**

| Component | Type | Value | Units | Source(s) |
|---|---|---|---|---|
| **$Hours_{daily}$** | Variable | See customer application | hours, daily | Customer application |
| | | Default: 5, per Table 6-3 | | Mid-Atlantic TRM 2019, p. 545 |
| **Days** | Variable | See customer application | days, annual | Customer application |
| | | Default: 180, per Table 6-3 | | Mid-Atlantic TRM 2019, p. 545 |
| **$lb_{daily}$** | Variable | See customer application | lb, daily | Customer application |
| | | Default: 100 | | Mid-Atlantic TRM 2019, p. 544 |
| **$E_{conv}$** | Fixed | 0.0732 | kWh/lb | Mid-Atlantic TRM 2019, p. 544 |
| **$PC_{base}$** | Fixed | Half Size: 45<br>Full Size: 90 | lb/hour | Mid-Atlantic TRM 2019, p. 545 |
| **$\eta_{base}$** | Fixed | Half Size: 0.68<br>Full Size: 0.65 | - | Mid-Atlantic TRM 2019, p. 545 |
| **$kW_{base,idle}$** | Fixed | Half Size:1.03<br>Full Size: 2.00 | kW | Mid-Atlantic TRM 2019, p. 545 |
| **$kW_{ee,idle}$** | Fixed | Half Size: 1.00<br>Full Size: 1.60 | kW | Mid-Atlantic TRM 2019, p. 545 |
| **$PC_{ee}$** | Fixed | Half Size: 50<br>Full Size: 90 | lb/hour | Mid-Atlantic TRM 2019, p. 545 |
| **$\eta_{ee}$** | Fixed | Half Size: 0.71<br>Full Size: 0.71 | - | Mid-Atlantic TRM 2019, p. 545 |

**Table 6-3: Operational Hours for Ovens by Building Type**

| Facility Type | Hour/Day | Day/Year |
|---|---|---|
| **Community College** | 11 | 283 |
| **Fast Food Restaurant** | 14 | 363 |
| **Full Service Restaurant** | 12 | 321 |
| **Grocery** | 12 | 365 |
| **Hospital** | 11 | 365 |
| **Hotel** | 20 | 365 |

| Facility Type | Hour/Day | Day/Year |
|---|---|---|
| **Miscellaneous** | 9 | 325 |
| **Motel** | 20 | 365 |
| **Primary School** | 5 | 180 |
| **Secondary School** | 8 | 180 |
| **Office** | 12 | 250 |
| **University** | 11 | 283 |

## 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 as follows:

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

$$= \left[100\ lb\ \times \frac{0.0732\,kW/lb}{0.68} + 1.03\ kW \times \left(5\ hr - \frac{100\ \ lb/day}{45\ \ lb/hr}\right)\right]$$

$$\times\ 180\ days$$

$$= 2{,}453\ kWh$$

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

$$= \left[100\ lb\ \times \frac{0.0732\,kW/lb}{0.71} + 1.00\ kW \times \left(5\ hr - \frac{100\ \ lb/day}{50\ \ lb/hr}\right)\right]$$

$$\times\ 180\ days$$

$$= 2{,}396\ kWh$$

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

$$= 2{,}453\ kWh - \ 2{,}396\ kWh$$

$$= 57\ kWh$$

The default gross coincident demand reduction are calculated using the following calculation:

$$\Delta kW = \frac{\Delta kWh}{(Hours_{daily} \times Days)}$$

$$= \frac{57\ kWh}{(5\ hr \times 180\ day)}$$

$$= 0.063\ kW$$

## Source(s)

The primary sources for this deemed savings approach is the Mid-Atlantic TRM 2019, pp. 543-546.

## Update Summary

The changes to this section, compared with last year, are described in Table 6-4.

**Table 6-4**: **Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **Source** | • Updated page numbers / version of the Mid-Atlantic TRM |
| **Input variable** | • Clarified default assumption values |

## 6.1.2 Commercial Electric Combination Oven

### 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.

### Savings Estimation Approach

$$\begin{aligned} &\textit{The baseline annual electric energy consumption is calculated as follows:} kWh_{base,conv} \\ &= Qty \times \left[ lb_{daily} \times \frac{E_{conv}}{\eta_{base}} + kW_{base,conv,idle} \times \left( Hours_{daily} - \frac{lb_{daily}}{PC_{base,conv}} \right) \right] \\ &\quad \times (1 - PCT_{steam}) \times Days \end{aligned}$$

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

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

The efficient annual electric energy consumption is calculated as follows:

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

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

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

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

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

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

$$\Delta kW \quad = \frac{\Delta kWh}{Hours_{daily} \; \times \; Days}$$

Where:

$\Delta$kWh = per measure gross annual electric energy savings
Qty = quantity of electric combination ovens
$\Delta$kW = per measure gross coincident 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
$Hours_{daily}$ = 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

## Input Variables

**Table 6-5: Input Parameters for Commercial Electric Combination Ovens**

| Component | Type | Value | Units | Source(s) |
|---|---|---|---|---|
| $Hours_{daily}$ | Variable | See customer application | hours, daily | Customer application |
| | | Default: 5, per Table 6-3 | | Mid-Atlantic TRM 2019, p. 545 |
| Days | Variable | See customer application | days, annual | Customer application |
| | | Default: 180, per Table 6-3 | | Mid-Atlantic TRM 2019, p. 545 |
| $lb_{daily}$ | Variable | See customer application | pounds, daily | Customer application |
| | | Default: 200 | | Mid-Atlantic TRM 2019, p. 549 |
| $PCT_{steam}$ | Variable | See customer application | - | Customer application |
| | | Default: 0.50 | | Mid-Atlantic TRM 2019, p. 550 |
| $E_{conv}$ | Fixed | 0.0732 | kWh/lb | Mid-Atlantic TRM 2019, p. 549 |
| $E_{steam}$ | Fixed | 0.0308 | kWh/lb | Mid-Atlantic TRM 2019, p. 549 |
| $PC_{base,conv}$ | Fixed | <15 pans: 79<br>≥15 pans: 166 | lb/hr | Mid-Atlantic TRM 2019, p. 550 |
| $PC_{base,steam}$ | Fixed | <15 pans: 126<br>≥15 pans: 295 | lb/hr | Mid-Atlantic TRM 2019, p. 550 |
| $\eta_{base,conv}$ | Fixed | 0.72 | - | Mid-Atlantic TRM 2019, p. 550 |
| $\eta_{base,steam}$ | Fixed | 0.49 | - | Mid-Atlantic TRM 2019, p. 550 |
| $kW_{base,conv,idle}$ | Fixed | <15 pans: 1.320<br>≥15 pans: 2.280 | kW | Mid-Atlantic TRM 2019, p. 550 |
| $kW_{base,steam,idle}$ | Fixed | <15 pans: 5.260<br>≥15 pans: 8.710 | kW | Mid-Atlantic TRM 2019, p. 550 |
| $kW_{ee,conv,idle}$[90] | Variable | <15 pans: 1.299<br>≥15 pans: 2.099 | kW | Mid-Atlantic TRM 2019, p. 550 |
| $kW_{ee,steam,idle}$[91] | Variable | <15 pans: 1.970<br>≥15 pans: 3.300 | kW | Mid-Atlantic TRM 2019, p. 550 |
| $PC_{ee,conv}$ | Fixed | <15 pans: 119<br>≥15 pans: 201 | lb/hr | Mid-Atlantic TRM 2019, p. 550 |

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[90] Mid-Atlantic TRM 2019 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 GL 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.

[91] Mid-Atlantic TRM 2019 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, we 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.

| Component | Type | Value | Units | Source(s) |
|---|---|---|---|---|
| $PC_{ee,steam}$ | Fixed | <15 pans: 177<br>≥15 pans: 349 | lb/hr | Mid-Atlantic TRM 2019, p. 550 |
| $\eta_{ee,conv}$ | Fixed | 0.76 | - | Mid-Atlantic TRM 2019, p. 550 |
| $\eta_{ee,steam}$ | Fixed | 0.55 | - | Mid-Atlantic TRM 2019, p. 550 |

## Default Savings

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

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

$$= 1 \times \left[200\ lb \times \frac{0.0732\ kWh/lb}{0.72} + 1.320\ kW \times \left(5\ hr - \frac{200\ lb}{79\ lb/hr}\right)\right] \times (1 - 0.50) \times 180\ days$$

$$= 2{,}123\ kWh$$

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

$$= 1 \times \left[200\ lb \times \frac{0.0308\ kWh/lb}{0.49} + 5.260\ kW \times \left(5\ hr - \frac{200\ lb}{126\ lb/hr}\right)\right] \times 0.50 \times 180\ days$$

$$= 2{,}747\ kWh$$

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

$$= 2{,}123\ kWh + \ 2{,}747\ kWh$$

$$= 4{,}870\ kWh$$

The efficient annual electric energy consumption is calculated as follows:

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

$$= 1 \times \left[200\ lb \times \frac{0.0732\ \ kWh/lb}{0.76} + 1.299\ kW \times \left(5\ hr - \frac{200\ lb}{119\ \ lb/hr}\right)\right] \times (1 - 0.50) \times 180\ days$$

$$= 2{,}122\ kWh$$

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

$$= 1 \times \left[200\ lb \times \frac{0.0308\ \ kWh/lb}{0.55} + 1.970\ kW \times \left(5\ hr - \frac{200\ lb}{177\ \ lb/hr}\right)\right] \times 0.50 \times 180\ days$$

$$= 1{,}694\ kWh$$

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

$$= 2{,}122\ kWh + 1{,}694\ kWh$$

$$= 3{,}816\ kWh$$

Gross annual electric energy savings are calculated using the following equation:

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

$$= 4{,}870\ kWh - 3{,}816\ kWh$$

$$= 1{,}054\ kWh$$

Gross coincident demand reduction is calculated using the following equation:

$$\Delta kW \quad = \frac{\Delta kWh}{Hours_{daily} \times Days}$$

$$= \frac{1{,}054\ kWh}{5\ hr \times 180\ days}$$

$$= 1.171\ kW$$

### Source(s)

The primary sources for this deemed savings approach is the Mid-Atlantic TRM 2019, pp. 445 and 548-550.

### Update Summary

The changes to this section, compared with last year, are described in Table 6-6.

**Table 6-6: Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **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 |

## 6.1.3 Commercial Electric Fryer

### 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, frypot 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.[92]

## Savings Estimation Approach

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

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

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

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

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

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

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

$$\Delta kW \quad = \frac{\Delta kWh}{(Hours_{daily} \times Days)}$$

Where:

$\Delta$kWh = per measure gross annual electric energy savings
$\Delta$kW = per measure gross coincident 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
$\eta_{base}$ = baseline equipment cooking energy efficiency
$\eta_{eff}$ = 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

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[92] 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.

## Input Variables

**Table 6-7: Input Parameters for Electric Commercial Fryer Measure**

| Component | Type | Value | Units | Source(s) |
|---|---|---|---|---|
| **Hours$_{daily}$** | Variable | See customer application | hours, daily | Customer application |
| | | Default:<br>Standard fryer: 16<br>Large-vat fryer: 12 | | Mid-Atlantic TRM 2019, pp. 528-529 |
| **E$_{fry}$** | Fixed | 0.167 | kWh/lb | Mid-Atlantic TRM 2019, pp. 528-529 |
| **lb$_{daily}$** | Variable | See customer application | lb, daily | Customer application |
| | | Default: 150 | | Mid-Atlantic TRM 2019, pp. 528-529 |
| **Days** | Variable | See customer application | days, annual | Customer application |
| | | Default: 365 | | Mid-Atlantic TRM 2019, pp. 528-529 |
| $\eta_{base}$ | Fixed | Standard fryer: 0.75<br>Large-vat fryer: 0.70 | - | Mid-Atlantic TRM 2019, pp. 528-529 |
| **kW$_{base,idle}$** | Fixed | Standard fryer: 1.05<br>Large-vat fryer: 1.35 | kW | Mid-Atlantic TRM 2019, pp. 528-529 |
| **PC$_{base}$** | Fixed | Standard fryer: 65<br>Large-vat fryer: 100 | lb/hr | Mid-Atlantic TRM 2019, pp. 528-529 |
| $\eta_{ee}$ | Fixed | Standard fryer: 0.83<br>Large-vat fryer: 0.80 | - | Mid-Atlantic TRM 2019, pp. 528-529 |
| **kW$_{ee,idle}$** | Fixed | Standard fryer: 0.80<br>Large-vat fryer: 1.10 | kW | Mid-Atlantic TRM 2019, pp. 528-529 |
| **PC$_{ee}$** | Fixed | Standard fryer: 70<br>Large-vat fryer: 110 | lb/hr | Mid-Atlantic TRM 2019, pp. 528-529 |

## 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):

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

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

$$= 17{,}439\ kWh$$

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

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

$$= 15{,}062\ kWh$$

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

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

$$= 2{,}377\ kWh$$

The default per measure gross coincident demand reduction are calculated using the following calculation:

$$\Delta kW = \frac{\Delta kWh}{(Hours_{daily} \times Days)}$$

$$= \frac{2{,}377\ kWh}{(16\ hr \times 365\ days)}$$

$$= 0.407\ kW$$

## Source(s)

The primary sources for this deemed savings approach is the Mid Atlantic TRM 2019, pp. 527-530.

## Update Summary

The changes to this section, compared with last year, are described in Table 6-8.

**Table 6-8**: **Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **Source** | - Updated page numbers / version of the Mid-Atlantic TRM |

## 6.1.4 Commercial Griddle

### 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%.

### Savings Estimation Approach

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

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

where,

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

and

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

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

$$\Delta kW \quad = \frac{\Delta kWh}{Hours_{daily} \times Days}$$

Where:

ΔkWh = per measure gross annual electric energy savings
Qty = quantity of griddles
ΔkW = per measure gross coincident 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
$\eta_{base}$ = baseline equipment cooking energy efficiency
$\eta_{ee}$ = efficient equipment cooking energy efficiency
$kW_{base,idle}$ = baseline equipment idle energy rate
$kW_{ee,idle}$ = efficient equipment equipment idle energy rate
$PC_{base}$ = baseline equipment production capacity
$PC_{ee}$ = efficient equipment production capacity

## Input Variables

**Table 6-9: Input Parameters for Commercial Griddle Measure**

| Component | Type | Value | Units | Source(s) |
|---|---|---|---|---|
| **$lb_{daily}$** | Variable | See customer application | lb (daily) | Customer application |
| | | Default: 100 | | Mid-Atlantic TRM 2019, p. 540 |
| **SqFt** | Variable | See customer application | $ft^2$ | Customer application |
| **$Hours_{daily}$** | Variable | See customer application | hours (daily) | Customer application |
| | | Default: 12 | | Mid-Atlantic TRM 2019, p. 540 |
| **Days** | Variable | See customer application | days (annual) | Customer application |
| | | Default: 365 | | Mid-Atlantic TRM 2019, p. 540 |
| **$E_{griddle}$** | Fixed | 0.139 | kWh/lb | Mid-Atlantic TRM 2019, p. 540 |
| **$PC_{base}$** | Fixed | 5.83 | $lb/hr/ft^2$ | Mid-Atlantic TRM 2019, p. 541 |
| **$\eta_{base}$** | Fixed | 0.65 | - | Mid-Atlantic TRM 2019, p. 541 |
| **$kW_{base,idle}$** | Fixed | 0.40 | $kW/ft^2$ | Mid-Atlantic TRM 2019, p. 541 |
| **$kW_{ee,idle}$** | Fixed | 0.32 | $kW/ft^2$ | Mid-Atlantic TRM 2019, p. 541 |
| **$PC_{ee}$** | Fixed | 6.67 | $lb/hr/ft^2$ | Mid-Atlantic TRM 2019, p. 541 |
| **$\eta_{ee}$** | Fixed | 0.70 | - | Mid-Atlantic TRM 2019, p. 541 |

## 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.

## Source(s)

The primary source for this deemed savings approach is the Mid-Atlantic TRM 2019, pp. 539-542.

## Update Summary

The changes to this section, compared with last year, are described in Table 6-10.

**Table 6-10: Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **Source** | • Updated page numbers / version of the Mid-Atlantic TRM |

## 6.1.5 Commercial Hot Food Holding Cabinet

### 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.

### Savings Estimation Approach

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

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

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

$$\Delta kW \quad = \frac{\left(watts_{base,idle} - watts_{ee,idle}\right)}{1{,}000\ W/kW}$$

Where:

ΔkWh = per measure gross annual electric energy savings
ΔkW = per measure gross coincident demand reduction
$\text{watts}_{\text{base,idle}}$ = idle energy rate of the baseline equipment
$\text{watts}_{\text{ee,idle}}$ = idle energy rate of the efficient equipment
1,000 = conversion factor for W to kW
$\text{Hours}_{\text{daily}}$ = average daily operating hours
Days = annual days of operation

### Input Variables

**Table 6-11: Input Parameters for Hot Food Holding Cabinet**

| Component | Type | Value | Units | Source(s) |
|---|---|---|---|---|
| **$\text{watts}_{\text{base,idle}}$** | Variable | 40 x Vol | watts | Mid-Atlantic TRM 2019, p. 537 |
| **$\text{watts}_{\text{ee,idle}}$** | Variable | Vol < 13: 21.5 x Vol + 0.0<br>13 ≤ Vol < 28: 2.0 x Vol + 254.0<br>Vol ≥ 28: 3.8 x Vol + 203.5 | watts | Mid-Atlantic TRM 2019, p. 537 |

| Component | Type | Value | Units | Source(s) |
|---|---|---|---|---|
| **Days** | Variable | See customer application | days, annual | Customer application |
| | | Default: 365 | | Mid-Atlantic TRM 2019, p. 537 |
| **$\text{Hours}_{\text{daily}}$** | Variable | See customer application | hours, daily | Customer application |
| | | Default: 15 | | Mid-Atlantic TRM 2019, p. 537 |

Note: Vol = the internal volume of the holding cabinet ($ft^3$) = actual volume of installed unit

## 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.

## Source(s)

The primary source for this deemed savings approach is the Mid-Atlantic TRM 2019, pp. 536-538.

## Update Summary

The changes to this section, compared with last year, are described in Table 6-12.

**Table 6-12**: **Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **Source** | - Updated page numbers / version of the Mid-atlantic TRM |

## 6.1.6 Commercial Steam Cooker

### 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.

### Savings Estimation

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

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

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

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

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

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

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

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

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

$$\Delta kW \quad = \frac{\Delta kWh}{Hours_{daily} \times Days}$$

Where:

$\Delta$kWh = per measure gross annual electric energy savings
$\Delta$kW = per measure gross coincident 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
$Hours_{daily}$ = 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
$\eta_{base}$ = baseline equipment cooking energy efficiency
$\eta_{ee}$ = 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

## Input Variables

**Table 6-13: Input Parameters for Commercial Steam Cooker Measure**

| Component | Type | Value | Units | Source(s) |
|---|---|---|---|---|
| **$Hours_{daily}$** | Variable | See customer application | hours, daily | Customer application |
| | | Default: 12 | | Mid-Atlantic TRM 2019, p. 532 |
| **Days** | Variable | See customer application | days, annual | Customer application |
| | | Default: 365 | | Mid-Atlantic TRM 2019, p. 532 |
| **$lb_{daily}$** | Variable | See customer application | lb, daily | Customer application |

| Component | Type | Value | Units | Source(s) |
|---|---|---|---|---|
| | | Default: 100 | | Mid-Atlantic TRM 2019, p. 532 |
| $\mathbf{Qty_{pans}}$ | Variable | See customer application | pans | Customer application |
| | | Default: 3[93] | | Mid-Atlantic TRM 2019, p. 532 |
| $\mathbf{E_{steam}}$ | Fixed | 0.0308 | kWh/lb | Mid-Atlantic TRM 2019, p. 532 |
| $\mathbf{PC_{base}}$ | Fixed | 23.3 | lb/hr, per pan | Mid-Atlantic TRM 2019, p. 532 |
| $\boldsymbol{\eta}_{\mathbf{base}}$ | Fixed | Steam generator: 0.30<br>Boiler-based: 0.26 | - | Mid-Atlantic TRM 201, p. 533 |
| | | Default = Boiler-based: 0.26 | | |
| $\mathbf{kW_{base,idle}}$ | Fixed | Steam generator: 1.20<br>Boiler-based: 1.00 | kW | Mid-Atlantic TRM 2019, p. 533 |
| | | Default = Boiler-based: 1.00 | | |
| $\mathbf{kW_{ee,idle}}$ | Fixed | 3 pans: 0.40<br>4 pans: 0.53<br>5 pans: 0.67<br>6+ pans: 0.80 | kW | Mid-Atlantic TRM 2019, p. 533 |
| | | Default = 3 pans: 0.40 | | |
| $\mathbf{PC_{ee}}$ | Fixed | 16.7 | lb/hr, per pan | Mid-Atlantic TRM 2019, p. 532 |
| $\boldsymbol{\eta}_{\mathbf{ee}}$ | Fixed | 0.50 | - | Mid-Atlantic TRM 2019, p. 533 |
| $\mathbf{PCT_{steam}}$ | Fixed | 0.40 | - | Mid-Atlantic TRM 2019, p. 532 |

## 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:

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

$$= 100\ lb \times \frac{0.0308\ kWh/lb}{0.26} \times 365\ days$$

$$= 4{,}324\ kWh$$

---

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

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

$$= \left[(1 - 0.40) \times 1.20\ kW + 0.40 \times 23.3\ \frac{lb}{hr} \times 3\ pans \times \frac{0.0308\ \ kWh/lb}{0.26}\right] \times \left(12\ hr - \frac{100\ lb}{3\ pans\ \times\ 23.3\ \ lb/hr}\right) \times 365\ days$$

$$=\ 15{,}555\ kWh$$

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

$$= 100\ lb \times \frac{0.0308\ \ kWh/lb}{0.50} \times 365\ days$$

$$= 2{,}248\ kWh$$

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

$$= \left[(1 - 0.40) \times 0.4\ kW + 0.40 \times 16.7\ \frac{lb}{hr}\ \times 3\ pans \times \frac{0.0308\ \ kWh/lb}{0.50}\right] \times \left(12\ hr - \frac{100\ lb}{3\ pans\ \times\ 16.7\ \ lb/hr}\right) \times 365\ days$$

$$= 5{,}384\ kWh$$

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

$$= 4{,}324\ kWh + 15{,}555\ kWh - (2{,}248\ kWh + 5{,}384\ kWh)$$

$$= 12{,}247\ kWh$$

The default per measure, gross coincident demand reduction is calculated using the following equation:

$$\Delta kW = \frac{\Delta kWh}{(Hours_{daily} \times Days)}$$

$$= \frac{12{,}247\ kWh}{(12\ hr/day \times 365\ days)}$$

$$= 2.796\ kW$$

## Source(s)

The primary source for this deemed savings approach is the 2019 Mid-Atlantic TRM, pp. 531-535.

## Update Summary

The changes to this section, compared with last year, are described in Table 6-14.

**Table 6-14**: **Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **Source** | • Updated page numbers / version of the Mid-Atlantic TRM |
| **Input Variable** | • Updated $PC_{ee}$ value |

## 6.2 Heating, Ventilation, and Air-Conditioning (HVAC) End Use

### 6.2.1 Duct Testing and Sealing

This measure is also provided by the Non-Residential Small Business Improvement Program. The savings are determined using the methodology described in Section 5.1.1.

### 6.2.2 Unitary/Split Air Conditioning, Heat Pump, and Chiller Tune-up

This measure is also provided by the Non-Residential Small Business Improvement Program. The savings are determined using the methodology described in Section 5.1.2.

## 6.2.3 Variable Speed Drives on Kitchen Exhaust Fan

### Measure Description

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

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

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

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

### Savings Estimation Approach

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

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

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

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

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

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

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

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

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

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

$$\Delta kW \quad = \frac{\Delta kWh}{HOU}$$

Where:

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

## Input Variables

**Table 6-15: Input Parameters for VSD on Kitchen Fan(s)**

| Component | Type | Value | Units | Source(s) |
|---|---|---|---|---|
| **$hp_{EF}$** | Variable | See customer application | hp | Customer application |

| Component | Type | Value | Units | Source(s) |
|---|---|---|---|---|
| $LF_{EF}$ | Fixed | Default: 90% | - | New Jersey Clean Energy Program Protocols to Measure Resource Savings: Revisions to FY2019 Protocols, p. 105 |
| $\eta_{EF}$ | Variable | See customer application | - | Customer application |
| | | Default: See Table 3-9 based on $hp_{EF}$ | | See Table 3-9 in Section 3.1.4 |
| HOU | Variable | See customer application | hours (annual) | Customer application |
| | | Default: See Table 6-16 that follows | | New Jersey Clean Energy Program Protocols to Measure Resource Savings: Revisions to FY2019 Protocols, p. 106 |
| $\Delta Power_{EF}$ | Variable | See Table 6-16 that follows | - | New Jersey Clean Energy Program Protocols to Measure Resource Savings: Revisions to FY2019 Protocols, p. 106 |
| $SqFt_{Kitchen}$ | Variable | See customer application | $ft^2$ | Customer application |
| $\frac{cfm}{SqFt}$ | Fixed | 0.7 | $cfm/ft^2$ | ASHRAE 62.1-2013, Table 6.5 – for Kitchen - Commercial |
| $OF_{EF}$ | Fixed | 1.4 | - | New Jersey Clean Energy Program Protocols to Measure Resource Savings: Revisions to FY2019 Protocols, p. 105 |
| $\Delta cfm_{EF}$ | Variable | See Table 6-16 that follows | - | New Jersey Clean Energy Program Protocols to Measure Resource Savings: Revisions to FY2019 Protocols, p. 106 |
| CDD | Variable | See Sub-appendix F2-I: Cooling and Heating Degree Days and Hours | Cooling Degree Days | |
| HDD | Variable | See Sub-appendix F2-I: Cooling and Heating Degree Days and Hours | Heating Degree Days | |
| $MUA_{cool}$ | Boolean | See customer application | True/False | Customer application |
| $COP_{MUA_{cool}}$ | Variable | See customer application | - | Customer application |
| | | Default: 3.0 | | New Jersey Clean Energy Program Protocols to Measure Resource Savings 2019, p. 105 |
| $MUA_{electric_{heat}}$ | Boolean | See customer application | True/False | Customer application |

| Component | Type | Value | Units | Source(s) |
|---|---|---|---|---|
| $\mathbf{COP_{MUA_{heat}}}$ | Variable | See customer application | - | Customer application |
| | | Default: 3.0 | | New Jersey Clean Energy Program Protocols to Measure Resource Savings 2019, p. 105 |

**Table 6-16: Annual Hours of Use, Power, and Airflow Reductions due to VSD**[94]

| Facility Type | Annual Hours of Use (hours) | Proportion of Power Reduction ($\Delta Power_{EF}$) | Proportion of Airflow Reduction ($\Delta cfm_{EF}$) |
|---|---|---|---|
| **Campus** | 5,250 | 0.568 | 0.295 |
| **Lodging** | 8,736 | 0.618 | 0.330 |
| **Restaurant** | 5,824 | 0.552 | 0.295 |
| **Supermarket** | 5,824 | 0.597 | 0.320 |
| **Other** | 5,250 | 0.584 | 0.310 |

## Default Savings

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

## Source(s)

The primary source for this deemed savings approach include the New Jersey Clean Energy Program Protocols to Measure Resource Savings 2019, pp. 104-107.

## Update Summary

The changes to this section, compared with last year, are described in Table 6-17.

**Table 6-17**: **Summary of Update(s) from Previous Version**

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

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

# 6.3 Plug Load End-Use

## 6.3.1 Smart Strip

### Measure Description

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

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

### Savings Estimation Approach

Per measure, gross annual electric energy savings are assigned per unit as follows:

$$\Delta kWh = 26.9\ kWh$$[95]

Per measure, gross coincident demand reduction is assigned as follows:

$$\Delta kW = 0\ kW$$

Where:

ΔkWh = per measure gross annual electric energy savings
ΔkW = per measure gross coincident demand reduction

### Source(s)

The primary source for this deemed savings approach is the Mid-Atlantic TRM 2019, pp. 525-526.

### Update Summary

The changes to this section, compared with last year, are described in Table 6-18.

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

**Table 6-18**: **Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **Source** | - Updated page numbers / version of the Mid-Atlantic TRM |

## 6.4 Refrigeration End-Use

### 6.4.1 Door Closer (Cooler and Freezer)

#### 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.[96] 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.

#### Savings Estimation Approach

Per measure, gross annual electric energy savings are assigned according to the refrigeration unit type and temperature setting:

**Cooler Doors:**

$$\Delta kWh \quad = \Delta kWh_{cooler}$$

**Freezer Doors:**

$$\Delta kWh \quad = \Delta kWh_{freezer}$$

Per measure, gross coincident demand reduction is assigned according to the refrigeration unit type and temperature setting:

**Cooler Doors:**

$$\Delta kW \quad = \Delta kW_{cooler}$$

**Freezer Doors:**

$$\Delta kW \quad = \Delta kW_{freezer}$$

---

[96] 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.”

Where:

$\Delta kWh$ = per measure gross annual electric energy savings
$\Delta kW$ = per measure gross coincident demand reduction
$\Delta kWh_{cooler}$ = annual electric energy savings for main cooler doors
$\Delta kW_{cooler}$ = 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

## Input Variables

**Table 6-19: Door Closer Gross Annual Electric Energy Savings and Gross Coincident Demand Reduction (per Closer)[97]**

| Refrigeration Unit Type | Location | Walk-In | | Reach-In | |
|---|---|---|---|---|---|
| | | ΔkWh | ΔkW | ΔkWh | ΔkW |
| **Cooler**<br>(High Temperature, 31°F to 55°F) | Richmond, VA | 44 | 0.0050 | 102 | 0.0116 |
| | Average of Elizabeth City and Rocky Mount-Wilson, NC | 42 | 0.0048 | 101 | 0.0115 |
| **Freezer**<br>(Medium Temperature, -35°F to 30 °F) | Richmond, VA | 173 | 0.0196 | 439 | 0.0501 |
| | Average of Elizabeth City and Rocky Mount-Wilson, NC | 168 | 0.0192 | 432 | 0.0494 |

## Default Savings

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

- If the door type is missing, assume it is a walk-in door type.
- If the refrigeration system type is missing, assume it is a high-temperature cooler.

## Source(s)

The primary source for this deemed savings approach is the Tennessee Valley Authority TRM 2018, pp. 127-128.

## Update Summary

The changes to this section, compared with last year, are described in Table 6-20.

**Table 6-20: Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **Source** | • Updated page numbers / version of the Tennessee Valley Authority TRM |

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[97] Methodology from Tennessee Valley Authority TRM 2018, pp. 127-128, was used. Savings were revised using the TMY3 weather data for Richmond, VA, Elizabeth City, NC and Rocky Mount-Wilson, NC.

| Type of Change | Description of Change |
|---|---|
| **Default Savings** | - Default savings were adjusted due to change of weather stations in North Carolina (from Charlotte to Elizabeth City and Rocky Mount-Wilson) |

## 6.4.2 Door Gasket (Cooler and Freezer)

### Measure Description

This measure realizes energy savings by replacing worn-out gaskets with new gaskets on refrigerator or freezer doors to reduce heat loss caused by air infiltration.

### Savings Estimation Approach[98]

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

$$\Delta kWh \quad = \frac{\Delta kWh}{ft} \times \ L$$

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

$$\Delta kW \quad = \frac{\Delta kW}{ft} \times \ L$$

Where:

ΔkWh = per measure gross annual electric energy savings
ΔkW = per measure gross coincident demand reduction
ΔkWh/ft = gross annual electric energy savings per linear foot
ΔkW/ft = gross coincident demand reduction per linear foot
L = length of gasket applied

### Input Variables

**Table 6-21: Input Values for Door Gasket Savings Calculations**

| Component | Type | Value | Unit | Source(s) |
|---|---|---|---|---|
| **ΔkWh/ft** | Variable | See Table 6-22 | kWh/ft | Tennessee Valley Authority TRM 2018, p. 123. |
| **ΔkW/ft** | Variable | See Table 6-22 | kW/ft | Tennessee Valley Authority TRM 2018, p. 123. |
| **L** | Variable | See customer application | feet | Customer application |
|  |  | Default = 15 |  | DNV GL engineering judgment |

---

[98] Electric energy and demand savings for this measure are based on modeled results found in the Tennessee Valley Authority TRM 2018, which based its model assumptions and equations on 3 sources: the California Database for Energy Efficiency Resources, www.deeresources.com (DEER 2008), the 2009 Southern California Edison Company- WPSCNRRN0004.1 - Door Gaskets for Glass Doors of Walk-In Coolers work paper, and the 2009 Southern California Edison Company- WPSCNRRN0001.1 - Door Gaskets for Main Door of Walk-in Coolers and Freezers work paper.

**Table 6-22: Door Gasket Gross Annual Electric Energy and Gross Coincident Demand Reduction (per Linear Foot)** [99]

| Refrigeration Type | ΔkWh/ ft | ΔkW/ft |
|---|---|---|
| **Freezer (-35°F to 30°F)** | | |
| **Walk-In Door** | 29.5 | 0.0036 |
| **Reach-In Glass Door** | 22.2 | 0.0025 |
| **Cooler (31°F to 55°F)** | | |
| **Walk-In Door** | 9.3 | 0.0011 |
| **Reach-In Glass Door** | 3.4 | 0.0004 |

## Default Savings

If the proper values are not supplied, a default savings may be applied using conservative input values assuming a reach-in, glass-door cooler.

The default per measure, gross annual electric energy savings per unit cooler/freezer will be assigned according to the following calculation:

$$\Delta kWh \quad = \frac{\Delta kWh}{ft} \times \ L$$

$$= 3.4 \frac{kWh}{ft} \times \ 15\, ft$$

$$= 51.0\, kWh$$

The default per measure, gross demand energy savings per unit cooler/freezer will be assigned according to the following calculation:

$$\Delta kW \quad = \frac{\Delta kW}{ft} \times \ L$$

$$= 0.0004 \frac{kW}{ft} \times 15\, ft$$

---

[99] Tennessee Valley Authority 2018, p. 123 - 124. Methodology was used. Weather data was applied for Richmond, VA and Charlotte, NC. The difference between these locations was less than 1%, so Richmond values are applied to both VA and NC installed measures.

$$= 0.006\, kW$$

## Source(s)

The primary source for this deemed savings approach is the Tennessee Valley Authority TRM 2018, pp. 123-124.

## Update Summary

The changes to this section, compared with last year, are described in Table 6-23.

**Table 6-23**: **Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **Source** | • Updated page numbers / version of the Tennessee Valley Authority TRM |

## 6.4.3 Commercial Freezers and Refrigerators

### Measure Description

This measure involves the installation of an ENERGY STAR® qualified commercial freezer or refrigerator. These models are designed for warm commercial kitchen enviornments with frequent door opening. Qualifying equipment utilize a varity of energy-efficiecnt components such as ECM fan motors, hot gas anti-sweat heaters, or high efficiency compressors. Qualifying equipment must not exceed the maxium daily kWh values determined by the volume, door type, and configuration specified by Version 4.0 specifications that went into effect March 2017.

### Savings 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 demand reduction is calculated according to the following equation:

$$\Delta kW \quad = \left(\frac{\Delta kWh}{EFLH}\right) \times CF$$

Where:

ΔkWh = per measure gross annual electric energy savings
ΔkW = per measure gross coincident 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 = demand coincidence factor

### Input Variables

**Table 6-24: Input Parameters for Commercial Freezers and Refrigerator Measure**

| Component | Type | Value | Units | Source(s) |
|---|---|---|---|---|
| **$kWh_{base}$** | Variable | See Table 6-25 | kWh | Federal Standards, Energy Efficiency Program for Certain Commercial and Industrial Equipment, title 10, sec. 431.66 (2013)[100] |

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[100] 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.

| Component | Type | Value | Units | Source(s) |
|---|---|---|---|---|
| **$kWh_{ee}$** | Variable | See Table 6-26 | kWh | ENERGY STAR® Certified-commercial-refrigerators-and-freezers[101] |
| **Days** | Fixed | 365 | days, annual | Constant |
| **EFLH** | Fixed | 5,858 | hours, annual | Mid-Atlantic TRM 2019, pp. 481 and 487[102] |
| **CF** | Fixed | 0.77 | - | Mid-Atlantic TRM 2019, pp. 481 and 488[103] |
| **Volume** | Variable | See customer application | cubic feet | Customer application |

**Table 6-25: 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 6-26: Calculated Efficient Unit Daily Energy Consumption from Volume**

| Equipment Type and Volume ($ft^3$) | Refrigerator Energy, kWh | Freezer Energy, kWh |
|---|---|---|
| **Vertical Closed** | | |
| **Solid Door** | | |
| $V < 15\ ft^3$ | =0.022 x V + 0.970 | =0.210 x V + 0.900 |
| $15 \leq V < 30\ ft^3$ | =0.066 x V + 0.310 | =0.120 x V + 2.248 |
| $30 \leq V < 50\ ft^3$ | =0.040 x V + 1.090 | =0.285 x V - 2.703 |
| $V \geq 50\ ft^3$ | =0.024 x V + 1.890 | =0.142 x V + 4.445 |

---

[101] Values are provided in ENERGY STAR Certified Commerercial 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

[102] 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.

[103] 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.

| Equipment Type and Volume ($ft^3$) | Refrigerator Energy, kWh | Freezer Energy, kWh |
|---|---|---|
| **Transparent Door** | | |
| $V < 15 ft^3$ | =0.095 x V + 0.445 | =0.232 x V + 2.360 |
| $15 \leq V < 30 ft^3$ | =0.050 x V + 1.120 | =0.232 x V + 2.360 |
| $30 \leq V < 50 ft^3$ | =0.076 x V + 0.340 | =0.232 x V + 2.360 |
| $V \geq 50 ft^3$ | =0.105 x V - 1.111 | =0.232 x V + 2.360 |
| **Horizontal Closed** | | |
| **Solid or Transparent Door** | | |
| All Volumes | =0.050 x V + 0.280 | =0.057 x V + 0.550 |

## Default Savings

This measure does not have default savings.

## Source(s)

The primary source for this deemed savings approach is the Mid-Atlantic TRM 2019, pp. 480–491.

## Update Summary

The changes to this section, compared with last year, are described in Table 6-23.

**Table 6-27: Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **Source** | • Updated page numbers / version of the Mid-Atlantic TRM |
| **Input Variable** | • Updated CF value |

## 6.4.4 Commercial Ice Maker

### Measure Description

This measure involves high-efficiency ice makers meeting ENERGY STAR® or CEE Tier 2 ice maker requirements. The measure applies to batch type (also known as cube type) and continuous type (also known as flake or nugget type) equipment. The equipment includes ice-making head (without storage bin), self-contained, or remote-condensing units. ENERGY STAR® ice makers are limited to only air-cooled units while CEE Tier 2 standards address water-cooled units. The baseline for each type of ice maker is the corresponding Federal standard for the same technology.

### Savings Estimation Approach

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

$$\Delta kWh \quad = \left(\frac{kWh_{base} - kWh_{ee}}{100\ lb}\right) \times H_{rated} \times DC \times Days$$

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

$$\Delta kW \quad = \frac{\Delta kWh}{8{,}760\ hours} \times CF$$

Where:

ΔkWh = per measure gross annual electric energy savings
ΔkW = per measure gross coincident demand reduction
$kWh_{base}$ = energy consumption per 100 lb of ice produced by the baseline equipment
$kWh_{ee}$ = energy consumption per 100 lb of ice produced by the new equipment
$H_{rated}$ = manufacturer-rated daily harvest rate of equipment
DC = duty cycle of ice machine
Days = number of days per year
CF = demand coincidence factor

## Input Variables

**Table 6-28: Input Parameters for Commercial Ice Maker**

| Component | Type | Value | Units | Source(s) |
|---|---|---|---|---|
| **kWh$_{base}$** | Variable | Batch-type:<br>see Table 6-29<br>Continuous-type:<br>see Table 6-30 | kWh/ 100-lb of ice | Federal Standards 80 FR 4645[104] |
| **kWh$_{ee}$** | Variable | Water-cooled:<br>CEE Tier 2 batch-type:<br>see Table 6-31<br>CEE Tier 2 continuous-type:<br>see Table 6-32<br>Air-cooled:<br>ENERGY STAR batch-type:<br>see Table 6-33<br>ENERGY STAR continuous-type:<br>see Table 6-34 | kWh/ 100-lb of ice | CEE Tier 2[105] and ENERGY STAR®[106] lists of qualifying equipment |
| **H$_{rated}$** | Variable | See customer application | lb (daily) | From application |
| **DC** | Fixed | 0.5 | - | Arkansas TRM 2018 Volume 8 p. 486[107] |
| **Days** | Fixed | 365 | days (annual) | Arkansas TRM 2018 Volume 8 p. 486 |
| **CF** | Fixed | 1.0 | - | Arkansas TRM 2018 Volume 8 p. 486[108] |

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[104] The standards are available here: https://www.regulations.gov/document?D=EERE-2010-BT-STD-0037-0137. Batch type ice maker efficiencies are on p. 5-4 and continuous type baseline efficiency levels are on p. 5-9.

[105] Currently qualifying ice makers meet CEE requirements effective 7/01/2011. Qualifying equipment is updated quarterly, avialble here: https://library.cee1.org/content/commercial-kitchens-ice-machines-qualifying-product-list.

[106] Currently qualifying ice makers meet ENERGY STAR® Version 3.0 program requirements effective January 28, 2018. The list of qualifying equipment can be found here: https://www.energystar.gov/productfinder/product/certified-commercial-ice-machines/results.

[107] Per Arkansas TRM, this value was selected based on the most conservative value from a collection of sources including TRMs in Vermont, Pennsylvania, Ohio, Wisconsin, and Missouri.

[108] Per Arkansas TRM, this value was selected based on building types and lighting CFs. There is limited information about the specific load profile of ice makers.

**Table 6-29: Batch-Type Ice Machine Baseline Efficiencies**[109]

| Ice Machine Type | Type of Cooling | Harvest Rate (lb/day) | $kWh_{base}$ (kWh/100-lb ice) |
|---|---|---|---|
| **Ice-Making Head** | Water | < 300 | $6.880 - 0.00550 \times H_{rated}$ |
| | | ≥ 300 and < 850 | $5.800 - 0.00191 \times H_{rated}$ |
| | | ≥ 850 and < 1,500 | $4.420 - 0.00028 \times H_{rated}$ |
| | | ≥ 1,500 and < 2,500 | 4.000 |
| | | ≥ 2,500 and < 4,000 | 4.000 |
| | Air | < 300 | $10.000 - 0.01233 \times H_{rated}$ |
| | | ≥ 300 and < 800 | $7.055 - 0.00250 \times H_{rated}$ |
| | | ≥ 800 and < 1,500 | $5.550 - 0.00063 \times H_{rated}$ |
| | | ≥ 1,500 and < 4,000 | 4.610 |
| **Remote-Condensing w/o Remote Compressor** | Air | ≥ 50 and < 1,000 | $7.970 - 0.00342 \times H_{rated}$ |
| | | ≥ 1,000 and < 4,000 | 4.590 |
| **Remote-Condensing w/ Remote Compressor** | Air | < 942 | $7.970 - 0.00342 \times H_{rated}$ |
| | | ≥ 942 and < 4,000 | 4.790 |
| **Self-Contained** | Water | < 200 | $9.500 - 0.00342 \times H_{rated}$ |
| | | ≥ 200 and < 2,500 | 5.700 |
| | | ≥ 2500 and < 4,000 | 5.700 |
| | Air | < 110 | $14.790 - 0.04690 \times H_{rated}$ |
| | | ≥ 110 and < 200 | $12.420 - 0.02533 \times H_{rated}$ |
| | | ≥ 200 and < 4,000 | 7.350 |

**Table 6-30: Continuous-Type Ice Machine Baseline Efficiencies**

| Ice Machine Type | Type of Cooling | Harvest Rate (lb/day) | $kWh_{base}$ (kWh/100-lb ice) |
|---|---|---|---|
| **Ice-Making Head** | Water | < 801 | $6.48 - 0.00267 \times H_{rated}$ |
| | | ≥ 801 and < 2,500 | 4.34 |
| | | ≥ 2,500 and < 4,000 | 4.34 |
| | Air | < 310 | $9.19 - 0.00629 \times H_{rated}$ |
| | | ≥ 310 and < 820 | $8.23 - 0.00320 \times H_{rated}$ |
| | | ≥ 820 and < 4,000 | 5.61 |

---

[109] 10 CFR Part 431 Subpart H, Automatic Commercial Ice Makers. 77 FR 1591. January 11, 2012. New minimum requirements effective January 28, 2018.

| Ice Machine Type | Type of Cooling | Harvest Rate (lb/day) | $kWh_{base}$ (kWh/100-lb ice) |
|---|---|---|---|
| **Remote-Condensing w/o remote compressor** | Air | < 800 | 9.70 – 0.00580 x $H_{rated}$ |
| | | ≥ 800 and < 4,000 | 5.06 |
| **Remote-Condensing w/ remote compressor** | Air | < 800 | 9.90 – 0.00580 x $H_{rated}$ |
| | | ≥ 800 and < 4,000 | 5.26 |
| **Self-Contained** | Water | < 900 | 7.60 – 0.00302 x $H_{rated}$ |
| | | ≥ 900 and < 2,500 | 4.88 |
| | | ≥ 2,500 and < 4,000 | 4.88 |
| | Air | < 200 | 14.22 – 0.03000 x $H_{rated}$ |
| | | ≥ 200 and < 700 | 9.47 – 0.00624 x $H_{rated}$ |
| | | ≥ 700 and < 4,000 | 5.10 |

**Table 6-31: Batch-Type CEE Tier 2 Ice Machine Qualifying Efficiencies**[110]

| Ice Machine Type | Type of Cooling | Harvest Rate (lb/day) | $kWh_{ee}$ (kWh/100-lb ice) |
|---|---|---|---|
| **Self-Contained** | Water | < 175 | 10.6 – 0.0241 x $H_{rated}$ |
| | | ≥ 175 and < 450 | 7.1 – 0.0062 x $H_{rated}$ |
| | | ≥ 450 and < 1,000 | 4.7 – 0.0011 x $H_{rated}$ |
| | | ≥ 1,000 | 3.7 – 0.0002 x $H_{rated}$ |

**Table 6-32: Continuous-Type CEE Tier 2 Ice Machine Qualifying Efficiencies**[111]

| Ice Machine Type | Type of Cooling | Harvest Rate (lb/day) | $kWh_{ee}$ (kWh/100-lb ice) |
|---|---|---|---|
| **Self-Contained** | Water | < 1,000 | 4.8 – 0.0017 x $H_{rated}$ |
| | | ≥ 1,000 | 3.2 |

---

[110] CEE Requirments are found here: https://library.cee1.org/system/files/library/4280/CEE_Ice_Machines_Spec_Final_Effective_01Jul2011_-_updated_July_7_2015.pdf

[111] Ibid

## Table 6-33: Batch-Type ENERGY STAR® Ice Machine Qualifying Efficiencies[112]

| Ice Machine Type | Type of Cooling | Harvest Rate (lb/day) | $kWh_{ee}$ (kWh/100-lb ice) |
|---|---|---|---|
| **Ice-Making Head** | Air | < 300 | 9.20 – 0.01134 x $H_{rated}$ |
| | | ≥ 300 and < 800 | 6.49 – 0.0023 x $H_{rated}$ |
| | | ≥ 800 and < 1,500 | 5.11 – 0.00058 x $H_{rated}$ |
| | | ≥ 1,500 and ≤ 4,000 | 4.24 |
| **Remote-Condensing (with and without Remote Compressor)** | Air | < 988 | 7.17 – 0.00308 x $H_{rated}$ |
| | | ≥ 988 and ≤ 4,000 | 4.13 |
| **Self-Contained** | Air | < 110 | 12.57 – 0.0399 x $H_{rated}$ |
| | | ≥ 110 and < 200 | 10.56 – 0.0215 x $H_{rated}$ |
| | | ≥ 200 and ≤ 4,000 | 6.25 |

## Table 6-34: Continuous-Type ENERGY STAR® Ice Machine Qualifying Efficiencies[113]

| Ice Machine Type | Type of Cooling | Harvest Rate (lb/day) | $kWh_{ee}$ (kWh/100-lb ice) |
|---|---|---|---|
| **Ice-Making Head** | Air | < 310 | 7.90 – 0.005409 x $H_{rated}$ |
| | | ≥ 310 and < 820 | 7.08 – 0.002752 x $H_{rated}$ |
| | | ≥ 820 and ≤ 4,000 | 4.82 |
| **Remote-Condensing (with and without Remote Compressor)** | Air | < 800 | 7.76 – 0.00464 x $H_{rated}$ |
| | | ≥ 800 and ≤ 4,000 | 4.05 |
| **Self-Contained** | Air | < 200 | 12.37 – 0.0261 x $H_{rated}$ |
| | | ≥ 200 and < 700 | 8.24 – 0.005429 x $H_{rated}$ |
| | | ≥ 700 and ≤ 4,000 | 4.44 |

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[112] Currently qualifying ice makers meet ENERGY STAR® Version 3.0 program requirments effective January 28, 2018. The list of qualifying equipment can be found here: https://www.energystar.gov/productfinder/product/certified-commercial-ice-machines/results. The current requirments are found here: https://www.energystar.gov/products/commercial_food_service_equipment/commercial_ice_makers/key_product_criteria

[113] Ibid

## 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.

## Source(s)

The primary source for this deemed savings approach is the Arkansas TRM 2018 Version 8.0, pp. 483–486.

## Update Summary

The changes to this section, compared with last year, are described in Table 6-35.

**Table 6-35: Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **Source** | • Updated page numbers of the Arkansas TRM |
| **Equation** | • Updated equation |

## 6.4.5 Evaporator Fan Electronically Commutated Motor (ECM) Retrofit (Reach-In and Walk-in Coolers and Freezers)

### Measure Description

The measure replaces the baseline shaded-pole (SP), evaporator-fan motors with electronically-commuted motors. 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.

### Savings Estimation Approach

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

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

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

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

If the application shows that the rated wattage of existing/baseline evaporator fan motor, $W_{base}$, is less than rated wattage of electronically commutated evaporator fan motor, $W_{ee}$, then it is assumed that the baseline motor was replaced with a larger energy efficient motor. In such instances, the default values for these variables—provided in Table 6-36—are to be used.

Where:

$\Delta$kWh = per measure gross annual electric energy savings
$\Delta$kW = per measure gross coincident demand reduction
$watts_{base}$ = rated wattage of existing/baseline evaporator fan motor
$watts_{ee}$ = rated wattage of electronically commutated evaporator fan motor
$DC_{evap}$ = duty cycle (effective run time) of uncontrolled 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 = peak demand Coincidence Factor

## Input Variables

**Table 6-36: Input Values for ECM Evaporator Savings Calculations**

| Component | Type | Value | Unit | Source(s) |
|---|---|---|---|---|
| **$watts_{base}$** | Variable | See customer application | watts | Customer application |
| | | Defaults:<br>Walk-in: 128<br>Reach-in: 31<br>Unknown: 31 | | Mid-Atlantic TRM 2019, p. 498[114] |
| **$watts_{ee}$** | Variable | See customer application | watts | Customer application |
| | | Defaults:<br>Walk-in: 50<br>Reach-in: 12<br>Unknown: 12 | | Commercial Refrigeration Loadshape Project 2015, NEEP, p. 5[115] |
| **$DC_{evap}$** | Fixed | 0.978 | - | Mid-Atlantic TRM 2019, p. 498 |
| **HOU** | Variable | 8,760 | hours, annual | Mid-Atlantic TRM 2019, p. 498 |
| **$WHF_e$** | Fixed | Low Temp (-35°F - -1°F): 1.76<br>Med Temp (0°F - 30°F): 1.76<br>High Temp (31°F - 55°F): 1.38 | - | Mid-Atlantic TRM 2019, p. 498 |
| | | Default: 1.38 | | |
| **$WHF_d$** | Fixed | Low Temp (-35°F - -1°F): 1.76<br>Med Temp (0°F - 30°F): 1.76<br>High Temp (31°F - 55°F): 1.38 | - | Mid-Atlantic TRM 2019, p. 498 |
| | | Default: 1.38 | | |
| **CF** | Fixed | 0.978[116] | - | Mid-Atlantic TRM 2019, p. 498 |

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[114] The Mid-Atlantic TRM approach states the default power reduction is 157%, The $W_{base}$ are based on the default $W_{ee}$ values and a 157% power reduction.

[115] The Commercial Refrigeration Loadshape Project NEEP 2015, p. 5, finds that the average new ECM motor is rated at 1/15 hp. This study had the majority of motors 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] Mid-Atlantic TRM 2017, p. 411. Coincidence factors 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, 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.

## 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:

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

$$= \frac{(31\, W - 12\, W)}{1{,}000\, W/kW} \times 0.978 \times 8{,}760\, hours \times 1.38$$

$$= 225\, kWh$$

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

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

$$= \frac{(31\, W - 12\, W)}{1{,}000\, W/kW} \times 1.38 \times 0.978$$

$$= 0.026\, kW$$

## Source(s)

The primary source for this deemed savings approach is the Mid-Atlantic TRM 2019, pp. 497-499.

## Update Summary

The changes to this section, compared with last year, are described in Table 6-37.

**Table 6-37: Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **Input variable** | • Deleted a conversion factor, $CW_{rated}$, as it was not needed |
| **Source** | • Updated page numbers / version of the Mid-Atlantic TRM |

## 6.4.6 Evaporator Fan Control (Cooler and Freezer)

### Measure Description

This measure realizes energy savings by installing evaporator controls for reach-in or walk-in coolers and freezers. Typically, evaporator fans run constantly (24 hours per day, 365 days per year) to provide cooling when the compressor is running, and to provide air circulation when the compressor is not running. This measure saves energy by cycling the fan off or reducing fan speed when the compressor is not running.  This results in a reduction in fan energy usage and a reduction in the 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.

### Savings Estimation Approach

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

$$\Delta kWh \quad = hp \times \frac{kW}{hp} \times \left(\%On_{base} - \%On_{ee}\right) \times HOU \times WHF_e$$

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

$$\Delta kW \quad = hp \times \frac{kW}{hp} \times \ WHF_d \times CF$$

Where:

ΔkWh = per measure gross annual electric energy savings
ΔkW = per measure gross coincident 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 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 = peak demand Coincidence Factor

## Input Variables

**Table 6-38: 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: 1/15 hp | | Mid-Atlantic TRM 2019, p. 501[117] |
| **kW/hp** | Fixed | Single-speed: 2.088 kW/hp<br>Multi-speed: 0.758 kW/hp | kW/hp | Mid-Atlantic TRM 2019, p. 501 |
| | | Default: 0.758 kW/hp | | |
| **$\%On_{base}$** | Fixed | 0.978 | - | Mid-Atlantic TRM 2019, p. 501 |
| **$\%On_{ee}$** | Fixed | Single-speed: 0.636<br>Multi-speed: 0.692 | - | Mid-Atlantic TRM 2019, p. 501 |
| | | Default: 0.692 | | |
| **HOU** | Fixed | 8,760 | hours (annual) | Mid-Atlantic TRM 2019, p. 501 |
| **WHFe** | Fixed | Low Temp (-35°F to -1°F): 1.76<br>Med Temp (0°F - 30°F): 1.76<br>High Temp (31°F - 55°F): 1.38 | - | Mid-Atlantic TRM 2019, p. 501 |
| | | Default: 1.38 | | |
| **WHFd** | Fixed | Low Temp (-35°F - -1°F): 1.76<br>Med Temp (0°F - 30°F): 1.76<br>High Temp (31°F - 55°F): 1.38 | - | Mid-Atlantic TRM 2019, p. 501 |
| | | Default: 1.38 | | |
| **CF** | Fixed | 0.26 | - | Mid-Atlantic TRM 2019, p. 501 |

## 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 cooler with a multi-speed evaporator motor will be assigned according to the following calculation:

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

---

[117] Default value not provided in Mid-Atlantic TRM, however the original source for the Mid-Atlantic approach was used to select a default: Cadmus. 2015. *Commercial Refrigeration Loadshape Projects.* Lexington, MA.

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

$$= 175\ kWh$$

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

$$\Delta kW \quad = hp \times \frac{kW}{hp} \times WHF_d \times CF$$

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

$$= 0.018\ kW$$

## Source(s)

The primary source for this deemed savings approach is the Mid-Atlantic TRM 2019, pp. 500-502.

## Update Summary

The changes to this section, compared with last year, are described in Table 6-39.

**Table 6-39**: **Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **Source** | • Updated page numbers / version of the Mid-Atlantic TRM |
| **Input variable** | • Clarified kW/hp, $WHF_e$ , and $WHF_d$ default assumptions for values<br>• Updated $\%On_{base}$ and $\%On_{ee}$ values |

## 6.4.7 Floating Head Pressure Control

### Measure Description

This measure realizes energy savings by adjusting the head-pressure setpoint in response to different outdoor temperatures. Without  controls, the head-peasure setpoint is based on the design conditions regardless of the actual condenser operating conditons. By installing the floating-head pressure controller, the head-pressure setpoint is adjusted based on outside-air temperature. When conditions allow, the compressor operates at a lower discharge-head pressure, resulting in compressor energy savings.

### Savings Estimation Approach

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

$$\Delta kWh \quad = \frac{kWh}{hp} \times \ hp_{comp}$$

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

$$\Delta kW^{118} \quad = 0$$

Where:

ΔkWh = per measure gross annual electric energy savings
ΔkW = per measure gross coincident demand reduction
kWh/hp = floating head pressure control gross annual electric energy savings per compressor horsepower (hp)
$hp_{comp}$ = compressor horsepower

### Input Variables

**Table 6-40: Input Values for Floating Head Pressure Control Savings Calculations**

| Component | Type | Value | Unit | Source(s) |
|---|---|---|---|---|
| **kWh/hp** | Variable | See Table 6-41<br>Default = 509 (High Temperature, Scroll Compressor) | kWh/ horsepower/ year | Maine Commercial TRM 2019.5, p. 82 |

---

[118] Gross coincident demand savings are zero since savings are realized during off-peak periods. No demand reduction is expected from this measure.

| Component | Type | Value | Unit | Source(s) |
|---|---|---|---|---|
| **hp**$_{comp}$ | Variable | See customer application. | horsepower | Customer application |
| | | Default = 5 | | Vermont TRM 2015, p. 132[119] |

**Table 6-41: Floating-head Pressure Control Gross Annual Electric Energy Savings (per Horsepower)[120]**

| Compressor Type | Electric Savings (kWh/hp/year) | | |
|---|---|---|---|
| | Low Temperature (-35°F to -1°F) (Temp$_{ref}$ -20°F SST) | Medium Temperature (0°F to 30°F) (Temp$_{ref}$ 20°F SST) | High Temperature (31°F to 55°F) (Temp$_{ref}$ 45°F SST) |
| **Standard Reciprocating** | 695 | 727 | 657 |
| **Discus** | 607 | 598 | 694 |
| **Scroll** | 669 | 599 | 509 |

## 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:

$$\Delta kWh = \frac{kWh}{hp} \times hp_{comp}$$

$$= 509\,\frac{kWh}{hp} \times 5\,hp$$

$$= 2{,}545\,kWh$$

The default gross coincident demand reduction will be assigned according to the following calculation:

$$\Delta kW = 0$$

---

[119] Vermont TRM 2015, p. 132. Assumes "5 HP compressor data used, based on average compressor size."

[120] Efficiency Maine Commercial TRM 2019.5, Table 12 – Floating Head Perssure Control kWh Savings per Horsepower, p. 83.

## Source(s)

The primary source for this deemed savings approach is the Maine Commercial TRM 2019, pp. 82-83. Additonally, the Vermont TRM 2015, p. 132, was used to estimate the default compressor size.

## Update Summary

The changes to this section, compared with last year, are described in Table 6-42.

**Table 6-42**: **Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **Source** | • Updated page numbers / version of the Maine Commercial TRM |

## 6.4.8 Low/Anti-Sweat Door Film

### Measure Description

This measure involves the installation of window film on the doors of refrigerated cooler and freezer cases. Anti-sweat film prevents consdesation from forming and collecting on refrigerated case doors. This measure saves energy by allowing anti-sweat heaters to be deactivated permanently. Typically, anti-sweat door heaters (ASDH) are installed on the glass itself to raise the surface temperature and prevent condensation from collecting on the glass. However, the low/anti-sweat door film elimates the need for these heaters.[121] Note that this measure does not affect frame heaters.

The savings methodology borrows from that of ASDH controls. The baseline condition for this measure is refrigerated case doors with operational ASDH, with or without controls. The measure case is door film with no ASDHs in use. Refrigerated case doors without ASDH are not allowed under this measure. Door size is assumed to be 12.5 sq.ft. based on program design assumptions.

### Savings Estimation Approach

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

$$\Delta kWh \quad = kW_{ASDH} \times DC \times HOU \times WHF_e$$

Per measure, gross coincident demand reduction is assigned as follows:

$$\Delta kW \quad = kW_{ASDH} \times DC \times WHF_d \times CF$$

Where:

$\Delta$kWh = per measure, gross annual electric energy savings
$\Delta$kW = per measure, gross coincident demand reduction
$kW_{ASDH}$ = rated power of the existing ASDH
DC = duty cycle (effective run time) of the existing ASDH based on existing controls

HOU = annual operating hours
$WHF_e$ = Waste Heat Factor represents the increased gross annual electric savings due to reduced heat from ASDH that must be rejected by the refrigeration equipment
$WHF_d$ = Waste Heat Factor represents the increased gross coincident demand reduction due to reduced heat from ASDH that must be rejected by the refrigeration equipment
CF = summer peak Coincidence Factor

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[121] In some cases ASDHs may not be deactivated altogether, but their controls are modified to drastically lower the dew-point setpoint thereby reducing the duration of heater operation. In these cases, it is assumed that the duration of heater operation is negligible.

## Input Variables

**Table 6-43: Input Parameters for Low/No-Sweat Door Film**

| Component | Type | Value | Units | Source(s) |
|---|---|---|---|---|
| **$\mathrm{kW}_{\mathrm{ASDH}}$** | Variable | See customer application | kW | Customer application |
| | | Default: 0.13 | | Mid-Atlantic TRM 2019, p. 495[122] |
| **DC** | Variable | No controls: 0.907<br>On/Off controls: 0.589<br>Micropulse controls: 0.428 | - | Mid-Atlantic TRM 2019, p. 495 |
| | | Default: 0.428 | - | Mid-Atlantic TRM 2019, p. 495 |
| **HOU** | Fixed | 8,760 | hours, annual | Mid-Atlantic TRM 2019, p. 495 |
| **$\mathrm{WHF}_{\mathrm{e}}$** | Fixed | Low Temp (-35°F - -1°F): 1.50<br>Med Temp (0°F - 30°F): 1.50<br>High Temp (31°F - 55°F): 1.25 | - | Mid-Atlantic TRM 2019, p. 495 |
| | | Default: 1.25 | | |
| **$\mathrm{WHF}_{\mathrm{d}}$** | Fixed | Low Temp (-35°F - -1°F): 1.50<br>Med Temp (0°F - 30°F): 1.50<br>High Temp (31°F - 55°F): 1.25 | - | Mid-Atlantic TRM 2019, p. 495 |
| | | Default: 1.25 | | |
| **CF[123]** | Variable | Freezer (Low/Med Temp) case:<br>On/Off controls: 0.21<br>Micropulse: 0.30<br>No controls: 1.00 | - | Mid-Atlantic TRM 2019, pp. 495–496. Without heater controls, uniform load throughout year is assumed. |
| | | Default for freezer case: 0.21 | | |
| | | Refrigerated (High Temp) case:<br>On/Off controls: 0.25<br>Micropulse: 0.36<br>No controls: 1.00 | | |
| | | Default for refrigerated case: 0.25 | | |

---

[122] Original source: Cadmus. 2015. Commercial Refrigeration Loadshape Project. Lexington, MA.

[123] Coincidence factors developed by dividing the PJM Summer Peak Savings for ASDH Controls from Table 52 of the original source by the product of the average wattage of ASDH per connected door (0.13 kW) and the Waste Heat Factor for Demand.

## Default Savings

When the application does not have information about the ASDH control type, it is assumed to have micropulse controls. When the temperature range and the case type are also unknown, the case is assumed to be a high-temperature, refrigerated case.

Accordingly, the default per measure gross annual energy savings are as follows:

$$\Delta kWh \quad = \ kW_{ASDH} \times DC \times HOU \times WHF_e$$

$$= 0.13\ kW \ \times \ 0.428 \ \times \ 8{,}760\ hours \ \times \ 1.25$$

$$= 609.3\ kWh$$

And the default per measure, gross demand reduction is:

$$\Delta kW \quad = kW_{ASDH} \times DC \times WHF_d \times CF$$

$$= 0.13\ kW \ \times \ 0.428 \ \times \ 1.25 \times \ 0.25$$

$$= 0.017\ kW$$

## Source(s)

The primary source for this deemed savings approach is the Mid-Atlantic TRM 2019 pp. 494–496. The method was adapted from the ASDH controls methodology.

## Update Summary

The changes to this section, compared with last year, are described in Table 6-44.

**Table 6-44**: **Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **Source** | • Updated page numbers / version of the Mid-Atlantic TRM |
| **Input variable** | • Clarified $WHF_e$ and $WHF_d$ default assumptions fors value |

## 6.4.9 Refrigeration Night Cover

### 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.

### Savings Estimation Approach

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

$$\Delta kWh = \frac{load}{\frac{12{,}000\, Btu/hour}{ton}} \times \frac{3.516\, kW/ton}{COP} \times L \times ESF \times HOU$$

Per measue, gross coincident demand reduction is assigned as follows:

$$\Delta kW^{124} = 0$$

Where:

ΔkWh = per measure gross annual electric energy savings
ΔkW = per measure gross coincident demand reduction
load = average refrigeration load per linear foot of refrigerated case without night covers deployed
L = linear feet of covered refrigerated case
COP = coefficient of performance of refrigerated case
ESF = energy savings factor; reflects the percentage reduction in refrigeration load due to the deployment of night covers
HOU = annual hours of use

### Input Variables

**Table 6-45: 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 | | Mid-Atlantic 2019, p. 492[125] |

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[124] Mid-Atlantic TRM 2019, p. 492. Assumed that continuous covers are deployed at night; therefore, no demand savings occur during the peak period.

[125] Mid-Atlantic 2019, p. 492. Original source: Davis Energy Group, Analysis of Standard Options for Open Case Refrigerators and Freezers, May 11, 2004. (accessed on 7/7/2010.). http://www.energy.ca.gov/appliances/2003rulemaking/documents/case_studies/CASE_Open_Case_Refrig.pdf.

| Component | Type | Value | Unit | Source(s) |
|---|---|---|---|---|
| **L** | Variable | See customer application. | feet | Customer application |
| | | Default = 6 | | DNV GL judgment |
| **COP**[126] | Fixed | 2.2 | - | Mid-Atlantic TRM 2019, p. 493 |
| **ESF**[127] | Fixed | 0.09 | - | Mid-Atlantic TRM 2019, p. 493 |
| **HOU** | Variable | 8,760 | hours (annual) | Mid-Atlantic TRM 2019, p. 493 |

## 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:

$$\Delta kWh \quad = \frac{load}{\underline{12{,}000\,Btu/hour}} \times L \times \frac{3.516\,kW/ton}{COP} \times ESF \times HOU$$
$$\phantom{=}\quad ton$$

$$= \frac{1{,}500\,\frac{Btu}{hour}/feet}{12{,}000\,\frac{Btu}{hour}/ton} \times \frac{3.516\,kW/ton}{2.2} \times \;6\;feet\;\times\;0.09\;\times\;8{,}760\;hours$$

$$= 945.0\;kWh$$

The default gross coincident demand reduction will be assigned as follows:

$$\Delta kW \quad = 0$$

## Source(s)

The primary source for this deemed savings approach is the Mid-Atlantic TRM 2019, pp. 492-493.

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[126] Kuiken et al, Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0, KEMA, March 22, 2010.

[127] Mid-Atlantic TRM 2019, p. 493. Original source: Effects of the Low Emissivity Shields on Performance and Power Use of a Refrigerated Display Case, Southern California Edison, August 8, 1997. (accessed on July 7, 2010). http://www.sce.com/NR/rdonlyres/2AAEFF0B-4CE5-49A5-8E2C-3CE23B81F266/0/AluminumShield_Report.pdf. Characterization assumes covers are deployed for six hours per day.

## Update Summary

The changes to this section, compared with last year, are described in Table 6-46.

**Table 6-46: Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **Source** | • Updated page numbers / version of the Mid-Atlantic TRM |
| **Default Savings** | • Corrected mistaken default annual energy savings |

## 6.4.10 Refrigeration Coil Cleaning

### Measure Description

This measure realizes energy savings by cleaning the condenser coils on reach-in and walk-in coolers and freezers. Eligible units will have 25% fouling or greater based on visual inspection. This measure may only receive energy savings and demand reduction when combined with the floating head pressure measure.

### Savings Estimation Approach

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

$$\Delta kWh = \frac{load}{12{,}000\ \frac{BTU/h}{ton}} \times \frac{3.156\frac{kW}{ton}}{COP} \times HOU \times ESF$$

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

$$\Delta kW = \frac{load}{12{,}000\ \frac{BTU/h}{ton}} \times \frac{3.156\frac{kW}{ton}}{COP} \times DRF$$

Where:

ΔkWh = per measure gross annual energy savings
ΔkW = per measure gross coincident demand reduction
load = total capacity of condensers (BTU per hour)
COP = coefficient of performance of refrigeration equipment
ESF = savings factor attributable to coil cleaning for annual energy
DRF = savings factor attributable to coil cleaning for demand reductions
HOU = annual hours of use

### Input Variables

**Table 6-47: Input Values for Refrigeration Coil Cleaning Savings Calculations**

| Component | Type | Value | Unit | Source(s) |
|---|---|---|---|---|
| **load** | Variable | See customer application | Btu/h | Customer application |

| Component | Type | Value | Unit | Source(s) |
|---|---|---|---|---|
| **COP** | Fixed | Low Temp (-35°F – -1°F): 1.3<br>Med Temp (0°F – 30°F): 1.3<br>High Temp (31°F – 55°F): 2.5 | - | Pennsylvania TRM 2016, p. 393 |
| **HOU** | Fixed | Low Temp (-35°F - -1°F): 6,370<br>Med Temp (0°F - 30°F): 6,370<br>High Temp (31°F - 55°F): 6,173 | hours, annual | Calculated duty cycle using weather factor, defrost factor, and capacity factor[128] |
| **ESF**[129] | Fixed | 0.048 | - | Qureshi and Zubair (2011) |
| **DRF**[130] | Fixed | 0.022 | - | Qureshi and Zubair (2011) |

## Default Savings

If the proper values are not supplied, no default savings will be awarded for this measure.

## Source(s)

The primary sources for this deemed savings approach are the Pennsylvania TRM 2016 and "Performance degradation of a vapor compression refrigeration system under fouled conditions" by Qureshi and Zubair (2011), published in the *International Journal of Refrigeration*.

## Update Summary

The changes to this section, compared with last year, are described in Table 6-48.

**Table 6-48**: **Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **None** | |

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[128] The duty cycle is calculated using the same method as is used by TVA 2016 TRM for refrigeration measures. For coolers, a defrost factor of 0.995, a capacity factor of 0.87, and a weather factor of 0.84 is assumed. For freezers, a defrost factor of 0.90, a capacity factor of 0.87, a and weather factor of 0.90 is assumed.

[129] Qureshi B.A. and Zubair S.M., "Performance degradation of a vapor compression refrigeration system under fouled conditions." International Journal of Refrigeration 24 (2011), p. 1016 – 1027. Figure 2-(a). Assumes a weighting of refrigerant types of 80% R-134 and 20% R-404.

[130] Ibid.

## 6.4.11 Suction Pipe Insulation (Cooler and Freezer)

### Measure Description

This measure realizes energy savings by installing insulation on existing bare suction lines (lines that run from evaporator to compressor) that are located outside of the refrigerated space.

### Savings Estimation Approach

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

$$\Delta kWh \quad = \frac{\Delta kWh}{ft} \times L$$

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

$$\Delta kW \quad = \frac{\Delta kW}{ft} \times \ L$$

Where:

ΔkWh = per measure gross annual electric energy savings
ΔkW = per measure gross coincident demand reduction
ΔkWh/ft = gross annual electric energy savings per linear foot
ΔkW/ft = gross coincident demand reduction per linear foot
L = length of insulation applied in linear feet

### Input Variables

**Table 6-49: Input Values for Suction Pipe Insulation Savings Calculations**

| Component | Type | Value | Unit | Source(s) |
|---|---|---|---|---|
| **ΔkWh/ft** | Variable | See Table 6-50 | kWh/feet | Pennsylvania TRM 2016, p. 418 |
| **ΔkW/ft** | Variable | See Table 6-50 | kW/feet | Pennsylvania TRM 2016, p. 418 |
| **L** | Variable | See customer application | feet | Customer application |
| | | Default = 1 | | Per unit savings |

**Table 6-50: Suction Pipe Insulation Gross Annual Electric Energy Savings and Gross Coincident Demand Reduction (per Linear Foot)**[131]

| Refrigeration Type | ΔkWh/year·ft | ΔkW/ft |
|---|---:|---:|
| Low Temperature (-35°F - -1°F) | 14.8 | 0.002726 |
| Medium Temperature (0°F - 30°F) | 14.8 | 0.002190 |
| High Temperature (31°F - 55°F) | 11.3 | 0.002190 |

## Default Savings

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

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

$$\Delta kWh \quad = \frac{\Delta kWh/year}{ft} \times\ L$$

$$= 24.8\, kWh/ft \times 1\, foot$$

$$= 24.8\, kWh$$

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

$$\Delta kW \quad = \frac{\Delta kW}{ft} \times\ L$$

$$= 0.005\, kW/ft \times 1ft$$

$$= 0.005\, kW$$

## Source(s)

The primary source for this deemed savings approach is the Pennsylvania TRM 2016, pp. 417–418.

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[131] Pennsylvania TRM 2016, p. 418, original source: Southern California Edison Company, "Insulation of Bare Refrigeration Suction Lines", Work Paper WPSCNRRN0003.

## Update Summary

The changes to this section, compared with last year, are described in Table 6-51.

**Table 6-51: Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **Source** | Updated footnote |

# 6.4.12 Strip Curtain (Cooler and Freezer)

## 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.

## Savings Estimation Approach

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

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

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

$$\Delta kW \quad = \frac{\Delta kWh}{HOU}$$

Where:

ΔkWh = per measure gross annual electric energy
ΔkW = per measure coincident demand reductions
$kWh/ft^2$ = average annual kilowatt hour savings per square foot of infiltration barrier
Area = area of doorway where strip curtains are installed

**Table 6-52: Input Values for Strip Curtain Savings Calculations**

| Component | Type | Value | Unit | Source(s) |
|---|---|---|---|---|
| **$\Delta kWh/ft^2$** | Variable | See Table 6-53 | $kWh/ft^2$ | Pennsylvania TRM 2016, Table 3-107, p. 400 |
| **Area** | Variable | Supermarkets: 35<br>Convenience Store: 21<br>Restaurant: 21<br>Refr. Warehouse: 80 | $ft^2$ | Supermarkets[132]<br>Convenience Stores[133]<br>Restaurant[134]<br>Refr. Warehouse[135] |
| | | Default = 21 | | Assume convenience store |
| **HOU** | Fixed | 8,760 | hours, annual | Pennsylvania TRM 2016, p. 398 |

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[132] Pennsylvania TRM 2016, Table 3-108, p. 401, per data from California Public Utility Commission evaluation of 2006-2008 Investor-Owned Utility Energy Efficiency Programs, http://www.calmac.org/publications/ComFac_Evaluation_V1_Final_Report_02-18-2010.pdf.

[133] Ibid., p. 402.

[134] Ibid., p. 403.

[135] Ibid., p. 404.

**Table 6-53: Strip Curtain Gross Annual Electric Energy Savings (per sq.ft.)**[136]

| Type | Baseline Curtain | Annual Electric Energy Savings per Square Foot ($\Delta kWh/ft^2$) |
|---|---|---|
| Supermarket - Cooler | Yes | 37 |
| | No | 108 |
| | Unknown | 108 |
| Supermarket - Freezer | Yes | 119 |
| | No | 349 |
| | Unknown | 349 |
| Convenience Store - Cooler | Yes | 5 |
| | No | 20 |
| | Unknown | 11 |
| Convenience Store - Freezer | Yes | 8 |
| | No | 27 |
| | Unknown | 17 |
| Restaurant - Cooler | Yes | 8 |
| | No | 30 |
| | Unknown | 18 |
| Restaurant - Freezer | Yes | 34 |
| | No | 119 |
| | Unknown | 81 |
| Refrigerated Warehouse | Yes | 254 |
| | No | 729 |
| | Unknown | 287 |
| Other[137] | Yes | 5 |
| | No | 20 |
| | Unknown | 11 |
| Not applicable | Yes | 0 |
| | No | 0 |
| | Unknown | 0 |

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[136] Pennsylvania TRM 2016, p. 400. "The assumption is based on general observation that refrigeration is constant for food storage, even outside of normal conditions. The most conservative approach, in lieu of a more sophisticated model, is based on continuous operation [8,760 hours/year of operation]."

[138] Massachusetts TRM 2016-2018 Plan Version, p. 268-270; Original source is USA Technologies Energy Management Product Sheets (2006): https://www.usatech.com/energy_management/energy_productsheets.php (accessed on April 18, 2012).

## 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 of unknown baseline conditions—according to the following calculation:

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

$$=11\ kWh/ft^2 \times 21\ ft^2$$

$$= 231\ kWh$$

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

$$\Delta kW \quad = \frac{\Delta kWh}{HOU}$$

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

$$= 0.026\ kW$$

## Source(s)

The primary source for this deemed savings approach is the Pennsylvania TRM 2016, p. 397 - 405.

## Update Summary

The changes to this section, compared with last year, are described in Table 6-54.

**Table 6-54**: **Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **Source** | • Updated page numbers / version of the Pennsylvania TRM |
| **Equation** | • Updated equations |

## 6.4.13 Vending Machine Miser

### 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.

### Savings Estimation Approach

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

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

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

$$\Delta kW \quad = \frac{\Delta kWh}{HOU}$$

Where:

$\Delta$kWh = per measure gross annual electric energy savings
$\Delta$kW = per measure gross coincident demand reduction
$kW_{rated}$ = rated kilowatts of connected equipment
HOU = annual hours of use
ESF = energy savings factor

### Input Variables

**Table 6-55: Input Values for Vending Miser Savings Calculations**

| Component | Type | Value | Unit | Source(s) |
|---|---|---|---|---|
| **$kW_{rated}$** | Variable | See customer application | kW | Customer application |
| | | Default: Non-Refrigerated Snack Vending Machine (see Table 6-56) | | Massachusetts TRM 2015, p. 268 |
| **ESF** | Variable | See Table 6-56 | - | Massachusetts TRM 2015, p. 268 |
| **HOU** | Fixed | 8,760 | hours (annual) | Massachusetts TRM 2015, p. 268 |

**Table 6-56: Vending Miser Rated Kilowatts and Energy Savings Factors**[138]

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

## 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:

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

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

$$= 343 kWh$$

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

$$\Delta kW \quad = \frac{\Delta kWh}{HOU}$$

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

$$= 0.039\, kW$$

## Source(s)

The primary source for this deemed savings approach is the Massachusetts TRM 2015, pp. 268-270.

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[138] Massachusetts TRM 2016-2018 Plan Version, p. 268-270; Original source is USA Technologies Energy Management Product Sheets (2006): https://www.usatech.com/energy_management/energy_productsheets.php (accessed on April 18, 2012).

## Update Summary

The changes to this section, compared with last year, are described in Table 6-57.

**Table 6-57: Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **None** | |

# 7 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.

## 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.

## Savings 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 7-1.

## 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.

$$Realization\ Rate_j \quad = \frac{\sum_i Measured\ Generation\ (kW)}{\sum_i Dispatched\ Generation\ (kW)}$$

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.

## Input Variables

**Table 7-1: 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 |

## Default Savings

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

## Source(s)

DNV GL developed the non-residential DG evaluation methodology according to standard EM&V protocols.[139]

## Update Summary

The changes to this section, compared with last year, are described in Table 7-2.

**Table 7-2**: **Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **None** | |

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[139] Miriam L. Goldberg & G. Kennedy Agnew. Measurement and Verification for Demand Response, National Forum on the National Action Plan on Demand Response, https://www.ferc.gov/industries/electric/indus-act/demand-response/dr-potential/napdr-mv.pdf.

# 8 SUB-APPENDICES

## 8.1 Sub-appendix F2-I: Cooling and Heating Degree Days and Hours

This section appears in Appendix F1 as Sub-appendix F1-I: Cooling and Heating Degree Days and Hours (a.k.a. Section 8.1).

**Table 8-1: Base Temperatures by Sector and End-use**

This table appears in Appendix F1 as Sub-appendix F1-I: Cooling and Heating Degree Days and Hours (a.k.a. Section 8.1).

**Table 8-2: Reference Cooling and Heating Degree Days**

This table appears in Appendix F1 as Sub-appendix F1-I: Cooling and Heating Degree Days and Hours (a.k.a. Section 8.1).

**Table 8-3: Reference Cooling and Heating Degree Hours**

This table appears in Appendix F1 as Sub-appendix F1-I: Cooling and Heating Degree Days and Hours (a.k.a. Section 8.1).

## 8.2 Sub-appendix F2-II: Non-residential HVAC Equivalent Full Load Hours

Table 8-4, Table 8-5, and Table 8-6 provide the full load heating and cooling hours that are used as defaults for non-residential programs. The Richmond, VA and a blend of Elizabeth City and Rocky Mount-Wilson, NC full-load cooling and heating hours are determined by using ratios of the annual full load cooling and heating hours listed in the ENERGY STAR® heat pump and central AC savings calculators to the 2019 Mid-Atlantic TRM for Baltimore, MD.

The Mid-Atlantic TRM hours are based on an evaluation of the EmPOWER Maryland program of utilities in the state of Maryland. According to the Mid-Atlantic TRM, the values are "based on average 5 utilities in Maryland from Navigant Consulting 'EmPOWER Maryland Draft Final Evaluation Report Evaluation Year 4 (June 1, 2012 – May 31, 2013) Residential HVAC Program.' April 4, 2014, table 30, page 48." Since that evaluation only produced full load hours for Baltimore, DNV GL calculated full load hours for Richmond and blended Elizabeth City and Rocky Mount-Wilson using the same adjustment method used by the Mid-Atlantic TRM convert the Baltimore full load hours to Wilmington, DE and Washington, DC hours (see page 72, footnote 197 in the Mid-Atlantic TRM). It appears that the Mid-Atlantic TRM considers the ENERGY STAR® air source heat pump and central AC calculator full load hours to be different from "full load cooling" and "full load heating hours" that it imputed using the methods described in its footnote and also used here. DNV GL is using the methods and values from the Mid-Atlantic TRM for full-load cooling and heating hours in this document.

The conversion method uses the ratio of Baltimore full load cooling and heating hours in the Mid-Atlantic TRM to Baltimore full load cooling and heating hours in the ENERGY STAR® heat pump and central AC calculators. This ratio is then multiplied with the ENERGY STAR® hours for Richmond and blended Elizabeth City and Rocky Mount-Wilson to determine each city's respective full-load hours. Below is an example of the calculation of Richmond's full-load cooling hours for air-source heat pump systems:

$$\textit{Mid-Atlantic TRM Baltimore EFLHcool} = \textit{744 hour/year}$$

$$\textit{ENERGY STAR® Baltimore EFLHcool} = \textit{1,050 hour/year}$$

$$\textit{ENERGY STAR® Richmond EFLHcool} = \textit{1,188 hour/year}$$

$$\textit{STEP Richmond EFLHcool} = ENERGY\ STAR^{®}\ Richmond\ FLH_{cool} \times \frac{Mid\!-\!Atlantic\ TRM\ Baltimore\ FLH_{cool}}{ENERGY\ STAR^{®}\ Baltimore\ FLH_{cool}}$$

$$= 1{,}188\ hour/year \times \frac{774\ hour/year}{1{,}050\ hour/year}$$

$$= 842\ hour/year$$

In 2019, a similar method is used to adjust full-load hour for North Carolina. TMY data from Elizabeth City and Rocky Mount are used to determine North Carolina's CDD, HDD, and CDH (Average value taken between Elizabeth City and Rocky Mount-Wilson, see sub-appendix I). The ratio of Baltimore full-load hours to Baltimore CDD or HDD is multiplied by the North Carolina CDD or HDD to determine a full-load hour that is more location accurate.

Example calculation for air-source heat pump:

$$Mid\text{-}Atlantic\ TRM\ Baltimore\ CDD = 1{,}233$$

$$STEP\ Baltimore\ EFLHcool = 744\ hour/year$$

$$TMY\ Elizabeth\ City/RM\ CDD = 1{,}552$$

$$STEP\ Elizabeth\ City/RM\ EFLHcool = STEP\ Baltimore\ EFLH_{cool}$$

$$\times \frac{TMY\ Rocky\ Mount - Wilson/Elizabeth\ City\ CDD}{Mid - Atlantic\ TRM\ Baltimore\ CDD}$$

$$= 744\ \ hour/year \times \frac{1{,}552}{1{,}233}$$

$$= 936\ hour/year$$

### 8.2.1 Annual Cooling Hours for Unitary Air Conditioners, Heat Pumps, VRF, and Mini-split Systems

**Table 8-4: Heat pump, Unitary AC, VRF, and Mini Split Equivalent Full-Load Cooling Hours for Non-residential Buildings**[140]

| Building Type | Baltimore, MD | Richmond, VA | Elizabeth City, NC & Rocky Mount-Wilson, NC, averaged |
|---|---|---|---|
| Education – Elementary and Middle School | 295 | 347 | 375 |
| Education – High School | 340 | 400 | 432 |
| Education – College and University[141] | 756 | 888 | 960 |
| Food Sales - Grocery | 678 | 797 | 861 |
| Food Sales – Convenience Store | 923 | 1,085 | 1,172 |
| Food Sales – Gas Station Convenience Store | 923 | 1,085 | 1,172 |
| Food Service - Full Service | 768 | 902 | 975 |
| Food Service - Fast Food | 730 | 858 | 927 |
| Health Care - Inpatient | 1,223 | 1,437 | 1,553 |
| Health Care - Outpatient | 650 | 764 | 826 |
| Lodging – (Hotel, Motel and Dormitory) | 1,831 | 2,152 | 2,325 |
| Mercantile (mall) | 887 | 1,042 | 1,127 |
| Mercantile (Retail, not mall) | 911 | 1,071 | 1,157 |
| Office – Small (<40,000 sq ft) | 634 | 745 | 805 |
| Office – Large (≥40,000 sq ft) | 733 | 861 | 931 |
| Other[142] | 245 | 288 | 311 |
| Public Assembly | 945 | 1,110 | 1,200 |
| Public Order and Safety (Police and Fire Station) | 245 | 288 | 311 |
| Religious Worship | 245 | 288 | 311 |
| Service (Beauty, Auto Repair Workshop) | 923 | 1,085 | 1,172 |
| Warehouse and Storage[143] | 2,081 | 2,445 | 2,643 |

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[140] Baltimore, MD full load cooling hours taken from Mid-Atlantic TRM 2019 p.583 for different building types. Richmond VA and Charlotte NC hours are adjusted using cooling degree day estimates from TMY3 data from the weather stations Richmond International Airport (Weather station number 724010; CDD=1,448), Charlotte Douglas

### 8.2.2 Annual Heating Hours for Heat Pumps, VRFs, and Mini-split Systems

**Table 8-5: Heat Pump, VRF, and Mini-split Equivalent Full Load Heating Hours for Non-residential Buildings[144]**

| Building Type | Baltimore, MD | Richmond, VA | Elizabeth City, NC & Rocky Mount-Wilson, NC, averaged |
|---|---|---|---|
| Education – Elementary and Middle School | 668 | 560 | 410 |
| Education – High School | 719 | 602 | 442 |
| Education – College and University | 622 | 521 | 382 |
| Food Sales - Grocery | 980 | 821 | 602 |
| Food Sales – Convenience Store | 623 | 522 | 383 |
| Food Sales – Gas Station Convenience Store | 623 | 522 | 383 |
| Food Service - Full Service | 1,131 | 948 | 695 |
| Food Service - Fast Food | 1,226 | 1,027 | 753 |
| Health Care-inpatient | 214 | 179 | 131 |
| Health Care-outpatient | 932 | 781 | 572 |
| Lodging – (Hotel, Motel and Dormitory) | 2,242 | 1,878 | 1,377 |
| Mercantile (mall) | 591 | 495 | 363 |
| Mercantile (Retail, not mall) | 739 | 619 | 454 |
| Office – Small (<40,000 sq ft) | 440 | 369 | 270 |
| Office – Large (≥40,000 sq ft) | 221 | 185 | 136 |
| Other | 146 | 122 | 90 |

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International Airport (Weather station number 723140; CDD=1,598), and Baltimore BLT – Washington International Airport (Weather station number 724060; CDD=1,233). See Sub-appendix F2-I: Cooling and Heating Degree Days and Hours for CDD and HDD.

[141] "Education – College and University" Baltimore, MD full load cooling hours is an average of the hours for "Education – Community College"(718 hours/year) and "Education – University" (793 hours/year) in the Mid-Atlantic TRM 2018, p.528

[142] "Other" building type is mapped to the building type with the most conservative full load heating hours in the Mid-Atlantic TRM 2018, p.528 "Manufacturing – Bio Tech/High Tech."

[143] "Warehouse and Storage" Baltimore, MD full load heating hours is an average of the hours for "Storage - Conditioned" (854 hours/year) and "Warehouse - Refrigerated" (342 hours/year) in the Mid-Atlantic TRM 2018, p.528

[144] Baltimore, MD full load cooling hours taken from Mid-Atlantic TRM 2018 p.529 for different building types. Richmond VA and Charlotte NC hours are adjusted using cooling degree day estimates from TMY3 data from the weather stations Richmond International Airport (Weather station number 724010; HDD=3,849), Charlotte Douglas International Airport (Weather station number 723140; HDD=3,140), and Baltimore BLT – Washington International Airport (Weather station number 724060; HDD=4,600). See Sub-appendix F2-I: Cooling and Heating Degree Days and Hours for CDD and HDD.

| Building Type | Baltimore, MD | Richmond, VA | Elizabeth City, NC & Rocky Mount-Wilson, NC, averaged |
|---|---|---|---|
| Public Assembly[145] | 1,114 | 933 | 684 |
| Public Order and Safety (Police and Fire Station)[146] | 146 | 122 | 90 |
| Religious Worship | 146 | 122 | 90 |
| Service (Beauty, Auto Repair Workshop) | 623 | 522 | 383 |
| Warehouse and Storage | 598 | 501 | 367 |

### 8.2.3 Annual Cooling Hours for Chiller Systems

**Table 8-6: Annual Chiller Full Load Cooling Hours at Non-Residential Buildings[147]**

| Building Type | Baltimore, MD | Richmond, VA | Elizabeth City, NC & Rocky Mount-Wilson, NC, averaged |
|---|---|---|---|
| Education – Elementary and Middle School | 743 | 873 | 944 |
| Education – High School | 369 | 434 | 469 |
| Education – College and University[148] | 780 | 917 | 991 |
| Food Sales - Grocery | 928 | 1,091 | 1,179 |
| Food Sales – Convenience Store | 928 | 1,091 | 1,179 |
| Food Sales – Gas Station Convenience Store | 928 | 1,091 | 1,179 |
| Food Service - Full Service | 928 | 1,091 | 1,179 |
| Food Service - Fast Food | 928 | 1,091 | 1,179 |
| Health Care-inpatient | 1,570 | 1,845 | 1,994 |
| Health Care-outpatient | 601 | 706 | 763 |

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[145] “Public Order and Safety (Police and Fire Station)” building type is mapped to the building type with the most conservative full load heating hours in the Mid-Atlantic TRM 2018, p.529 “Manufacturing – Bio Tech/High Tech.”

[146] “Regligous Worship” building type is mapped to the building type with the most conservative full load heating hours in the Mid-Atlantic TRM 2018, p.529 “Manufacturing – Bio Tech/High Tech.”

[147] Baltimore, MD full load cooling hours taken from Mid-Atlantic TRM 2018 p.437 for different building types. Richmond VA and Charlotte NC hours are adjusted using cooling degree day estimates from TMY3 data from the weather stations Richmond International Airport, Charlotte Douglas International Airport. https://www.google.com/fusiontables/DataSource?docid=1EsB07O-9SiqyJDlzl69GO8jTHsomsNIpkA1SLL8#rows:id=1 , accessed July, 2018. See Sub-appendix F2-I: Cooling and Heating Degree Days and Hours for CDD and HDD.

[148] “Education – College and University” Baltimore, MD full load cooling hours is an average of the hours for “Education – Community College”(743 hours/year) and “Education – University” (816 hours/year) in the Mid-Atlantic TRM 2018, p. 437.

| Building Type | Baltimore, MD | Richmond, VA | Elizabeth City, NC & Rocky Mount-Wilson, NC, averaged |
|---|---|---|---|
| Lodging – (Hotel, Motel and Dormitory) | 1,801 | 2,116 | 2,287 |
| Mercantile (mall) | 928 | 1,091 | 1,179 |
| Mercantile (Retail, not mall) | 928 | 1,091 | 1,179 |
| Office – Small (<40,000 sq ft) | 559 | 657 | 710 |
| Office – Large (≥ 40,000 sq ft) | 603 | 709 | 766 |
| Other | 369 | 434 | 469 |
| Public Assembly | 369 | 434 | 469 |
| Public Order and Safety (Police and Fire Station) | 369 | 434 | 469 |
| Religious Worship | 369 | 434 | 469 |
| Service (Beauty, Auto Repair Workshop) | 928 | 1,091 | 1,179 |
| Warehouse and Storage | 810 | 952 | 1,029 |

### 8.2.4 Annual Hours for Variable Frequency Drives

**Table 8-7: Variable Frequency Drive Annual Hours of Use by Facility Type[149]**

| Building Type | Fan Motor Hours | Chilled Water Pumps[150] | 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** | 6,456 | 2,742 | 5,376 |
| **Health Care - Inpatient** | 7,666 | 3,177 | 8,760 |
| **Health Care - Outpatient** | 3,748 | 1,767 | 5,376 |
| **Lodging – (Hotel, Motel, and Dormitory)** | 3,064 | 1,521 | 5,492 |

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[149] Mid-Atlantic TRM 2019, pp. 431-433. 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.

[150] For condenser water pumps, use the same operating hours as chilled water pumps

| Building Type | Fan Motor Hours | Chilled Water Pumps[150] | Heating Pumps |
|---|---|---|---|
| **Mercantile (Mall)** | 4,833 | 2,157 | 5,376 |
| **Mercantile (Retail, not Mall)** | 4,057 | 1,878 | 2,344 |
| **Office – Small (<40,000 sq ft)** | 3,748 | 1,767 | 3,038 |
| **Office – Large (≥ 40,000 sq ft)** | 3,748 | 1,767 | 3,038 |
| **Other** | 2,857 | 1,446 | 5,376 |
| **Public Assembly** | 1,955 | 1,121 | 5,376 |
| **Public Order and Safety (Police and Fire Station)** | 7,665 | 3,177 | 5,376 |
| **Religious Worship** | 1,955 | 1,121 | 5,376 |
| **Service (Beauty, Auto Repair Workshop)** | 3,750 | 1,768 | 5,376 |
| **Warehouse and Storage** | 2,602 | 1,354 | 5,376 |

### 8.2.5 Update Summary

The changes to this section, compared with last year, are described in Table 8-8.

**Table 8-8: Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **New Weather Stations** | Replaced the Charlotte, NC weather station with the average results from two weather stations located within the Company's service territory: Elizabeth City, NC and Rocky Mount-Wilson, NC. |
| **Updated HOU** | By-building hours of use values were updated and—in some case, corrected—based upon revisions to HDD/CDD adjustments due to change of weather stations in NC. |
| **New Table** | A table was added for the HOU for VFDs. |

## 8.3 Sub-appendix F2-III: Non-residential HVAC Equipment Efficiency Ratings

This sub-appendix contains the minimum efficiency metrics that are required by building codes for four categories of equipment:

- Unitary air conditioners and condensing units, in Table 8-9
- Unitary and applied heat pumps, in Table 8-10
- Variable Refrigerant Flow (VRF) air conditioners and heat pumps, in Table 8-11
- Water chilling packages (a.k.a. chillers), in Table 8-12

### 8.3.1 Cooling Efficiencies of Unitary Air Conditioners and Condensing Units

**Table 8-9: Unitary Air Conditioners and Condensing Units - Minimum Efficiency[151]**

| Equipment Type | Size Category (Btu/h) | Heating System Type | Subcategory | Minimum Annual Efficiency | Minimum Demand Efficiency |
|---|---|---|---|---|---|
| **Air conditioners, air cooled** | < 65,000 Btu/h | All | Split system/ Single package | 13.0 SEER | 11.1 EER[152] |
| **Through the wall (air cooled)** | ≤ 30,000 Btu/h | All | Split system/ Single package | 12.0 SEER | 10.5 EER[152] |
| **Small-duct, high-velocity (air cooled)** | < 65,000 Btu/h | All | Split system/ Single package | 11.0 SEER | 9.9 EER[152] |

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[151] ASHRAE 90.1 2013, Table 6.8.1-1 - Electrically Operated Unitary Air Conditioners and Condensing Units - Minimum Efficiency Requirement.

[152] This value was not provided in ASHRAE 90.1 2013, Table 6.8.1-1, so Equation 3 in Sub-appendix F2-V: General Equations was used to convert SEER to EER.

| Equipment Type | Size Category (Btu/h) | Heating System Type | Subcategory | Minimum Annual Efficiency | Minimum Demand Efficiency |
|---|---|---|---|---|---|
| **Air conditioners, air cooled** | ≥ 65,000 Btu/h and < 135,000 Btu/h | Electric resistance (or none) | Split system/ Single package | 12.9 IEER | 11.2 EER |
| | | All other | Split system/ Single package | 12.7 IEER | 11.0 EER |
| | ≥ 135,000 Btu/h and < 240,000 Btu/h | Electric resistance (or none) | Split system/ Single package | 12.4 IEER | 11.0 EER |
| | | All other | Split system/ Single package | 12.2 IEER | 10.8 EER |
| | ≥ 240,000 Btu/h and < 760,000 Btu/h | Electric resistance (or none) | Split system/ Single package | 11.6 IEER | 10.0 EER |
| | | All other | Split system/ Single package | 11.4 IEER | 9.8 EER |
| | ≥ 760,000 Btu/h | Electric resistance (or none) | Split system/ Single package | 11.2 IEER | 9.7 EER |
| | | All other | Split system/ Single package | 11.0 IEER | 9.5 EER |

| Equipment Type | Size Category (Btu/h) | Heating System Type | Subcategory | Minimum Annual Efficiency | Minimum Demand Efficiency |
|---|---|---|---|---|---|
| **Air conditioners, water cooled** | < 65,000 Btu/h | All | Split system/ Single package | 12.3 IEER | 12.1 EER |
| | ≥ 65,000 Btu/h and < 135,000 Btu/h | Electric resistance (or none) | Split system/ Single package | 13.9 IEER | 12.1 EER |
| | | All other | Split system/ Single package | 13.7 IEER | 11.9 EER |
| | ≥ 135,000 Btu/h and < 240,000 Btu/h | Electric resistance (or none) | Split system/ Single package | 13.9 IEER | 12.5 EER |
| | | All other | Split system/ Single package | 13.7 IEER | 12.3 EER |
| | ≥ 240,000 Btu/h and < 760,000 Btu/h | Electric resistance (or none) | Split system/ Single package | 13.6 IEER | 12.4 EER |
| | | All other | Split system/ Single package | 13.4 IEER | 12.2 EER |
| | ≥ 760,000 Btu/h | Electric resistance (or none) | Split system/ Single package | 13.5 IEER | 12.2 EER |
| | | All other | Split system/ Single package | 13.3 IEER | 12.0 EER |
| **Air conditioners, evaporatively cooled**[153] | < 65,000 Btu/h | All | Split system/ Single package | 12.3 IEER | 12.1 EER |
| | ⩾ 65,000 Btu/h and < 135,000 Btu/h | All | Split system/ Single package | 12.3 IEER | 12.1 EER |
| | | Electric resistance (or none) | Split system/ Single package | 12.1 IEER | 11.9 EER |
| | ⩾ 135,000 Btu/h and < 240,000 Btu/h | All | Split system/ Single package | 12.2 IEER | 12.0 EER |
| | | Electric resistance (or none) | Split system/ Single package | 12.0 IEER | 11.8 EER |

| Equipment Type | Size Category (Btu/h) | Heating System Type | Subcategory | Minimum Annual Efficiency | Minimum Demand Efficiency |
|---|---|---|---|---|---|
|  | ⩾ 240,000 Btu/h and < 760,000 Btu/h | All | Split system/ Single package | 12.1 IEER | 11.9 EER |
|  |  | Electric resistance (or none) | Split system/ Single package | 11.9 IEER | 11.7 EER |
|  | ⩾ 760,000 Btu/h | All | Split system/ Single package | 11.9 IEER | 11.7 EER |
|  |  | Electric resistance (or none) | Split system/ Single package | 11.7 IEER | 11.5 EER |
| **Condensing units, air cooled**[153] | ⩾ 135,000 Btu/h | - | - | 11.8 IEER | 10.5 EER |
| **Condensing units, water cooled**[153] | ⩾ 135,000 Btu/h | - | - | 14.0 IEER | 13.5 EER |
| **Condensing units, evaporatively cooled**[153] | ⩾ 135,000 Btu/h | - | - | 14.0 IEER | 13.5 EER |

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[153] These systems types were added in ASHRAE 90.1-2013. Therefore, these systems are not retroactively used for the Non-residential Heating and Cooling Efficiency Program offered under the DSM Phase III program, due to data requirement constraints. However, these systems will be included in the DNV GL analysis for the Non-residneital Heating and Cooling Efficiency Program offered under the DSM Phase VII program.

## 8.3.2 Heating Efficiencies of Unitary and Applied Heat Pumps

**Table 8-10: Unitary and Applied Heat Pumps - Minimum Efficiency[154]**

| Equipment Type | Cooling Capacity/ Size Category | Heating System Type | Subcategory or Rating Conditions | Minimum Annual Efficiency | Minimum Demand Efficiency |
|---|---|---|---|---|---|
| **Air Cooled (cooling mode)** | < 65,000 Btu/h | All | Split System/ Single package | 14.0 SEER | 11.8 EER[155] |
| **Through-the-wall (air-cooled cooling mode)** | ≤ 30,000 Btu/h | All | Split System/ Single package | 12.0 SEER | 10.5 EER[155] |
| **Single-duct** | < 65,000 Btu/h | All | Split System/ Single package | 11.0 SEER | 9.9 EER[155] |
| **Air Cooled (cooling mode)** | ≥ 65,000 Btu/h and < 135,000 Btu/h | Electric resistance (or none) | Split system/ Single package | 12.2 IEER | 11.0 EER |
| | | All other | Split system/ Single package | 12.0 IEER | 10.8 EER |
| | ≥ 135,000 Btu/h and < 240,000 Btu/h | Electric resistance (or none) | Split system/ Single package | 11.6 IEER | 10.6 EER |
| | | All other | Split system/ Single package | 11.4 IEER | 10.4 EER |
| | ≥ 240,000 Btu/h | Electric resistance (or none) | Split system/ Single package | 10.6 IEER | 9.5 EER |
| | | All other | Split system/ Single package | 10.4 IEER | 9.3 EER |
| **Water source[156] (Cooling mode)** | < 17,000 Btu/h | All | 86°F entering water | Retrofits: 14.0 SEER[156] | Retrofits: 11.7 EER[155] |
| | | | | RCx:[157] 13.1 $EER_{part-load}$ | RCx: 11.2 EER |
| | ≥ 17,000 Btu/h and | All | 86°F entering water | Retrofits: 14.0 SEER[156] | Retrofits: 11.7 EER[155] |

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[154] ASHRAE 90.1 2013, Table 6.8.1-2 - Electrically Operated Unitary and Applied Heat Pumps - Minimum Efficiency Requirement.

[155] This value was not provided in ASHRAE 90.1 2013, Table 6.8.1-2, so Equation 3 in Sub-appendix F2-V: General Equationswas used to convert between SEER and EER.

[156] Although ASHRAE values reflect the Building Code minimum, savings are calculated using the efficiencies shown. This is due to the Mid-Atlantic TRM 2019 assumption that the baseline technology—for residential ground source heat pump applications—is an air-cooled heat pump. (There is no corresponding commercial measure in the Mid-Atlantic TRM 2019.)

[157] Two types of measures are categorized as retro-commissioning (RCx) ones: Duct Testing & Sealing and AC/HP/Chiller Tune-ups.

| Equipment Type | Cooling Capacity/ Size Category | Heating System Type | Subcategory or Rating Conditions | Minimum Annual Efficiency | Minimum Demand Efficiency |
|---|---|---|---|---|---|
|  | < 65,000 Btu/h |  |  | RCx:<br>14.5 EER$_{\text{part-load}}$ | RCx:<br>12.0 EER |
|  | ≥ 65,000 Btu/h and < 135,000 Btu/h | All | 86°F entering water | Retrofits:<br>12.2 IEER[156] | Retrofits:<br>10.9 EER[158] |
|  |  |  |  | RCx:<br>13.4 EER$_{\text{part-load}}$ | RCx:<br>12.0 EER |
| **Ground source[156] (cooling mode)** | < 65,000 Btu/h | All | 77°F entering water | Retrofits:<br>14.0 SEER[156] | Retrofits:<br>11.7 EER[155] |
|  |  |  |  | RCx:<br>17.4 EER$_{\text{part-load}}$ | RCx:<br>13.4 EER |
|  | ≥ 65,000 Btu/h and < 135,000 Btu/h | All | 77°F entering water | Retrofits:<br>12.2 IEER[156] | Retrofits:<br>10.9 EER[158] |
|  |  |  |  | RCx:<br>14.9 EER$_{\text{part-load}}$ | RCx:<br>13.4 EER |
| **Air cooled (heating mode)** | < 65,000 Btu/h | - | Split system/ Single system | 7.7 HSPF | N/A |
| **Through-the-wall (air-cooled heating mode)** | ≤ 30,000 Btu/h | - | Split system/ Single system | 7.4 HSPF | N/A |
| **Air cooled (heating mode)** | ≥ 65,000 Btu/h and < 135,000 Btu/h | - | 47°F DBT/ 43°F WBT outdoor air | 3.3 COP | N/A |
|  | ≥ 135,000 Btu/h (cooling capacity) | - | 47°F DBT/ 43°F WBT outdoor air | 3.2 COP | N/A |
| **Water source (heating mode)** | < 135,000 Btu/h (cooling capacity) | - | 68°F entering water | 4.3 COP | N/A |
| **Ground source (heating mode)** | < 135,000 Btu/h (cooling capacity) | - | 32°F entering water | 3.2 COP | N/A |

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[158] This value was not provided in ASHRAE 90.1 2013, Table 6.8.1-2, so Equation 4 in Sub-appendix F2-V: General Equations was used to convert between IEER and EER.

## 8.3.3 Cooling Efficiencies of Variable Refrigerant Flow Air Conditioners and Heat Pumps

**Table 8-11: Variable Refrigerant Flow Air Conditioners and Heat Pumps - Minimum Efficiency[159]**

| Equipment Type | Size Category | Heating Section Type | Subcategory or Rating Conditions | Minimum Annual Cooling Efficiency | Minimum Peak Cooling Efficiency | Minimum Heating Efficiency |
|---|---|---|---|---|---|---|
| **VRF Air Conditioners, Air Cooled** | < 65,000 Btu/h | All | VRF Multi-Split System | 13.0 SEER | 11.1 EER[160] | N/A |
| | ≥ 65,000 Btu/h and < 135,000 Btu/h | Electric Resistance (or none) | VRF Multi-Split system | 13.1 IEER | 11.2 EER[160] | N/A |
| | ≥ 135,000 Btu/h and < 240,000 Btu/h | Electric Resistance (or none) | VRF Multi-Split system | 12.9 IEER | 11.0 EER[160] | N/A |
| | ≥ 240,000 Btu/h | Electric Resistance (or none) | VRF Multi-Split system | 11.6 IEER | 10.0 EER[160] | N/A |
| **VRF Heat Pumps, Air Cooled** | < 65,000 Btu/h | All | VRF Multi-Split system | 13.0 SEER | 11.1 EER[160] | 7.7 HSPF |
| | ≥ 65,000 Btu/h and < 135,000 Btu/h | Electric Resistance (or none) | VRF Multi-Split system | 12.9 IEER | 11.0 EER[160] | 3.3 COP |
| | ≥ 135,000 Btu/h and < 240,000 Btu/h | Electric Resistance (or none) | VRF Multi-Split system | 12.3 IEER | 10.6 EER[160] | 3.2 COP |
| | ≥ 240,000 Btu/h | Electric Resistance (or none) | VRF Multi-Split system | 11.0 IEER | 9.5 EER[160] | 3.2 COP |

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[159] ASHRAE 90.1 2013, Tables 6.8.1-9 - Electrically Operated Variable Refrigerant Flow Air Conditioners- Minimum Efficiency Requirement and 6.8.1J - Electrically Operated Variable Refrigerant Flow Heat Pumps - Minimum Efficiency Requirement.

[160] This value was not provided in ASHRAE 90.1 2013, Table 6.8.1-9, so Equation 3 in Sub-appendix F2-V: General Equations was used to convert between SEER and EER.

### 8.3.4 Cooling Efficiencies of Water Chilling Packages

**Table 8-12: Water Chilling Packages–Minimum Efficiency**[161]

| | | | Path A | | Path B | |
|---|---|---|---|---|---|---|
| Equipment Type | Size Category | Units | Full Load | IPLV | Full Load | IPLV |
| **Air Cooled Chillers** | < 150 tons | EER | ≥ 10.100 | ≥ 13.700 | ≥ 9.700 | ≥ 15.800 |
| | ≥ 150 tons | EER | ≥ 10.100 | ≥ 14.000 | ≥ 9.700 | ≥ 16.100 |
| **Water-cooled, electrically operated, positive displacement** | < 75 tons | kW/ton | ≤ 0.750 | ≤ 0.600 | ≤ 0.780 | ≤ 0.500 |
| | ≥ 75 tons and < 150 tons | kW/ton | ≤ 0.720 | ≤ 0.560 | ≤ 0.750 | ≤ 0.490 |
| | ≥ 150 tons and < 300 tons | kW/ton | ≤ 0.660 | ≤ 0.540 | ≤ 0.680 | ≤ 0.440 |
| | ≥ 300 tons and < 600 tons | kW/ton | ≤ 0.610 | ≤ 0.520 | ≤ 0.625 | ≤ 0.410 |
| | ≥ 600 tons | kW/ton | ≤ 0.560 | ≤ 0.500 | ≤ 0.585 | ≤ 0.380 |
| **Water-cooled, electrically operated, centrifugal** | <150 tons | kW/ton | ≥ 0.610 | ≤ 0.550 | ≤ 0.695 | ≤ 0.440 |
| | ≥ 150 tons and < 300 tons | kW/ton | ≤ 0.610 | ≤ 0.550 | ≤ 0.635 | ≤ 0.440 |
| | ≥ 300 tons and < 400 tons | kW/ton | ≤ 0.560 | ≤ 0.520 | ≤ 0.595 | ≤ 0.390 |
| | ≥ 400 tons and < 600 tons | kW/ton | ≤ 0.560 | ≤ 0.500 | ≤ 0.585 | ≤ 0.380 |
| | ≥ 600 tons | kW/ton | ≤ 0.560 | ≤ 0.500 | ≤ 0.585 | ≤ 0.380 |

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[161] ASHRAE 90.1-2013, Table 6.8.1-3 - Water Chilling Packages - Efficiency Requirements. Consistent with International Energy Conservation Code 2015, Table C403.2.3(7) Water Chilling Packages, Efficiency Requirements, used in the 2019 Mid-Atlantic TRM. Compliance with this standard can be obtained by meeting the minimum requirements of Path A or Path B. However, both the full load and IPLV must be met to fulfill the requirements of Path A or Path B.

| Equipment Type | Size Category | Units | Path A | | Path B | |
|---|---|---|---|---|---|---|
| | | | Full Load | IPLV | Full Load | IPLV |
| **Water-cooled, unknown** | < 75 tons | kW/ton | ≤ 0.750 | ≤ 0.600 | ≤ 0.780 | ≤ 0.500 |
| | ≥ 75 tons and < 150 tons | kW/ton | ≤ 0.720 | ≤ 0.560 | ≤ 0.750 | ≤ 0.490 |
| | ≥ 150 tons and < 300 tons | kW/ton | ≤ 0.660 | ≤ 0.540 | ≤ 0.680 | ≤ 0.440 |
| | ≥ 300 tons and < 600 tons | kW/ton | ≤ 0.610 | ≤ 0.520 | ≤ 0.625 | ≤ 0.410 |
| | ≥ 600 tons | kW/ton | ≤ 0.560 | ≤ 0.500 | ≤ 0.585 | ≤ 0.380 |

### 8.3.5 Update Summary

The changes to this section, compared with last year, are described in Table 8-13.

**Table 8-13: Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **Standards Update** | Both VA and NC building codes were updated from ASHRAE 2010 to ASHRAE 2013 in 2019. This resulted in widespread increases to the minimum efficiency requirements of many equipment types. |

## 8.4 Sub-appendix F2-IV: Non-residential Lighting Factors: Annual Equivalent Hours, Coincidence Factors and Waste Heat Factors

For the purposes of this STEP Manual, Table 8-15 provides the annual lighting (interior CFL and non-CFL) hours of use, summer seasonal peak coincidence factors, and waste heat factors by building types for interior lighting fixtures that are designated for the Dominion territory. All of these are gathered from the Mid-Atlantic TRM, which pulls from a combinations of the Connecticut Program Savings Document (PSD) and the EmPOWER Maryland 2014 Evaluation Report. Table 8-14 provides the same variables for exterior lights and LED exit signs.

Since the building types in the Mid-Atlantic TRM do not map directly to those used in this STEP Manual, a separate mapping was conducted to arrive at the values. Under each STEP Manual building type in Table 8-15 are listings of the Mid-Atlantic TRM building types that were mapped to this document.

For all non-residential lighting measures, DNV GL assigns these variables based on the measure characteristics in this descending order:

1. Measure location (interior or exterior)
2. Fixture name
3. Building type

For example, when calculating savings for a specific non-residential lighting type (fixtures), variables (hours of use, coincidence factor, waste heat factors) are assigned based on if the fixture indicates it is for "exterior" use. All fixtures that contain the word "exterior" in the fixture name, from the tracking data provided to DNV GL, should assign parameters based on the lighting type in Table 8-14.

All fixtures that contain the phrase "24/7" in the fixture name, from the tracking data provided to DNV GL, shall be assigned variables appropriate for "LED Exit Sign". All fixtures that do not specify "exterior" in the fixture name are assumed to be for interior use and should be assigned variables based on the building type as shown in Table 8-15.

Summary of terms used in this section:

- $CF_{PJM}$ – PJM summer peak coincidence factor is from June to August, weekdays between 2 p.m. and 6 p.m. EDT.
- $CF_{SSP}$ – Summer system peak coincidence factor refers to the hour ending 5 p.m. EDT on the hottest summer weekday.
- Interior CFL lighting refers to general-purpose CFL screw-based bulbs

- Interior Non-CFL lighting type includes:
    - T5 Lighting
    - Pulse-Start Metal Halide fixture – interior
    - Solid State Lighting (LED) Recessed Downlight Luminaire
    - Delamping
    - Occupancy Sensor - wall box

**Table 8-14: Non-residential Lighting Parameters By Exterior Lighting Type**

| Lighting Type | Exterior Lighting Annual Hours (hour/year) | $CF_{SSP}$ | Demand Waste Heat Factor and Annual Energy Waste Heat Factor[162] | Source |
|---|---|---|---|---|
| Pulse Start Metal Halide - exterior | 3,338 | 0.0 | 1.0 | Mid-Atlantic TRM 2019, p. 387 |
| High Pressure Sodium | 3,338 | 0.0 | 1.0 | Mid-Atlantic TRM 2019, p. 387 |
| LED Exit Sign and "24/7" lights[163] | 8,760 | 1.0 | 1.0 | Mid-Atlantic TRM 2019, p. 312;<br>DNV GL judgement |
| LED Parking Garage | Canopy: 3,338<br>Parking garage: 8,760 | Canopy: 0.0<br>Parking garage: 1.0 | 1.0 | Mid-Atlantic TRM 2019, p. 586 |
| Outdoor LED and Roadway Lighting | 3,338 | 0.0 | 1.0 | Mid-Atlantic TRM 2019, p. 586 |

The hours and coincident factors (CF) shown in Table 8-15 apply only to the Non-Residential Lighting Systems and Controls Programs (DSM Phases III and VII) and Non-Residential Cooling and Heating Programs (DSM Phases III and VII).

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[162] "If cooling and heating equipment types are unknown or the space is unconditioned, assume WHFd = WHFe = 1.0." Mid-Atlantic TRM 2019, p. 527.

[163] DNV GL judgement that if non-residential lighting measure name contains "24/7" in the tracking data provided to DNV GL, treat it the same as "LED Exit Sign" when calculating savings.

**Table 8-15: Non-Residential Interior Lighting Parameters by Facility Type**

| Building Types | Interior Lighting Annual Hours (hours)[164] | $CF_{SSP}$[165] | Demand Waste Heat Factor[166] | Annual Energy Waste Heat Factor[167] |
|---|---|---|---|---|
| Education – College and University | 2,233 | 0.36 | 1.44 | 0.96 |
| Education – High School | 2,233 | 0.36 | 1.44 | 0.96 |
| Education – Elementary and Middle School | 2,233 | 0.36 | 1.44 | 0.96 |
| Food Sales – Convenience Store | 7,272 | 0.97 | 1.35 | 0.93 |
| Food Sales – Gas Station Convenience Store | 7,272 | 0.97 | 1.35 | 0.93 |
| Food Sales – Grocery | 7,272 | 0.97 | 1.35 | 0.93 |
| Food Service - Fast Food | 4,696 | 0.83 | 1.27 | 0.95 |
| Food Service - Full Service | 4,696 | 0.83 | 1.27 | 0.95 |
| Health Care – inpatient | 3,817 | 0.68 | 1.35 | 0.93 |
| Health Care – outpatient | 3,817 | 0.68 | 1.35 | 0.93 |
| Lodging – (Hotel, Motel and Dormitory) | 4,058 | 0.61 | 1.35 | 0.93 |
| Mercantile (Retail, Not Mall) | 4,696 | 0.83 | 1.27 | 0.95 |
| Mercantile (Mall) | 4,696 | 0.83 | 1.27 | 0.95 |
| Office – Small (<40,000 sq ft) | 3,044 | 0.69 | 1.36 | 0.94 |
| Office – Large (>= 40,000 sq ft) | 3,044 | 0.69 | 1.36 | 0.94 |
| Other | 4,058 | 0.61 | 1.35 | 0.93 |
| Public Assembly | 4,058 | 0.61 | 1.35 | 0.93 |
| Public Order and Safety (Police and Fire Station) | 4,058 | 0.61 | 1.35 | 0.93 |
| Religious Worship | 4,058 | 0.61 | 1.35 | 0.93 |
| Service (Beauty, Auto Repair Workshop) | 4,696 | 0.83 | 1.27 | 0.95 |
| Warehouse and Storage | 4,361 | 0.80 | 1.23 | 0.89 |

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[164] Mid-Atlantic TRM 2019, p. 586 Table D-3: C&I Interior Midstream Lighting Parameters by Building Type. Midstream lighting tables are referenced because downstream table parameters require knowledge of the location of the product installation—information that is unavailable for midstream programs.

[165] Ibid.

[166] Mid-Atlantic TRM 2019, pp. 587-588. Selected waste heat factors from "Washington, D.C. All utilities", AC (utility) $WHF_d$ and heat pump $WHF_e$. Waste heat factors were provided for only five building types (1. Office, 2. Retail, 3. School, 4. Warehouse, 5. Other), therefore they were mapped to the full list of building types as appropriate. Original source of waste heat factor values are from the "EmPOWER Maryland DRAFT Final Impact Evaluation Report Evaluation Year 4 (June 1, 2012 – May 31, 2013) Commercial & Industrial Prescriptive & Small Business Programs, Navigant, March 31, 2014. Values for Washington D.C. and Delaware assume values from Maryland, Pepco and Maryland, DPL, respectively."

[167] Ibid.

## Update Summary

The changes to this section, compared with last year, are described in Table 8-16.

**Table 8-16: Summary of Update(s) from Previous Version**

| Type of Change | Description of Change |
|---|---|
| **Source** | • Updated page numbers / version of the Mid-Atlantic TRM |

## 8.5 Sub-appendix F2-V: General Equations

This section appears in Appendix F1 as Sub-appendix F1-V: General Equations (a.k.a. Section 8.5).

**Equation 1: Cooling Capacities – Btu/h to tons**

This equation appears in Appendix F1 as Sub-appendix F1-V: General Equations (a.k.a. Section 8.5).

**Equation 2: Cooling Capacities – tons to Btu/h**

This equation appears in Appendix F1 as Sub-appendix F1-V: General Equations (a.k.a. Section 8.5).

**Equation 3: Energy Efficiencies - SEER to EER, for systems < 65,000 Btu/h**

This equation appears in Appendix F1 as Sub-appendix F1-V: General Equations (a.k.a. Section 8.5).

**Equation 4: Energy Efficiencies - EER to IEER, for systems ≥ 65,000 Btu/h**

This equation appears in Appendix F1 as Sub-appendix F1-V: General Equations (a.k.a. Section 8.5).

**Equation 5: Energy Efficiencies - HSPF to COP**

This equation appears in Appendix F1 as Sub-appendix F1-V: General Equations (a.k.a. Section 8.5).

**Equation 6: Energy Efficiencies - COP to HSPF**

This equation appears in Appendix F1 as Sub-appendix F1-V: General Equations (a.k.a. Section 8.5).

**Equation 7: Energy Efficiencies - COP to EER**

This equation appears in Appendix F1 as Sub-appendix F1-V: General Equations (a.k.a. Section 8.5).

### Equation 8: Energy Efficiencies – kW/ton$_{\text{full-load}}$ to kW/ton$_{\text{IPLV}}$

This equation appears in Appendix F1 as Sub-appendix F1-V: General Equations (a.k.a. Section 8.5).

### Equation 9: Energy Efficiencies – EERfull-load to EERIPLV

This equation appears in Appendix F1 as Sub-appendix F1-V: General Equations (a.k.a. Section 8.5).

### Equation 10: Heat to electric energy – Btu/h to kW

This equation appears in Appendix F1 as Sub-appendix F1-V: General Equations (a.k.a. Section 8.5).

# Appendix G. Residential Income and Age Qualifying Home Improvement Program EM&V Plan

# DEMAND-SIDE MANAGEMENT PHASE VII, PORTFOLIO EVALUATION, MEASURE, AND VERIFICATION APPROACH

This document contains the evaluation, measurement, and verification (EM&V) plans for the following DSM Phase VII programs proposed in this filing. The plans are organized in the following manner:

- **Program Summary** – high-level program description
- **Measures** – high-level description of proposed program measures
- Evaluation, Measurement, and Verification Overview – high-level description of EM&V approach
    - **Deemed Savings Approach** – planned deemed savings estimation approach, upon program approval
    - **Evaluated Savings Approach** or **Verified Savings Approach** – planned evaluation approach based on program as filed, upon program approval, and should an evaluation of the program and/or measures in the program be appropriate, based on the portfolio assessment
- **Lost Revenue Methodology** – steps for calculating lost revenue, should the Company pursue lost revenue recovery in Virginia and/or North Carolina
- **Timeline and Scope of Work** – description of the EM&V schedule and scope of work, upon program approval
- **Document Revision History**

The evaluation methods described in the following EM&V plans meet the standards of section A of 20 VAC 5-318-40. All evaluation methodologies align with Options A, B, C, or D from the International Performance Measurement and Verification Protocol (January 2012 or later) (IPMVP) and the guidance developed through the U.S. Department of Energy's Uniform Methods Project for Determining Energy Efficiency Program Savings (UMP).[1]

DNV GL takes a holistic approach to evaluation planning for the Company's portfolio of energy conservation programs. DNV GL balances cost effectiveness and rigor to its evaluation planning so the Company can insure its programs are cost effective and yield planned savings. Some programs will be evaluated on a rolling basis at program inception, like methods described as advanced M&V or M&V 2.0, others will follow a staged evaluation plan.

For programs following a staged evaluation plan, DNV GL takes a two-step approach. During program start-up, kilowatts and kilowatt-hour savings are estimated using a deemed savings approach. Deemed approaches are a cost-effective method for determining reasonable savings estimates in the early stage of implementation, and in the periods between more rigorous EM&V.

Once participation has levelized or reached planned levels, and realized savings can be quantified, the program is considered for evaluation. Based on results from the DSM Phase I through III programs – programs that were implemented for more than three years as of this filing, and similar programs in other jurisdictions, DNV GL anticipates this will occur in year two of program operations.

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[1] Efficiency Value Organization. 2016. Core Concepts, International Performance Measurement and Verification Protocol (IPMVP). And Li, M.; Haeri, H.; Reynolds, A. (2018). The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-70472. http://www.nrel.gov/docs/fy18osti/70472.pdf

Early in the third year of the program, or earlier at the Company's discretion – and assuming they are approved for the five years that they have been filed – programs will be evaluated with the method most suitable to the program, program measures, and evaluation objectives. Methods include impact analysis using engineering analysis or whole facility methods, market studies, and process evaluations. Programs selected for evaluation in each year will be prioritized based on several factors, including, but not limited to, the uncertainty or variability of realized savings, its contribution to portfolio savings, program costs relative to all programs, the elapsed time since the last evaluation, or to address targeted research questions.

For both the Residential Smart Thermostat Management Program (Demand Response and Energy Efficiency) and the Residential Customer Engagement Programs, savings can vary due to program implementation methods and/or customer mix. For this reason, the staged approach will not be applied. The Residential Smart Thermostat Management Program (Demand Reduction and Energy Efficiency) and the Residential Customer Engagement Programs will be evaluated using consumption data analysis on a rolling basis starting at program inception to track program performance and provide early feedback for program staff.

The summary EM&V plans presented here reflect DNV GL's current understanding of the Company's proposed DSM Phase VII program designs prior to approval by the commission. The plans will be revised if merited by changes in approved measures, funding levels, or implementation strategies following consideration and/or final approval by the Commission.

**Deemed Savings Approach**

All deemed calculations will continue to be documented in the Standard Tracking and Engineering Protocol Manual ("STEP Manual"), also known as the Company's technical reference manual ("TRM"). It has been included as an appendix to the annual EM&V report since 2010. The STEP Manual is a collection of deemed engineering equations used to calculate kilowatt and kilowatt-hour savings for each of the measures and program that the Company implements in Virginia and North Carolina for a given program year. It is updated annually.

In the absence of a state-wide TRM in Virginia and North Carolina, DNV GL will derive deemed savings equations from the Mid-Atlantic TRM. The Mid-Atlantic TRM is used in states that neighbor Virginia and elsewhere in the mid-Atlantic region of the United States (e.g., Maryland, District of Columbia, Delaware). For program measures that are not available in the Mid-Atlantic TRM, DNV GL assesses recent TRMs in the region, and nationally, if necessary to identify the most appropriate source or sources for deriving the deemed savings equations and/or inputs.

Each STEP Manual contains the sources for every deemed savings equation and input, including titles, version numbers, publication dates, and page numbers of all source documents, as appropriate.

As much as practicable, DNV GL currently produces kilowatt and kilowatt-hour savings estimates using utility-specific program participant data as inputs to the equations described above.

To gather utility-specific program data, DNV GL provides the Company with a list of the EM&V data variables and other data requirements that are necessary for estimating deemed savings, and for documenting the measure baseline. DNV GL develops this list, keeping in mind when it may be impractical to collect specific data variables (e.g., equipment name plate may be sun-bleached and illegible). The Company's program managers, analysts, and information technology (“IT”) staff ensures that the program data is generated, and the Company’s IT staff defines the information management system needed to ensure delivery of the data to DNV GL monthly.

When utility-specific data are unavailable or impracticable to collect, DNV GL uses proxy utility-specific program participant data to assign assumed inputs derived from Virginia-specific data or data from non-Virginia jurisdictions, and with appropriate citation to the source documents.

DNV GL applies the combination of program-generated utility-specific data, and other default inputs to the deemed equations documented in the STEP Manual to calculate the kilowatt and kilowatt-hour savings for each implemented measure and aggregates it at the measure level, where appropriate, and reports it in the annual EM&V report for each program, without adjustment for free-ridership values. DNV GL reports the savings after adjustments for free-ridership based on either initial program design assumed free-ridership value or evaluated free-ridership value determined through EM&V. We will continue to report savings in this manner.

# G. RESIDENTIAL INCOME AND AGE QUALIFYING HOME IMPROVEMENT PROGRAM EM&V PLAN (VERSION 10.0)

## G.1 Program Summary

The Income and Age Qualifying Home Improvement Program is designed to provide qualifying low-income (60% or less of Virginia state median income) and elderly (60+ and household income of up to 120% Virginia state median income) residential customers of the Company with a free energy audit that identifies certain areas where they can save money on their monthly electric bill. If homeowners (or authorized renters) approve, auditors may immediately make certain improvements while at the home.

## G.2 Measures

The following high efficiency measures are covered by the program:

- Incandescent lighting changed to LEDs (up to 6 lamps per home)
- Pipe wrap installed on any exposed and accessible hot water supply lines from electric water heater
- Showerhead changed from 2.5 gpm to low flow 2.0 gpm for electric heaters
- Kitchen and bathroom aerators changed from 2.2 gpm to low flow 1.5 gpm for electric heaters
- Attic insulation of a maximum of R-49

## G.3 Evaluation, Measurement & Verification Overview

International Performance Measurement and Verification Protocol (IPMVP - Option C): The savings measurement approach defined in IPMVP Option C and ASHRAE Guideline 14 determines energy and demand savings through the use of whole-facility energy (end-use) data, which may be measured by utility meters or data loggers. This approach will involve the use of monthly utility billing data from a main meter for a twelve-month period before and after the audit/install date, and adjust the savings estimates derived from engineering algorithms applied to the Company’s program participation data. The adjustment factor, also called a realization rate, is then applied to the population of participants to estimate program savings. This approach will capture Company-specific customer usage data, which will be applied to actual participating households to quantify energy and peak demand savings.

Baseline Estimation Approach: The baseline wattage of all installed measures will be computed using baseline conditions tracked in the program participation data using the DNV GL Energy Standard Tracking and Engineering Protocols (STEP) Manual. The original source of these deemed savings approaches is derived from the Mid-Atlantic Technical Resource Manual and other TRMs. The baseline will also be represented in the billing analysis by the pre-retrofit data period for the household, overall, and will be analyzed for measure-specific impacts.

Deemed Savings Approach: Deemed savings values will be estimated per the DNV GL Energy STEP Manual. The deemed savings approaches therein are largely derived from the Mid-Atlantic TRM.

Measured Savings Approach: The energy savings will be estimated from a billing analysis of participants based on comparing pre-installation and post-installation data.

## G.4 Deemed Savings Approach

Refer to the Residential Income and Age Qualifying Home Improvement Program section of the STEP Manual for the standard deemed savings approach for the measures in this program.

## G.5 Evaluated Savings Approach

During program implementation Dominion Energy will determine, in consultation with DNV GL, the appropriateness of conducting evaluations to estimate program net savings in net kilowatt and net kilowatt-hours.

According to Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol of The Uniform Methods Project (UMP), the evaluation approach will include a billing analysis with a comparison group.[2] The analysis will use a site-level and panel-model billing analysis approach (see section 2.5.1). The analysis will also follow the general approach of The International Performance Measurement and Verification Protocol (IPMVP), Option C, Whole Facility.[3]

### G.5.1 Savings Estimation

The billing analysis for the Residential Income and Age Qualifying Home Improvement Program will require a comparison group of non-participating customers. The matched comparison group customers will be selected based on their similarity to program participant consumption characteristics.

The billing analysis will use two approaches cited in the UMP, Chapter 8. Results will consider actual weather conditions and weather-normalized results for both approaches.

1. The site-level approach will estimate site-level models for each customer in the participant and comparison group. The site-level models control for heating and cooling using a method that facilitates weather normalization at the site-level. The weather-normalized annual consumption (NAC) estimates are then combined in a second stage regression to provide either average customer savings or average measure-level savings.
2. The panel model approach estimates a single model for all participant and comparison group customers. The model accounts for heating and cooling, differences between the participant and comparison groups, and the participant pre-post consumption difference.

### G.5.2 Sample Design Considerations

Billing analysis is conducted on the program population, or census, over the analysis period. Sampling may be applied for a free-ridership survey, if applicable.

The following characteristics will be considered:

- Confidence interval: 85 to 90%
- Relative precision: 10 to 15%
- Installed measures
- Budget, schedule, and geographical distribution

### G.5.3 Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV GL standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

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[2] Agnew, K., Goldberg, M. (2017). Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory; NREL/SR-7A40-68564. http://www.nrel.gov/docs/fy17osti/68564.pdf

[3] Efficiency Value Organization. 2016. Core Concepts, International Performance Measurement and Verification Protocol.

## G.6 Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the measured data based off the on-site studies.
2. Apply the measured data to the actual participant data to arrive at program level energy and demand savings, reflected on a monthly basis. Program savings are annualized in the EM&V tracking reports based on monthly participation data.
3. Develop cumulative monthly energy savings based on measured and verified data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, and exclude Fuel Charge Rider A and all other applicable riders) for the rate period to arrive at lost revenues.

## G.7 Timeline and Scope of Work

- Analysis of program tracking data: Annual Report (May 15th of each year following program launch).
- Annual updates to STEP Manual for updates that occurred to its referenced sources.
- Develop baseline, measure savings, and efficient load shapes.
- Provide regulatory support as necessary

## G.8 Residential Income and Age Qualifying Home Improvement Program EM&V Plan Document Revision History

| Version | Notes |
|---|---|
| **Version 7.0** | New version |
| **Version 8.0** | Edited "EM&V Measurement, Timeline, and Scope of Work" section to be consistent with other programs |
| **Version 9.0** | Formatting updates<br>Updated from DNV GL Energy to DNV GL Energy Insights |
| **Version 10.0** | Formatting updates<br>Updated "Evaluated Savings Approach" section |

# Appendix G-1. Residential Income and Age Qualifying Home Improvement Program Manual

# Dominion Energy Income and Age Qualifying Home Improvement Program Manual

August 2018

# Contents

# Contents (continued)

# Preface

## Marginal and Text Markings

Solid vertical lines in the margins within the body of the code indicate a change or new clarification from the previous program requirements.

(➡) Deletion indicators are provided in the margin where a paragraph or item has been deleted.

Underlines within the body of the code indicate a clarification compared to the previous program requirements.

# 1 Introduction

The Income and Age Qualifying Home Improvement program (Program) has been designed to help qualifying low-income and elderly customers reduce energy expenses through installation of a select set of energy conservation measures (ECMs). The design of this program aligns with the Virginia Department of Housing and Community Development Weatherization Assistance Program (DHCD WAP), providing an opportunity for Dominion Energy approved Weatherization Service Providers to:

- Install eligible equipment funded by Dominion Energy
- Free up DOE and LIHEAP funds for addition measures under the VA WAP program
- Potentially reach more customers
- Provide energy efficiency measures for customers not traditionally eligible under DOE and LIHEAP

Virginia weatherization providers interested in applying as Dominion Energy Weatherization Service Providers (WSP) must be currently active and in good standing with Virginia's Department of Housing and Community Development (DHCD), and have a service territory that overlaps with Dominion's assigned electric service territory.

## 1.1 Program Implementer

The Dominion Energy (Dominion) Program is implemented by Nexant, Inc. Dominion has contracted and authorized the Program Implementer to perform activities including, but not limited to: reviewing, processing, and approving WSP and customer applications; qualifying, training, and educating WSPs; inspecting customer projects; and issuing incentive checks.

## 1.2 Program Manual

This Income and Age Qualifying Home Improvement Manual (Program Manual) is designed for use by Weatherization Service Providers (WSPs) approved to provide services to eligible Dominion customers through the Program. The Program Manual outlines the specific requirements for the Program and is designed to assist WSPs in understanding the program process; customer and measure eligibility requirements; project services; and WSP role.

## 1.3 Program Manual Updates for 2018

- The sections in the Program Manual have been re-arranged in a format that is similar to other weatherization guidelines.
- Program starts July 1, 2018 and all projects must be submitted by November 30, 2018 to be eligible to receive an incentive in 2018.
- Section 2.2 has been updated. Eligible low income master metered multi-family properties are eligible to participate only under the Energy Share Weatherization Services Program.
- Section 3.1.3 clarification on WSPs working within the confines of their Designated Service Areas. Weatherization agencies that own or manage low income properties are now required to coordinate with the assigned agency to include the property in the local agency's annual spending plan.
- Section 3.3.1 clarification on timeline for application submission. Failure to submit within the designated timeline can result in non-payment.
- Section 3.3.3 and the individual measures have been updated to state that photographs for 10% of each unit type must be submitted for multifamily buildings. 100% of Single Family homes need photos submitted.
- Section 3.3.3 clarification on timeline for completing applications in Missing Information Status and WSP responsibility for reviewing and providing feedback on Weekly Status Report.
- Added Section 3.3.4 WSP site inspection requirements for multi-family units.
- Section 5 Tables:
    - Required Documentation has been updated in each table, including new requirements for including bill of materials and site inspection documents for multi-family properties.
    - Updated the pipe wrap eligibility in Table 5.4 to include that pipe insulation shall be taped (using a high quality tape with good adhesion), caulked (with appropriate caulk to secure and adhere to insulation), or glued at all joints.
- Added Section 5.2.1 to clarify photographic documentation requirements for installed energy conservation measures (ECMs).
- Added Appendix C - Example Ineligible Address List and Signed Attestation
- Added Appendix D – Program Notices. This section is a placeholder for 2018 Program Notices.
- Added Appendix E – Weatherization Agency Site Inspection Checklist

# 2 Customer Eligibility

This section outlines the customer and property eligibility requirements as well as the requirements for project pre-approvals.

## 2.1 Customer Eligibility Requirements

WSPs are required to verify the eligibility of potential customers before performing the energy assessment. All customers will be required to certify being income eligible for the Program by executing a Program consent form. To qualify for the Program, a customer must meet the following eligibility requirements:

- Customer must be a current Dominion or a new service customer intending to receive electric services on a residential rate schedule; and either
- Customer must have a total household income that does not exceed 60% of the Virginia Median Income; or
- Customer is 60 years or older with a total household income that does not exceed 120% of the Virginia Median Income.

Both owner-occupied and renter-occupied households are eligible to participate in the Program. Eligible customers must be responsible for the electric bill and either own the home or be able to secure permission from the owner to perform the Program qualifying installations or improvements.

Customer measures receiving incentives through this Program are not eligible to receive incentives through any other programs offered by Dominion. In addition, only one application may be submitted per household.

## 2.2 Property Eligibility

Eligible customers must be living in single family residences, townhomes, mobile homes, and separately metered multi-family dwellings (apartments and condos) with electric or non-electric heating and electric cooling. Customers residing in a multi-family facility must be in a multi-family facility that is sub-metered. Multifamily facilities owned by local housing authorities are not eligible under the Income and Age Qualifying Home Improvement Program.

Some measures have fuel restrictions (see Section 5.2 for details).

## 2.3 Multi-family Eligibility – Properties that aren't 100% Income Qualified Properties

Steps to qualification:

1) Responsible weatherization agency shall meet with the property manager or owner to confirm program eligibility requirements are met. In the meeting, the property management firm will bring a list containing the apartment unit number and tenant income. The weatherization agency will provide the income and other program requirements. On a unit by unit basis, the property management representative will confirm whether the individual resident(s) qualify for participation in the program. Please Note: this responsibility falls on the weatherization agency, and is not to be assigned to the subcontractor(s) performing the work
2) Property management representative will execute an attestation that this review has been performed. The items that must be included in the attestation are illustrated in Appendix C of this Program Notice.
3) Units that do not meet the program requirements are to be listed in the project application on the Ineligible Address List tab.
4) Weatherization agency must complete and sign attestation on the Ineligible Address List tab. See Appendix C for example of the ineligible address list tab and example of the signed attestation.
5) Note: Vacant units in properties that are not 100% tax credit or section 8 do not automatically qualify for program eligibility. Weatherization agency understands that if measures are installed, the units may not qualify for reimbursement once the unit is occupied.

## 2.4 Pre-Approval and Pre-Qualification

- All multifamily projects must secure pre-qualification prior to installation of equipment, regardless of incentive amount. Pre-qualification allows the Program Implementer to ensure that the residents meet the program age and income requirements and approve the measures for the project. To submit a project for pre-qualification, provide an email containing the following information 14 days in advance of scheduled ECM installation:
    - Contact name and information for the apartment's property manager
    - Number of units
    - A list of expected measures per unit type (1 bedroom, 2 bedroom, etc.)
    - The income limits for the apartment complex
- Failure to provide advance notice may delay WSP planned installation schedule.
- Dominion Energy is allowing installation of more than 6 LEDs on a case-by-case basis. Nexant must visually pre-qualify any property with more than 6 LEDs to confirm

applicability, and written confirmation (via email) will be provided if approved.  The written confirmation is to be submitted with the rebate application.

- The maximum number of LEDs approved to be installed in any individual unit is no greater than 12 LEDs.

# 3 WSP/Contractor Expectations

This section outlines the roles and responsibilities of the WSP.

## 3.1 WSP Commitment and Customer Satisfaction

WSPs are the key to success and customer satisfaction for the Program.

### 3.1.1 Participation Commitment

Program-qualified WSPs are assigned an annual budget allocation for the IAQHI program. On a weekly basis, participation levels are tracked and a weekly status report is emailed to individual WSPs summarizing the status of that WSP's projects. A sample WSP Weekly report is provided in Appendix A.

Program approved WSPs shall provide a spending plan for the assigned allocation by the communicated delivery date for that year. Should Program approved WSPs not provide a spending plan, or if they fail to meet the submitted spending plan by a designated date each year, Dominion reserves the right to service eligible low income customers via a third party subcontractor.

### 3.1.2 Customer Satisfaction

Customer satisfaction is one of the top priorities of the Program. As such, it is the WSP's responsibility to represent the Program and interact with customers professionally and communicate the requirements for Program qualification accurately. WSPs shall be solely responsible to the customer for the installation of the ECM, and all WSPs are required to enter into a service agreement with customers for the installation services. Failure to do so will result in removal from the Program.

### 3.1.3 WSP Service Area

WSPs may only perform Program weatherization services in the service area for which the WSP has been approved by the Virginia DHCD or an area defined by Dominion or Program Implementer (Designated Service Area). Dominion and Program Implementer reserve the right to change the Program at any time.

### 3.1.4 Customer Information

Program Qualified WSPs receiving Customer information shall:

- Treat a customer's personal information as confidential;
- Safeguard customer information and take all reasonable precautions to prevent any unauthorized use or disclosure;
- Not use customer information for any purposes other than for the purpose of performing Program related services;

- Only disclose customer information to WSP employees and subcontractors directly involved in the Program, or as otherwise required by law and comply with all legal requirements to safeguard the customer's information.

## 3.2 Program Marketing Materials

WSP shall not use Dominion's or Program Implementer's corporate name, trademark, trade name, logo, identity, or any affiliation on WSP marketing or other materials (printed copy or electronic) for any reason, including, without limitation, soliciting customers, without Program Implementer's prior written consent. Approved Program marketing materials will be provided to WSPs with a space for a business card to be added; these materials may only be used for the sole purpose of promoting the Program and may only be used during the Program term.

## 3.3 WSP Role

### 3.3.1 Project Services

The WSP's role includes providing the following project services to eligible Dominion customers:

- Recruiting of and assistance to eligible customers participating in the Program including distribution of marketing materials; assistance in completing Program related documentation including completing the energy assessment form with customer; submitting the required documentation for each measure; answering any questions asked by the customer on the Program; and answering any questions or requests for documentation by the Program Implementer or Dominion concerning customer projects;
- Respond to all inquiries from Program Implementer, Dominion and its customers within two (2) business days. WSP shall communicate with the Program staff and Dominion customers, and resolve any customer issues related to a customer project in a timely, professional, and responsive manner;
- Verify customer eligibility prior to performing energy assessment and installing the proposed Program qualifying energy efficiency improvement and measures (ECM) project by:
    - Ensuring that the customer is a current Dominion residential electric customer,
    - Ensuring that the income qualifying customer meets Virginia Department of Housing and Community Development's (DHCD) Income requirements as outlined in the Program Manual, and
    - Ensuring that the age-qualifying customer meets the income threshold of 120% of the State of Virginia's median income if they are 60 years or older;
- Completing an accurate energy assessment of customer's project to identify Program eligible ECMs that would result in energy savings at the customer facility;
- Reviewing the energy assessment form and recommended improvements with the customer and obtain customer approval of WSP's installation of the customer selected ECMs with a signature on an installation agreement between WSP and the customer. Only one energy assessment form may be completed for a qualifying customer facility;

- Installing the ECMs in a professional and safe manner, in compliance with the customer installation agreement and Program requirements;
- Provide a copy of the energy assessment summary to the customer;
- Purchase and stock necessary Program-eligible ECMs;
- Submitting within 30 days of project completion, an invoice (Incentive Worksheet) to Program Implementer for Program Incentives, accurately reporting quantity of measures installed, and providing necessary documentation. In the case of delayed invoice submission, WSP is to communicate reason for delay to Program Implementer. Projects that are not submitted within 90 days risk non-payment.

### 3.3.2 Qualifying Energy Conservation Measures (ECM)

WSPs are required to submit ECM product technical specifications to Program Implementer for review and approval prior to placing orders, stocking inventory, and installing in customers' homes. Product specification sheet(s) must clearly indicate product and model number, and contain information that illustrates the product's compliance with *Eligibility Requirements* as stated in Tables 5-1 through 5-10.

Periodically the Program Implementer will pull the approved technical specifications and confirm product eligibility throughout the life cycle of the measure. This includes periodic inspection of equipment in the warehouse (or in transit to a site), inspection during installation, or inspection post-installation.

### 3.3.3 Project Documentation

The WSP shall collect and submit all required Program information and documentation on customer projects. As noted under 3.1.4, Customer Information, customer's personal information is to be treated as confidential. To ensure customer information is protected, the WSP shall submit the following program documentation through the SFTP service provided by the Program Implementer:

- Excel and PDF versions of the energy assessment form.
- PDF versions of the required project documentation for each ECM installed as outlined in Section 5.2. Pre-approved product sheets are not required to be submitted with project applications.
- Photographs, Multi-family – Pre- and post-installation photographs must be submitted for 10% of the total number of units (apartments) participating in the program and must also be distributed to cover 10% of each unit type (i.e. 1 BR, 2 BR, etc.). In addition, photos of the insulation in each building receiving attic insulation must be submitted.
- Photographs, Single Family - 100% of Single Family homes must have photos submitted.
- **All** photos must be equal to the measures shown on the Incentive Worksheet. Inaccurate documentation can result in projects getting stuck in Missing Information status or worse – unapproved for reimbursement. To reduce file sizes, photographs may be uploaded in a JPEG format.

- A copy of the executed (signed) WSP invoice (Incentive Worksheet) for Program eligible ECMs.
- A copy of the executed (wet signature) WSP installation agreement (Project Application) with the customer. Electronic or digital customer signatures are not acceptable.
- A copy of the material invoice or bill of materials for multi-family units
- A copy of the final inspection report for multi-family units
- Emailing documents is not permitted.
- All project applications must be complete prior to uploading to the SFTP. Incomplete applications may be rejected.
- Project applications that cannot be processed as a result of Missing Information must be resolved within 90 days or risk non-payment AND with no exception will payments for work completed in one year be paid after February 28th of the following year.

### 3.3.4 Site Inspections and Subcontractors

Weatherization Service Providers (WSPs) are required to perform a final inspection of a project before the job is submitted for rebate. In situations where a subcontractor is used to perform a portion or all of the weatherization work, the WSP is responsible for inspecting and certifying that the work has been completed to the program standards.

### 3.3.5 Other WSP Responsibilities

- Spend the annual budget allocation consistently throughout the program year. Failure to participate and serve eligible customers will result in assignment of a third party contractor to ensure Dominion's customers are served.
- Use the proper personal protective equipment. All Program services shall be performed by WSP in compliance with all applicable local, state, and federal laws, regulations, and ordinances.
- Assume full responsibility for removal of old equipment from the customer facility and for sorting, storage, recycling and proper disposal of equipment and waste material in compliance with all applicable laws and regulations and the prevailing local jurisdiction.
- Provide additional information and documentation, and right to inspect retained Program records, with respect to Program and customers and ECM pertaining to Program when requested by Program Implementer or Dominion.
- Conduct professional and ethical business at all times.

### 3.3.6 WSP Non-compliance Process

- Weatherization Service Providers (WSPs) are expected to meet the Program service expectations which include, but are not limited to:
    - Commitment to servicing customers and promoting the Program,
    - Customer satisfaction and education,

  - Accurate and timely project document submissions,
  - Performing quality workmanship,
  - Providing a safe work environment, and
  - Conducting business in accordance with all applicable laws.

- WSPs will promote an atmosphere of respect and fair business dealings with Dominion's customers, suppliers, business partners and competitors in compliance with applicable law. WSPs will not take unfair advantage of any individual or company through manipulation, concealment, abuse of privileged information, misrepresentation of material facts, or any other unfair practices. WSPs shall deal fairly with all customers and competitors and will not enter into any type of agreement, understanding or arrangement between customers or competitors, whether written or oral, formal or informal, express or implied, that limits or restricts competition.
- Implementing Contractor may suspend WSP's right to participate in the Program if Implementing Contractor determines that there is non-compliance with Program requirements. Upon notice of suspension, all of WSPs rights with regards to the Program Benefits will be terminated during the period of suspension which may include Program customer acquisition and installation work.

  *Program Benefits:*

  a. *Payment for approved Incentives*
  b. *Program promotional materials*
  c. *Customer referrals*
  d. *Program-related training*

- If WSPs work is not in conformance with project pre-approval documents, the WSP shall correct such work, at its own expense, within seven (7) calendar days of written notice of non-compliance from Implementing Contractor. If the WSP fails or refuses to correct such non-conformance within seven (7) days after such notice, Implementing Contractor shall have the right to withhold the funds from the WSP.
- If WSP fails to comply with the guidelines outlined in this Program Manual or those in the Weatherization Service Provider Application and Agreement, Implementing Contractor may provide WSP with written notice of non-compliance. The written notice of non-compliance shall contain:
  - A summary of the non-compliant action;
  - Expectations for resolution;
  - A time frame for resolution; and
  - Scheduling of a resolution follow-up meeting, if required.
- The Implementing Contractor may terminate this Agreement for any WSP who receives two (2) or more notices of non-compliance.
- If the Implementing Contractor determines, in its sole discretion, that WSP is involved in fraudulent activity, the Implementing Contractor may immediately terminate this

Agreement and remove WSP from the Program. Such fraudulent activity that may result in immediate termination and removal include:

  - Falsifying invoices;
  - Invoicing for more measures than actually installed;
  - Providing inaccurate information in a customer application, project documentation, or invoice in order to obtain or increase incentive amounts;
  - Misrepresenting the eligibility requirements for the Program to the customer; or
  - Misrepresenting its relationship to third parties.

- Implementing Contractor may withhold payment to WSP for any of the reasons noted below. Implementing Contractor shall give WSP written notice, by email is sufficient, stating the specific reasons for disapproval of WSPs submission for incentive payment. When the reason for withholding payment is removed or corrected, payment will be made.
  - WSP fails to submit project documentation or deliverables in accordance with Program documentation submission requirements;
  - Nonconforming or defective work has not been corrected in a timely fashion; or
  - Implementing Contractor has reasonable suspicion that WSP is involved in fraudulent activity.

*Removed WSPs*

- In the event the WSP is removed from the Program, WSP shall:
  - Not perform any Program customer acquisition or installation work after the termination date or a date approved by the Implementing Contractor in writing (email is sufficient).
  - Cooperate with Implementing Contractor in the Project Close-out Procedures provided below.
  - Immediately cease promoting its participation in the Program
- A removed WSP is not permitted to perform any work on Program projects as a subcontractor to any other WSP.
- A removed WSP is eligible to reapply to the Program after twelve (12) calendar months from the date of notification of removal.

*Project Close-out Procedures*

- After notice of termination, WSP will not be able to submit any projects to the Implementing Contractor for project pre-approval.
- For previously approved projects, WSP shall complete the pre-approved scope and submit final project documentation to Implementing Contractor within sixty (60) calendar days of the date of the termination notice in order to be considered for payment of incentives, regardless if a pre-approval notice has stated otherwise. NO PROJECT CLOSE-OUT TIMEFRAME EXTENSION REQUESTS WILL BE GRANTED. If WSP fails to submit the required documentation within the specified timeframe, Implementing

Contractor has the right to reassign the customer application and project to another WSP for completion of any outstanding work.

- All pre-approved projects with completed final documentation will be inspected by the Implementing Contractor and incentives will be paid on actual measures installed that are in compliance with Program requirements.

The above remedies are in addition to any other remedies that are available to Implementing Contractor and Utility under this Agreement or by law.

# 4 WSP/Contractor Participation Requirements

WSPs participating in the Program are required to comply with the below participation requirements throughout the term of their agreement. WSP is responsible for submitting all required participation documentation to the Program Implementer annually and for updating any changes or additions to their information immediately. During the term of its agreement, WSP shall provide to Program Implementer satisfactory evidence that it continues to be fully licensed and insured along with quality and timely submission of appropriate materials, consistent with the terms of its agreement, within (15) fifteen days of any request by Program Implementer for such verification.

## 4.1 Background Investigation Requirements

Prior to permitting any individuals to perform Program services on WSP's behalf, WSPs are required to perform background investigations on all WSP employees, and require their subcontractors to perform for their employees, who will have access to a Dominion's customer information and/or will be performing services at a customer's residence through the Program. Background investigations shall include a seven (7) year criminal history check for misdemeanor and felony convictions. WSP must conduct all background investigations in accordance with applicable federal and state laws.

WSP must certify to Program Implementer that background investigations have been completed for all applicable WSP employees and subcontractors prior to performing any services for the Program by submitting the WSP Background Certification Form (Certification) provided below as Exhibit 1. The certification provided by the WSP is an affirmative statement that background investigations for all relevant WSP employees and subcontractors have been completed in compliance with these Background Investigation Requirements and that no material items were discovered during the investigation that would impact performance of services for the Program or that may be deemed to pose an unacceptable safety or security risk to Dominion or its customers ("Adverse Findings"), and that all WSP employees and subcontractors will continue to be in compliance with these terms throughout performance of the services under the Program.

WSP shall not permit any WSP employee or subcontractor to perform services for a Dominion customer under this Program if an investigation shows Adverse Findings or such individuals fail to maintain compliance with these terms. If at any time after the Certification has been provided to Program Implementer, WSP becomes aware of Adverse Findings for employees or subcontractors who were listed in the Key Personnel List as part of the Certification, WSP shall discontinue use of such individual in performance of the Program services and WSP shall notify Program Implementer immediately.

## 4.2 Insurance Requirements

WSP shall cause its insurers to provide valid proof of insurance to Program Implementer of the applicable coverage and endorsements or copies of the applicable policy language affecting coverage as required before performance of any Program Services. Such insurance will remain in full effect for the term of the agreement. Failure of Program Implementer to enforce the minimum insurance requirements will not relieve the WSP of responsibility for maintaining the coverage(s). WSP is solely responsible for all premiums and deductibles for insurance required by the agreement.

- Automobile Liability Insurance for coverage of owned, non-owned, hired or rented, autos used in the performance of Program Services with minimum combined single limits of $1,000,000 per accident for bodily injury, including death, and property damage.
- Workers’ Compensation Insurance for WSP’s employees to the extent required by applicable state statutory limits where services are performed or, as required by law, anywhere else a WSP’s employee performing services is normally employed. Employers’ liability with limits no less than $500,000 Bodily Injury for Each Accident; $500,000 Bodily Injury by Disease for Each Employee; $500,000 Bodily Injury Disease Aggregate.
- Commercial General Liability Insurance on an occurrence basis including bodily injury and property damage, including premises liability, products/completed operations liability, and blanket contractual liability with limits no less than $1,000,000 each occurrence; $1,000,000 general aggregate; $1,000,000 products/completed operations aggregate.

**Additional Insurance Provisions**

Any insurance required to be carried by WSP will be primary and is not contributing with any other insurance carried by Program Implementer.

Dominion, Nexant Inc., and their respective subsidiaries and each of their officers, directors, and employees shall be named as additional insureds on Commercial General Liability and Automobile Liability policies by a policy provision or endorsement.

WSP's insurer will provide Program Implementer with thirty (30) days prior written notice of cancellation, non-renewal or any material change of its insurance coverage.

WSP hereby grants to Program Implementer a waiver of any right to subrogation which any WSP insurer may acquire by virtue of the payment of any loss under such insurance against (i) the beneficiary, (ii) all additional insureds, (iii) Program Implementer and its subsidiaries, and (iv) the Utility. WSP agrees to obtain any endorsement that may be necessary to effect and permit waiver of subrogation, but this provision applies regardless of whether or not Program Implementer has received a waiver of subrogation endorsement from the insurer.

WSP shall ensure that WSP insurance covers the actions of any WSP subcontractors providing installation services and shall require its subcontractors at all tiers, if any, providing services to

Program customers, to comply with these insurance requirements. WSP shall provide proof of insurance for such subcontractors, as requested by Program Implementer.

Program Implementer reserves the right to modify these requirements, including limits, based on the nature of the risk, prior experience, insurer, coverage, or other special circumstances.

## 4.3 Licensing and Certification Requirements

WSP licensing and certification requirements are specified below. WSP shall provide copies of all required licenses and certifications to Program Implementer for all applicable WSP employees and subcontractors. The WSP firm must have a current Virginia Department of Professional and Occupational Regulation (DPOR) Contractor's License – Class A, B or C as appropriate - and Residential Building Energy Analyst Firm License.

WSP's field staff and subcontractors performing Program services must meet current Virginia Department of Housing and Community Development (DHCD) Weatherization Assistance Program requirements which include OSHA and EPA training/certifications, DPOR licensing requirements, Building Performance Institute (BPI) certification. These requirements are specified in more detail below:

**Required for WAP Energy Auditors (required within 12 - 18 months of employment):**

- Retrofit Installer Technician (RIT)
- HVAC Fundamentals
- Duct Sizing Class
- NEAT/MHEA Energy Audit Software
- ASHRAE 62.2
- Energy Auditor Classroom Revised June 2013 Chapter 9 – Training and Technical Assistance Virginia Weatherization Assistance Program Page 3 of 3 Program Operations Manual

**Required for WAP Workers (required within 9 months of employment):**

- Retrofit Installer Technician (RIT)
- Lead Safe Weatherization (LSW)
- OSHA 10 Construction Safety Course

**Required for WAP Crew Leaders (required within 12 months of employment):**

- Retrofit Installer Technician (RIT)
- Lead Safe Weatherization (LSW)
- OSHA 30 Construction Safety Course
- Required Lead training

- Lead Safe Weatherization (LSW)

**All WAP crew workers and subcontractors working on Weatherization, LIHEAP, or SERC must complete this class:**

- Renovation, Repair and Painting (EPA RRP rule)

## 4.4 Safety Requirements

WSP is responsible for ensuring that all individuals performing Program services on behalf of WSP comply with reasonable safety practices and protocols required to perform the services. WSP is required to have a safety program to be used as guidelines and direction for WSP employees and subcontractors, as applicable. The safety program must meet all federal, state, and local laws. WSP shall provide a copy of WSPs written safety policy to Program Implementer.

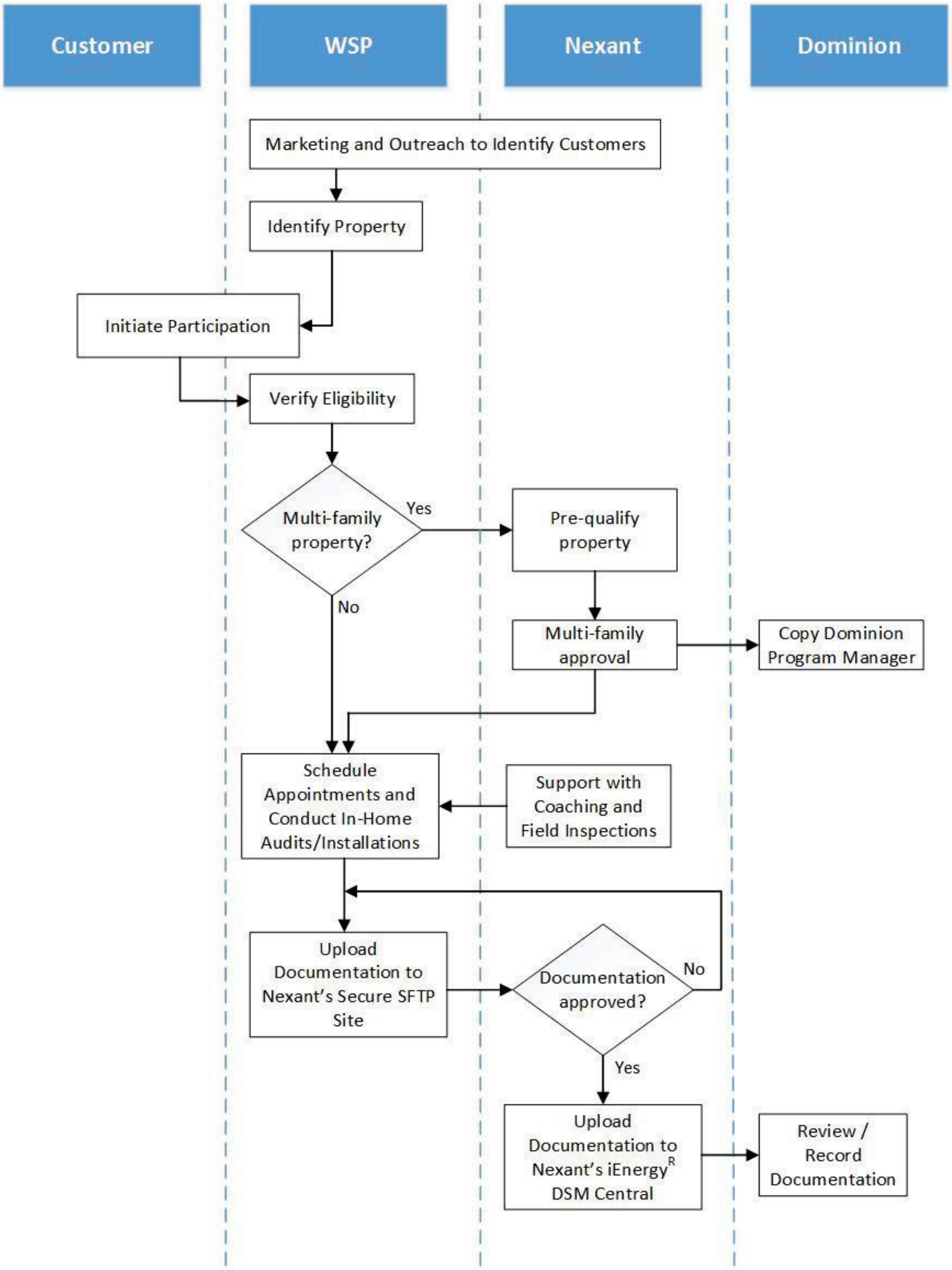
WSP’s safety program must include the following minimum requirements:

- Safety policy and procedures which address all required local, state and federal occupational safety and health standards and trade-specific licensing and certification requirements and a safety officer responsible for program implementation;
- Safety rules and safe working practices which must be followed by employees at any location for the prevention of illness and injury;
- Processes addressing identification, prevention and control, and communication of safety and health hazards;
- Employee training which includes addressing site specific safety and health requirements;
- Tools, instruments, and safety equipment that meet minimum safety specifications (e.g., ASTM and ANSI standards) which are available and provided to employees by Contractor;
- Requirements for the use of appropriate personal protective equipment in all operations where there is an exposure to hazardous conditions or where regulations indicate the need for using such equipment;
- An injury and incident response and reporting procedure including Whistleblower protections and emergency action planning and enforcement procedures to address violations.

# 5 Program Process

## 5.1 Process Flow Diagram

Figure 5-1: Process Flow Diagram



# 5.2 Measure Description and Documentation Requirements

Energy saving products—i.e., energy conservation measures (ECM)—selected for the Program are aimed to target the most common lighting, space conditioning and water heating related measures that income qualifying customers typically use. The Program includes free installation of the following selected ECM identified in Table 5-1, Table 5-2, Table 5-3, Table 5-4, and Table 5-5 on the following pages.

**Table 5-1: LED Lighting**

| **LED Lighting** | |
|---|---|
| **Description** | ENERGY STAR® qualified LED light bulbs (screw base) |
| **Applicability** | Up to six LED light bulbs per dwelling unit that must replace incandescent light bulbs (CFL not eligible) installed in high use applications. Refer to section 2.4 for guidelines on seeking approval for more than 6 and no more than 12 LEDs.<br>▪ Light fixtures must be permanent unless exception approved.<br>▪ Existing incandescent lamps must be operational – nonfunctional lamps are not to be replaced.<br>▪ Installation of LEDs in closets, storage rooms, or exterior fixtures is not approved.<br>▪ Hall corridors are not typically designated as high use areas.<br>Applicable to homes with electric or non-electric space or water heating. |
| **Bulb Eligibility** | LED lights must meet the following requirements:<br>➢ **Rating:** 40 Watt or 60 Watt equivalent lumen output<br>➢ **Certification:** ENERGY STAR<br>➢ **Rated Life:** 25,000 hours<br>➢ **Efficacy:** 43 Lumens per watt (LPW) for down lights, and 50 LPW for omnidirectional lights<br>➢ **CRI minimum:** 80 |
| **Required Documentation** | ➢ **Pre-approved Energy Conservation Measure (ECM):** submit lighting technical specifications for review and approval prior to placing orders, stocking inventory, and installing in customers' homes. *See Section 4.3.2 Qualifying ECMs.*<br>➢ **Photographic Documentation of Product Installation:** Pre- and post-installation photograph requirements are detailed in Section 5.2.1. For multifamily buildings, photographs for 10% of each unit type must be submitted. Pre-qualification email must be submitted with the application when more than 6 LEDs have been previously approved. |

| | |
|---|---|
| | ➢ **Multi-family Project Material Documentation:** Weatherization agencies are required to submit a copy of the material invoice or bill of materials demonstrating quantity of ECMs ordered for individual projects (prices may be redacted from invoices). Refer to Section 5.2.2 for additional information on the bill of materials.<br>➢ **Weatherization Agency Use of Subcontractors:** Agencies are required to inspect each multi-family project where installation has been performed by a subcontractor. A copy of the subcontractor job completion form must be submitted with the application. |

**Lighting Eligibility Question & Answer:**

1. The customer has mixed 40 and 60 Watt bulbs in a single fixture. Are bulbs to be replaced exactly as installed, or are identical wattage bulbs to be installed in the fixture?

**ANSWER:**

The program is designed to be a 1 for 1 equivalent Wattage replacement with limited flexibility.

*Example:*

*Living room ceiling fan has two (2) 60 W bulbs and (2) 40 W bulbs. Replacement options:*

- a) Install 2 – 9 W and 2 – 6 W LEDs
- b) De-rate the 60W incandescent bulbs to 40W bulbs, and install only 6W LEDs. The customer must be made aware that the lumen output is lower and approve of this de-ration substitution.

2. Can incandescent bulbs other than 40 or 60 Watt be replaced?
The following Incandescent replacements are allowed with proper photo documentation is required.

| Incandescent Lamp Rating, Watts | Allowed LED Replacement |
|---|---|
| 38 Watt, 40 Watt, 43 Watt | 6 Watt |
| 60 Watt, 65 Watt | 9 Watt |

3. Can Hollywood bulbs or candelabra bulbs be replaced?
If the Wattage rating stamped in the brass base is 40 or 60 Watts the bulb is eligible for replacement.

4. Can unmarked bulbs be replaced?
No. Unfortunately the Wattage rating on some bulbs deteriorates over time. Existing bulbs must be marked to be eligible for replacement.

### Table 5-2: Energy Saving Showerhead

| Energy Saving Showerhead | |
|---|---|
| **Description** | Energy and water saving showerhead |
| **Applicability** | Must replace standard showerhead with flow of 2.5 gallons per minute (gpm) or greater in homes with electric water heating. Two (2) showerheads per dwelling unit maximum. |
| **Showerhead Eligibility** | Showerhead with flow of 2.0 gpm or less at 80PSI |
| **Required Documentation** | ➢ **Pre-approved Energy Conservation Measure (ECM):** submit showerhead technical specifications for review and approval prior to placing orders, stocking inventory, and installing in customers' homes. *See Section 3.3.2 Qualifying ECMs*<br>➢ **Photographic Documentation of Product Installation:** Pre- and post-installation photograph requirements are detailed in Section 5.2.1. For multifamily buildings, photographs for 10% of each unit type must be submitted.<br>➢ **Multi-family Project Material Documentation:** Weatherization agencies are required to submit a copy of the material invoice or bill of materials demonstrating quantity of ECMs ordered for individual projects (prices may be redacted from invoices). Refer to Section 5.2.2 for additional information on the bill of materials.<br>➢ **Weatherization Agency Use of Subcontractors:** Agencies are required to inspect each multi-family project where installation has been performed by a subcontractor. A copy of the subcontractor job completion form must be submitted with the application. |

**Shower Head Eligibility Question & Answer:**

1. How is a device determined to be eligible when the GPM marking is damaged or illegible?
   Perform a flow test to confirm GPM of existing device.
   - Place bucket or container under fixture with ounce markings
   - Turn cold water faucet on for exactly 10 seconds (use stopwatch on cell phone)
   - Determine the number of ounces of water captured in 10 seconds
   - Compute GPM:

$$\frac{\#\text{ ounces x } 6}{128} = \text{GPM rating}$$

2. How is eligibility determined for unmarked devices?
   Unmarked devices are treated the same as illegible devices, UNLESS unmarked devices are identified and measured during pre-qualification of multi-family projects. If unmarked devices identified during pre-qualification are determined to be eligible as a result of the flow test, then any unmarked devices located in the remaining units will be deemed eligible.

### Table 5-3: High Efficiency Faucet Aerator

| High Efficiency Faucet Aerator | |
|---|---|
| **Description** | High efficiency faucet aerator |
| **Applicability** | Must replace existing standard faucet aerator with a flow rate of 2.0 GPM or greater in homes with electric water heating. Two (2) faucet aerators per home maximum. |
| **Faucet Aerator Eligibility** | Faucet aerator with flow of 1.5 GPM or less |
| **Required Documentation** | ➢ **Pre-approved Energy Conservation Measure (ECM):** submit faucet aerator technical specifications for review and approval prior to placing orders, stocking inventory, and installing in customers' homes. *See Section 4.3.2 Qualifying ECMs*<br>➢ **Photographic Documentation of Product Installation:** Pre- and post-installation photograph requirements are detailed in Section 5.2.1. For multifamily buildings, photographs for 10% of each unit type must be submitted.<br>➢ **Multi-family Project Material Documentation:** Weatherization agencies are required to submit a copy of the material invoice or bill of materials demonstrating quantity of ECMs ordered for individual projects (prices may be redacted from invoices). Refer to Section 5.2.2 for additional information on the bill of materials.<br>➢ **Weatherization Agency Use of Subcontractors:** Agencies are required to inspect each multi-family project where installation has been performed by a subcontractor. A copy of the subcontractor job completion form must be submitted with the application. |

**Aerator Eligibility Question & Answer:**

1. How is a device determined to be eligible when the GPM marking is damaged or illegible?
   Perform a flow test to confirm GPM of existing device.
    - Place bucket or container under fixture with ounce markings
    - Turn cold water faucet on for exactly 10 seconds (use stopwatch on cell phone)
    - Determine the number of ounces of water captured in 10 seconds
    - Compute GPM:

$$\frac{\#\text{ ounces x } 6}{128} = \text{GPM rating}$$

2. How is eligibility determined for unmarked devices?
   Unmarked devices are treated the same as illegible devices, UNLESS unmarked devices are identified and measured during pre-qualification of multi-family projects. If unmarked devices identified during pre-qualification are determined to be eligible as a result of the flow test, then any unmarked devices located in the remaining units will be deemed eligible.

Table 5-4: Pipe Wrap

| Pipe Wrap | |
|---|---|
| **Description** | Pipe wrap insulation for hot water pipes |
| **Applicability** | Homes with electric water heating. All exposed hot water pipes with no previous insulation. Existing insulation that is worn or torn is not eligible for replacement. |
| **Pipe Wrap Eligibility** | Self-sealing pipe wrap insulation for hot water pipes. Pipe insulation shall be taped (using a high quality tape with good adhesion), caulked (with appropriate caulk to secure and adhere to insulation), or glued at all joints. |
| **Required Documentation** | ➢ **Pre-approved Energy Conservation Measure (ECM):** submit pipe wrap technical specifications for review and approval prior to placing orders, stocking inventory, and installing in customers' homes. *See Section 3.3.2 Qualifying ECMs*<br>➢ **Photographic Documentation of Product Installation:** Pre- and post-installation photograph requirements are detailed in Section 5.2.1. For multifamily buildings, photographs for 10% of each unit type must be submitted.<br>➢ **Multi-family Project Material Documentation:** Weatherization agencies are required to submit a copy of the material invoice or bill of materials demonstrating quantity of ECMs ordered for individual projects (prices may be redacted from invoices). Refer to Section 5.2.2 for additional information on the bill of materials.<br>➢ **Weatherization Agency Use of Subcontractors:** Agencies are required to inspect each multi-family project where installation has been performed by a subcontractor. A copy of the subcontractor job completion form must be submitted with the application. |

Table 5-5: Attic Insulation

| Attic Insulation | |
|---|---|
| **Description** | Attic insulation addition |
| **Applicability** | Homes with electric or non-electric space heating. Insulation must be installed between a heated and an unconditioned space. |
| **Attic Insulation Eligibility** | ➢ Insulation type may be fiberglass or cellulose<br>➢ Homes with electric space heating may be insulated to a maximum of R-49<br>➢ Homes with non-electric space heating may be insulated to a maximum of R-38<br>➢ Attic insulation must be installed by an approved WSP in qualifying households. |
| **Required Documentation** | ➢ **Pre-approved Energy Conservation Measure (ECM):** submit technical specifications for review and approval prior to placing orders, stocking inventory, and installing in customers' homes. *See Section 3.3.2 Qualifying ECMs*<br>➢ **Photographic Documentation of Product Installation:** Pre- and post-installation photograph requirements are detailed in Section 5.2.1. For multifamily buildings, photographs for 10% of each unit type that receives attic insulation must be submitted. Additionally, a photograph of each attic insulation certificate is required. The address including the unit number must be written on the certificate.<br>➢ **Weatherization Agency Use of Subcontractors:** Agencies are required to inspect each multi-family project where installation has been performed by a subcontractor. A copy of the subcontractor job completion form must be submitted with the application. |

### 5.2.1 PHOTOGRAPHIC DOCUMENTATION OF PRODUCT INSTALLATION:

The 2018 IAQHIP has new documentation requirements for measures.

1. **All photos must include a date and time stamp on the photo.**
2. An exterior photo of each home, building and unit number. The photos must allow visual confirmation that the home, building and unit number match the submitted application.

3. Pre- and post-installation photos per measure:
    a) Lighting:
        - Photo of space (room) where fixture is installed
        - Photo of existing incandescent lamp(s) clearly showing wattage rating
        - Photo of incandescent lamps(s) turned ON
        - For lamps that are unmarked or manufacturer's rating is not legible, the incandescent will be assumed to be rated at 40 Watts
        - Photo of LED lamp wattage
        - Photo of fixture with LED(s) installed and turned ON


Notice 1 lamp is burned out

ROOM, LAMPS ON


3 operational lamps captured

LAMP WATTAGE

LED WATTAGE


3 Lamps replaced

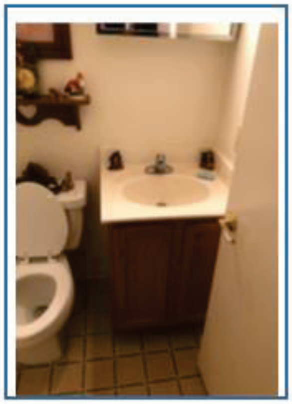
NEW LEDs

3. Pre- and post-installation photos per measure, continued:

   b) Aerators

      - Photo of room and sink
      - Photo of existing aerator GPM. Aerator should be unscrewed and GPM ratings photo-documented if the rating on the installed faucet cannot be captured.
      - Photo of faucet with new aerator

BATHROOM



ROOM

Note: GPM on submitted photo is legible

OLD AERATOR

CLOSE UP

Note: GPM on submitted photo is legible

NEW AERATOR

KITCHEN

ROOM

KITCHEN SINK

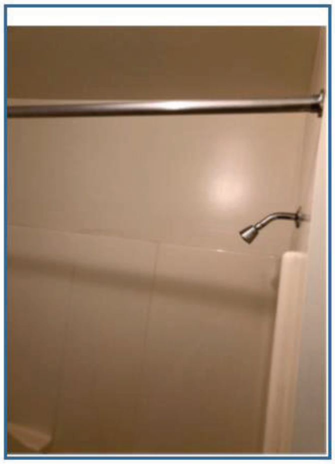
AERATOR GPM

NEW AERATOR

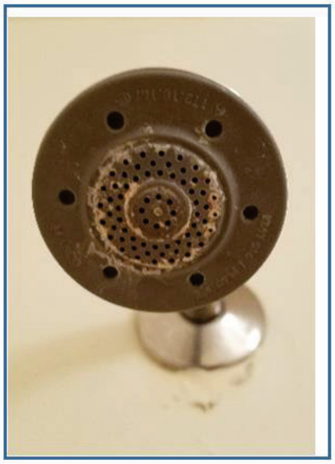
Photo of Ineligible Aerator to be replaced:

c) Showerheads

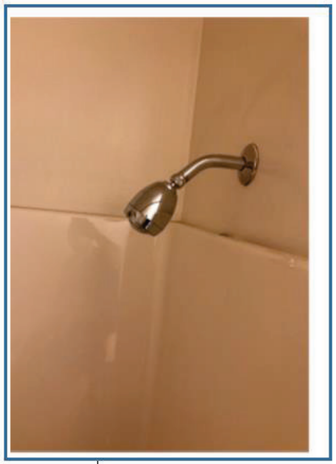
- Photo of room with showerhead
- Photo of existing showerhead GPM rating
- Shower enclosure with new showerhead



ROOM, OLD SHOWER



SHOWER GPM



NEW SHOWER

Note: GPM on submitted photo is legible

d) Pipe wrap

- Photo of water heater in room / space, including uninsulated pipe
- Photo of insulated hot water line

ROOM

UNINSULATED

INSULATED

e) Attic insulation, single family home

- Photo(s) of space to be insulated
- Photo(s) of existing insulation levels at attic ruler
- Photo(s) of installed insulation levels at attic ruler

ATTIC EXISTING

ATTIC EXISTING

ATTIC NEW

Note: ruler is legible
in submitted image

f) Attic insulation, multi-family units, 10% requirement:

- Exterior photo identifying building within property
- Photo(s) of space to be insulated
- Photo(s) of existing insulation levels at attic ruler
- Photo(s) of installed insulation levels at attic ruler

g) Attic insulation, multi-family units, all buildings requirement:

- Photos of the insulation certificate for each insulated space
- Certificate must capture the address / unit number(s) for each space

### 5.2.2 BILL OF MATERIALS:

The excel application contains a Project Summary tab, created to provide a snapshot summary of all of the measures installed for a single property.

If the quantity of ECMs listed on the bill of materials is greater than the total quantity of ECMs (installed) listed on the project summary tab, the copy of the Bill of Materials is sufficient.

If the quantity of ECMs listed on the bill of materials is less than the total quantity of ECMs (installed) listed on the project summary tab, provide multiple documents to account for the total ECMs installed.

## 5.3 Incentives

WSPs are required to fund the resources, procure the workforce and material, and install Program qualifying measures at customer households. Dominion will only reimburse the incentive amounts shown in Table 5-6 for the Program ECMs installed according to Program rules and requirements.

**Table 5-6: IAQHI Program ECMs and Incentives**

| Measure Name | Unit | Incentive per Unit |
|---|---|---|
| LED Lighting | Per lamp installed | [redacted] |
| Energy Saving Showerhead | Per low flow showerhead installed | [redacted] |
| High Efficiency Faucet Aerator | Per faucet aerator installed | [redacted] |
| Pipe Wrap for Water Heaters | Per linear foot of pipe wrap installed | [redacted] |
| Attic Insulation | Per R-value per square foot installed | [redacted] |

***Note: there is a program cap of $4,000 in incentives per home, townhome, apartment, or manufactured home.***

### ATTIC INSULATION INCENTIVE CALCULATION EXAMPLES:

<u>Example 1:</u> 1,000 ft$^2$ attic; no existing insulation; electric heat

**Incentive** = [redacted]

<u>Example 2:</u> 1,000 ft$^2$ attic; R-11 existing insulation; gas heat

**Incentive** = [redacted]

## 5.4 Program Timeline

The Dominion Income and Age Qualifying Home Improvement Program is a three-year program. The associated rebates outlined in this manual are effective starting July 2018. In early December each year, Dominion suspends processing new applications so they can close the books on the current program year.

To ensure a project is processed in the current year, the cutoff date for submitting applications is the last Friday in November. This allows the processing team time to review and submit projects to Dominion for approval. Projects submitted after the cutoff date will continue to be accepted and processed by Nexant. These projects may be processed in the following program year and be applied against the following year's program funds.

Rebate applications are transmitted by the Program Implementer to Dominion on a weekly basis. Section 5.5 contains additional details concerning project applications.  To ensure a project is processed in the current year complete project documentation must be received by Program Implementer by November 30th of each year.

Projects submitted by or before November 30th must be resolved by February 28th of the following year.  Payments for work completed in one year will not be paid after February 28 of the following year.

Project applications that cannot be processed as a result of Missing Information must be resolved within 90 days or risk non-payment.

Projects submitted in December will be processed with the next year‘s allocation.

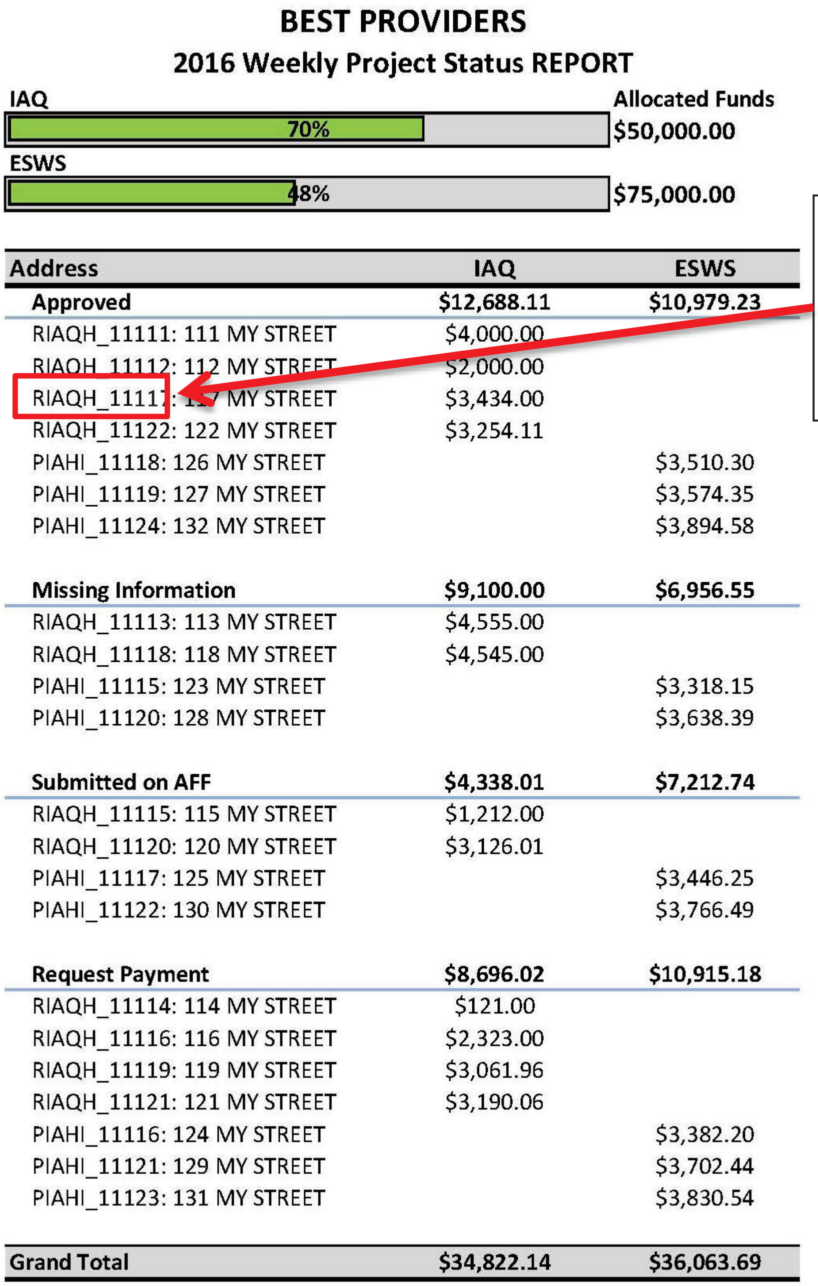
## 5.5 Project Application Approval Timeline

Providers are encouraged to submit applications as projects are completed. Details of the required documents are contained in section **3.3.3 Project Documentation**. Applications submitted by Weatherization Service Providers are extracted from the Nexant SFTP site on a daily basis and are reviewed.

The quality and accuracy of submitted applications has a direct effect on processing times. Providers submitting applications that are error-free, have an active Dominion account, are eligible to participate in the program, and have included all of the required documentation are processed quickly. Applications submitted with partial information take longer to review and process. Once a week, Nexant will submit a file of approved applications to Dominion for review and approval for payment.

The expected turnaround time for incentive payment checks is 4 to 6 weeks from the date of approved project application submission.

# Appendix A Example WSP Weekly Report



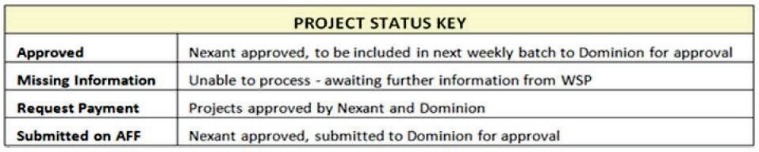
**BEST PROVIDERS**

**2016 Weekly Project Status REPORT**

| | | |
|---|---|---|
| **IAQ** | | **Allocated Funds** |
| 70% | | **$50,000.00** |
| **ESWS** | | |
| 48% | | **$75,000.00** |

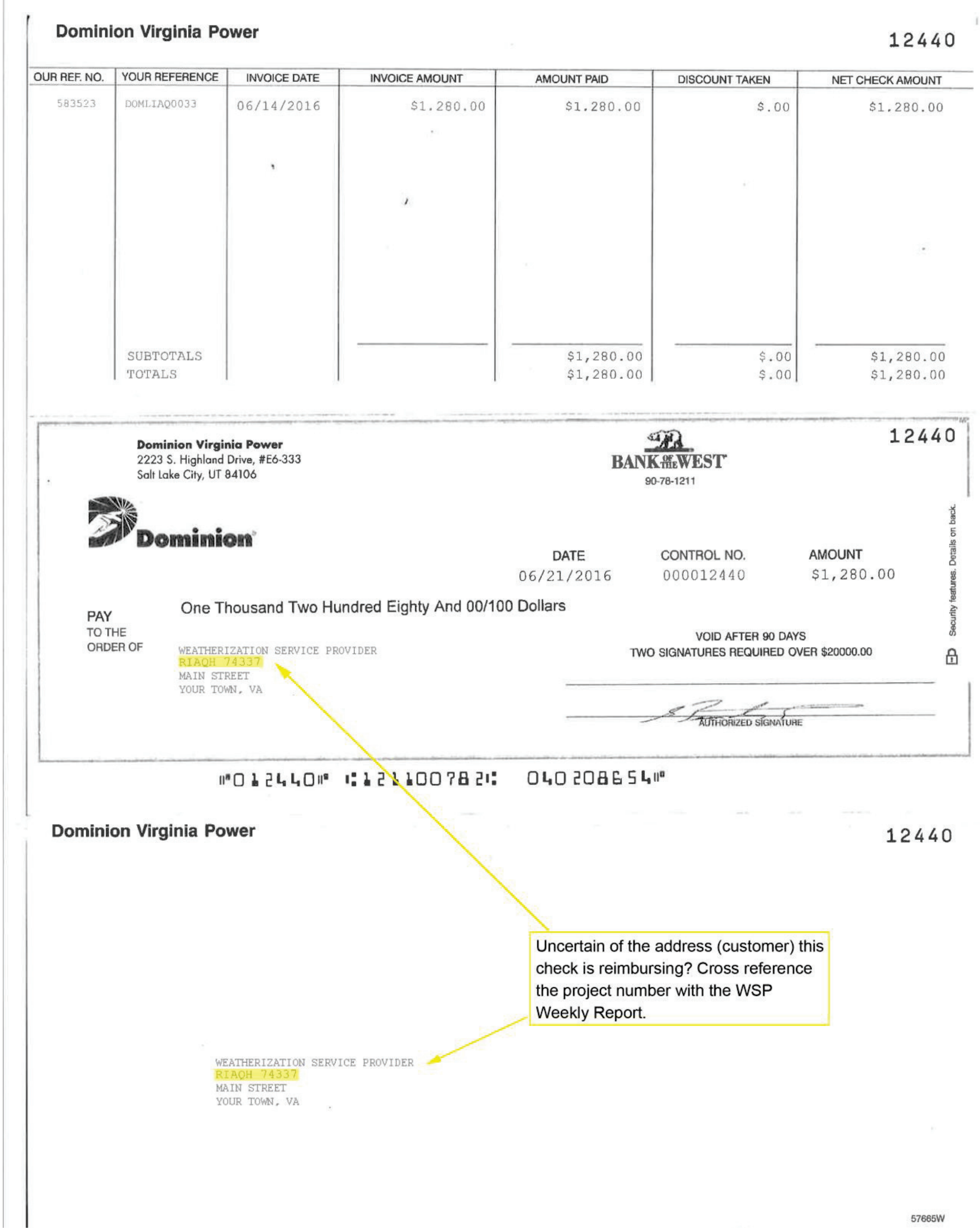
| **Address** | **IAQ** | **ESWS** |
|---|---|---|
| **Approved** | **$12,688.11** | **$10,979.23** |
| RIAQH_11111: 111 MY STREET | $4,000.00 | |
| RIAQH_11112: 112 MY STREET | $2,000.00 | |
| RIAQH_11117: 117 MY STREET | $3,434.00 | |
| RIAQH_11122: 122 MY STREET | $3,254.11 | |
| PIAHI_11118: 126 MY STREET | | $3,510.30 |
| PIAHI_11119: 127 MY STREET | | $3,574.35 |
| PIAHI_11124: 132 MY STREET | | $3,894.58 |
| **Missing Information** | **$9,100.00** | **$6,956.55** |
| RIAQH_11113: 113 MY STREET | $4,555.00 | |
| RIAQH_11118: 118 MY STREET | $4,545.00 | |
| PIAHI_11115: 123 MY STREET | | $3,318.15 |
| PIAHI_11120: 128 MY STREET | | $3,638.39 |
| **Submitted on AFF** | **$4,338.01** | **$7,212.74** |
| RIAQH_11115: 115 MY STREET | $1,212.00 | |
| RIAQH_11120: 120 MY STREET | $3,126.01 | |
| PIAHI_11117: 125 MY STREET | | $3,446.25 |
| PIAHI_11122: 130 MY STREET | | $3,766.49 |
| **Request Payment** | **$8,696.02** | **$10,915.18** |
| RIAQH_11114: 114 MY STREET | $121.00 | |
| RIAQH_11116: 116 MY STREET | $2,323.00 | |
| RIAQH_11119: 119 MY STREET | $3,061.96 | |
| RIAQH_11121: 121 MY STREET | $3,190.06 | |
| PIAHI_11116: 124 MY STREET | | $3,382.20 |
| PIAHI_11121: 129 MY STREET | | $3,702.44 |
| PIAHI_11123: 131 MY STREET | | $3,830.54 |
| **Grand Total** | **$34,822.14** | **$36,063.69** |

The project number is unique to each project and can be found on the check contained in the Payee information. See Appendix B.



| **PROJECT STATUS KEY** | |
|---|---|
| **Approved** | Nexant approved, to be included in next weekly batch to Dominion for approval |
| **Missing Information** | Unable to process - awaiting further information from WSP |
| **Request Payment** | Projects approved by Nexant and Dominion |
| **Submitted on AFF** | Nexant approved, submitted to Dominion for approval |

# Appendix B Sample Incentive Check



**Dominion Virginia Power**

12440

| OUR REF. NO. | YOUR REFERENCE | INVOICE DATE | INVOICE AMOUNT | AMOUNT PAID | DISCOUNT TAKEN | NET CHECK AMOUNT |
|---|---|---|---|---|---|---|
| 583523 | DOMLIAQ0033 | 06/14/2016 | $1.280.00 | $1.280.00 | $.00 | $1.280.00 |
| | SUBTOTALS | | | $1,280.00 | $.00 | $1,280.00 |
| | TOTALS | | | $1,280.00 | $.00 | $1,280.00 |

12440

**Dominion Virginia Power**
2223 S. Highland Drive, #E6-333
Salt Lake City, UT 84106

BANK OF THE WEST
90-78-1211

Dominion

| DATE | CONTROL NO. | AMOUNT |
|---|---|---|
| 06/21/2016 | 000012440 | $1,280.00 |

PAY One Thousand Two Hundred Eighty And 00/100 Dollars

TO THE ORDER OF

WEATHERIZATION SERVICE PROVIDER
RIAQH 74337
MAIN STREET
YOUR TOWN, VA

VOID AFTER 90 DAYS
TWO SIGNATURES REQUIRED OVER $20000.00

Security features. Details on back.

AUTHORIZED SIGNATURE

⑈012440⑈ ⑆121100782⑆ 040208654⑈

**Dominion Virginia Power**

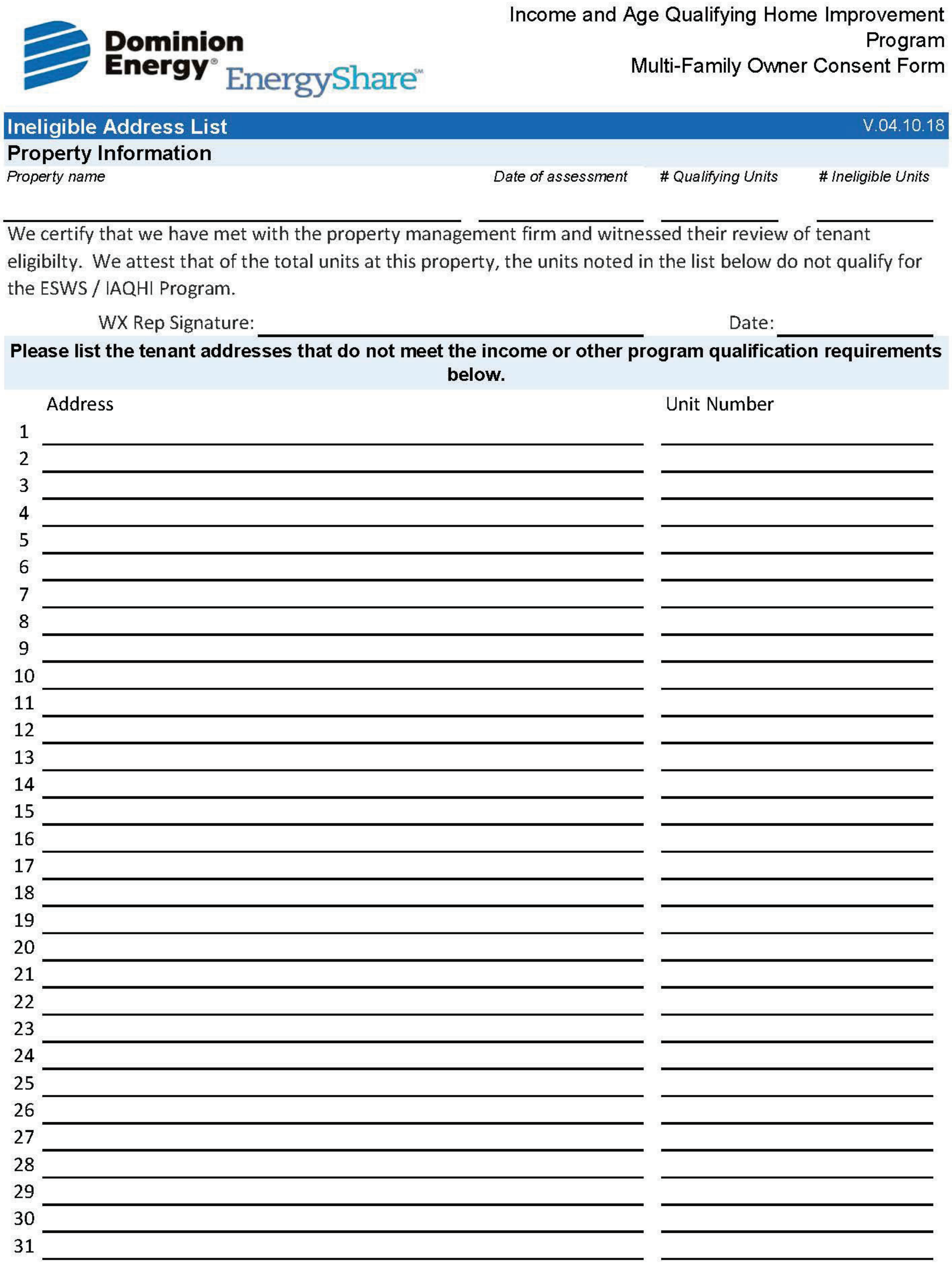
12440

Uncertain of the address (customer) this check is reimbursing? Cross reference the project number with the WSP Weekly Report.

WEATHERIZATION SERVICE PROVIDER
RIAQH 74337
MAIN STREET
YOUR TOWN, VA

57665W

# Appendix C Ineligible Address List and Signed Attestation



**Dominion Energy**® EnergyShare℠

Income and Age Qualifying Home Improvement Program
Multi-Family Owner Consent Form

**Ineligible Address List** V.04.10.18

**Property Information**

| *Property name* | *Date of assessment* | *# Qualifying Units* | *# Ineligible Units* |
|---|---|---|---|
| | | | |

We certify that we have met with the property management firm and witnessed their review of tenant eligibilty. We attest that of the total units at this property, the units noted in the list below do not qualify for the ESWS / IAQHI Program.

WX Rep Signature: ____________________ Date: __________

**Please list the tenant addresses that do not meet the income or other program qualification requirements below.**

| | Address | Unit Number |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |
| 8 | | |
| 9 | | |
| 10 | | |
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| 31 | | |

## Weatherization Agency or Property Management Agency Letterhead Example

To all concerned:

This letter is to certify that all residents of Sherwood Forest Homes have been reviewed for compliance with the Tenant Eligibility Criteria noted as follows:

- Customer must have a total household income that does not exceed 60% of the Virginia Median Income; or
- Customer is 60 years of age or older with a total household income that does not exceed 120% of the Virginia Median Income; or
- The account holder is otherwise qualified to receive an energy audit by a Weatherization Assistance Provider certified by the Virginia DHCD; or
- A member of the household is currently receiving disability payments from the Social Security Administration; or
- A member of the household is currently receiving disability payments or supplemental income payments from the Veteran's Administration.

Eligibility Summary for property is as follows:

25 Residents have a total household income that does not exceed 60% of the currently published Virginia Median Income

15 Residents are over 60 and their income does not exceed 120% of the Virginia Median Income

10 Residents are receiving disability payments from the SS Administration, Veteran's Administration, or other state or federal agencies

5 Residents do not meet the program requirements

55 = Total Units at this property

Signature: Robin Hood

Date: April 10, 2018

Printed Name: Robin Hood

Title: Property Manager

Company: Nottingham Properties Inc.

# Appendix D 2018 Program Notices

Placeholder for Program Notices

# Appendix E Background Investigation Certification (“Certification”) and Key Personnel List

Capitalized terms have the meanings given in the WSP Agreement. WSP certifies and agrees as follows:

1) (a) WSP performs, or causes its subcontractors to perform, investigations on all employees in accordance with the requirements described in the Background Investigation Requirements of the Program Manual; (b) WSP employees and subcontractors who will be performing services for the Program and will (i) have access to any customer information, and/or (ii) will be performing services at a customer’s residence through the Program are identified on the attached Key Personnel List (c) the investigation(s) were conducted in accordance with the provisions of the Fair Credit Reporting Act, applicable federal and state laws, and the Background Investigation Requirements; (d) WSP has reviewed the results of the investigations for all such WSP employees and obtained Certifications for listed subcontractor employees; and (e) WSP did not discover any Adverse Findings in the investigation(s);

2) WSP agrees that if at any time after this Certification is provided, WSP begins utilizing any employee or subcontractor for the Program who were not included as part of the original Certification, WSP shall conduct background investigation, or cause its subcontractors to perform, on such individuals and provide Program Implementer with an updated Certification, or complete updated background investigations on employees, as reasonably requested by Program Implementer or Dominion; and

3) If at any time after this Certification has been provided to Program Implementer, WSP becomes aware of Adverse Findings for employees or subcontractors who were listed in the Key Personnel List as part of this Certification, WSP shall discontinue use of such individual in performance of the Program services and WSP shall notify Program Implementer in accordance with the Background Investigation Requirements.

I am a duly authorized representative of WSP and have read, understand and agree to the accuracy of this Certification.

WSP Name: ______________________________________________________

WSP Representative Signature: _____________________________________

Printed Name: ___________________________________________

Title: __________________________________________ Date: ____________________

**Once completed, return this Certification along with the Key Personnel List to the Program Implementer.**

**Key Personnel List**

List the names of the WSP employees and WSP’s subcontractor employees who are the subjects of the Background Investigation Certification.

| Name | Company | Title | Date Completed |
|---|---|---|---|
| | | | |
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Nexant

Nexant, Inc.

**866-254-2237**

www.nexant.com

# Appendix H. Residential Appliance Recycling Program EM&V Plan

# H. RESIDENTIAL APPLIANCE RECYCLING PROGRAM EM&V PLAN (VERSION 1.0)

## H.1 Program Summary

This program would provide incentives to residential customers to recycle freezers and refrigerators that are of a specific age and size. Appliance pick-up and proper recycling services are included.

## H.2 Measures

The removal of and recycling of operational refrigerators and freezers treated as an energy efficiency measure are covered by the program.

## H.3 Evaluation, Measurement, and Verification Overview

DNV GL will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[4] The EM&V method estimates gross and net program energy savings, including net-to-gross savings (NTG) and free-ridership estimates.

The basis for DNV GL's savings evaluation approach are:

1. Baseline Consumption: The baseline wattage of all installed measures will be computed using baseline conditions tracked in the program participation data using protocols developed in the DNV GL Standard Tracking and Engineering Protocols (STEP) Manual. Therein, the deemed savings approach for each measure is predominantly derived from the most recent version of the Mid-Atlantic Technical Resource Manual (TRM) and, as appropriate, from other TRMs.
2. Deemed Savings: Deemed savings (or gross savings) values will be estimated using calculation approaches in the DNV GL STEP Manual, which are derived primarily from the most recent version of the Mid-Atlantic Technical Resource Manual (TRM), and as appropriate, other TRMs.
3. Verified Savings: Verified savings (or net savings) will be determined using a combination of on-site and telephone/website survey data. The wattage and hours-of-use data for the removed appliance will be collected and metered through an on-site study of the appliances—just prior to their removal—from a representative sample of participants.

DNV GL takes a holistic approach to evaluation planning for the Company's portfolio of energy conservation programs. DNV GL balances cost-effectiveness and rigor to its evaluation planning so the Company can insure its programs are cost effective and yield planned savings. This program will follow a staged evaluation plan, where DNV GL will take a two-step approach. During program start-up, kilowatts and kilowatt-hour savings are estimated using a deemed savings approach. Deemed approaches are a cost-effective method for determining reasonable savings estimates in the early stage of implementation, and in the periods between more rigorous EM&V.

Once participation has levelized or reached planned levels, and realized savings can be quantified, the program is considered for evaluation. Based on results from the DSM Phase I through III programs –

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[4] 20 VAC 5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

programs that were implemented for more than three years as of this filing, and similar programs in other jurisdictions, DNV GL anticipates this will occur in year two of program operations.

Early in the third year of the program, or earlier at the Company's discretion – and assuming they are approved for the five years that they have been filed, they will be evaluated with the method most suitable to the program, program measures, and evaluation objectives. Methods include impact analysis using engineering analysis or whole facility methods, market studies, and process evaluations. Programs selected for evaluation in each year will be prioritized based on several factors, including but not limited to the uncertainty or variability of realized savings, its contribution to portfolio savings, program costs relative to all programs, the elapsed time since the last evaluation, or to address targeted research questions.

## H.4 Deemed Savings Approach

Upon program approval by the Virginia State Corporation Commission, deemed savings approach or protocol for the Residential Appliance Recycling Program will be developed through research primarily in the most recent version of the Mid-Atlantic Technical Reference Manual (TRM), and other TRMs or relevant studies, as appropriate. The deemed savings protocol for measures in this program will be documented in the STEP Manual, also known as the Company's TRM, and calculated using utility-reported program participant data. DNV GL will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatt and kilowatt-hours. Where such data is impractical for implementation contractors to collect, DNV GL will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV GL will take into consideration the priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

## H.5 Evaluated Savings Approach

During program implementation Dominion Energy will determine, in consultation with DNV GL, the appropriateness of conducting evaluations to estimate program net savings in net kilowatt and net kilowatt-hours.

According to Chapter 7: Refrigerator Recycling Evaluation Protocol[5] of The Uniform Methods Project[6] (UMP), the key parameters necessary for determining gross savings and peak demand reductions include measure verification, annual energy consumption data, and the proportion of the year that the appliance was in operation.

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[5] Keeling, J.; Bruchs, D. (2017). Chapter 7: Refrigerator Recycling Evaluation Protocol. The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68563. http://www.nrel.gov/docs/fy17osti/68563.pdf

[6] Li, M.; Haeri, H.; Reynolds, A. (2018). The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-70472. http://www.nrel.gov/docs/fy18osti/70472.pdf

At a high level, the ratio of the measured and verified savings to the deemed savings for the sample, also called a realization rate,[7] is then applied to the population of participants to estimate overall program savings. This approach will capture Company-specific customer usage data, and then apply those to the actual measures installed to quantify energy and peak demand savings.

### H.5.1 Sample Design Considerations

The sample frame will be comprised of the earlier of either approximately 2,000 participants or all participants in the first three years of program activity (whichever milestone is reached first). Planned sample size and design are determined by considering the participant population and may change from the estimated sample size. Using standard sampling approaches and tools, the following characteristics will be considered:

- Confidence interval: 85 to 90%
- Relative precision: 10 to 15%
- Measure-level error ratio: to be updated prior to sample selection
- Budget, schedule, and geographical distribution

### H.5.2 Measurement and Verification

Measurement and verification of the installation and operation of a sample of premise-level participants will be performed using one or more of the following levels of rigor:

- Telephone-survey or online-survey verification, only
- On-site verification, short-term measurements, and long-term metering of approximately two to three weeks during a period of typical operations

The above efforts will be used to determine the verified annual energy savings and peak coincident demand reductions using gathered data, as appropriate, for each sampled project at the premises.

In a limited set of cases, other kinds of verification strategies, such as whole-house simulation modeling incorporating various types of data can be used to estimate changes in energy use associated with customer participation in the program. Similarly, DNV GL may opt to use a billing analysis approach if billing data can be obtained and other conditions necessary for the application of this family of methods are met.

According to the UMP, the appropriate approach to use is defined by the International Performance Measurement and Verification Protocol[8] (IPMVP) Option B, Retrofit Isolation. Using Option B, savings are determined by field measurement of the energy use of the refrigerators or freezers to be recycled (separate from the energy use of the rest of the home). This approach can be used to determine the change in energy and demand due to the removal of the appliance from the home at a representative sample of participants.

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[7] The "realization rate" is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or a given sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and the extent to which these were affected by exogenous changes.

[8] Efficiency Valuation Organization (2012). International Performance Measurement and Verification Protocol: Concepts and Options for Determining Energy and Water Savings, Volume 1. EVO 10000-1:2012, www.evo-world.org.

These efforts will be considered to determine the verified annual energy savings and peak demand reductions using gathered data, as appropriate, for each sampled project at the premises.

### H.5.3 Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV GL standard attribution question strategy to determine the quantity, location, type of usage, and timing of removal had the program not been available.

## H.6 Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the measured data based off the on-site studies.
2. Apply the measured data to the actual participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation data.
3. Develop cumulative monthly energy savings based on measured and verified data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

## H.7 Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 15th of each year following program launch).
- Update STEP Manual annually for updates that occurred to its referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.
- If appropriate, support lost revenue recovery activities.

## H.8 Residential Appliance Recycling Program EM&V Plan Document Revision History

| Version | Notes |
|---|---|
| **Version 1.0** | New version |

# Appendix H-1. Residential Appliance Recycling Program Quality Control Description

# Appendix I. Residential Efficient Products Marketplace Program EM&V Plan

# I. RESIDENTIAL EFFICIENT PRODUCTS MARKETPLACE PROGRAM EM&V PLAN (VERSION 1.0)

## I.1 Program Summary

The program would provide residential customers an incentive to purchase specific energy efficient appliances with a rebate through an online marketplace and through stores.

## I.2 Measures

The following measures are included in the Residential Efficient Products Marketplace Program:

**Table 1. Residential Efficient Products Marketplace Program Measures**

| Lighting Measures | Appliance Measures |
|---|---|
| 1. A-Lines[9] | 1. Freezer |
| 2. Reflectors | 2. Refrigeration |
| 3. Decorative | 3. Clothes Washer |
| 4. Globes | 4. Dehumidifier |
| **5.** Retrofit Kit and Fixture | 5. ENERGY STAR® Air Purifier |
| | 6. Clothes Dryer |
| | 7. Dishwasher |

## I.3 Evaluation, Measurement, and Verification Overview

DNV GL will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[10]

The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV GL's savings evaluation approach are:

1. Baseline Consumption: Baseline consumption will be calculated from AMI participant and AMI non-participant consumption data.
2. Deemed Savings: Deemed savings (or gross savings) values will be estimated from the DNV GL Standard Tracking and Engineering Protocol (STEP) Manual, which are derived primarily from the most recent version of the Mid-Atlantic Technical Resource Manual (TRM), and as appropriate, other TRMs.
3. Evaluated Savings: Evaluated savings (or net savings) will be determined by the methods described in Section 5.5. The evaluated savings will use program tracking data, customer energy consumption data, other customer data, and equipment data to estimate program savings.

DNV GL takes a holistic approach to evaluation planning for the Company's portfolio of energy conservation programs. DNV GL balances cost-effectiveness and rigor to its evaluation planning so the Company can insure its programs are cost effective and yield planned savings. This program will follow a staged evaluation

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[9] Lighting measure planned for 2019 only

[10] 20 VAC 5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

plan, where DNV GL will take a two-step approach. During program start-up, kilowatts and kilowatt-hour savings are estimated using a deemed savings approach. Deemed approaches are a cost-effective method for determining reasonable savings estimates in the early stage of implementation, and in the periods between more rigorous EM&V.

Once participation has levelized or reached planned levels, and realized savings can be quantified, the program is considered for evaluation. Based on results from the DSM Phase I through III programs – programs that were implemented for more than three years as of this filing, and similar programs in other jurisdictions, DNV GL anticipates this will occur in year two of program operations.

Early in the third year of the program, or earlier at the Company's discretion – and assuming they are approved for the five years that they have been filed, they will be evaluated with the method most suitable to the program, program measures, and evaluation objectives. Methods include impact analysis using engineering analysis or whole facility methods, market studies, and process evaluations. Programs selected for evaluation in each year will be prioritized based on several factors, including but not limited to the uncertainty or variability of realized savings, its contribution to portfolio savings, program costs relative to all programs, the elapsed time since the last evaluation, or to address targeted research questions.

## I.4 Deemed Savings Approach

Upon program approval by the Virginia State Corporation Commission, deemed savings approach or protocol for the Residential Efficient Products Marketplace Program will be developed through research primarily in the most recent version of the Mid-Atlantic Technical Reference Manual (TRM), and other TRMs or relevant studies, as appropriate. The deemed savings protocol for measures in this program will be documented in the STEP Manual, also known as the Company's TRM, and calculated using utility-reported program participant data. DNV GL will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatt and kilowatt-hours. Where such data is impractical for implementation contractors to collect, DNV GL will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV GL will take into consideration the priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

## I.5 Evaluated Savings Approach

According to Chapter 12: Survey Design and Implementation for Estimating Gross Savings Cross-Cutting Protocol of The Uniform Methods Project (UMP), the evaluation uses a survey approach to estimate gross and net program energy savings, and free-ridership. Sample design will follow the protocols set forth in Chapter 11: Sample Design Cross-Cutting Protocol of the UMP.[11]

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[11] Baumgartner, Robert. (2017). Chapter 12: Survey Design and Implementation for Estimating Gross Savings Cross-Cutting Protocol The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory, NREL/SR-7A40-68568, https://www.nrel.gov/docs/fy17osti/68568.pdf; Khawaja, Sami M. Rushton, Josh. Keeling, Josh. (2017). Chapter 11: Sample Design Cross-Cutting Protocol: The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68567, https://www.nrel.gov/docs/fy17osti/68567.pdf.

During program implementation Dominion Energy will determine, in consultation with DNV GL, the appropriateness of conducting evaluations to estimate program net savings in net kilowatt and net kilowatt-hours.

The EM&V method estimates gross and net program energy savings, including net-to-gross savings and free-ridership. The following data will be used to determine evaluated program savings:

- **Lighting supplier interviews**: The benefit of these interviews is to collect information for net-to gross calculations.
- **Survey of appliance rebate participants**: If end-user data is available, participants will be asked whether the program influenced the energy efficiency of the appliance and timing of their purchase.
- **Survey of upstream lighting participants**: If lighting participants are surveyed, alternate recruitment methods will be employed since retail lighting channels do not collect end-user information.
- **Program tracking data**: Review of lighting shipment invoices

If end-user data is available, participants and end users may be surveyed. Table 2 describes EM&V activities, survey modes, and the data that estimates net savings.

### I.5.1 Sample Design Considerations

DNV GL will attempt to interview the population of participating lighting suppliers. A random sampling strategy, stratified by appliance type, will be used for the appliance participants.

The following characteristics will be considered:

- Confidence interval: 85 to 90% (at the appliance level)
- Relative precision: 10 to 15% (at the appliance level)
- Upstream measures
- Rebate measures
- Budget, schedule, and geographical distribution

If applicable, for the lighting participants, a pre-survey sample design is not possible, since the types of customers responding to a web survey is unknown. However, post-stratification of the sample to develop weights based on lighting type and retail channel can be performed.

Table 2 describes the EM&V activities, data collection modes, and the data that estimates net and gross savings.

**Table 2. EM&V Activities, Data Collection Modes, and the Data that Estimates Net and Gross Savings**

| Activity | Data Collection Mode | Net Savings Data |
|---|---|---|
| Lighting supplier interviews | In-depth phone interview | Confirmation of shipment quantities<br>Retrospective and prospective net-to-gross ratios |
| Survey of appliance participants | Computer assisted telephone interviewing (CATI) phone survey with optional web component | Confirm the appliance is installed and operating correctly |
| Pending available data: Surveys of lighting participants | Web survey | Confirm gross savings estimation inputs (e.g. lighting quantity, installation rate, etc.)<br>Retrospective and prospective net-to-gross ratios |

## I.5.2 Net-to-Gross Assessment

If applicable, free-ridership may be estimated using the approaches described below:

**Free-ridership Estimates from the Lighting Supplier Interviews**

In-depth interviews with participating lighting suppliers are one source of net savings estimates. For prospective net-to-gross ratios, suppliers are asked to project what share of their future lighting sales in the Virginia/North Carolina market will be LEDs.

To reliably estimate the program impact on sales, the volume of program sales must be significant enough for the suppliers to report the fluctuation in sales between program and non-program periods, or between participating and non-participating stores. The volume of appliance sales through the program, especially when appliances are sourced from multiple suppliers, is not large enough to estimate program effects. Therefore, appliance suppliers will not be interviewed.

**Free-ridership Estimates from the Participating End Users**

Surveys of appliance and lighting participants are used obtain net-to-gross estimates. An end-user self-report net-to-gross method uses three attribution factors: timing, efficiency, and quantity, to calculate net savings.

**Participant Spill-over**

Spill-over energy savings are awarded under the following criteria:

5. The original tracked purchase is at least partially attributable to the program

6. The subsequent purchase is at least partially attributable to the participant’s experience with their earlier tracked purchase

## I.6 Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the evaluation.[12]
2. Apply the evaluated savings to the participant data to arrive at program level energy savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation.
3. Develop cumulative monthly energy savings based on measured and evaluated data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

## I.7 Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 1 of each year following program launch).
- Update STEP Manual annually for updates that occurred to its referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.
- If appropriate, support lost revenue recovery activities.

## I.8 Residential Efficient Products Marketplace Program EM&V Plan Document Revision History

| Version | Notes |
|---|---|
| **Version 1.0** | New version |

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[12] The realization rate is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

# Appendix I-1. Residential Efficient Products Marketplace Program Manual

STATE CORPORATION COMMISSION
RECEIVED

MAR 20 2019

Case No. PUR-2018-00168
Sponsor: ("DOMINION")
Exhibit No. 8

Witness: MICHAEL T. HUBBARD
Bailiff: DEBORAH P. BELL

# WITNESS DIRECT TESTIMONY SUMMARY

Witness: Michael T. Hubbard

Title: Manager – Energy Conservation

Summary:

Company Witness Michael T. Hubbard provides an update on the Company's approved DSM Programs. Mr. Hubbard provides an overview of the development and design of the Company's proposed Phase VII Programs, including the request for proposals ("RFP") process. He also discusses the quality assurance process and gives an update on the Company's controls surrounding the rebate approval process and any changes therein. Finally, Mr. Hubbard addresses certain provisions of the State Corporation Commission's (the "Commission") Rules Governing Utility Promotional Allowances ("Promotional Allowances Rules") (20 VAC 5-303-10, et seq.).

Mr. Hubbard provides an update on the status of the Company's approved DSM Programs, and describes in detail the following eleven Phase VII Programs being proposed in the Company's Application:

- Non-residential Heating and Cooling Efficiency Program
- Non-residential Lighting Systems & Controls Program
- Non-residential Window Film Program
- Non-residential Office Program
- Non-residential Small Manufacturing Program
- Residential Appliance Recycling Program
- Residential Home Energy Assessment Program
- Residential Smart Thermostat Management Program (DR)
- Residential Smart Thermostat Management Program (EE)
- Residential Efficient Products Marketplace Program
- Residential Customer Engagement Program

Mr. Hubbard explains that the Company plans to implement the proposed Phase VII Programs through fully outsourced implementation vendors, similar to the approach successfully taken for previously-approved DSM Programs. The implementation vendor(s), in conjunction with the Company, often utilizes a contractor network to assist in delivering the program in the field, similar to previous phases.

As with the previously approved DSM Programs, Mr. Hubbard further explains that the Company will require detailed reporting from its implementation vendors to help ensure that each Program meets its desired performance levels and participation targets. The Company will conduct evaluation, measurement and verification ("EM&V") on each Program, and will use internal Program Managers to monitor vendor performance, Program success, and customer satisfaction. In addition, the Program Managers will ensure vendor compliance with contractual requirements and performance targets through regular reporting, and the proper coordination with the Company's systems and processes.

EXHIBIT# 8

# DIRECT TESTIMONY
# OF
# MICHAEL T. HUBBARD
# ON BEHALF OF
# VIRGINIA ELECTRIC AND POWER COMPANY
# BEFORE THE
# STATE CORPORATION COMMISSION OF VIRGINIA
# CASE NO. PUR-2018-00168

**Q. Please state your name, position with Virginia Electric and Power Company ("Dominion Energy Virginia" or the "Company"), and business address.**

A. My name is Michael T. Hubbard, and I am Manager – Energy Conservation for Dominion Energy Virginia. My business address is 701 East Cary Street, Richmond, Virginia 23219. A statement of my background and qualifications is attached as Appendix A.

**Q. Please describe your areas of responsibility with the Company.**

A. I am responsible for implementing the Company's Demand-Side Management ("DSM") programs (individually "DSM Program(s)" or "Program(s)," collectively "DSM Portfolio" or "Portfolio"), which includes oversight of Program planning and the requests for proposals ("RFPs") through which the Company selects vendors to administer the Programs, and oversight of the vendors during Program implementation.

**Q. What is the purpose of your testimony in this proceeding?**

A. My testimony supports the Company's petition for approval to (1) implement eleven new DSM programs as the Company's "Phase VII" Programs; and (2) provide an annual update application for approval to continue two rate adjustment clauses ("RACs"), Riders C1A and C2A (collectively, the "Application").

Specifically, I will provide an update on the status of the Company's approved DSM

Programs. My testimony will also provide an overview of the development and design of the proposed Phase VII Programs, including the request for proposals ("RFP") process. I will also discuss the quality assurance process and give an update on the Company's controls surrounding the rebate approval process and any changes therein. Lastly, I will address certain provisions of the State Corporation Commission's (the "Commission") Rules Governing Utility Promotional Allowances ("Promotional Allowances Rules") (20 VAC 5-303-10, et seq.).

**Q. Are you sponsoring an exhibit in this proceeding?**

A. Yes, Company Exhibit No. __, MTH, consisting of Schedules 1-5, was prepared under my supervision, and is accurate and complete to the best of my knowledge and belief. Schedule 1 provides a description of the proposed Phase VII Programs. Schedule 2 includes a matrix that specifies the simultaneous eligibility constraints for the Company's approved DSM Program. Schedule 3 was prepared at the direction of Ordering Paragraph (5) of the Commission's Final Order in the Company's 2017 DSM Proceeding ("2017 DSM Final Order"). It summarizes the DSM Programs proposed by the Company in Phases I through VI with information regarding each Program's approval status, costs requested, costs approved, actual costs and participation through June 30, 2018, and start and end dates, among other content. Schedule 4 provides an overview of the Company's rebate review and approval process. Schedule 5 illustrates the pre-approval operational procedure that the Company's implementation vendor has utilized since the issuance of the 2016 DSM Final Order.

I am also sponsoring Filing Schedule 46A, Statement 1 and Statement 2 (Public and Extraordinarily Sensitive versions filed under seal and subject to the Company's Motion for Protective Order and Additional Protective Treatment filed coincident with the Application), which has been prepared under my direction and supervision, and is accurate and complete to the best of my knowledge and belief. Filing Schedule 46A, Statement 1, provides the scope of work that serves as the basis of the RFP for the proposed Phase VII DSM Programs; Extraordinarily Sensitive Statement 2 contains the vendor contracts and change orders executed since the Company's last DSM filing.

**Q. How is your testimony organized?**

A. My testimony is organized as follows:

Section I – Status of Phase I and Phase II Programs;

Section II – Status of Phase III and Phase IV Programs;

Section III – Status of Phase V and VI Programs;

Section IV – Phase VII Program Development and Implementation; and

Section V – Quality Assurance and Controls and Compliance with Commission Orders and Rules.

## I. STATUS OF PHASE I AND PHASE II PROGRAMS

**Q. Does the Company have any active Phase I Programs?**

A. Yes. The Company has one active Phase I DSM Program, the Residential Air Conditioner ("AC") Cycling Program, approved on March 24, 2010, in the Company's 2009 DSM proceeding, Case No. PUE-2009-00081. In the 2012 DSM proceeding, Case No. PUE-2012-00100, the Commission approved the continuation of the AC Cycling Program through March 31, 2016. The Program was subsequently extended through March 31, 2021, pursuant to the Commission's Final Order in the Company's 2015 DSM proceeding, Case No. PUE-2015-00089.

The Company's other Phase I Programs are no longer available to customers.

**Q. Please provide an update on the AC Cycling Program.**

A. Through the AC Cycling Program, the Company installs an AC cycling switch on participating customers' outdoor air conditioner or heat pump system. In periods of high demand during summer months, the Company calls "events," during which the Company cycles customers' air conditioners or heat pump compressors on and off for periods of about two to four hours, while the fan stays on, circulating previously cooled air.

The Program continues to be an active peak-shaving program, with approximately 88,454 participating customers as of June 30, 2018. Following the grant of the five-year extension of the AC Cycling Program, the Company has continued working with its third-party contractor to operate the Program.

Since launching in 2010, the AC Cycling Program has continued to be a highly utilized resource that provides a substantial amount of load curtailment capability which the Company calls upon during times of peak demand. In fact, as of September 20, 2018, the Company has activated the Program 27 times during the 2018 summer cycling season.

**Q. Does the Company have any active Phase II Programs?**

A. Yes. The Company has one active Phase II DSM Program, the Non-residential Distributed Generation ("DG") Program, which provides qualifying customers with an incentive to curtail load by operating customer backup generation when called upon, up to a maximum number of hours annually. The Program is implemented by a contractor who is responsible for installing equipment to enable remote operation and monitoring of the customers' backup generation equipment and for dispatching load curtailment events under the Company's direction. The Program was initially approved on April 30, 2012, in the Company's 2011 DSM proceeding (Case No. PUE-2011-00093) through April 30, 2017. In the 2016 DSM Proceeding, the Commission approved the Company's request to extend the Program for an additional five years, through May 31, 2022.

The Company's other Phase II Programs are no longer available to customers.

Q. **Please provide an update on the Non-residential DG Program.**

A. The Non-residential DG Program continues to be an active peak-shaving program and is an important resource for the Company and its participating customers. Between January 1, 2018 and September 20, 2018, the Company has activated the Program 32 times at 21 customer sites.

## II. STATUS OF PHASE III AND PHASE IV PROGRAMS

Q. **Mr. Hubbard, please begin by listing the Company's approved Phase III Programs.**

A. The approved Phase III Programs are the Non-residential Heating and Cooling Efficiency Program, the Non-residential Lighting Systems & Controls Program, and the Non-residential Window Film Program, which are marketed as part of a bundle of programs.

Q. **Please provide an update on the Phase III Programs.**

A. The Company launched the Phase III Programs in June 2014. The Non-residential Lighting Systems & Controls Program has provided incentives for efficient lighting technologies to approximately 3,644 customers as of June 30, 2018. The Non-residential Heating and Cooling Efficiency Program has provided incentives for efficient HVAC equipment to approximately 341 customers, and the Non-residential Window Film Program has provided incentives to 191 customers. Additionally, approximately 475 contractors are participating in the contractor network for these Programs. These Programs are set to wind down between late 2018 and early 2019 consistent with the Commission's approval periods for these programs.

**Q. Please discuss current plans for the closure of the Phase III Non-residential programs.**

A. The Company and its program implementation vendor have worked together to implement a proposed DSM Phase III Programs closure timeline consistent in process with previous programs. The Company posted an update to its website in June, informing customers that all initial DSM Phase III Program assessments must be submitted by October 26, 2018; all projects must be completed by December 28, 2018; and all Program rebate applications must be submitted online or postmarked by February 11, 2019.

**Q. Does the Company have any active DSM Phase IV Programs?**

A. Yes. The Company has one active DSM Phase IV Program, the Residential Income and Age Qualifying Home Improvement Program, which provides income- and age-qualifying residential customers with energy assessments and direct install measures at no cost to the customer. As of June 30, 2018, approximately 15,893 audits have been performed for eligible customers since the Program launched in 2015. Pursuant to the Commission's Final Order in the 2014 DSM proceeding, Case No. PUE-2014-00071, the Company will continue to file quarterly reports updating the implementation data for the Residential Income and Age Qualifying Home Improvement Program. In the 2017 DSM Proceeding, the Commission approved the Company's request to extend the Program for an additional three years, through May 31, 2021. With the Commission-approved extension of this program, including the re-launch of the program in July, the first quarterly report for the extended program will be filed on November 14.

The Company's other Phase IV Program, the Residential Appliance Recycling Program, is no longer available to customers.

**Q. Please provide an update on the Residential Income and Age Qualifying Home Improvement Program.**

A. In July 2018, the Company re-launched the Phase IV Residential Income and Age Qualifying Home Improvement Program following the Commission's approval to extend that Program in last year's 2017 DSM Proceeding. The Company and its implementation vendor are working collaboratively with state weatherization providers and in-take agencies to reach as many qualifying customers as possible, in order to deliver much needed energy efficiency improvements to some of the most vulnerable customers in the Company's service territory who would otherwise be unable to make energy efficiency improvements in their homes.

## III. STATUS OF PHASE V and VI PROGRAMS

**Q. Mr. Hubbard, please begin by listing the Company's approved Phase V and Phase VI Programs.**

A. The approved Phase V Program is the Small Business Improvement Program, and the approved Phase VI Program is the Non-residential Prescriptive Program.

**Q. Please provide an update on the status of the Phase V Program.**

A. The Company launched the Phase V Non-residential Small Business Improvement Program in July 2016. It provides qualifying customers with an energy use assessment and a tune-up or re-commissioning of electric heating and cooling systems, along with financial incentives for the installation of specific energy efficiency measures. As of June 30, 2018, the Program has provided approximately 1,780 on-site energy assessments to qualifying customers. Of these 1,780 on-site energy assessments, approximately 1,284 customers have installed rebate-qualifying measures as part of the Program. Thus far, approximately nine contractors with differing measure focus areas are participating in the contractor network for this Program, and these contractors are trained to interact with each other to ensure customer energy saving opportunities are maximized through referrals.

**Q. Please provide a status update for the Phase VI Program.**

A. The Company launched its Phase VI Non-residential Prescriptive Program in July 2017, which provides eligible customers incentives for the installation of energy efficiency improvements including measures such as duct testing and sealing, HVAC system tune-ups, and upgrades to refrigeration systems and commercial kitchen appliances. As of June 30, 2018, the Program has provided incentives to 628 customers, with 20 participating contractors in the contractor network for this Program.

## IV. Phase VII Program Development and Implementation

**Q. Please summarize the Company's request in this proceeding with respect to new DSM Programs.**

A. The Company is seeking approval of Phase VII of its DSM Portfolio in this proceeding. Phase VII is compromised of the following eleven DSM Programs:

- Non-residential Heating and Cooling Efficiency Program
- Non-residential Lighting Systems & Controls Program

- Non-residential Window Film Program
- Non-residential Office Program
- Non-residential Small Manufacturing Program
- Residential Appliance Recycling Program
- Residential Home Energy Assessment Program
- Residential Smart Thermostat Management Program (DR)
- Residential Smart Thermostat Management Program (EE)
- Residential Efficient Products Marketplace Program
- Residential Customer Engagement Program

The Company requests approval of the proposed Phase VII Programs for a five-year period.

The Company recognizes that, in some cases, the Commission has approved programs for a three-year term. The Company continues to believe that a five-year implementation period is more appropriate and should be approved in this case. A five-year period allows for a program to properly launch and gain acceptance without the potential risk of having to wind it down as it begins to hit full customer acceptance and anticipated deployment levels.

**Q. Please elaborate on each of the proposed Phase VII Programs.**

A. The Company is proposing eleven new programs that will, if approved, be marketed as bundled programs, one for the Company's residential customers and the other for its non-residential customers. The bundles are combinations of several programs that include multiple measures as suggested to the Company through various channels, including

DSM stakeholders, DSM Market Potential Studies, the Stakeholder Review Process, requests for information, and RFPs. The Company plans to launch these programs by mid to late summer 2019, pending Commission approval. I will briefly describe each of the proposed Phase VII DSM Programs that the Company is proposing. Additional details, including eligible rate schedules for each non-residential program, can be found in my Schedule 1 and Company Witness Deanna R. Kesler's direct testimony schedules.

### Residential Appliance Recycling Program
### (Energy Efficiency)

This Program would provide incentives to residential customers to recycle specific types of qualifying appliances, including appliance pick-up and proper recycling services. Qualifying appliances would be refrigerators and freezers subject to the same limitations that were deemed reasonable by the Commission in the Phase IV Program (i.e., limitations on the size, age, and number of appliances to be recycled).

### Residential Customer Engagement Program
### (Energy Efficiency)

This Program would provide educational insights into the customer's energy consumption via a Home Energy Report (on-line and/or paper version). The Home Energy report is intended to provide periodic suggestions on how to save on energy depending upon an analysis of the customer's energy usage.

### Residential Efficient Products Marketplace Program
### (Energy Efficiency)

The Program would offer rebates for energy efficient products purchased through an online marketplace or through participating retail stores. Purchases through the online store would be rebated upon approval of the payment and customer verification; rebates on purchases through retail stores would be provided upon approval of an application for the rebate and upon customer verification. Products rebated through the program would include A-line bulbs (prior to 2020), reflectors, decoratives, globes, retrofit kits and fixtures, freezers, refrigerators, clothes washers, dehumidifiers, air purifiers, clothes dryers, and dishwashers. All rebates will be tied to a Company account prior to approval of a rebate. Purchases through the online marketplace will be verified electronically as being made by a Company customer in real-time and purchases from retail stores will be verified after purchase but prior to issuance of a rebate though a rebate request/application process. The online marketplace will also be used to cross-market other DSM programs offered by the Company and will provide a means for interested customers to locate a participating retail store in their area.

## Residential Home Energy Assessment Program

## (Energy Efficiency)

This Program would provide residential customers within the Company's Virginia service territory an incentive to install a variety of energy saving measures following completion of a walk-through home energy assessment. The energy saving measures would include the replacement of existing light bulbs with LED bulbs, heat pump tune-up, duct insulation/sealing, fan motors upgrades, installation of efficient faucet aerators and showerheads, water heater turndown, replacement of electric domestic hot water with a heat pump water heater, heat pump upgrades (ducted and ductless), cool roofs, and water heater and pipe insulation.

## Residential Smart Thermostat Management Program

## (Demand Response Component)

All residential customers who are not already participating in the Company's DSM Phase I AC Cycling Program and who have a qualifying smart thermostat would be offered the opportunity to enroll in this peak demand response Program. In exchange for an annual incentive, smart thermostats enrolled by participating customers would be gradually adjusted remotely during specific demand response events called by the Company. Thermostat adjustments would be designed to achieve a specific amount of load reduction while maintaining reasonable customer comfort and allowing customers to opt-out of events if they choose to do so. Opting out of events will be limited before a participant forfeits his or her annual incentive.

## Residential Smart Thermostat Management Program

## (Energy Efficiency Component)

This Program would provide an incentive to customers to either purchase a qualifying smart thermostat and/or enroll in an energy efficiency program, which would help customers manage their daily heating and cooling energy usage by allowing remote optimization of their thermostat operation, and would provide specific recommendations by e-mail or letter that customers can further act on to realize additional energy savings. The Program would be open to several thermostat manufacturers, makes, and models that meet or exceed the Energy Star requirements and have the required communicating technology. Rebates for the purchase of a smart thermostat would be provided on a one-time basis; incentives for participation in remote thermostat management would be provided on an annual basis. For those customers who enroll in thermostat management, additional energy-saving suggestions, based on operational data specific to the customer's heating and cooling system, would be provided to the customer at least quarterly.

## Non-residential Lighting Systems & Controls Program
## (Energy Efficiency)

This Program would provide qualifying non-residential customers with an incentive to implement efficient lighting technologies that can produce verifiable savings. The Program would offer incentives for the installation of energy efficiency measures including high efficiency T8/T5 lamps and fixtures, LED lamps and fixtures, and occupancy sensors. The proposed DSM Phase VII Lighting Systems and Controls Program was re-designed to reflect updates in technology and market conditions relative to the DSM Phase III Program and to address the new customer exemption threshold of 500 kW. Older CFL technology was not included in the new design. Similarly, measures specifying the replacement of T12 linear fluorescent technology were removed, as the manufacturing of T12s is now prohibited by code changes that occurred since the approval of the Phase III Program. In instances were such technologies are replaced, savings will only be claimed according to the latest base standard.

## Non-residential Heating and Cooling Efficiency Program
## (Energy Efficiency)

This Program would provide qualifying customers with incentives for installing high efficiency heating and cooling systems in their non-residential facilities. The Program would offer incentives for the installation of energy efficiency measures including: air conditioner upgrades, heat pump upgrades, chiller upgrades, economizers, variable frequency drives, variable refrigerant flow, installation or upgrades to unitary AC systems and mini splits. The proposed DSM Phase VII Heating and Cooling Efficiency Program differs from the previously-approved DSM Phase III Heating and Cooling Efficiency Program in that it has been redesigned to reflect a customer exemption threshold 500kW and current technology. This redesign had the effect of excluding measures that would be more appropriate for larger facilities. Additionally, updates to energy codes were considered and certain minimum equipment ratings were updated to reflect higher efficiency units available in the marketplace.

### Non-residential Window Film Program

### (Energy Efficiency)

This Program would provide qualifying non-residential customers with an incentive to install solar reduction window film to lower their cooling bills and improve occupant comfort. The proposed DSM Phase VII Window Film program was modeled using an updated solar heat gain coefficient compared to the Company's DSM Phase III Program design. The redesign also addresses the new customer exemption threshold of 500 kW.

### Non-residential Small Manufacturing Program

### (Energy Efficiency)

This Program would provide qualifying customers incentives for the installation of energy efficiency improvements, consisting of primarily improvements in compressed air systems measures for small manufacturing facilities. The Program would offer incentives for the installation of a variety of energy efficiency measures, including compressed air nozzles, leak repair, no loss drains, addition of storage, heat of compression dryer, low pressure drop filter, variable speed drive compressor, cycling refrigerant dryer, dewpoint controls, pressure reduction, and downsized compressor.

## Non-residential Office Program
## (Energy Efficiency)

This Program would provide qualifying customer incentives for the installation of energy efficiency improvements, consisting of recommissioning measures at smaller office facilities. The Program would offer incentives for the installation of a variety of measures relevant to building systems, including lighting scheduling, HVAC maintenance scheduling, temperature setback, condenser water reset, discharge air temp reset, static pressure reset, enthalpy economizer adjustment, and variable air volume box minimum adjustment.

Q. **Will you describe the eligibility requirements for the proposed Phase VII DSM Programs?**

A. The proposed Phase VII DSM Programs are designed for specific classes of customers: residential and non-residential. Customers may be enrolled if they meet the eligibility requirements for each program and agree to the applicable terms and conditions. Schedule 2 to my testimony includes a matrix that specifies the simultaneous eligibility constraints for the Company's approved and proposed Programs.

Q. **Are the proposed DSM Phase VII Non-residential Lighting Systems & Controls, Heating and Cooling Efficiency and Window Film Programs extensions of the Company's DSM Phase III Programs?**

A, No. While the programs are conceptually similar, the program designs and the specifics therein vary from the past programs. The program design vendor incorporated the following programmatic updates to develop the measures for these three newly proposed programs: (1) code changes since inception of DSM Phase III Programs; (2) market shifts toward newer technologies; (3) customer size limit being imposed at 500 kW; and (4) comparison of program measures to other state utility program measures to ensure consistency across similar programs.

**Q. Please describe the RFP process that led to the development of the Phase VII Programs.**

A. The Company issued an RFP for the Phase VII Programs in March 2018. A copy of the scope of work that serves as the basis of the RFP is included in Filing Schedule 46A, Statement 1. The program design scope includes, but is not limited to: development of specific program measures, incentives, parameters and assumptions, projected participation, projected costs, load profiles, projected energy and demand savings, and eligibility requirements. The RFP process, as well as the subsequent evaluation of proposals received, resulted in the Program proposals in this filing.

In addition, the Company has met with stakeholders several times throughout the summer. The Company held several smaller stakeholder meetings earlier in the summer with energy efficiency proponents with the intent of incorporating feedback for its upcoming 2018 DSM filing and to report on the Company's progress on the 2018 RFP evaluations. The Company also held a larger energy efficiency stakeholder meeting on September 12, 2018, and invited a wide range of audience members from numerous organizations and public sectors.

**Q. How were the results from the RFP used for purposes of this Application?**

A. The Company used the RFP responses to define measures that would be included in Programs and to develop the estimated penetrations, costs, energy and load reductions associated with the proposed Programs for purposes of the cost/benefit evaluations.

**Q. How does the Company propose to implement the Phase VII Programs?**

A. The Company plans to implement the proposed Phase VII Programs through fully outsourced implementation vendors, similar to the approach successfully taken for previously-approved DSM Programs. The implementation vendor(s), in conjunction with the Company, often utilizes a contractor network to assist in delivering the program in the field, similar to previous phases. Final implementation details will be negotiated with the selected implementation contractor(s) upon Program approval.

**Q. When does the Company anticipate the Phase VII Programs will be available to customers?**

A. With Commission approval, the Company anticipates the Phase VII Programs will be available to customers beginning in August 2019, with launch activities beginning shortly after the Commission's Final Order.

**Q. How will the Company oversee the vendors selected to implement and manage these proposed Programs?**

A. As with the previously approved DSM Programs, the Company will require detailed reporting from its implementation vendors to help ensure that each Program meets its desired performance levels and participation targets. The Company will conduct evaluation, measurement and verification ("EM&V") on each Program and will include those results in its annual EM&V filing with the Commission, as discussed further in the pre-filed direct testimony of Company Witness Dan Feng, of DNV-GL.

As with the currently approved Programs, the Company will use internal Program Managers to monitor vendor performance, Program success, and customer satisfaction. In addition, the Program Managers will ensure vendor compliance with contractual requirements and performance targets through regular reporting, and the proper coordination with the Company's systems and processes. Such monitoring and oversight should go unnoticed by the customer and will help to ensure successful and efficient interaction between the Company and its vendors.

## V. QUALITY ASSURANCE AND CONTROL AND COMPLIANCE WITH COMMISSION ORDERS AND RULES

Q. **Please describe the difference between the Company's quality control and quality assurance processes.**

A. The Company has a quality control process that utilizes internal automated queries and staff to track and flag measures installed in its programs. Rebate application information and installation work must be completed before rebates are funded and approved during the weekly review process. Each measure is tracked for accuracy in the Company's Business Intelligence ("BI") system (the official system of record that all rebates are approved from) and checked again against the Program's applicable eligibility criteria. The final information is also submitted to DNV-GL, the Company's EM&V vendor, to calculate energy savings and check data quality on a monthly basis. The BI system validates measures and prevents acceptance of measures previously installed under the same customer account. Company personnel work closely with the implementation vendor to help ensure that rebates and supporting application data are accurate. Any errors that are identified in the Company's weekly exception reports are captured and corrected by the appropriate program manager and analyst prior to being processed. The rebate back-up documentation is scanned and stored in the Company's implementation vendor's systems, as with the quality assurance field work when performed. This supporting documentation can be matched to completed work once a completed rebate application is submitted and approved for payment.

In addition to the quality control processes discussed above, the Company's field and quality assurance process is used to check and verify the quality of work on a percentage of each vendor's projects. It should also be noted that the program implementation vendor often meets with customers and participating contractors to address work to be performed. All of these ongoing quality controls and quality assurance observations help to ensure that legitimate work is rebated and not duplicated.

**Q. Please elaborate on the Company's quality assurance process for DSM Program measure installations.**

A. As outlined in my Schedules 4 and 5, the Company has detailed guidelines and processes to confirm that approved Programs are being implemented as planned and tracked closely as to participation levels and spending. Data quality control and field inspections are done by our implementation vendors, EM&V vendors and the Company's Energy Conservation department staff.

**Q. Please provide an update on the controls and procedures surrounding the rebate approval process.**

A. Since the 2016 DSM Final Order was issued in June 2017, the Company and its implementation vendors have worked together to make improvements, where applicable, to existing controls and procedures surrounding the rebate approval process. In particular, the Company's implementation vendor has improved its operating procedures for its program pre-approval process. Employees were trained to incorporate a six-step procedure as part of the implementation vendor's program pre-approval process. The Company's implementation vendor has continued to focus on adhering to the necessary steps in the current process and upholding the rigorous program standards at each and every step. See my Schedule 5 for a detailed overview of this pre-approval training process.

**Q. Does the Company have plans for any other future improvements or changes to its DSM Program and measure controls?**

A. In addition to continuing enhancements to the pre-approval processes, one of the Company's program implementation vendors has recently launched a new rebate tracking system, which will continue to safeguard and securely transfer data between the implementation vendor and the Company while processing rebate applications more swiftly.

Additionally, pursuant to the 2017 DSM Final Order, the Company will conduct bi-annual internal audits on its DSM Programs, the next of which will take place in 2019 and could identify additional areas where improvement is possible.

**Q. Is the Company providing information in this filing that outlines the fixed versus variable costs associated with each implementation vendor contract?**

A. As with the Company's previous annual DSM filing updates, the Company will continue to provide new or changed vendor information that identifies fixed and variable costs within each implementation vendor contract, as outlined in my Schedule 46A. Note that incentive costs should be treated as variable costs.

**Q. Do the proposed Programs promote appliances and equipment subject to the federal standards contained in the National Appliance Energy Conservation Act ("NAECA") in accordance with Rule 40(1)(d) of the Promotional Allowance Rules (20 VAC 5-303-40(1)(d))?**

A. Yes. The NAECA standards establish minimum energy efficiency requirements for certain types of residential appliances sold in the United States. The Residential Efficient Products Marketplace Program does promote appliances or equipment that fall within the scope of NAECA.

**Q. Has the Company considered whether the proposed DSM Phase VII Programs will have any significant effect on the sales levels of an alternative energy supplier in accordance with Rule 40(1)(e) of the Promotional Allowances Rules (20 VAC 5-303-40(1)(e))?**

A. As required by Rule 40(1)(e), the Company has considered this issue and does not believe the proposed DSM Phase VII Programs will have a significant effect on the sales levels of alternative energy suppliers. The proposed Programs are not designed or expected to influence the use of one energy source over another but, rather, are designed to specifically target electric applications.

Q. **How will the proposed DSM Programs conform to Rule 40(1)(c) of the Promotional Allowances Rules (20 VAC 5-303-40(1)(c)), which requires that the DSM Programs be designed to minimize the potential for placing private businesses at an undue competitive disadvantage?**

A. The RFP issued for the potential Phase VII Programs requested information regarding how each contractor plans to use other small and/or diverse businesses or subcontractors. When evaluating the bids, the Company favorably considered the bidders' affirmative responses and responsive examples to these questions. This requirement is further embodied in the Company's implementation contracts. Additionally, private businesses serve as the delivery mechanism for services and energy saving measures within the Programs. This approach directly supports local and private businesses.

Q. **Has the Company defined customer classes in compliance with Rule 40(1)(b) of the Promotional Allowances Rules (20 VAC 5-303-40(1)(b))?**

A. Yes, the Company has defined the residential, commercial, and industrial customer classes in compliance with Rule 40(1)(b). The Company uniformly extends the DSM Programs to all customers in each defined class, provided they meet the eligibility requirements.

Q. **How does the Company plan to make customers aware of the proposed Phase VII Programs?**

A. As with the previously-approved DSM Programs, all awareness efforts will be specifically tied to the Programs. As part of the RFP selection process, the successful implementation vendors for the proposed Programs will work with Company's Energy Conservation department staff to review demographic information, target customers, and develop marketing plans. As previously mentioned, the Company anticipates the DSM Phase VII Programs will be implemented through turn-key vendor(s) utilizing a participating contractor network in many instances, similar to many of the previously approved DSM Programs. The Company anticipates using various marketing tactics to promote the Phase VII Programs, such as providing information on its website, www.dominionenergy.com, its social media outlets, on bill inserts, through direct mail, and through in-store promotions.

The Company continues to work with various other departments and use customer newsletters, bill inserts, direct mail campaigns, news releases, outreach seminars, trade shows, and speaking engagements to heighten customer awareness of its energy conservation offerings.

Importantly, the Company will use its experience from its pilots and previously-approved DSM Programs to increase its effectiveness in communicating with customers about the proposed Programs.

**Q. Does this conclude your pre-filed direct testimony?**

A. Yes, it does.

APPENDIX A

# BACKGROUND AND QUALIFICATIONS
# OF
# MICHAEL T. HUBBARD

Michael T. Hubbard is Manager – Energy Conservation for Dominion Energy Virginia. Since 2008, his responsibilities have included oversight of the design and implementation of new DSM programs, including vendor retention and oversight. In 2010, he served on the Governor's Operational Review Taskforce to reduce costs and improve efficiencies for state government. He also served on the board of the Richmond Region Energy Alliance, and is currently on the board of the Virginia Energy Efficiency Council, working with stakeholders on key energy efficiency issues and the promotion of cost effective DSM programs. He is a certified Six Sigma Green Belt.

Mr. Hubbard joined Dominion Energy Virginia in 1996 and has served in a number of regulatory and customer service-related leadership roles in the Delivery and Service Company organizations.

While in the position of Underground Damage Prevention Manager, he was appointed to serve on the Commission's Advisory Committee for matters concerning the enforcement of the Virginia Underground Utility Line Damage Prevention Act, and also served on the board of directors that formed a new statewide Miss Utility call center.

Mr. Hubbard has a B.S. in History from Hampden-Sydney College and M.S.L.S. (Masters in Library Sciences) from the University of Kentucky., and is a member of the Phi Beta Kappa National Honor Society.

Mr. Hubbard has previously presented testimony before the State Corporation Commission of Virginia and the North Carolina Utilities Commission.

## Residential Appliance Recycling Program

**Program Type:**
Energy Efficiency

**Program Description:**
This Program would provide incentives to residential customers to recycle freezers and refrigerators that are of specific age and size. Appliance pick-up and proper recycling services are included.

**Eligibility Requirements:**
All residential customers with qualifying appliances in the Company's Virginia service territory who are on a residential rate schedule.

**Projected Participation:**
Participation is based upon operation of the Program in the Company's service territory for a five-year period.

**Participation Incentive:**
Incentive levels are consistent with program operation of five years.

**Program Measures:**

- Refrigerator recycling
- Freezer recycling

## Residential Customer Engagement Program

**Program Type:** Energy Efficiency (EE)

**Program Description:**
This Program would provide educational insights into the customer's energy consumption via a Home Energy Report (on-line and/or paper version). The Home Energy report is intended to provide periodic suggestions on how to save on energy based upon an analysis of the customer's energy usage. Customers can opt-out of participating in the program at any time.

**Eligibility Requirements:**
This program is available to all eligible Dominion Energy residential account holders. An AMI meter is not required to participate in the Program.

**Projected Participation:**
Participation is based upon operation of the Program in the Company's service territory for a five-year period.

**Participation Incentive:**
There is no direct financial incentive for this Program because it is an educational program.

**Program Measures:**
- Electronic Home Energy Report
- Paper Home Energy Report

## Residential Efficient Products Marketplace Program

**Program Type:** Energy Efficiency (EE)

**Program Description:**
The program would provide residential customers an incentive to purchase specific energy efficient appliances with a rebate through an online marketplace and through stores. The Program would offer rebates for the purchase of specific energy efficient appliances, including lighting efficiency upgrades such as A-line bulbs (prior to 2020), reflectors, decoratives, globes, retrofit kit and fixtures, as well as other appliances such as freezers, refrigerators, clothes washers, dehumidifiers, air purifiers, clothes dryers, and dishwashers.

**Eligibility Requirements:**
This program is available to all eligible Dominion Energy residential account holders. There would be an appropriate limit on the number of appliances that could be purchased by a single customer.

**Projected Participation:**
Participation is based upon operation of the Program in the Company's service territory for a five-year period.

**Participation Incentive:**
Incentive levels are consistent with program operation of five years.

**Program Measures:**
- A-Lines (pre 2020)
- Reflectors
- Decoratives
- Globes
- Retrofit Kit and Fixture
- Freezer
- Refrigeration
- Clothes Washer
- Dehumidifier
- Energy Star Air Purifier
- Clothes Dryer
- Dishwasher

## Residential Home Energy Assessment Program

**Program Type:**
Energy Efficiency

**Program Description:**
This Program would provide residential customers within the Company's Virginia service territory an incentive to install a variety of energy saving measures following completion of a walk-through home energy assessment. The energy saving measures would include the replacement of existing light bulbs with LED bulbs, heat pump tune-up, duct insulation/sealing, fan motors upgrades, installation of efficient faucet aerators and showerheads, water heater turndown, replacement of electric domestic hot water with heat pump water heater, heat pump upgrades (ducted and ductless), and water heater and pipe insulation.

**Eligibility Requirements:**
The Program would be available to residential customers in the Company's Virginia service territory who are on a residential rate schedule. Customers must be responsible for the electric bill and either own the residence or be able to secure permission from the owner to perform the improvements recommended. A customer premise is eligible for one Home Energy Assessment during the proposed initial five year program approval period.

**Projected Participation:**
Participation is based upon operation of the Program in the Company's service territory for a five-year period.

**Participation Incentive:**
Incentive levels are consistent with program operation of five years.

**Program Measures:**
- Water heater pipe insulation
- AC and heat pump duct insulation
- LED lamp upgrades
- Low-flow showerheads and aerators
- Heat pump tune-up / upgrade / duct sealing
- Water heater thermostat set point adjustment
- High-efficiency fan motors
- Water heater replacement with a heat pump water heater
- HVAC ductless unit upgrades

## Residential Smart Thermostat Management Program

**Program Type:** Demand Response (DR)

**Program Description:**
All residential customers who are not already participating in the Company's DSM Phase I Smart Cooling Rewards Program and who have a qualifying smart thermostat would be offered the opportunity to enroll in a peak demand response (DR) Program. Demand response would be called by the Company during times of peak system demand throughout the year and thermostats of participating customers would be gradually adjusted to achieve a specified amount of load reduction while maintaining reasonable customer comfort and allowing customers to opt-out of specific events if they choose to do so.

**Eligibility Requirements:**
This program is available to all eligible Dominion Energy residential account holders who are responsible for their own electric bill and are either the owner of the home or reasonably able to secure permission from the building owner to install a qualified smart thermostat or who already use a qualifying smart thermostat in their residence.

**Projected Participation:**
Participation is based upon operation of the Program in the Company's service territory for a five-year period.

**Participation Incentive:**
Incentive levels are consistent with program operation of five years.

**Program Measures:**
- HP System DR Peak Reduction
- AC System DR Peak Reduction

## Residential Smart Thermostat Management Program

**Program Type:** Energy Efficiency (EE)

**Program Description:**
This Program would provide an incentive to customers to either purchase a qualifying smart thermostat and/or enroll in an energy efficiency program, which would help customers manage their daily heating and cooling energy usage by allowing remote optimization of their thermostat operation, and would provide specific recommendations by e-mail or letter that customers can act on to realize additional energy savings. The Program would be open to several thermostat manufacturers, makes, and models that meet or exceed the Energy Star requirements and have communicating technology. Rebates for the purchase of a smart thermostat would be provided on a one-time basis; incentives for participation in remote thermostat management would be provided on an annual basis. For those customers who enroll in thermostat management, additional energy-saving suggestions, based on operational data specific to the customer's heating and cooling system, would be provided to the customer at least quarterly.

**Eligibility Requirements:**
This program is available to all eligible Dominion Energy residential account holders who are responsible for their own electric bill and are either the owner of the home or reasonably able to secure permission from the building owner to install a qualified smart thermostat or who already use a qualifying smart thermostat in their residence.

**Projected Participation:**
Participation is based upon operation of the Program in the Company's service territory for a five-year period.

**Participation Incentive:**
Incentive levels are consistent with program operation of five years.

**Program Measures:**
- Smart Thermostat

## Non-residential Lighting Systems & Controls Program

**Program Type:**
Energy Efficiency

**Program Description:**
This Program would provide qualifying non-residential customers with an incentive to implement more efficient lighting technologies that can produce verifiable savings. The Program promotes the installation of lighting technologies including but not limited to LED-based bulbs and lighting control systems.

**Eligibility Requirements:**
All non-residential customers, who are not exempt by statute, are eligible. This includes customers in the following rate schedules: 5, 25, 5C, 5P, GS-1, GS-2T, 6, 6TS, 7, 29, GS-2 ND, DP-1, DP-2, and SP.

**Projected Participation:**
Participation is based upon operation of the Program in the Company's service territory for a five-year period.

**Participation Incentive:**
Incentive levels are consistent with program operation of five years.

**Program Measures:**

- High efficiency T8/T5 lamps
- LED lamps
- Occupancy sensors / lighting controls

## Non-residential Heating and Cooling Efficiency Program

**Program Type:**
Energy Efficiency

**Program Description:**
This Program would provide qualifying non-residential customers with incentives to implement new and upgrade existing high efficiency heating and cooling system equipment to more efficient HVAC technologies that can produce verifiable savings.

**Eligibility Requirements:**
All non-residential customers, who are not exempt by statute, are eligible. This includes customers in the following rate schedules: 5, 25, 5C, 5P, GS-1, GS-2T, 6, 6TS, 7, 29, GS-2 ND, DP-1, DP-2, and SP.

**Projected Participation:**
Participation is based upon operation of the Program in the Company's service territory for a five-year period.

**Participation Incentive:**
Incentive levels are consistent with program operation of five years.

**Program Measures:**

- Air conditioner upgrade
- Heat pump upgrade
- Geothermal heat pumps
- Water source heat pumps
- Chiller upgrade
- Economizers
- Variable frequency drives
- Variable refrigerant flow
- Unitary AC
- Mini splits

## Non-residential Window Film Program

**Program Type:**
Energy Efficiency

**Program Description:**
This Program would provide qualifying non-residential customers with an incentive install solar reduction window film to lower their cooling bills and improve occupant comfort.

**Eligibility Requirements:**
All non-residential customers, who are not exempt by statute, are eligible. This includes customers in the following rate schedules: 5, 25, 5C, 5P, GS-1, GS-2T, 6, 6TS, 7, 29, GS-2 ND, DP-1, DP-2, and SP

**Projected Participation:**
Participation is based upon operation of the Program in the Company's service territory for a five-year period.

**Participation Incentive:**
Incentive levels are consistent with program operation of five years.

**Program Measures:**

- Solar window film

## Non-residential Small Manufacturing Program

**Program Type:**
Energy Efficiency

**Program Description:**
This Program would provide qualifying customers incentives for the installation of energy efficiency improvements, consisting of primarily compressed air systems measures for small manufacturing facilities.

**Eligibility Requirements:**
All non-residential customers, who are not exempt by statute, are eligible. This includes customers in the following rate schedules: 5, 25, 5C, 5P, GS-1, GS-2T, 6, 6TS, 7, 29, GS-2 ND, DP-1, DP-2, and SP.

**Projected Participation:**
Participation is based upon operation of the Program in the Company's service territory for a five-year period.

**Participation Incentive:**
Incentive levels are consistent with program operation of five years.

**Program Measures:**
- Compressed air nozzles
- Leaks
- No loss drains
- Add storage
- Heat of compression dryer
- Low PD Filter
- Variable speed drive air compressor
- Cycling refrigerant dryer
- Dewpoint controls
- Pressure reduction
- Downsized variable frequency drive compressor

## Non-residential Office Program

**Program Type:**
Energy Efficiency

**Program Description:**
This Program would provide qualifying customers incentives for the installation of energy efficiency improvements, consisting of recommissioning measures at smaller office facilities.

**Eligibility Requirements:**
All non-residential customers, who are not exempt by statute, are eligible. This includes customers in the following rate schedules: 5, 25, 5C, 5P, GS-1, GS-2T, 6, 6TS, 7, 29, GS-2 ND, DP-1, DP-2, and SP

**Projected Participation:**
Participation is based upon operation of the Program in the Company's service territory for a five-year period.

**Participation Incentive:**
Incentive levels are consistent with program operation of five years.

**Program Measures:**

- Schedule lighting
- Schedule HVAC
- Temperature setback
- Condenser water reset
- Discharge air temp reset
- Static pressure reset
- Enthalpy economizer
- Variable air volume box minimum

## VIRGINIA ELECTRIC & POWER COMPANY
## SIMULTANEOUS PROGRAMS MATRICES[1]

| **Residential Programs** | AC Cycling | Income and Age Qualifying | Residential Smart Thermostat Management (DR) | Residential Smart Thermostat Management (EE) | Residential Customer Engagment | Residential Efficients Products Marketplace | Residential Home Energy Assessment | Residential Appliance Recycling | Dynamic Pricing |
|---|---|---|---|---|---|---|---|---|---|
| AC Cycling | | | | | | | | | |
| Income and Age Qualifying Home Improvement Program | | | | | | | | | |
| Residential Smart Thermostat Management (DR) | | | | | | | | | |
| Residential Smart Thermostat Management (EE) | | | | | | | | | |
| Residential Customer Engagement | | | | | | | | | |
| Residential Efficient Products Marketplace | | | | | | | | | |
| Residential Home Energy Assessment | | | | | | | | | |
| Residential Appliance Recycling | | | | | | | | | |
| Dynamic Pricing Rate Schedule | | | | | | | | | |

[1] Gray shading reflects Programs where simultaneous participation is prohibited

Company Exhibit No. __
Witness: MTH
Schedule 2
Page 1 of 2

## VIRGINIA ELECTRIC & POWER COMPANY
## SIMULTANEOUS PROGRAMS MATRICES[1]

| **Non-residential Programs** | DG | Window Film (Phase VII) | Lighting Systems (Phase VII) | Heating & Cooling Efficiency (Phase VII) | Small Business Improvement | Non-Residential Prescriptive | Non-residential Office | Non-residential Small Manufacturing | Dynamic Pricing | SG/CS | Schedule 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DG | | | | | | | | | | | |
| Window Film | | | | | | | | | | | |
| Lighting Systems & Controls | | | | | | | | | | | |
| Heating & Cooling Efficiency | | | | | | | | | | | |
| Small Business Improvement Program | | | | | | | | | | | |
| Non-residential Prescriptive | | | | | | | | | | | |
| Non-residential Office | | | | | | | | | | | |
| Non-residential Small Manufacturing | | | | | | | | | | | |
| Dynamic Pricing Rate Schedule | | | | | | | | | | | |
| Standby Generation (SG)/ Curtailable Service (CS) Rate Schedules | | | | | | | | | | | |
| Schedule 10 Rate Schedule | | | | | | | | | | | |

[1] Gray shading reflects Programs where simultaneous participation is prohibited

Company Exhibit No. __
Witness: MTH
Schedule 24
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Company Exhibit No. __
Witness: MTH
Schedule 3
Page 1 of 7

## Dominion Virginia Power
## Virginia-based DSM Programs

**Phase I**
**Case No. PUE-2009-00081**
**Filed: July 28, 2009**
**Order: March 24, 2010**
**Dollars in Millions**

| Program | Segment | Type | Result | Costs Requested[1] | Costs Approved[2] | Costs to Date[3] | Start Date[4] | End Date | Currently In | Participation[5] |
|---|---|---|---|---|---|---|---|---|---|---|
| AC Cycling | Residential | Peak Shaving | Approved[6][7] | $46.5M+ 61.6M+$54M | $175.1M (46.5M+61.6M +13.0M+$54M) | $73.4M | 6/1/10 | Active | Base Rates | 150,607 Gross Customers |
| Lighting (2 Years Only) | Residential | Energy Efficiency | Approved | $13.0M | | $12.6M | 5/1/10 | 12/1/11 | N/A | 4,222,509 Bulbs |
| Low Income | Residential | Energy Efficiency | Approved[8] | $27.4M | $41.0M (27.4M+13.6M) | $16.7M | 4/1/10 | 12/31/14 | N/A | 11,487 Customers |
| Lighting | Non-Residential | Energy Efficiency | Approved[9] | $12.8M | $15.4M | $10.7M | 6/1/10 | 7/1/12 | N/A | 2,409 Customers |
| HVAC | Non-Residential | Energy Efficiency | Approved[9] | $2.6M | | $2.9M | 7/1/10 | 7/1/12 | N/A | 123 Customers |
| Refrigerator Turn-In | Residential | Energy Efficiency | Denied | $3.9M | | | | | | |
| Heat Pump Upgrade | Residential | Energy Efficiency | Denied | $14.1M | | | | | | |
| Heat Pump Tune-Up | Residential | Energy Efficiency | Denied | $19.9M | | | | | | |
| Energy Star New Homes | Residential | Energy Efficiency | Denied | $8.1M | | | | | | |
| Distributed Generation | Non-Residential | Peak Shaving | Denied | $12.1M | | | | | | |
| Curtailment Service | Non-Residential | Peak Shaving | Denied | $11.8M | | | | | | |

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[1] Derived from Exhibit 51 in Case No. PUE-2009-00081, which calculated cost caps (exclusive of lost revenues) based on 11 proposed programs. The Commission approved 5 Programs, so these figures are based on the elimination of 6 programs from Exhibit 51.

[2] Not calculated to include lost revenues for Cost limits in Case PUE-2009-00081.

[3] As of June 30, 2018.

[4] Indicates the month in which the first participant was recorded.

[5] As of June 30, 2018.

[6] Program extension of three years approved in Case No. PUE-2012-00100, with additional cost cap approval of $61,622,665 (to include lost revenues).

[7] Program extension of five years approved in Case No. PUE-2015-00089, with additional cost cap approval of $54,131,049 (to include lost revenues).

[8] Program extension of two years approved in Case No. PUE-2012-00100, with additional cost cap approval of $13,617,854 (to include lost revenues).

[9] Program additional funding denied in Case No. PUE-2011-00093.

Company Exhibit No. __
Witness: MTH
Schedule 3
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| | |
|---|---|
| **Voltage Conservation** | Withdrawn |

Company Exhibit No. __
Witness: MTH
Schedule 3
Page 3 of 7

# Dominion Virginia Power
## Virginia-based DSM Programs

**Phase II**
**Case No. PUE-2011-00093**
**Filed: September 1, 2011**
**Order: April 30, 2012**
**Dollars in Millions**

| Program | Segment | Type | Result | Costs Requested[10] | Costs Approved[11] | Costs to Date[12] | Start Date | End Date | Currently In | Participation |
|---|---|---|---|---|---|---|---|---|---|---|
| **Home Energy Checkup** | Residential | Energy Efficiency | Approved | $5.9M | $90.0M[13] | $20.2M | Oct. 2012 | 6/30/17 | A5 – C2A | 51,914 Customers |
| **Duct Sealing** | Residential | Energy Efficiency | Approved | $7.7M | | $5.1M | Oct. 2012 | 6/30/17 | A5 – C2A | 3,298 Heat Pumps |
| **Heat Pump Upgrade** | Residential | Energy Efficiency | Approved | $24.5M | | $11.8M | Oct. 2012 | 6/30/17 | A5 – C2A | 17,785 Heat Pumps |
| **Heat Pump Tune-Up** | Residential | Energy Efficiency | Approved | $27.9M | | $18.6M | Oct. 2012 | 6/30/17 | A5 – C2A | 87,126 Heat Pumps |
| **Energy Audit** | Non-Residential | Energy Efficiency | Approved | $8.8M | $45.0M[14] | $12.0M | Dec. 2012 | 6/30/17 | A5 – C2A | 1,625 Customers |
| **Duct Testing & Sealing** | Non-Residential | Energy Efficiency | Approved | $24.1M | | $29.0M | Nov. 2012 | 6/30/17 | A5 – C2A | 4,444 Customers |
| **Distributed Generation** | Non-Residential | Peak Shaving | Approved | $14.2M+$4.8M | $19.0M($14.2M +$4.8M[15]) | $8.0M | N/A[16] | Active | A5 – C1A | 36.1 Megawatts |
| **EV Pilot Cost Recovery** | Residential | Peak Shaving | Approved | $.825M | $.825M | $.8M | Oct. 2011 | Active | A5 – C1A | 588 Customers |
| **Lighting Phase II** | Residential | Energy Efficiency | Denied | $25.2M | | | | | | |
| **Refrigeration** | Non-Residential | Energy Efficiency | Denied[17] | $47.9M | | | | | | |

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[10] Includes Program O&M Costs, Margin on Program Costs, and Common Costs associated with approved programs.
[11] Includes Program O&M Costs, Margin on Program Costs, Common Costs associated with approved programs, and Lost Revenues.
[12] As of June 30, 2018.
[13] Dominion should strive to allocate a significant portion of its program expenditures to the Residential Home Energy Check-Up Program.
[14] Dominion should strive to allocate a significant portion of its program expenditures to the Commercial Energy Audit Program.
[15] Includes Program O&M Costs of $4.6M, and Common Costs of $.275M. PUE-2016-00111
[16] Some participants originally enrolled during the Distributed Generation Pilot Program.
[17] Commission ordered in Case No. PUE-2011-00093 that condenser coil measure should be added to the Non-Residential Energy Audit.

Company Exhibit No. __
Witness: MTH
Schedule 3
Page 4 of 7

## Dominion Virginia Power
## Virginia-based DSM Programs

**Phase III**
**Case No. PUE-2013-00072**
**Filed: August 30, 2013**
**Order: April 29, 2014**
**Dollars in Millions**

| Program | Segment | Type | Result | Costs Requested | Costs Approved | Costs to Date[18] | Start Date | End Date | Currently In | Participation |
|---|---|---|---|---|---|---|---|---|---|---|
| **Window Film** | Non-Residential | Energy Efficiency | Approved | $114.4M[19] | $71.6M | $2.1M | 7/1/2014 | Active | A5 – C2A | 191 Customers |
| **Lighting Systems & Controls** | Non-Residential | Energy Efficiency | Approved | | | $29.0M | 7/1/2014 | Active | A5 – C2A | 3,644Customers |
| **Heating & Cooling Efficiency** | Non-Residential | Energy Efficiency | Approved | | | $5.9M | 7/1/2014 | Active | A5 – C2A | 341 Customers |

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[18] As of June 30, 2018.

[19] Includes Program O&M Costs of $71.9M, Margin on Program Costs of $8.3M, Common Costs of $12M, and $22.2M of Lost Revenues.

Company Exhibit No. __
Witness: MTH
Schedule 3
Page 5 of 7

**Phase IV**
**Case No. PUE-2014-00071**
**Filed: August 29, 2014**
**Order: April 24, 2015**
**Dollars in Millions**

| Program | Segment | Type | Result | Costs Requested | Costs Approved | Costs to Date | Start Date | End Date | Currently In | Participation |
|---|---|---|---|---|---|---|---|---|---|---|
| **Income and Age Qualifying Home Improvement** | Residential | Energy Efficiency | Approved | $109.4M[20]+<br>$23.6M[21] | $15.2M+$12.7M[22]<br>$4.8M | $15.1M | 7/1/2015 | Active | A5 – C2A | 15,893 Customers |
| **Residential Appliance Recycling** | Residential | Energy Efficiency | Approved | | | $4.5M | 7/1/2015 | 7/31/2017 | A5 – C2A | 14,144 Appliances |
| **Qualifying Small Business Improvement** | Non-Residential | Energy Efficiency | Denied | | | | | | | |

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[20] Includes Program O&M Costs of $74.3M, Margin on Program Costs of $7.4M, Common Costs of $4.9M, and $22.8M of Lost Revenues.

[21] Includes Program O&M Costs of $19.1M, Margin on Program Costs of $1.8M, Common Costs of $1.1M, and $1.6M of Lost Revenues.

[22] Program extension of three years approved in Case No. PUR-2017-00129, with additional cost cap approval of $12.7M.

**Phase V**
**Case No. PUE-2015-00089**
**Filed: August 28, 2015**
**Order: April 19, 2016**
**Dollars in Millions**

| Program | Segment | Type | Result | Costs Requested | Costs Approved | Costs to Date | Start Date | End Date | Currently In | Participation |
|---|---|---|---|---|---|---|---|---|---|---|
| **Small Business Improvement** | Non-Residential | Energy Efficiency | Approved | $51.4M[23] | $23.5M | $7.2M | 7/1/2016 | Active | A5 – C2A | 1,284 Customers |
| **Residential Programmable Thermostat** | Residential | Energy Efficiency | Denied | | | | | | | |

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[23] Includes Program O&M Costs of $35.1M, Margin on Program Costs of $3.5M, Common Costs of $2.5M, and $10.2M of Lost Revenues.

**Phase VI**
**Case No. PUE-2016-00111**
**Filed: October 3, 2016**
**Order: June 1, 2017**
**Dollars in Millions**

| Program | Segment | Type | Result | Costs Requested | Costs Approved | Costs to Date | Start Date | End Date | Currently In | Participation |
|---|---|---|---|---|---|---|---|---|---|---|
| **Home Energy Assessment** | Residential | Energy Efficiency | Denied | $64.6M[24] | | | | | | |
| **Non-Residential Prescriptive** | Non-Residential | Energy Efficiency | Approved | $70.3M[25] | $36.0M | $5.3M | 7/1/2017 | Active | A5 - C2A | 628 Customers |

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[24] Includes Program O&M Costs of $43.8M, Margin on Program Costs of $4.5M, Common Costs of $2.6M, and $13.6M of Lost Revenues.
[25] Includes Program O&M Costs of $29.0M, Margin on Program Costs of $2.8M, Common Costs of $1.7M, and $36.7M of Lost Revenues.

Company Exhibit No.__
Witness: MTH
Schedule 4
Page 1 of 2

## Rebate Review and Approval Process

- Program Terms and Conditions (T&Cs) for each Program clearly state eligibility requirements, Program guidelines and the documentation that must be submitted before a rebate is eligible to be issued. T&Cs are incorporated into each rebate application and require a customer signature reflecting the acceptance and understanding of those T&Cs.
- Prior to a Program's launch, the Company's Implementation Contractor (IC), the Company's EM&V Vendor and the Company determine data and eligibility requirements for the Company's Technical Validations, Daily Activity Files (DAFs), and Rebate Funding Requests. Those data requirements are then used to develop the required information on rebate application forms and data filters that are used to flag potential issues of concern.
- All rebate applications are reviewed for missing information or documentation by the IC. Applications requiring pre-approval or reservations are verified against IC's pre-approval / reservation records. Customers and/or contractors are contacted to supply any missing information prior to entry of the application into the IC's tracking and processing system. Each new participating contractor must have its first five (5) projects field inspected by our IC before it can become a participating vendor/contractor. Afterwards, 5% of all projects by all contractors are randomly selected for quality field inspections. Those quality inspections of the jobsite provide additional data verification by our IC's Quality Assurance Team.
- DAFs for complete projects are passed to Dominion Energy's Business Intelligence Datamart (BI) from the IC. When the DAFs are transferred to the BI, records must pass technical validation via Program-specific data filters to ensure that data is in the proper format, that all required data is present and that the data falls within the allowable range, as agreed prior to the Program's launch.
- Upon receipt of a rebate funding request, the request is matched to the associated DAF in the BI and technical validations are run for the funding request. The validation compares the Company's Billing system, DAFs, and previously submitted rebate requests for the subject premises.
- The responsible Program manager and analyst for each Program receive an account funding report containing all submitted rebate requests weekly. All rebate requests flagged with failing any validation are automatically rejected and flagged for Program Manager/Program Analyst attention. All rebate funding requests are individually reviewed by the Program Manager/Analyst and any rejections must be manually overridden to fund the rebate. Rebate requests that are rejected by the Company are noted in a report sent to the IC to either notify the customer of the rejection or to remedy the problem for resubmission in a later rebate funding request.

Company Exhibit No.__
Witness: MTH
Schedule 4
Page 2 of 2

- All approved requests are funded in accordance with the Program guidelines and the funding is electronically transmitted to the Company's IC for payment. Following receipt of the funding, IC only issues payment of the rebates to the customer of record (in the Company's billing system) or the customer's contractor, if the customer designates payment directly to the contractor during the rebate application process.
- The Company's EM&V vendor receives a monthly download from Dominion Energy's BI of all paid rebates by Program. This data is used to calculate Program savings, but also is used for Program follow-up with regard to customer satisfaction, determination of realization rates and assessment of free ridership. In the course of these activities, any inconsistencies associated with previously paid rebates are reported to the Company for follow-up, offering additional assurance that proper controls are in place.

Company Exhibit No. __
Witness: MTH
Schedule 5
Page 1 of 1

# Operational Procedures

| | | | |
|---|---|---|---|
| Procedure: | Pre-Approval Process Overview | | |
| Version: | 1.0 | Created: | 08/29/17 |
| Audience | Program Coordinators, Field Reps, Data Entry Reps | | |

| **Steps** | **Instructions** |
|---|---|
| Research Past Participation | Assess whether customer participated in same measure previously [note: this is allowed for some programs]. Search by account # and service address. |
| Account Verification | 1. Create work order – key items, upload images, determine expected rebate amount (reserved $$)<br>2. Check account eligibility:<br>Rate code (SBI Program: Only specific codes eligible)<br>Opt Out<br>Masterfile account exceptions<br>kW Usage & number of eligible locations (SBI Program only)<br>3. Cancel this work order AFTER pre-approval completed. Cancellation reason = account verification. |
| Pre-Inspection | Determine if measure requires Program Coordinator sign off and/or on-site pre-inspection, based on program-level requirements |
| Notification | Notify sender of pre-approval docs whether approved or denied.<br>Email notification preferred (documentation).<br>Customers/contractors are given 180 days to complete the installation. |
| Document system | 1. Log: Update pipeline file in HON internal sharepoint with expected start & end dates, $$ reserved, measures, approval status.<br>2. System: Add interaction note ref pre-approval decision (approved, denied, pre-inspection pending) |
| Process Rebate Application | After installs completed, upon receipt of rebate application cross reference the application with the pre-approval documents, address any discrepancies between measures approved versus measures installed with customer/contractor. |

Attachment A

# SUPPLEMENTAL DIRECT TESTIMONY
# OF
# MICHAEL T. HUBBARD
# ON BEHALF OF
# VIRGINIA ELECTRIC AND POWER COMPANY
# BEFORE THE
# STATE CORPORATION COMMISSION OF VIRGINIA
# CASE NO. PUR-2018-00168

**Q. Please state your name, position with Virginia Electric and Power Company ("Dominion Energy Virginia" or the "Company"), and business address.**

A. My name is Michael T. Hubbard, and I am Manager – Energy Conservation for Dominion Energy Virginia. My business address is 701 East Cary Street, Richmond, Virginia 23219.

**Q. Have you previously submitted testimony in this proceeding?**

A. Yes, my pre-filed direct testimony was filed with the State Corporation Commission of Virginia ("Commission") on behalf of Dominion Energy Virginia in this proceeding on October 3, 2018.

**Q. What is the purpose of your supplemental direct testimony?**

A. My supplemental direct testimony addresses the program description and overview of the Residential Efficient Products Marketplace Program on pages 10-11 of my direct testimony. In particular, I am updating the language on page 11 of my direct testimony from "All rebates will be tied to a Company account prior to approval of a rebate. Purchases through the online marketplace will be verified electronically as being made by a Company customer in real-time and purchases from retail stores will be verified after purchases but prior to issuance of a rebate through a rebate request/application process" to "All rebates will be tied to a Company account prior to approval of a rebate with the exception of lighting products. Purchases through the online marketplace will be verified electronically as being made by a Company customer in real-time and purchases from retail stores, *with the exception of lighting products*, will be verified after purchases but prior to issuance of a rebate through a rebate request/application process."

**Q. Can you elaborate further on the program description update?**

A. Yes. Since filing my direct testimony, the Company has received clarifying information from the program designer of the Residential Efficient Products Marketplace Program regarding the customer verification process proposed to be included within their design. The design, as proposed by the program designer, would include a customer verification process, prior to the rebate or discount being received by the customer, for all products sold through the online marketplace (including lighting) and most products sold in physical stores with the exception of lighting products sold in physical stores.

The program designer has indicated to the Company that this approach is important in order to minimize barriers to customer participation, which, in turn, maximizes energy savings and overall cost-effectiveness of the Program. For small purchases, such as energy efficient light bulbs purchased in stores, the program designer believes that requiring customer verification prior to receiving a rebate or discount would substantially reduce participation, overall energy savings, and cost-effectiveness of the Program.

Rather than require individual customer verification for in-store, low-cost light bulb purchases, the program designer proposes to employ a statistical tool to minimize program leakage (*i.e.*, minimize the number of non-Dominion Energy Virginia customers purchasing bulbs). The statistical tool proposed for use in this Program is known as the

Retail Sales Allocation Tool ("RSAT") and is used in the energy efficiency industry specifically to reduce program leakage associated with retail energy efficient product programs. For the Company's proposed Program, the RSAT tool would be used to analyze the actual available retail stores within the Company's service territory. The RSAT tool utilizes retailer and product specific "drive time" information to develop a trade area for each selected retailer. This trade area is then analyzed to determine the percentage of customers within the trade area that are Dominion Energy Virginia customers. This percentage is then utilized to determine if the selected retailer should be included in the program. Furthermore, the RSAT methodology models the way consumers interact with retailers within a store's local trade area and the geographic region around the store where most potential customers live and where the majority of purchases are installed. Key elements of the model include the type of product being purchased, retailer environment, drive time, population density around the store, geographic features near the store, road networks, proximity of other retail locations, and demographics of households in trade area and utility territories.

The program designer believes that using this approach to carefully select stores in which to place light bulbs for sale under this Program would substantially improve participation from Dominion Energy Virginia customers, energy-savings, and cost-effectiveness of the Program relative to requiring a rebate application / customer verification process for small, low-cost light bulb purchases at the in-store, retail level.

The Company has found through examination of bids from other program designers who included in-store customer verification processes for the lighting products in the Residential Efficient Products Marketplace Program that the increased cost of such processes led to programs that were not cost-effective and not generally consistent with successful programs in other jurisdictions. The Company believes that use of the RSAT tool for in-store retail purchases of lighting products is a reasonable, industry-standard, method to reduce leakage of the Program. The program designer has further applied a net-to-gross ratio of 70% in order to discount energy and demand savings estimates to account for savings that are not readily attributable to the Program.

Q. **Does the Company propose any further assessment of leakage for this Program?**

A. Yes. In order to maximize overall success and cost-effectiveness of the Program, the Company believes that the Program should be approved as proposed, with full verification of purchases made through the online marketplace and full verification of products made in stores, with the exception of lighting products. In order to assess program leakage associated with this Program, if approved, the Company further proposes to direct its program implementation contractor and/or evaluation, measurement, and verification ("EM&V") contractor to perform appropriate surveys to specifically assess program leakage associated with this Program and to include the results in relevant future EM&V reports.

Q. **Does this conclude your pre-filed supplemental direct testimony?**

A. Yes, it does.

# Appendix J. Residential Home Energy Assessment Program EM&V Plan

# J. RESIDENTIAL HOME ENERGY ASSESSMENT PROGRAM EM&V PLAN (VERSION 1.0)

## J.1 Program Summary

The Residential Home Energy Assessment Program provide residential customers an incentive to install a variety of energy saving measures following completion of a walk-through home energy assessment. Recommendations from the program may lead to participation in other Dominion Energy programs.

## J.2 Measures

A home energy assessment is required for a customer to be eligible for the direct-install and incentivized measures:

1. Water heater pipe insulation
2. AC and heat pump duct insulation
3. LED lamp upgrades
4. Low-flow showerheads and aerators
5. Heat pump tune-up / upgrade / duct sealing
6. Water heater thermostat set point adjustment
7. High-efficiency fan motors
8. Water heater replacement with a heat pump water heater
9. HVAC ductless unit upgrades

## J.3 Evaluation, Measurement, and Verification Overview

DNV GL will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[13] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV GL's savings evaluation approach are:

1. Baseline Consumption: Baseline consumption will be calculated from monthly or AMI participant and non-participant consumption data.
2. Deemed Savings: Deemed savings (or gross savings) values will be estimated from the DNV GL Standard Tracking and Engineering Protocol (STEP) Manual, which are derived primarily from the most recent version of the Mid-Atlantic Technical Resource Manual (TRM), and as appropriate, other TRMs.
3. Evaluated Savings: Evaluated savings (or net savings) will be determined by the methods described in Section 2.5. The evaluated savings will use program tracking data, customer energy consumption data, and other customer data to estimate program savings.

DNV GL takes a holistic approach to evaluation planning for the Company's portfolio of energy conservation programs. DNV GL balances cost-effectiveness and rigor to its evaluation planning so the Company can insure its programs are cost effective and yield planned savings. This program will follow a staged evaluation plan, where DNV GL will take a two-step approach. During program start-up, kilowatts and kilowatt-hour

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[13] 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

savings are estimated using a deemed savings approach. Deemed approaches are a cost-effective method for determining reasonable savings estimates in the early stage of implementation, and in the periods between more rigorous EM&V.

Once participation has levelized or reached planned levels, and realized savings can be quantified, the program is considered for evaluation. Based on results from the DSM Phase I through III programs – programs that were implemented for more than three years as of this filing, and similar programs in other jurisdictions, DNV GL anticipates this will occur in year two of program operations.

Early in the third year of the program, or earlier at the Company's discretion – and assuming they are approved for the five years that they have been filed, they will be evaluated with the method most suitable to the program, program measures, and evaluation objectives. Methods include impact analysis using engineering analysis or whole facility methods, market studies, and process evaluations. Programs selected for evaluation in each year will be prioritized based on several factors, including but not limited to the uncertainty or variability of realized savings, its contribution to portfolio savings, program costs relative to all programs, the elapsed time since the last evaluation, or to address targeted research questions.

## J.4 Deemed Savings Approach

Upon program approval by the Virginia State Corporation Commission, deemed savings approach or protocol for the Residential Home Energy Assessment Program will be developed through research primarily in the most recent version of the Mid-Atlantic Technical Reference Manual (TRM), and other TRMs or relevant studies, as appropriate. The deemed savings protocol for measures in this program will be documented in the STEP Manual, also known as the Company's TRM, and calculated using utility-reported program participant data. DNV GL will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatt and kilowatt-hours. Where such data is impractical for implementation contractors to collect, DNV GL will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV GL will take into consideration the priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

## J.5 Evaluated Savings Approach

During program implementation Dominion Energy will determine, in consultation with DNV GL, the appropriateness of conducting evaluations to estimate program net savings in net kilowatt and net kilowatt-hours.

According to Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol of The Uniform Methods Project (UMP), the evaluation approach will include a billing analysis with a comparison group.[14] The analysis will use a site-level and panel-model billing analysis approach (see section 2.5.1). The

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[14] Agnew, K., Goldberg, M. (2017). Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory; NREL/SR-7A40-68564. http://www.nrel.gov/docs/fy17osti/68564.pdf

analysis will also follow the general approach of The International Performance Measurement and Verification Protocol (IPMVP), Option C, Whole Facility.[15]

### J.5.1 Savings Estimation

The billing analysis for the Residential Home Energy Assessment Program will require a comparison group of non-participating customers. The matched comparison group customers will be selected based on their similarity to program participant consumption characteristics.

The billing analysis will use two approaches cited in the UMP, Chapter 8. Results will consider actual weather conditions and weather-normalized results for both approaches.

1. The site-level approach will estimate site-level models for each customer in the participant and comparison group. The site-level models control for heating and cooling using a method that facilitates weather normalization at the site-level. The weather-normalized annual consumption (NAC) estimates are then combined in a second stage regression to provide either average customer savings or average measure-level savings.
2. The panel model approach estimates a single model for all participant and comparison group customers. The model accounts for heating and cooling, differences between the participant and comparison groups, and the participant pre-post consumption difference.

### J.5.2 Sample Design Considerations

Billing analysis is conducted on the program population, or census, over the analysis period. Sampling may be applied for a free-ridership survey, if applicable.

The following characteristics will be considered:

- Confidence interval: 85 to 90%
- Relative precision: 10 to 15%
- Installed measures
- Budget, schedule, and geographical distribution

### J.5.3 Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV GL standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

## J.6 Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the billing analysis.[16]

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[15] Efficiency Value Organization. 2016. Core Concepts, International Performance Measurement and Verification Protocol.

[16] The realization rate is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

2. Apply the evaluated savings to the participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation.
3. Develop cumulative monthly energy savings based on measured and evaluated data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

## J.7 Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 15th of each year following program launch).
- Update STEP Manual annually for updates that occurred to its referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.
- If appropriate, support lost revenue recovery activities.

## J.8 Residential Home Energy Assessment Program EM&V Plan Document Revision History

| Version | Notes |
|---|---|
| **Version 1.0** | New version |

# Appendix K. Non-residential Lighting Systems & Controls Program (DSM Phase VII) EM&V Plan

# K. NON-RESIDENTIAL LIGHTING SYSTEMS & CONTROLS PROGRAM EM&V PLAN (VERSION 1.0)

## K.1 Program Summary

This program would provide qualifying non-residential customers with an incentive to implement more efficient lighting technologies that can produce verifiable savings. The program promotes the installation of lighting technologies, including, but not limited to, LED-based bulbs and lighting control systems.

## K.2 Measures

The following high efficiency lighting measures are included in the program:

1. High efficiency T8/T5 lamps
2. LED lamps
3. Occupancy sensor(s) and lighting controls

## K.3 Evaluation, Measurement, and Verification Overview

DNV GL will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[17] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV GL's savings evaluation approach are:

1. Baseline Consumption: The baseline wattage will be computed using the prescriptive replacement combinations presented in the Standard Tracking and Engineering Protocols (STEP) Manual. The replaced lighting fixtures from the rebate application data will be used, applying hours of use as metered in on-site studies of installed rebated measures from a representative sample of participants in Virginia.
2. Deemed Savings: Deemed savings (or gross savings) values will be estimated from the DNV GL STEP Manual, which are derived primarily from the most recent version of the Mid-Atlantic Technical Resource Manual (TRM), and as appropriate, other TRMs.
3. Verified Savings: Verified savings (or net savings) will be determined using on-site data. The wattage and hours of use data for the installed efficiency measure will be collected and metered through an on-site study of installed rebated measures from a representative sample of participants.

DNV GL takes a holistic approach to evaluation planning for the Company's portfolio of energy conservation programs. DNV GL balances cost-effectiveness and rigor to its evaluation planning so the Company can insure its programs are cost effective and yield planned savings. This program will follow a staged evaluation plan, where DNV GL will take a two-step approach. During program start-up, kilowatts and kilowatt-hour savings are estimated using a deemed savings approach. Deemed approaches are a cost-effective method for determining reasonable savings estimates in the early stage of implementation, and in the periods between more rigorous EM&V.

Once participation has levelized or reached planned levels, and realized savings can be quantified, the program is considered for evaluation. Based on results from the DSM Phase I through III programs –

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[17] 20 VAC5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

programs that were implemented for more than three years as of this filing, and similar programs in other jurisdictions, DNV GL anticipates this will occur in year two of program operations.

Early in the third year of the program, or earlier at the Company's discretion – and assuming they are approved for the five years that they have been filed, they will be evaluated with the method most suitable to the program, program measures, and evaluation objectives. Methods include impact analysis using engineering analysis or whole facility methods, market studies, and process evaluations. Programs selected for evaluation in each year will be prioritized based on several factors, including but not limited to the uncertainty or variability of realized savings, its contribution to portfolio savings, program costs relative to all programs, the elapsed time since the last evaluation, or to address targeted research questions.

## K.4 Deemed Savings Approach

Upon program approval by the Virginia State Corporation Commission, deemed savings approach or protocol for the Non-residential Lighting Systems & Controls Program will be developed through research primarily in the most recent version of the Mid-Atlantic Technical Reference Manual (TRM), and other TRMs or relevant studies, as appropriate. The deemed savings protocol for measures in this program will be documented in the STEP Manual, also known as the Company's TRM, and calculated using utility-reported program participant data. DNV GL will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatt and kilowatt-hours. Where such data is impractical for implementation contractors to collect, DNV GL will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV GL will take into consideration the priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

## K.5 Evaluated Savings Approach

During program implementation Dominion Energy will determine, in consultation with DNV GL, the appropriateness of conducting evaluations to estimate program net savings in net kilowatt and net kilowatt-hours.

According to Chapter 2: Commercial and Industrial Lighting Evaluation Protocol[18] of The Uniform Methods Project[19] (UMP), the key measured parameters for lighting retrofits include the hours of use and the fixture wattages (energy efficient and baseline). According to Chapter 3: Commercial and Industrial Lighting Controls Evaluation Protocol,[20] the key measured parameters for occupancy sensor retrofits include the hours of use (energy efficient and baseline) and the controlled fixture wattages.

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[18] Gowans, D.; Telarico, C. (2017). Chapter 2: Commercial and Industrial Lighting Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68558. http://www.nrel.gov/docs/fy17osti/68558.pdf

[19] Li, M.; Haeri, H.; Reynolds, A. (2018). The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-70472. http://www.nrel.gov/docs/fy18osti/70472.pdf

[20] Carlson, Stephen. (2017). Chapter 3: Commercial and Industrial Lighting Controls Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/ SR-7A40-68559. http://www.nrel.gov/docs/fy17osti/68559.pdf

At a high level, the ratio of the measured and verified savings to the deemed savings for the sample, also called a realization rate,[21] is then applied to the population of participants to estimate overall program savings. This approach will capture Company-specific customer usage data, and then apply those to the actual measures installed to quantify energy and peak demand savings.

## K.5.1 Sample Design Considerations

The sample frame will be comprised of the earlier of either approximately 2,000 participants or all participants in the first three years of program activity (whichever milestone is reached first). Planned sample size and design are determined by considering the participant population and may change from the estimated sample size. Using standard sampling approaches and tools, the following characteristics will be considered:

- Confidence interval: 85 to 90%
- Relative precision: 10 to 15%
- Measure-level error ratio: to be updated prior to sample selection
- Budget, schedule, and geographical distribution

## K.5.2 Measurement and Verification

Measurement and verification of the installation and operation of a sample of premise-level participants will be performed using one or more of the following levels of rigor:

- On-site verification, only
- On-site verification and short-term measurements
- On-site verification, short-term measurements, and long-term metering of approximately six to eight weeks during a period of typical operations

According to UMP, International Performance Measurement and Verification Protocol[22] (IPMVP) Option A—Retrofit Isolation, Key Parameter Measurement Approach) is the appropriate method for lighting fixture retrofits and most occupancy sensor retrofits. IPMVP Option A is a partially measured retrofit isolation study that determines the actual energy and demand of an installed efficiency measure from a representative sample of participants, and adjusts the savings estimates derived from engineering algorithms applied to Dominion Energy's reported program participation data. The adjustment factor, also called a realization rate,[23] is then applied to the population of participants to estimate program savings.

DNV GL will verify the hours of use, quantity of fixtures, and the type and wattage of fixtures for a representative sample of the energy efficient retrofits. To verify the hours of use, electronic metering equipment is typically installed temporarily throughout the duration of the measurement period. For

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[21] The "realization rate" is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or a given sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and the extent to which these were affected by exogenous changes.

[22] Efficiency Valuation Organization (2012). International Performance Measurement and Verification Protocol: Concepts and Options for Determining Energy and Water Savings, Volume 1. EVO 10000-1:2012, www.evo-world.org.

[23] The "realization rate" is the proportion of deemed or reported energy savings and peak demand reductions that have been verified for all customers or projects in a sample. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

facilities with constant schedules, the measurement period must last for a minimum of four weeks; for facilities with variable schedules, additional metering time may be required to be representative of the average operation over the full range of variable schedules. In facilities with energy management systems (EMS) that monitor lighting circuits, hours of use may be verified by gathering EMS data.

To verify the baseline conditions, a facility representative will be interviewed. If no lighting controls measures were implemented at a given lighting circuit in the sample, the baseline hours of use equal the efficient; otherwise, they will usually be greater. Next, the heating and cooling status and associated fuel type will also be verified to account for interactive effects using stipulated values. DNV GL will either confirm or correct all reported values described in this section.

In a limited set of cases, other kinds of verification strategies, such as building or campus simulation modelling incorporating various types of data can be used to estimate changes in energy use associated with customer participation in the program. Similarly, DNV GL may opt to use a billing analysis approach, if billing data can be obtained and other conditions necessary for the application of this family of methods are met.

All of these efforts will be considered to determine the verified annual energy savings and peak demand reductions using gathered data, as appropriate, for each sampled project at the premises.

### K.5.3 Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV GL standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

## K.6 Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the measured data based off the on-site studies.
2. Apply the measured data to the actual participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation data.
3. Develop cumulative monthly energy savings based on measured and verified data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

## K.7 Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 15th of each year following program launch).
- Update STEP Manual annually for updates that occurred to its referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies upon sufficient program participation.
- Provide regulatory support as necessary.

- If appropriate, support lost revenue recovery activities.

## K.8 Non-residential Lighting Systems & Controls Program EM&V Plan Document Revision History

| Version | Notes |
|---|---|
| **Version 1.0** | New version |

# Appendix L. Non-residential Heating and Cooling Efficiency Program (DSM Phase VII) EM&V Plan

# L. NON-RESIDENTIAL HEATING AND COOLING EFFICIENCY PROGRAM EM&V PLAN (VERSION 1.0)

## L.1 Program Summary

This program would provide qualifying non-residential customers with incentives to implement new and upgrade existing high efficiency heating and cooling system equipment to more efficient HVAC technologies that can produce verifiable savings.

## L.2 Measures

The following high efficiency HVAC measures are included in the program:

1. Air conditioner upgrade
2. Heat pump upgrade
3. Geothermal heat pumps
4. Water source heat pumps
5. Chiller upgrade
6. Economizers
7. Variable frequency drives
8. Variable refrigerant flow
9. Unitary AC
10. Mini splits

## L.3 Evaluation, Measurement, and Verification Overview

DNV GL will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[24] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV GL's savings evaluation approach are:

1. Baseline Usage Estimate: The baseline load shape will be computed based on pre-retrofit capacity data from the rebate application data, applying Equivalent Full Load Hours (EFLH) as metered in on-site studies of installed rebated measures from a representative sample of participants.
2. Deemed Savings: Deemed savings (or gross savings) values will be estimated from the DNV GL Standard Tracking and Engineering Protocols (STEP) Manual, which are derived primarily from the most recent version of the Mid-Atlantic Technical Resource Manual (TRM), and as appropriate, other TRMs.
3. Verified Savings: Verified savings (or net savings) will be determined using on-site data. The wattage and hours of use data for the installed efficiency measure will be collected and metered through an on-site study of installed rebated measures from a representative sample of participants.

DNV GL takes a holistic approach to evaluation planning for the Company's portfolio of energy conservation programs. DNV GL balances cost-effectiveness and rigor to its evaluation planning so the Company can

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[24] 20 VAC 5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

insure its programs are cost effective and yield planned savings. This program will follow a staged evaluation plan, where DNV GL will take a two-step approach. During program start-up, kilowatts and kilowatt-hour savings are estimated using a deemed savings approach. Deemed approaches are a cost-effective method for determining reasonable savings estimates in the early stage of implementation, and in the periods between more rigorous EM&V.

Once participation has levelized or reached planned levels, and realized savings can be quantified, the program is considered for evaluation. Based on results from the DSM Phase I through III programs – programs that were implemented for more than three years as of this filing, and similar programs in other jurisdictions, DNV GL anticipates this will occur in year two of program operations.

Early in the third year of the program, or earlier at the Company's discretion – and assuming they are approved for the five years that they have been filed, they will be evaluated with the method most suitable to the program, program measures, and evaluation objectives. Methods include impact analysis using engineering analysis or whole facility methods, market studies, and process evaluations. Programs selected for evaluation in each year will be prioritized based on several factors, including but not limited to the uncertainty or variability of realized savings, its contribution to portfolio savings, program costs relative to all programs, the elapsed time since the last evaluation, or to address targeted research questions.

## L.4 Deemed Savings Approach

Upon program approval by the Virginia State Corporation Commission, the deemed savings approach or protocol for the Non-residential Heating and Cooling Efficiency Program will be developed through research primarily in the most recent version of the Mid-Atlantic Technical Reference Manual (TRM), and other TRMs or relevant studies, as appropriate. The deemed savings protocol for measures in this program will be documented in the STEP Manual, also known as the Company's TRM, and calculated using utility-reported program participant data. DNV GL will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate demand and energy savings in kW and kWh, respectively. Where such data is impractical for implementation contractors to collect, DNV GL will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV GL will take into consideration the data source priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

## L.5 Evaluated Savings Approach

During program implementation, Dominion Energy will determine, in consultation with DNV GL, the appropriateness of conducting evaluations to estimate program savings in kilowatt and kilowatt-hours. Our approach relies heavily on the DOE's Uniform Methods Project protocols (UMP):[25]

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[25] Li, M.; Haeri, H.; Reynolds, A. (2018). The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-70472. http://www.nrel.gov/docs/fy18osti/70472.pdf

According to Chapter 4—Small Commercial and Residential Unitary and Split System HVAC Heating and Cooling Equipment,[26] the key measured parameters for HVAC measures include the unit size, unit rated efficiency (energy efficient and baseline), annual operating hours, and—for peak demand reductions—coincidence factor. The first two parameters can be verified by either a desk review or on-site audit.

According to Chapter 18—VFD,[27] the key measured parameters at VFD installations include: hours of operation at each VFD speed, fan/pump motor horsepower, rotational speed, motor enclosure type, motor efficiency, and VFD efficiency.

According to Chapter 19—HVAC Controls,[28] the key measured parameters at dual-enthalpy economizer installations include: pre- and post-installation energy consumption of HVAC system components. These are normalized to TMY3 weather data.

For all measures in this program, the annual operating hours vary by climate, building type, occupancy type, etc. A high-rigor evaluation would require metering for a sample of the participants that represented all of these categories. However, because this approach can be expensive, a lower-rigor approach using metering for only a sample of the predominant building types may be considered.

At a high level, the ratio of the measured and verified savings to the deemed savings for the sample, also called a realization rate,[29] is then applied to the population of participants to estimate overall program savings. This approach will capture Company-specific customer usage data, and then apply those to the actual measures installed to quantify energy and peak demand savings.

### **L.5.1** Sample Design Considerations

The sample frame will be comprised of the earlier of either approximately 2,000 participants or all participants in the first three years of program activity (whichever milestone is reached first). Planned sample size and design are determined by considering the participant population and may change from the estimated sample size. Using standard sampling approaches and tools, the following characteristics will be considered:

- Confidence interval: 85 to 90%
- Relative precision: 10 to 15%
- Measure-level error ratio: to be updated prior to sample selection
- Budget, schedule, and geographical distribution

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[26] Jacobson, D. and Metoyer, J. (2017). Chapter 4: Small Commercial and Residential Unitary and Split System HVAC Heating and Cooling Equipment-Efficiency Upgrade Evaluation Protocol. The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68560. http://www.nrel.gov/docs/fy17osti/68560.pdf

[27] Romberger, Jeff. (2017). Chapter 18: Variable Frequency Drive Evaluation Protocol. The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/ SR-7A40-68574. http://www.nrel.gov/docs/fy17osti/68574.pdf

[28] Romberger, Jeff. (2017). Chapter 19: HVAC Controls (DDC/EMS/BAS) Evaluation Protocol. The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/ SR-7A40-68575. http://www.nrel.gov/docs/fy17osti/68575.pdf

[29] The "realization rate" is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or a given sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

## L.5.2 Measurement and Verification

Measurement and verification of the installation and operation of a sample of participants at the premises-level will be performed using one or more of the following levels of rigor:

- Desk-review verification
- On-site verification, only
- On-site verification and short-term measurements
- On-site verification, short-term measurements, and long-term metering of approximately six to eight weeks during a period of typical operations

If metering is used, it will be conducted according to the International Performance Measurement and Verification Protocol[30] (IPMVP) as shown in Table 3.

**Table 3. Preferred IPMVP Options for Non-residential Heating and Cooling Program Measures**

| Measure | IPMVP Option | Key Parameter(s) |
|---|---|---|
| **Package Terminal Air Conditioners and Package Terminal Heat Pumps** | Option A. Retrofit Isolation: Key Parameter Measurement Approach | • Cooling loads<br>• Heating loads (if applicable)<br>• Annual hours of operation |
| **Unitary and Split Air-conditioning Systems and Air-source Heat Pumps** | Option A. Retrofit Isolation: Key Parameter Measurement Approach | • Cooling loads<br>• Heating loads (if applicable)<br>• Annual hours of operation |
| **Variable Frequency Drives** | Option B. Retrofit Isolation: All Parameter Measurement | • Annual hours of operation at part-load conditions |
| **Economizers** | Option D. Calibrated Simulation | • Verify proper operation<br>• Annual hours of operation |
| **Water- and Air-cooled Chillers** | Option A. Retrofit Isolation: Key Parameter Measurement Approach<br>or<br>Option C. Whole Facility, if energy management system data are available and project-level savings are large compared to other energy variations at facility | • Cooling loads<br>• Outside air temperatures<br>• Manufacturer part-load efficiency data<br>• Annual hours of operation |
| **Geothermal Heat Pumps** | Option A. Retrofit Isolation: Key Parameter Measurement Approach | • Cooling loads<br>• Heating loads (if applicable)<br>• Annual hours of operation |
| **Variable-refrigerant-flow systems and mini-split heat pumps** | Option A. Retrofit Isolation: Key Parameter Measurement Approach | • Cooling loads<br>• Heating loads (if applicable)<br>• Annual hours of operation |

According to UMP, IPMVP Option A: A Retrofit Isolation, Key Parameter Measurement Approach is most appropriate for HVAC system replacement measures. IPMVP Option A is a partially-measured, retrofit-isolation study that meters the actual energy and demand reduction of an installed efficiency measure from

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[30] Efficiency Valuation Organization (2012). International Performance Measurement and Verification Protocol: Concepts and Options for Determining Energy and Water Savings, Volume 1. EVO 10000-1:2012, www.evo-world.org.

a representative sample of participants, and adjusts the savings estimates derived from engineering algorithms applied to Dominion Energy's reported program participation data.

According to UMP, IPMVP Option B, Retrofit Isolation is most appropriate for economizer retrofits. Using Option B, savings are determined by field measurement of the energy use of the HVAC system components. By performing a bin analysis of the pre- and post-installation energy data, and local weather data, it is possible for determine the energy savings and demand reductions.

According to UMP, IPMVP Option D—Calibrated Simulation is most appropriate for installed or replaced economizer measures. IPMVP Option D uses computer simulation software (e.g., DOE-2.2 software) to predict the change in energy and demand of efficiency measures from a representative sample of participants, and adjusts the savings estimates derived from engineering algorithms applied to Dominion Energy's reported program participation data. The computer simulation is developed using economizer system inputs collected on-site or through interviews with installation and service contractors. On-site hourly meter data is collected from the cooling systems and is used to calibrate the simulation for accuracy.

In a limited set of cases, other kinds of verification strategies, such as building or campus simulation modelling incorporating various types of data can be used to estimate changes in energy use associated with customer participation in the program. Similarly, DNV GL may opt to use a billing analysis approach if billing data can be obtained and other conditions necessary for the application of this family of methods are met.

All of these efforts will be considered to determine the verified annual energy savings and peak demand reductions using gathered data, as appropriate, for each sampled project at the premises.

### L.5.3 Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV GL standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

## L.6 Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the measured consumption and demand data based off the on-site studies.
2. Apply the measured data to the actual participant data to arrive at program level energy and demand impacts, reflected on a monthly basis. Program savings are annualized in the EM&V tracking reports based on monthly participation data.
3. Develop cumulative monthly energy savings based on measured and verified data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

## L.7 Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 15th of each year following program launch).
- Update STEP Manual annually for updates that occurred to its referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.
- If appropriate, support lost revenue recovery activities.

## L.8 Non-residential Heating and Cooling EM&V Plan Revision History

| Version | Notes |
|---|---|
| **Version 1.0** | New version |

# Appendix M. Non-residential Window Film Program (DSM Phase VII) EM&V Plan

# M. NON-RESIDENTIAL WINDOW FILM PROGRAM EM&V PLAN (VERSION 1.0)

## M.1 Program Summary

This program would provide qualifying non-residential customers with an incentive install solar reduction window film to lower their cooling bills and improve occupant comfort.

## M.2 Measures

Solar window film installation(s) are eligible for rebate through the program under specified conditions.

## M.3 Evaluation, Measurement, and Verification Overview

DNV GL will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[31] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV GL's savings evaluation approach are:

1. Baseline Usage Estimate: The baseline load shape will be computed based on pre-retrofit capacity data from the rebate application data, applying Equivalent Full Load Hours (EFLH) as metered in on-site studies of installed rebated measures from a representative sample of participants.
2. Deemed Savings: Deemed savings (or gross savings) values will be estimated from the DNV GL Standard Tracking and Engineering Protocols (STEP) Manual. The source of the deemed savings values will be models of 21 prototypical building types using Database for Energy Efficiency Resources (DEER) average values for building parameters (building sq. ft., EFLH, etc.). Variations in deemed savings values are provided in the STEP manual for some important parameters reported on customer rebate applications, including: weather zone, window orientation, and heating system type.
3. Verified Savings: Verified savings (or net savings) will be determined using on-site data. Solar emittance spot measurement data and operation schedules will be collected through an on-site study of installed rebated measures from a representative sample of participants. Load data from applicable non-residential HVAC measures across all other Dominion programs will be used in the simulation model as the basis of the measured savings load shape.

DNV GL takes a holistic approach to evaluation planning for the Company's portfolio of energy conservation programs. DNV GL balances cost-effectiveness and rigor to its evaluation planning so the Company can insure its programs are cost effective and yield planned savings. This program will follow a staged evaluation plan, where DNV GL will take a two-step approach. During program start-up, kilowatts and kilowatt-hour savings are estimated using a deemed savings approach. Deemed approaches are a cost-effective method for determining reasonable savings estimates in the early stage of implementation, and in the periods between more rigorous EM&V.

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[31] 20 VAC 5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

Once participation has levelized or reached planned levels, and realized savings can be quantified, the program is considered for evaluation. Based on results from the DSM Phase I through III programs – programs that were implemented for more than three years as of this filing, and similar programs in other jurisdictions, DNV GL anticipates this will occur in year two of program operations.

Early in the third year of the program, or earlier at the Company's discretion – and assuming they are approved for the five years that they have been filed, they will be evaluated with the method most suitable to the program, program measures, and evaluation objectives. Methods include impact analysis using engineering analysis or whole facility methods, market studies, and process evaluations. Programs selected for evaluation in each year will be prioritized based on several factors, including but not limited to the uncertainty or variability of realized savings, its contribution to portfolio savings, program costs relative to all programs, the elapsed time since the last evaluation, or to address targeted research questions.

## M.4 Deemed Savings Approach

Upon program approval by the Virginia State Corporation Commission, deemed savings approach or protocol for the Non-residential Window Film Program will be developed through research primarily in the most recent version of the Mid-Atlantic Technical Reference Manual (TRM), and other TRMs or relevant studies, as appropriate. The deemed savings protocol for measures in this program will be documented in the STEP Manual, also known as the Company's TRM, and calculated using utility-reported program participant data. DNV GL will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatt and kilowatt-hours. Where such data is impractical for implementation contractors to collect, DNV GL will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV GL will take into consideration the priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

## M.5 Evaluated Savings Approach

For the window film measure, the evaluation will select a sample for on-site verification. Savings will be based on the DNV GL STEP Manual deemed values with adjustments to key inputs that can be verified while on-site. Although The Uniform Methods Project[32] (UMP) does not specifically address this measure, the key parameter for determining gross savings and peak demand reductions include: surface area of treated windows and the SHGC.

At a high level, the ratio of the measured and verified savings to the deemed savings for the sample, also called a realization rate,[33] is then applied to the population of participants to estimate overall program

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[32] Li, M.; Haeri, H.; Reynolds, A. (2018). The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-70472. http://www.nrel.gov/docs/fy18osti/70472.pdf

[33] The "realization rate" is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or a given sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and the extent to which these were affected by exogenous changes.

savings. This approach will capture Company-specific customer usage data, and then apply those to the actual measures installed to quantify energy and peak demand savings.

### M.5.1 Sample Design Considerations

The sample frame will be comprised of the earlier of either approximately 2,000 participants or all participants in the first three years of program activity (whichever milestone is reached first). Planned sample size and design are determined by considering the participant population and may change from the estimated sample size. Using standard sampling approaches and tools, the following characteristics will be considered:

- Confidence interval: 85 to 90%
- Relative precision: 10 to 15%
- Measure-level error ratio: to be updated prior to sample selection
- Budget, schedule, and geographical distribution

### M.5.2 Measurement and Verification

Measurement and verification of the installation and operation of a sample of premise-level participants will be performed using one or more of the following levels of rigor:

- On-site verification, only
- On-site verification and short-term measurements
- On-site verification, short-term measurements, and long-term metering of approximately six to eight weeks during a period of typical operations

As recommended in UMP, the International Performance Measurement and Verification Protocol (IPMVP) Option D. Calibrated Simulation,[34] is a calibrated simulation study that uses computer simulation software (e.g. DOE 2 eQUEST or Energy Plus software packages), will be used to predict the change in energy and demand of efficiency measures from a representative sample of participants, and adjusts the savings estimates derived from engineering algorithms applied to Dominion Energy's program participation data. The computer simulation is developed using building and window film parameters collected on-site or through interviews with installation and service contractors.

In a limited set of cases, other kinds of verification strategies, such as building or campus simulation modelling incorporating various types of data can be used to estimate changes in energy use associated with customer participation in the program. Similarly, DNV GL may opt to use a billing analysis approach if billing data can be obtained and other conditions necessary for the application of this family of methods are met.

The above efforts will be used to determine the verified annual energy savings and peak demand reductions using gathered data, as appropriate, for each sampled project at the premises.

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[34] Efficiency Valuation Organization (2012). International Performance Measurement and Verification Protocol: Concepts and Options for Determining Energy and Water Savings, Volume 1. EVO 10000-1:2012, www.evo-world.org.

### M.5.3 Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV GL standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

## M.6 Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the measured data based off the on-site studies.
2. Apply the measured data to the actual participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation data.
3. Develop cumulative monthly energy savings based on measured and verified data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

## M.7 Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 15th of each year following program launch).
- Update STEP Manual annually for updates that occurred to its referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.
- If appropriate, support lost revenue recovery activities.

## M.8 Non-residential Window Film Program EM&V Plan Document Revision History

| Version | Notes |
|---|---|
| **Version 1.0** | New version |

# Appendix N. Non-residential Small Business Improvement Program EM&V Plan

# N. NON-RESIDENTIAL SMALL BUSINESS IMPROVEMENT PROGRAM EM&V PLAN (VERSION 10.0)

## N.1 Program Summary

The Non-Residential Small Business Improvement Program provides low cost energy assessments, direct install measures, and incentives for energy efficiency improvements to small businesses meeting certain size and need-based requirements. It is available to non-residential, small business customers in the Company's Virginia service territory with historic demand not exceeding 100 kW more than 3 times in the past 12 months. Participants must be privately-owned small businesses with five or fewer qualifying locations within the Company's service territory. Participation in this program is strictly voluntary. This program is part of demand side management (DSM) Phase V in Virginia and North Carolina.

## N.2 Measures

HVAC Retrofit Measures

1. Unitary/split AC & HP upgrades
2. Variable frequency drives (VFDs)
3. Dual enthalpy, air-side economizers
4. Mini-split heat pumps
5. Programmable thermostats

HVAC Re-commissioning Measures

1. Duct testing and sealing
2. AC/HP tune-ups
3. AC/HP Refrigerant charge adjustment

Lighting Measures

1. T8/T5 lamps/fixtures
2. LED lamps/fixtures
3. Occupancy sensors & controls

Other Measure

1. Air compressor leak repairs

## N.3 Evaluation, Measurement & Verification Overview

International Performance Measurement and Verification Protocol (IPMVP) Option A: For physically accessible equipment measures, an EM&V method like IPMVP Option A is applied. IPMVP Option A is a partially-measured retrofit isolation study that measures the selected parameters leading to the change in energy and demand of an installed efficiency measure from a representative sample of participants, and adjusts the savings estimates derived from engineering algorithms applied to the Company's program participation data. IPMVP Option A shall be applied to a sample of unitary/split AC & HP upgrades, variable frequency drives, mini-split heat pumps, and air compressor leak repairs.

IPMVP Option D: IPMVP Option D is a calibrated simulation study that uses computer simulation software (e.g. DOE-2.2 software) to predict the change in energy and demand of the installed efficiency measures from a representative sample of participants, and adjusts the savings estimates derived from engineering algorithms applied to the Company’s program participation data. IPMVP Option D shall be applied to sample of economizer measures.

For all measures, the evaluation will select a sample for on-site verification. Savings will be based on the DNV GL Energy STEP Manual deemed values with adjustments to key inputs that can be verified while on-site. The ratio of the weighted, measured, and verified savings to the weighted deemed savings, also called a realization rate, is then applied to the population of participants to estimate program savings. This approach will capture Company-specific customer usage data, which will be applied to the actual measures installed to quantify energy and peak demand savings.

Baseline Estimation Approach: The baseline load shape will be computed based on pre-retrofit capacity data from the rebate application data, applying Equivalent Full Load Hours (EFLH) as metered from an on-site study of installed rebated measures from a representative sample of participants.

Deemed Savings Approach: Deemed savings values will be developed and incorporated into the DNV GL Energy Standard Tracking and Engineering Protocols (STEP) Manual for planning purposes.

Measured Savings Approach: The wattage and hours of use data for each measure will be collected and metered through an on-site study of installed efficiency measures from a representative sample of participants.

## N.4 Deemed Savings Approach

Refer to the Non-Residential Small Business Improvement Program section of the STEP Manual for the standard deemed savings approaches for the measures in this program.

## N.5 Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the measured data based off the on-site studies.
2. Apply the measured data to the actual participant data to arrive at program level energy and demand savings, reflected on a monthly basis. Program savings are annualized in the EM&V tracking reports based on monthly participation data.
3. Develop cumulative monthly energy savings based on measured and verified data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, and exclude Fuel Charge Rider A and all other applicable riders) for the rate period to arrive at lost revenues.

## N.6 Timeline and Scope of Work

- Analysis of program tracking data; Annual Report (May 15th of each year following program launch).
- Annual updates to STEP Manual for updates that occurred to its referenced sources.
- Develop baseline, measure savings, and efficient load shapes.
- Provide regulatory support as necessary.

## N.7 Non-Residential Small Business Improvement Program EM&V Plan Document Revision History

| Version | Notes |
|---|---|
| **Version 7.0** | New version |
| **Version 8.0** | Updated "April 1" report date to "May 1" in "EM&V Measurement, Timeline, and Scope of Work" section |
| **Version 9.0** | Formatting updates<br>Updated from DNV GL Energy to DNV GL Energy Insights |
| **Version 10.0** | Formatting updates |

# Appendix O. Non-residential Prescriptive Program EM&V Plan

# O. NON-RESIDENTIAL PRESCRIPTIVE PROGRAM EM&V PLAN (VERSION 10.0)

## O.1 Program Summary

In the Non-residential Prescriptive program, qualifying customers are eligible to pursue one or more of the qualified energy efficiency measures through a local, participating contractor in Dominion's contractor network. To qualify for this program, the customer must be responsible for the electric bill and must be the owner of the facility or reasonably able to secure permission to complete the measures.

This program is part of demand side management (DSM) Phase VI in Virginia and North Carolina.

## O.2 Measures

Cooking

- Commercial Convection Oven
- Commercial Electric Combination Oven
- Commercial Electric Fryer
- Commercial Griddle
- Commercial Hot Food Holding Cabinet
- Commercial Steam Cooker

HVAC

- Duct Testing & Sealing
- Unitary/Split AC & HP Tune-up
- Variable Speed Drives on Kitchen Fan

Plug Load

- Smart Strip

Refrigeration

- Door Closer
- Door Gasket
- Evaporator Fan Control
- Floating Head Pressure Control
- Refrigeration Night Cover
- Refrigeration Coil Cleaning
- Suction Pipe Insulation
- Strip Curtain
- Vending Machine Miser
- Commercial Freezers and Refrigerators – Solid Door
- Ice Maker
- Low/No-Sweat Door Film

## O.3 Evaluation, Measurement & Verification Overview

International Performance Measurement and Verification Protocol (IPMVP) Option A: For physically accessible equipment measures, an EM&V method like IPMVP Option A is applied. IPMVP Option A is a partially-measured retrofit isolation study that measures the selected parameters leading to the change in energy and demand of an installed efficiency measure from a representative sample of participants, and adjusts the savings estimates derived from engineering algorithms applied to the Company's program participation data. IPMVP Option A shall be applied to a sample of all implemented measures.

For all measures, the evaluation will select a sample for on-site verification. Savings will be based on the DNV GL Energy STEP Manual deemed values with adjustments to key inputs that can be verified while on-site. The ratio of the weighted, measured, and verified savings to the weighted deemed savings, also called a realization rate, is then applied to the population of participants to estimate program savings. This approach will capture Company-specific customer usage data, which will be applied to the actual measures installed to quantify energy and peak demand savings.

Baseline Estimation Approach: The baseline load shape will be computed based on pre-retrofit capacity data from the rebate application data, applying Equivalent Full Load Hours (EFLH) as metered from an on-site study of installed rebated measures from a representative sample of participants.

Deemed Savings Approach: Deemed savings values will be developed and incorporated into the DNV GL Energy Standard Tracking and Engineering Protocols (STEP) Manual for planning purposes.

Measured Savings Approach: The wattage and hours of use data for each measure will be collected and metered through an on-site study of installed efficiency measures from a representative sample of participants.

## O.4 Deemed Savings Approach

Refer to the Non-Residential Prescriptive Program section of the STEP Manual for the standard deemed savings approaches for the measures in this program.

## O.5 Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the measured data based off the on-site studies.
2. Apply the measured data to the actual participant data to arrive at program level energy and demand savings, reflected on a monthly basis. Program savings are annualized in the EM&V tracking reports based on monthly participation data.
3. Develop cumulative monthly energy savings based on measured and verified data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, and exclude Fuel Charge Rider A and all other applicable riders) for the rate period to arrive at lost revenues.

## O.6 Timeline and Scope of Work

- Analysis of program tracking data; Annual Report (May 15th of each year following program launch).
- Annual updates to STEP Manual for updates that occurred to its referenced sources.
- Develop baseline, measure savings, and efficient load shapes.
- Provide regulatory support as necessary.

## O.7 Non-residential Prescriptive Program EM&V Plan Document Revision History

| Version | Notes |
|---|---|
| **Version 8.0** | New version |
| **Version 9.0** | Formatting updates<br>Updated from DNV GL Energy to DNV GL Energy Insights |
| **Version 10.0** | Formatting updates |

# Appendix P. Non-residential Small Manufacturing Program EM&V Plan

# P. NON-RESIDENTIAL SMALL MANUFACTURING PROGRAM EM&V PLAN (VERSION 1.0)

## P.1 Program Summary

This program would provide qualifying customers incentives for the installation of energy efficiency improvements, consisting of primarily compressed air systems measures for small manufacturing facilities.

## P.2 Measures

The following measures are included in the Non-residential Small Manufacturing Program:

1. Compressed air nozzles
2. Leaks
3. No loss drains
4. Additional compressed air storage
5. Heat of compression dryer
6. Low Pressure Drop filter
7. Variable speed drive air compressor
8. Cycling refrigerant dryer
9. Dewpoint controls
10. Pressure reduction
11. Downsized variable frequency drive compressor

## P.3 Evaluation, Measurement, and Verification Overview

DNV GL will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[35] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV GL's savings evaluation approach are:

1. Baseline Usage Estimate: The baseline load shape will be computed based on pre-retrofit capacity data from the rebate application data, applying Equivalent Full Load Hours (EFLH) as metered from an on-site study of installed rebated measures from a representative sample of participants.
2. Deemed Savings: Deemed savings (or gross savings) values will be developed and incorporated into the DNV GL Standard Tracking and Engineering Protocol (STEP) Manual, which are derived primarily from the most recent version of the Mid-Atlantic Technical Resource Manual (TRM), and as appropriate, other TRMs.
3. Verified Savings: Verified savings (or net savings) will be determined using on-site data. The wattage and hours of use data for each measure will be collected and metered through an on-site study of installed efficiency measures from a representative sample of participants.

DNV GL takes a holistic approach to evaluation planning for the Company's portfolio of energy conservation programs. DNV GL balances cost-effectiveness and rigor to its evaluation planning so the Company can insure its programs are cost effective and yield planned savings. This program will follow a staged evaluation plan, where DNV GL will take a two-step approach. During program start-up, kilowatts

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[35] 20 VAC 5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

and kilowatt-hour savings are estimated using a deemed savings approach. Deemed approaches are a cost-effective method for determining reasonable savings estimates in the early stage of implementation, and in the periods between more rigorous EM&V.

Once participation has levelized or reached planned levels, and realized savings can be quantified, the program is considered for evaluation. Based on results from the DSM Phase I through III programs – programs that were implemented for more than three years as of this filing, and similar programs in other jurisdictions, DNV GL anticipates this will occur in year two of program operations.

Early in the third year of the program, or earlier at the Company's discretion – and assuming they are approved for the five years that they have been filed, they will be evaluated with the method most suitable to the program, program measures, and evaluation objectives. Methods include impact analysis using engineering analysis or whole facility methods, market studies, and process evaluations. Programs selected for evaluation in each year will be prioritized based on several factors, including but not limited to the uncertainty or variability of realized savings, its contribution to portfolio savings, program costs relative to all programs, the elapsed time since the last evaluation, or to address targeted research questions.

## P.4 Deemed Savings Approach

Deemed savings approach or protocol for the Non-residential Small Manufacturing Program will be developed through research primarily in the most recent version of the Mid-Atlantic Technical Reference Manual (TRM), and other TRMs or relevant studies, as appropriate. The deemed savings protocol for measures in this program will be documented in the STEP Manual, also known as the Company's TRM, and calculated using utility-reported program participant data. DNV GL will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatt and kilowatt-hours. Where such data is impractical for implementation contractors to collect, DNV GL will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV GL will take into consideration the data source priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

## P.5 Evaluated Savings Approach

For all measures, the evaluation will select a sample for on-site verification. Savings will be based on the DNV GL STEP Manual deemed values with adjustments to key inputs that can be verified while on-site. In keeping with accepted practices defined by Chapter 22: Compressed Air Evaluation Protocol[36] of The Uniform Methods Project[37] (UMP), the key parameters for determining gross savings and peak demand reductions include: airflow rate, line pressure, compressor power, production rates, and operating hours.

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[36] Benton, N.; Burns, P. (2017). Chapter 22: Compressed Air Evaluation Protocol. The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68577. http://www.nrel.gov/docs/fy18osti/68577.pdf

[37] Li, M.; Haeri, H.; Reynolds, A. (2018). The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-70472. http://www.nrel.gov/docs/fy18osti/70472.pdf

At a high level, the ratio of the measured and verified savings to the deemed savings for the sample, also called a realization rate,[38] is then applied to the population of participants to estimate overall program savings. This approach will capture Company-specific customer usage data, and then apply those to the actual measures installed to quantify energy and peak demand savings.

## P.5.1 Sample Design Considerations

The sample frame will be comprised of the earlier of either approximately 2,000 participants or all participants in the first three years of program activity (whichever milestone is reached first). Planned sample size and design are determined by considering the participant population and may change from the estimated sample size. Using standard sampling approaches and tools, the following characteristics will be considered:

- Confidence interval: 85 to 90%
- Relative precision: 10 to 15%
- Measure-level error ratio: to be updated prior to sample selection
- Budget, schedule, and geographical distribution

## P.5.2 Measurement and Verification

Measurement and verification of the installation and operation of a sample of premise-level participants will be performed using one or more of the following levels of rigor:

- On-site verification, only
- On-site verification and short-term measurements
- On-site verification, short-term measurements, and long-term metering of approximately six to eight weeks during a period of typical operations

If metering is used, it will be conducted according to the International Performance Measurement and Verification Protocol[39] (IPMVP).

IPMVP Option A. Retrofit Isolation, Key Parameter Measurement: It is a partially-measured retrofit isolation study that measures the selected parameters leading to the change in energy and demand of an installed efficiency measure from a representative sample of participants, and adjusts the savings estimates derived from engineering algorithms applied to Dominion Energy's program participation data. IPMVP Option A shall be applied to a sample of air-compressor system retrofit and re-commissioning measures by performing spot measurements of compressor load current or root-mean-square power. These are supplemented by on-site observations of airflow and line pressure, site-contact reported hours of use and historical production data, and manufacturer specifications and standard data sheets.

In a limited set of cases, other kinds of verification strategies, such as building or campus simulation modelling incorporating various types of data can be used to estimate changes in energy use associated with customer participation in the program. Similarly, DNV GL may opt to use a billing analysis approach if billing data can be obtained and other conditions necessary for the application of this family of methods are met.

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[38] The "realization rate" is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

[39] Efficiency Valuation Organization (2012). International Performance Measurement and Verification Protocol: Concepts and Options for Determining Energy and Water Savings, Volume 1. EVO 10000-1:2012, www.evo-world.org.

The above efforts will be used to determine the verified annual energy savings and peak demand reductions using gathered data, as appropriate, for each sampled project at the premises.

### P.5.3 Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV GL standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

## P.6 Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the measured data based off the on-site studies.
2. Apply the measured data to the actual participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation data.
3. Develop cumulative monthly energy savings based on measured and verified data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

## P.7 Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 15th of each year following program launch).
- Update STEP Manual annually for updates that occurred to its referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.
- If appropriate, support lost revenue recovery activities.

## P.8 Non-residential Small Manufacturing Program EM&V Plan Document Revision History

| Version | Notes |
|---|---|
| **Version 1.0** | New version |

# Appendix Q. Non-residential Office Program EM&V Plan

# Q. NON-RESIDENTIAL OFFICE PROGRAM EM&V PLAN (VERSION 1.0)

## Q.1 Program Summary

This program would provide qualifying customers incentives for the installation of energy efficiency improvements, consisting of recommissioning measures at smaller office facilities.

## Q.2 Measures

The following measures are included in the Non-residential Office Program:

1. Schedule lighting
2. Schedule HVAC
3. Temperature setback
4. Condenser water reset
5. Discharge air temp reset
6. Static pressure reset
7. Enthalpy economizer
8. Variable air volume box minimum

## Q.3 Evaluation, Measurement, and Verification Overview

DNV GL will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[40] The EM&V method estimates gross and net program energy savings, including net-to-gross (NTG) savings and free-ridership estimates.

The basis for DNV GL's savings evaluation approach are:

1. Baseline Usage Estimate: The baseline load shape will be computed based on pre-retrofit capacity data from the rebate application data, applying Equivalent Full Load Hours (EFLH) as metered from an on-site study of installed rebated measures from a representative sample of participants.
2. Deemed Savings: Deemed savings (or gross savings) values will be developed and incorporated into the DNV GL Standard Tracking and Engineering Protocol (STEP) Manual, which are derived primarily from the most recent version of the Mid-Atlantic Technical Resource Manual (TRM), and as appropriate, other TRMs.
3. Verified Savings: Verified savings (or net savings) will be determined using on-site data. The wattage and hours of use data for each measure will be collected and metered through an on-site study of installed efficiency measures from a representative sample of participants.

DNV GL takes a holistic approach to evaluation planning for the Company's portfolio of energy conservation programs. DNV GL balances cost-effectiveness and rigor to its evaluation planning so the Company can insure its programs are cost effective and yield planned savings. This program will follow a staged evaluation plan, where DNV GL will take a two-step approach. During program start-up, kilowatts and kilowatt-hour savings are estimated using a deemed savings approach. Deemed approaches are a cost-effective method for determining reasonable savings estimates in the early stage of implementation, and in the periods between more rigorous EM&V.

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[40] 20 VAC 5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

Once participation has levelized or reached planned levels, and realized savings can be quantified, the program is considered for evaluation. Based on results from the DSM Phase I through III programs – programs that were implemented for more than three years as of this filing, and similar programs in other jurisdictions, DNV GL anticipates this will occur in year two of program operations.

Early in the third year of the program, or earlier at the Company's discretion – and assuming they are approved for the five years that they have been filed, they will be evaluated with the method most suitable to the program, program measures, and evaluation objectives. Methods include impact analysis using engineering analysis or whole facility methods, market studies, and process evaluations. Programs selected for evaluation in each year will be prioritized based on several factors, including but not limited to the uncertainty or variability of realized savings, its contribution to portfolio savings, program costs relative to all programs, the elapsed time since the last evaluation, or to address targeted research questions.

## Q.4 Deemed Savings Approach

Upon program approval by the Virginia State Corporation Commission, the deemed savings approach or protocol for the Non-residential Office Program will be developed through research primarily in the most recent version of the Mid-Atlantic Technical Reference Manual (TRM), and other TRMs or relevant studies, as appropriate. The deemed savings protocol for measures in this program will be documented in the STEP Manual, also known as the Company's TRM, and calculated using utility-reported program participant data. DNV GL will work with program implementers and Dominion Energy to identify the data to collect from program participants, where practical, to estimate savings in kilowatt and kilowatt-hours. Where such data is impractical for implementation contractors to collect, DNV GL will use either proxy variables or defaults that are determined based on secondary research. In selecting the most appropriate values, DNV GL will take into consideration the data source priority order in 20 VAC 5-318-40. Sources for all savings protocols, inputs, and assumptions will be documented to include titles, version numbers, publication dates, and page numbers, as appropriate.

## Q.5 Evaluated Savings Approach

For all measures, the evaluation will select a sample for on-site verification. Savings will be based on the DNV GL STEP Manual deemed values with adjustments to key inputs that can be verified while on-site. In keeping with accepted practices defined by Chapter 16: Retrocommissioning Evaluation Protocol[41] of The Uniform Methods Project[42] (UMP), the key parameters for determining gross savings and peak demand reductions include: equivalent full-load operating hours, building energy management data, and estimated savings.

At a high level, the ratio of the measured and verified savings to the deemed savings for the sample, also called a realization rate,[43] is then applied to the population of participants to estimate overall

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[41] Tiessen, A. (2017). Chapter 16: Retrocommissioning Evaluation Protocol. The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68572. http://www.nrel.gov/docs/fy17osti/68572.pdf

[42] Li, M.; Haeri, H.; Reynolds, A. (2018). The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-70472. http://www.nrel.gov/docs/fy18osti/70472.pdf

[43] The "realization rate" is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or a given sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and the extent to which these were affected by exogenous changes.

program savings. This approach will capture Company-specific customer usage data, and then apply those to the actual measures installed to quantify energy and peak demand savings.

### Q.5.1 Sample Design Considerations

The sample frame will be comprised of the earlier of either approximately 2,000 participants or all participants in the first three years of program activity (whichever milestone is reached first). Planned sample size and design are determined by considering the participant population and may change from the estimated sample size. Using standard sampling approaches and tools, the following characteristics will be considered:

- Confidence interval: 85 to 90%
- Relative precision: 10 to 15%
- Measure-level error ratio: to be updated prior to sample selection
- Budget, schedule, and geographical distribution

### Q.5.2 Measurement and Verification

Measurement and verification of the installation and operation of a sample of participants at the premises-level will be performed using one or more of the following levels of rigor:

- On-site verification, only
- On-site verification and short-term measurements
- On-site verification, short-term measurements, and long-term metering of approximately six to eight weeks during a period of typical operations

If metering is used, it will be conducted according to the International Performance Measurement and Verification Protocol[44] (IMPVP protocols). IPMVP Option A. Retrofit Isolation, Key Parameter Measurement: For physically accessible equipment measures, an EM&V method like IPMVP Option A is applied. IPMVP Option A is a partially-measured retrofit isolation study that measures the selected parameters leading to the change in energy and demand of an installed retrocommissioning measure from a representative sample of participants, and adjusts the savings estimates derived from engineering algorithms applied to Dominion Energy's program participation data. IPMVP Option A shall be applied to a sample of HVAC Retrocommissioning measures for which annual savings are <75,000 kWh.

IPMVP Option C. Whole Facility: Where multiple retrocommissioning measures are implemented at a given premises, a whole-facility study that makes use of Building Energy Management System data may be more cost effective. This requires access to at least one year, each, of pre- and post-retrocommissioning data, including electric energy consumption data, for analysis.

At facilities for which neither Option A nor Option C is feasible and cost-effective, deemed savings may be appropriate upon verifying the implementation of the retrocommissioning measures. For all measures, the evaluation will select a sample for on-site verification. Savings will be based on the DNV GL STEP Manual deemed values with adjustments to key inputs that can be verified while on-site.

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[44] Efficiency Valuation Organization (2012). International Performance Measurement and Verification Protocol: Concepts and Options for Determining Energy and Water Savings, Volume 1. EVO 10000-1:2012, www.evo-world.org.

The ratio of the weighted, measured, and verified savings to the weighted deemed savings, also called a realization rate,[45] is then applied to the population of participants to estimate program savings. This approach will capture Company-specific customer usage data, which will be applied to the actual measures installed to quantify energy and peak demand savings.

### Q.5.3 Net-to-Gross Assessment

If applicable, free-ridership may be estimated using a standard survey-based, self-report method. The survey will follow a DNV GL standard attribution question strategy to determine the quantity, efficiency, and timing of installations had the program not been available.

## Q.6 Lost Revenue Methodology

Measured and verified lost revenues for this program will be calculated as follows:

1. Calculate program savings by applying the realization rate derived from the measured data based off the on-site studies.
2. Apply the measured data to the actual participant data to arrive at program level energy and demand savings, reflected monthly. Program savings are annualized in the EM&V tracking reports based on monthly participation data.
3. Develop cumulative monthly energy savings based on measured and verified data to represent the lost sales (kWh) associated with the program.
4. Multiply the cumulative monthly energy savings by the monthly marginal base distribution and generation rate derived using a marginal rate analysis of the participants in this program (such analysis will exclude the Basic Customer Charges, the Fuel Charge Rider A, and all other applicable riders) for the rate period to arrive at lost revenues.

## Q.7 Timeline and Scope of Work

- Develop and update EM&V plan annually.
- Analyze program tracking data: Annual report (May 15th of each year following program launch).
- Update STEP Manual annually for updates that occurred to its referenced sources.
- Develop baseline use, efficient use, and measure savings load shapes annually.
- If appropriate, conduct impact evaluation studies.
- Provide regulatory support as necessary.
- If appropriate, support lost revenue recovery activities.

## Q.8 Non-residential Office Program EM&V Plan Document Revision History

| Version | Notes |
|---|---|
| **Version 1.0** | New version |

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[45] The "realization rate" is the proportion of deemed or estimated energy and peak demand savings that have been verified for all customers or projects in a sample or sample stratum. It is expressed as a percentage and is derived from follow-up research (e.g. billing analyses, on-site visits, and/or customer surveys) to verify that measures were installed, are operating as intended, and whether these were affected by exogenous changes.

# Appendix R. Residential Air Conditioner Cycling Program EM&V Plan

# R. RESIDENTIAL AIR CONDITIONER CYCLING PROGRAM EM&V PLAN (VERSION 10.0)

## R.1 Program Summary

The Residential Air Conditioner (AC) Cycling Program, marketed as "Smart Cooling Rewards," compensates customers who allow the Company to reduce the cycle of their central air conditioning during peak load conditions by 30–50%. When AC cycling events are called, a radiofrequency (RF) paging signal is broadcast throughout the Company's service area. The signal is received by load curtailment switches installed on central air conditioners and heat pumps of participating residential customers. The dispatch of the RF signal to the load curtailment switch reduces the duty cycle of the registered AC units up to 50% during an event. The AC Cycling event season spans June 1 through September 30 on non-holiday weekdays.

## R.2 Measures

The program measure is the AC cycling control switch. The eligible classes of air conditioners and heat pumps in the AC Cycling Program are:

1. Electric residential central air conditioners
2. Electric and duel fuel heat pumps

## R.3 Evaluation, Measurement & Verification Overview

DNV GL will support Dominion Energy in its EM&V activities to be compliant with 20 VAC 5-318.[46] The EM&V method empirically estimates demand reduction (kW) during AC Cycling program events. The Residential AC Cycling program is evaluated annually for the life of the program.

The basis for DNV GL's savings evaluation approach are:

1. Baseline Consumption: Baseline consumption will be calculated from AMI participant consumption data.
2. Demand reduction will be evaluated using the methods described in Section 1.5. The evaluated approach will use program tracking data, customer energy consumption data, and customer specific control histories to estimate demand reduction.

The evaluation follows protocols established in International Performance Measurement and Verification Protocol (IPMVP-Option C) and Measurement and Verification for Demand Response, Prepared for the National Forum on the National Action Plan on Demand Response.[47]

## R.4 Deemed Savings Approach

Deemed savings are not calculated for the Residential AC Cycling Program

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[46] 20 VAC 5-318, Title 20. Virginia State Corporation Commission, Chapter 318, Final Regulation, Rules Governing the Evaluation, Measurement, and Verification of the Effects of Utility-Sponsored Demand-Side Management Programs. Effective Date: January 1, 2018.

[47] Efficiency Value Organization. 2016. Core Concepts, International Performance Measurement and Verification Protocol, Option C, Whole Facility; Measurement and Verification for Demand Response Prepared for the National Forum on the National Action Plan on Demand Response.: Measurement and Verification Working Group, February 2013. https://www.ferc.gov/industries/electric/indus-act/demand-response/dr-potential.asp

## R.5 Evaluated Savings Approach

Given the investment in this program and the planned peak shaving reductions, this EM&V plan calls for an annual impact evaluation using interval data collected from all participating accounts with AMI meters. Consumption data is collected at 30-minute intervals for each sampled household and is transferred to the EM&V contractor monthly. The evaluation will report ex post impacts, event average THI's, event opt-out percentages, and the ex ante estimates by event hour and THI.

Representative 8,760-hour load shapes for the program resource will be updated following each event season.

## R.6 Data

Four sources of data are used in the impact analysis:

1. Event records of controlled participants
2. Half-hourly AMI customer consumption data collected from customer meters
3. Regional weather data to account for customer-specific temperature and
4. Humidity for each event hour.[48]

## R.7 Methodology

The following steps are used to calculate the kW impact demand reduction estimates for the program:

1. Customer baselines and ex post impacts for each event hour are calculated using regression analysis with AMI data, event participation data, and weather data from the nearest first-order weather station of each customer account.
2. The ex ante program impacts are calculated using a regression analysis of the ex post impacts for each event-hour and THI. Using the range of event hour and THI impacts, an ex ante estimate is produced for the Company's peak planning conditions of 95°F at 43% relative humidity at hour-ending 17 (THI 83.4).[49]

## R.8 Lost Revenue Methodology

Not applicable.

## R.9 Timeline and Scope of Work

- Conduct a monthly review of program tracking and AMI participant consumption data
- Prepare monthly tracking indicator tables
- Evaluate impacts of dispatch events and prepare an annual impact evaluation report
- Enter annual updates of model specifications to the STEP Manual
- Provide program and regulatory support as necessary
- Update EM&V plans as needed

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[48] National Oceanic and Atmospheric Association (NOAA), National Centers for Environmental Information, Local Climatological Data.

[49] Dominions Energy's peak planning condition is hour-ending 17 at 95°F at 43% RH, or 83.4 THI. Temperature Humidity Index = THI = Td – (0.55 – 0.55*RH) * (Td – 58) where Td is dry bulb temperature and RH is relative humidity. Source: PJM Glossary: http://www.pjm.com/Glossary.aspx

## R.10 Residential Air Conditioner Cycling Program EM&V Plan Document Revision History

| Version | Notes |
|---|---|
| **Version 1.0** | Added semi-annual program tracking summary table in the "Frequency of EM&V Measurement & Timeline" section.<br>Changed assumed error ratio from 0.5 to 0.96 (computed) with an error margin of 9.12%. |
| **Version 2.0** | Updated document formatting.<br>Updated "KEMA" to "DNV KEMA."<br>Modified the required sample size from 300.<br>Changed "Program Penetration & Initial Baseline Assumptions" section title to "Program Penetration" and removed initial baseline assumptions.<br>Updated planned penetrations and added "Source" column to the "Program Penetration" table.<br>Changed "Revision History" section title to "Document Revision History." |
| **Version 3.0** | Updated "EM&V Summary and Sampling Strategy" section with description of experimental design analysis for 2013. |
| **Version 4.0** | Update Program Penetration Table based on 2013 IRP. |
| **Version 5.0** | Removed 2013 planned customer penetration numbers.<br>Added sentence on PJM requirements to end of "EM&V Method."<br>Updated deemed savings approach to utilize ex ante estimates for aggregate program impacts conditional on temperature humidity index and hour, developed from a regression analysis of historical program performance. Changes affected EM&V Method and EM&V Summary and Sampling Strategy sections. |
| **Version 6.0** | Updated DNV KEMA to DNV GL Energy.<br>Updated EM&V method to IPMVP Option C to reflect impact estimation using premise level AMI data.<br>Added description of analytical tasks to meet requirements for PJM compliance.<br>Updated error ratio to reflect results used in 2014 sample design.<br>Added planned annual updates to the representative load shape of the program resource.<br>Renamed "Frequency of EM&V Measurement and Timeline" section title to "EM&V Measurement, Timeline and Scope of Work" to more accurately reflect the content in that section.<br>Added on-going scope that was not explicitly mentioned to "EM&V Measurement, Timeline and Scope of Work" section.<br>Deleted program penetrations section. |
| **Version 7.0** | Updated "EM&V Summary and Sampling Strategy" section with description of the 2016 study population which includes all participants with AMI meters.<br>Changed "semi-annual" to "monthly" program tracking summary table in the "Frequency of EM&V Measurement & Timeline" section.<br>Prior to 2016, the measured average load reduction was computed from the interval load data of a sample of participating homes with AMI. Starting in 2016 the measured average load reduction is computed from the interval load data of all participants with AMI.<br>Removed reference to a 96% operability rate.<br>Added scope description for ex ante and ex post demand reduction estimates in EM&V Measurement, Timeline and Scope of Work. |

| | |
|---|---|
| **Version 8.0** | Updated with 2017 ex ante evaluated results. |
| **Version 9.0** | Formatting and minor edits.<br>Updated from DNV GL Energy to DNV GL Energy Insights.<br>Removed 2018 ex ante impact estimates. |
| **Version 10.0** | Formatting updates. |

# Appendix R-1. Residential AC Cycling Program, Impact Evaluation of 2019 Dispatch Events

DNV·GL

RESIDENTIAL AC CYCLING PROGRAM

# Appendix R-1
# Impact Evaluation of 2019 Dispatch Events

Dominion Energy

Date: May 15, 2020

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# EXECUTIVE SUMMARY

This report presents the load impacts of the 2019 Residential AC Cycling Program administered by Dominion Energy (the Company) in Virginia and North Carolina. The AC Cycling Program, marketed as Smart Cooling Rewards, began in 2010 as a resource to help the Company reduce summer peak demand.

Under the program, when AC cycling events are called, a radiofrequency (RF) paging signal is broadcast throughout the Company's service area. The signal is received by load curtailment switches installed on central air conditioners and heat pumps of participating residential customers. The dispatch of the RF signal to the load curtailment switch reduces the duty cycle of the registered AC units up to 50% during an event.

DNV GL evaluates the AC Cycling Program on an annual basis. The objectives of the evaluation are:

1. To estimate the demand reduction impacts of each dispatch event
2. To estimate the expected amount of peak kW delivered by the AC Cycling resource in different weather conditions and times of day, including the Company's summer peak planning conditions.

This report summarizes the event history between 2017 and 2019, reviews 2019 event participation across the Company's service areas, and presents the results of the ex post and ex ante impact analyses. It also presents sample event-day plots, hourly ex post impact estimates, and modeled impacts for varying weather conditions and time of day.

## 1.1 Overview of Findings

In 2019, the AC Cycling Program called fewer events than 2018 over fewer controlled hours overall. However, for the first time since the start of the program in 2010, a two-hour event was called outside the normal event season. On October 2, 2019, PJM Interconnection (PJM) declared an unusual "Pre-Emergency Load Management Reduction Action" at 14:00 because of unusually high temperatures in the region.

2019's per-participant demand reduction of .63 kW at the Company's peak condition was the same as 2018, reversing slight declines in 2017 and 2018. This ex ante analysis uses the results of the ex post analysis to forecast kW impacts by hour, temperature, and humidity conditions.[1]

***In 2019, the evaluated load impact for weather conditions observed during Dominion Energy's peak day conditions was 0.63 kW per participant.***

The ex post analysis provides estimates of the average kW impacts that occur during each event hour. Ex post impacts over the 2019 event season ranged from 0.36 kW to 0.76 kW per participant under varying weather conditions. The highest average event impact occurred on August 19, and the lowest on August 8. The maximum impact for a single interval in 2019 was 0.76 kW on July 19 and August 19 and plotted in Figure 5-2.

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[1] Peak conditions correspond with an 83.4 temperature-humidity index at hour ending 17. This is equivalent to a temperature of 95°F and a relative humidity of 43% at 5:00 PM.

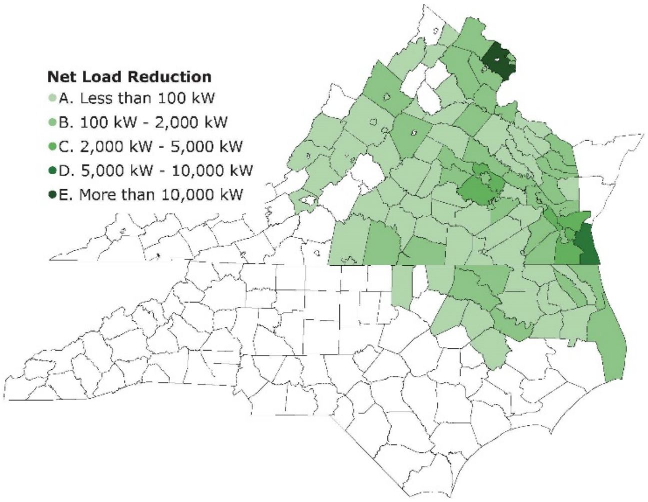
# 2 INTRODUCTION

This report summarizes the event history between 2017 and 2019, reviews event participation in 2019, and presents the results of the ex post and ex ante impact analyses. It also presents sample event-day plots, hourly ex post impact estimates, and modeled impacts for varying weather conditions and time of day. Peak demand reduction estimates for demand response programs are important for the Company's stakeholders and DSM portfolio, and for registration with PJM when applicable.

The AC Cycling event season spans June 1 through September 30 on non-holiday weekdays.[2] Events typically last between two and four hours. Under the program, when AC cycling events are called, a radiofrequency (RF) paging signal is broadcast throughout the Company's service area. The signal is received by load curtailment switches installed on central air conditioners and heat pumps of participating residential customers. The dispatch of the RF signal to the load curtailment switch reduces the duty cycle of the registered AC units up to 50%.

When the AC Cycling Program was launched in 2010, the estimated impacts were based on a statistical regression model of consumption data from other utilities in the region. Since 2011, the modeled impact estimates have used site-level interval data, the connected load of the unit, and actual weather conditions during the Company's summer event season. In compliance with the order from the Virginia State Corporation Commission (the Commission), the impact evaluation transitioned from an analysis based on a random sample of participants with advanced metering infrastructure (AMI) to using consumption data from every AMI-enabled Residential AC Cycling participant.[3]

**Figure 2-1. Distribution of Demand Reduction Potential for AC Cycling Participants in Virginia and North Carolina by County, as of December 31, 2019**



In 2019, the evaluation was conducted with 7,793 AMI-enabled participants. As with the Company's energy efficiency programs, the Virginia counties with the highest demand reduction potential center around Richmond, Norfolk, and northern Virginia (Figure 2-1).

Comparing 2019's results with prior years' results is difficult without additional analysis. Although the relationships between temperature, humidity, and demand reduction are strong, other factors drive demand reduction. Long hot periods and/or stretches of consecutive event-days affect AC usage and the response to events. Conversely, a single hot day in the midst of an otherwise cool period also produces different demand

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[2] Events may be called after September 30 under extenuating circumstances.

[3] Required as part of the Final Order, State Corporation Commission of Virginia, Case No. PUE-2015-00089, April 19, 2016.

reductions. Because demand reduction is a function of both the amount of cooling demanded at the time of an event (i.e., potential demand reduction) and the customer response (i.e., the customer turning on their AC equipment), the complex relationship between demand reduction, long-term temperature trends, and event call schedules is difficult to predict from event to event or season to season. Despite this, 2019’s demand reduction was consistent with 2018, reversing slight declines in 2017 and 2018.

# 3 2018 AC CYCLING EVENTS AND PARTICIPATION

Under the program, AC cycling seasons are distinguished from year to year by the number of events, the number of controlled hours, and the number of controlled participants. This section summarizes 2019's events, including event hours, the number of events that dispatched the partial participant population (Table 3-1), and the number of controlled participants (Table 3-2). Data from prior years are provided for comparison.

**Table 3-1. Summary of 2019 Events**

| | 2017 | 2018 | 2019 |
|---|---|---|---|
| Number of events | 29 | 27 | 23 |
| Total controlled hours over 2018 events | 96 | 75 | 66 |
| Number events with partial population dispatched | 8 | 1 | 0 |

## 3.1 Frequency

Compared to 2018, 2019 had fewer events and fewer event hours.

The AC Cycling program called 23 events in the summer of 2019. Four events were called in June, ten in July, six in August, two in September, and one in October.

Normally, the AC Cycling event season spans June 1 through September 30 on non-holiday weekdays. However, for the first time since the start of the program, a two-hour event was called at 14:00 on October 2. The event was called because PJM declared a "Pre-Emergency Load Management Reduction Action" as temperatures in the mid-Atlantic and Northeast hovered around 98°F during an unusual heat event.[4]

## 3.2 Participation

Approximately 80,000 accounts and 84,000 air conditioners and heat pumps were controlled in 2019. Table 3-2 shows the number of total and AMI-enabled participants by division. The relative proportion of AMI to non-AMI participants remained consistent with 2018, at approximately 9.5%.

**Table 3-2. 2019 Total and AMI Participants by Division[5]**

| Division | Number of Total Participants by Division | Number of AMI Participants by Division |
|---|---|---|
| Eastern | 32,624 | 111 |
| Northwest | 25,221 | 7,286 |
| Central | 19,000 | 311 |
| North Carolina | 3,041 | 85 |
| **Total** | **79,886** | **7,793** |

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[4] Events may be called after September 30 under extenuating circumstances.

[5] Total and AMI participants in the first event on 25 June 2019

# 4 IMPACT ANALYSIS

The following sections describe the evaluation data, methodology, and ex post and ex ante results.

This ex post analysis estimates the kW impacts per participant realized at the end of each event hour for the 23 events dispatched in 2019, the time of each event, and its length (Section 5.2). The ex ante analysis uses the results of the ex post analysis to forecast kW impacts by hour, temperature, and humidity conditions (Section 5.3). For example, 0.63 kW is the estimated impact for the Company's peak planning conditions, which are 17:00 at 95°F and 43% RH (Table 5-3).[6]

## 4.1 Data

Four sources of data are used in the impact analysis:

1. Half-hourly AMI customer consumption data collected from customer meters
2. A record of controlled participants for each event provided by the implementer
3. Program tracking data that identifies the location of each controlled account and confirms that switch control records match the Company's records of active participants
4. Regional weather data used to account for customer-specific temperature and humidity for each event hour.[7]

Descriptions of the data quality control (QC) procedures and results are provided in Section 5.4.

## 4.2 Methodology

The following steps are used to calculate the kW impact demand reduction estimates for the program:

1. Half-hourly interval AMI consumption data for each participant are delivered to DNV GL monthly and subject to QC tests.
2. AMI customer accounts are assigned weights based on the state, connected loads, and divisions of all participants to ensure that the AMI analysis is representative of the program population. The assigned weights and methods are included in Appendix II, Extrapolating the AMI-enabled Account Impacts to the Program Population.
3. AMI interval data are merged with the record of customers who participated in each event.

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[6] Dominions Energy's peak planning condition is hour-ending 17 at 95°F at 43% RH, or 83.4 THI. Temperature Humidity Index = THI = Td – (0.55 – 0.55*RH) * (Td – 58) where Td is dry bulb temperature and RH is relative humidity. Source: PJM Glossary: http://www.pjm.com/Glossary.aspx

[7] National Oceanic and Atmospheric Association (NOAA), National Centers for Environmental Information, Local Climatological Data.

4. Using AMI data, event participation data, and weather data, regression analysis is used to calculate ex post impacts for each event hour. The results of the ex post analysis are provided in Section 5.1.
5. The ex ante estimates are calculated using a regression analysis of the ex post impacts for each event-hour and temperature humidity index (THI). Ex ante results are the expected impacts extrapolated to each hour and THI. The ex ante empirically estimates program impacts at the Company’s peak planning conditions of 95°F at 43% relative humidity at hour-ending 17 (THI 83.4). The ex ante results are provided in Section 5.3.

# 5 RESULTS

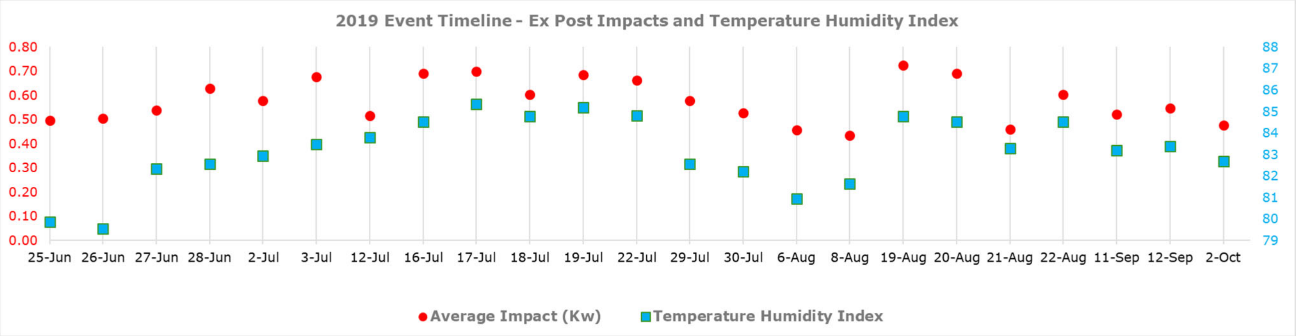
This section presents the results of the 2019 ex post and ex ante analyses. The presentation of the ex post analysis begins with a seasonal timeline showing the impacts and THI for each event (Figure 5-1), moves to event-level plots illustrating the event days with the highest and lowest impacts (Figure 5-2 and Figure 5-3), and ends with the ex post impacts calculated for each event hour (Table 5-1 and Table 5-2).

## 5.1 Ex Post Impacts

The 2019 timeline in Figure 5-1 shows the average impact (in kW) and THI for each event. For most events, the magnitude of the impacts moves with temperature and humidity. This suggests that event days could be called based on favorable weather conditions if impacts are the primary goal.

However, because demand reduction is a function of both the amount of cooling demanded at the time of an event (i.e., potential demand reduction) and the customer response (i.e., if the customer turns on a room AC), the complex relationship between demand reduction, long-term temperature trends, and event call schedules is difficult to predict. Gaining insight into how these factors may have influenced 2019 impacts would require further analysis.

**Figure 5-1. Timeline of 2019 Events by Impacts (Red) and THI (Blue)**



### 5.1.1 Event-Day Plots

The plots in Figure 5-2 and Figure 5-3 on the next pages illustrate two events with the highest and lowest impacts, respectively. The plots are described briefly below.

The ex post estimate, or what happened during the event, is the difference between the adjusted baseline during the event (solid red line) and the pre- and post-event baseline (purple line). Impacts are calculated at the end of each event hour and referred to as "hour ending."

Results are illustrated in time-series representations of:

- ***Event-day load profile for the AC Cycling Program participant population (solid purple line).*** The beginning of events is clearly visible and is typically followed by a post-event load spike (snapback or rebound) before the load resumes to non-event levels.
- ***Baseline during the event (solid red line*)**. The solid red line plots the baseline for the event-day load curve during the event. The baseline is modeled from the non-event days.
- ***Reference load outside the event (dashed red line).*** This line plots the baseline load profile before and after the event.

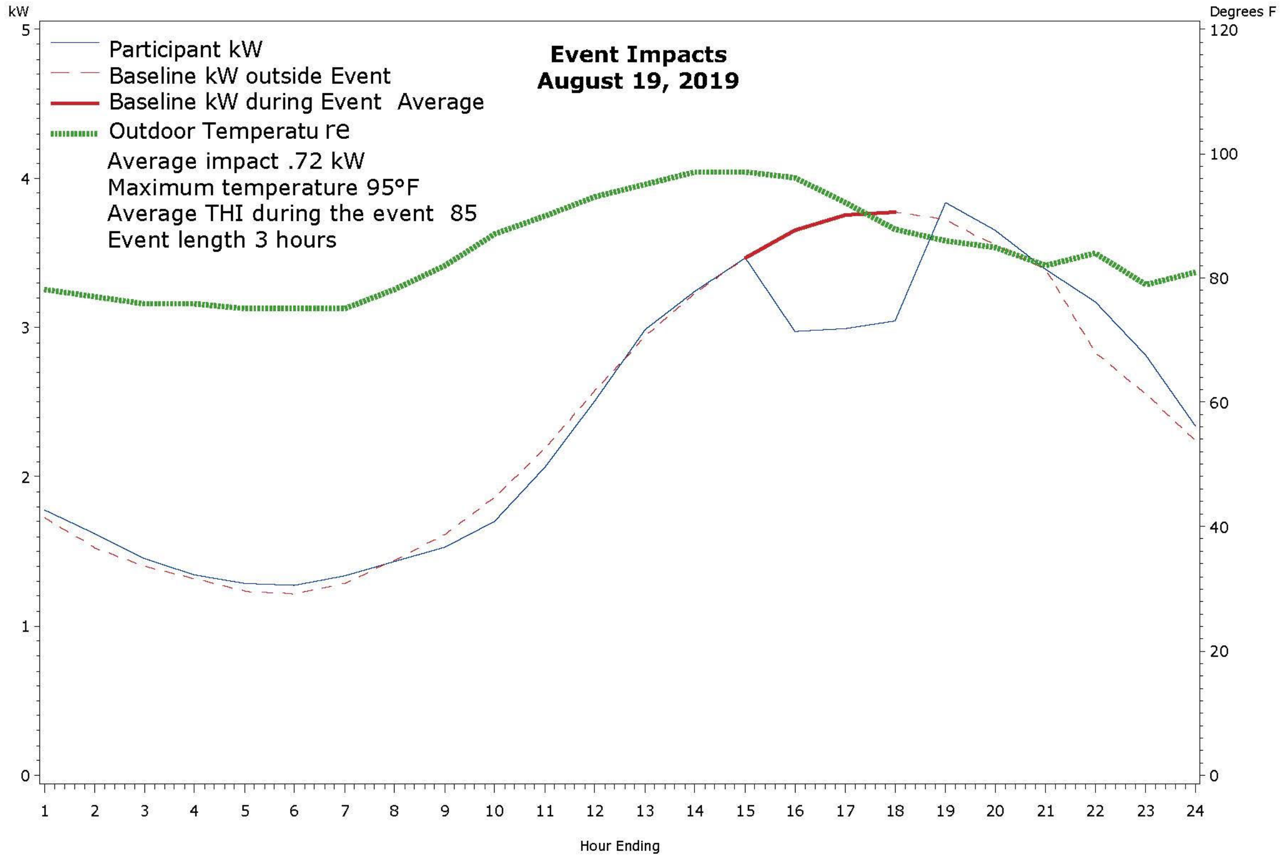
- ***Event-day temperature* (green line)**. Hourly temperatures are plotted to give context for the load curves.

## Load Profile with High Impacts

The highest impact for 2019 occurred on August 19 with a recorded event-average THI of 85. This was the highest event THI recorded in 2019 and occurred in 65% (8 of 13) of events.

The event was called at 15:00 with demand reduction clearly visible at hours ending 16, 17, and 18 (Figure 5-2). The estimated average impact was 0.72 kW per participant.

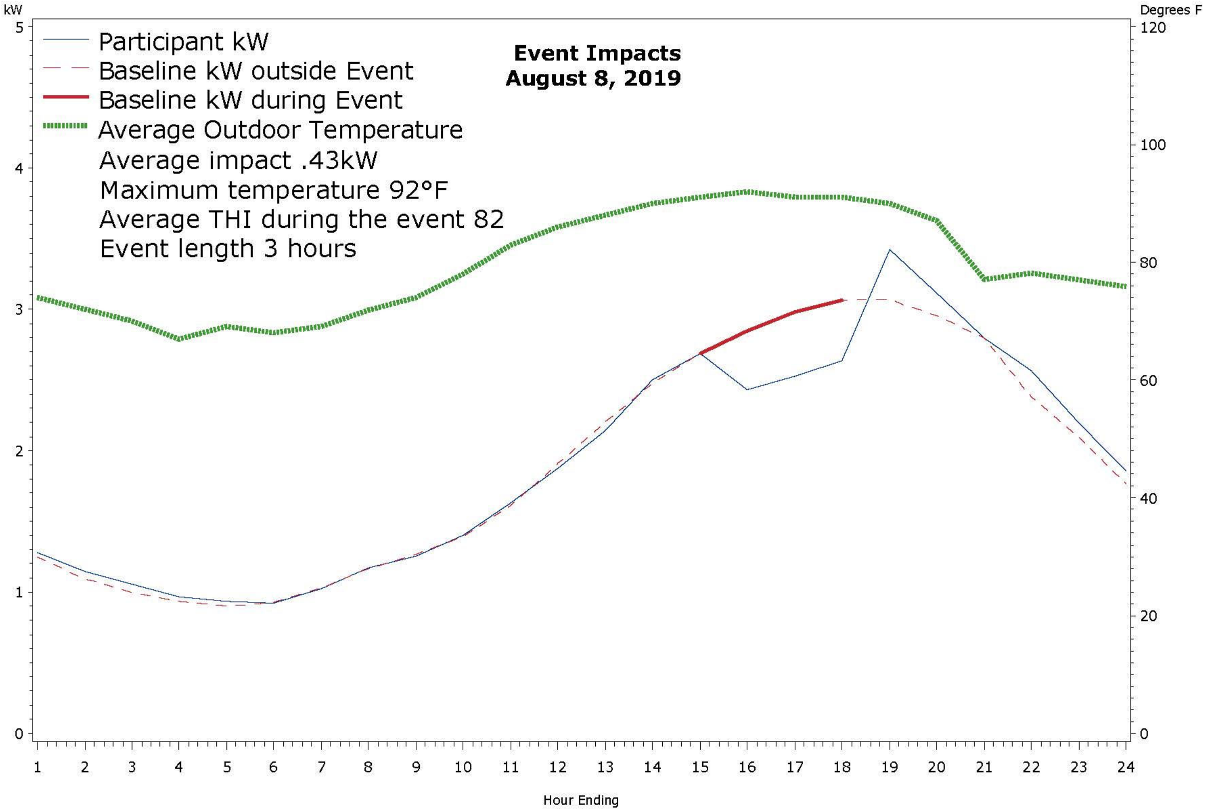
**Figure 5-2. Load Profile for the Event Day with the Highest Impacts (August 19, 2019)**



## Load Profile with Low Impact

The lowest event impact for 2019 occurred on August 8, the event day with the lowest THI (82). The event was called at 15:00 with demand reduction clearly visible at hours ending 16, 17, and 18 (Figure 5-3). The estimated average impact was 0.43 kW per participant.

**Figure 5-3. Load Profile for the Event Day with the Lowest Impact (August 8, 2019).**

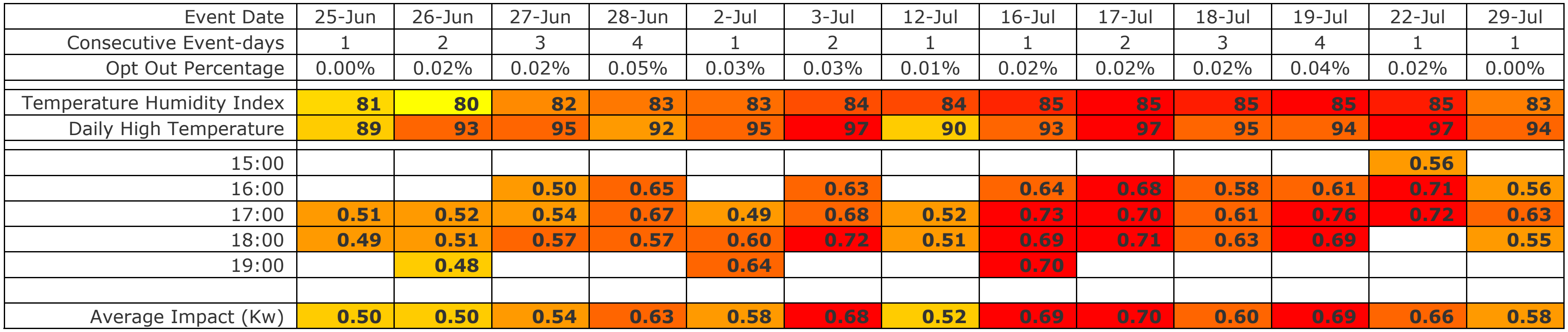


## 5.2 Ex Post Impacts

Ex post impacts by day and hour are presented in Table 5-1 and Table 5-2. Also shown are the maximum recorded event average THIs, the opt-out percentage, and a day number indicating the event's order in a series of consecutive events.

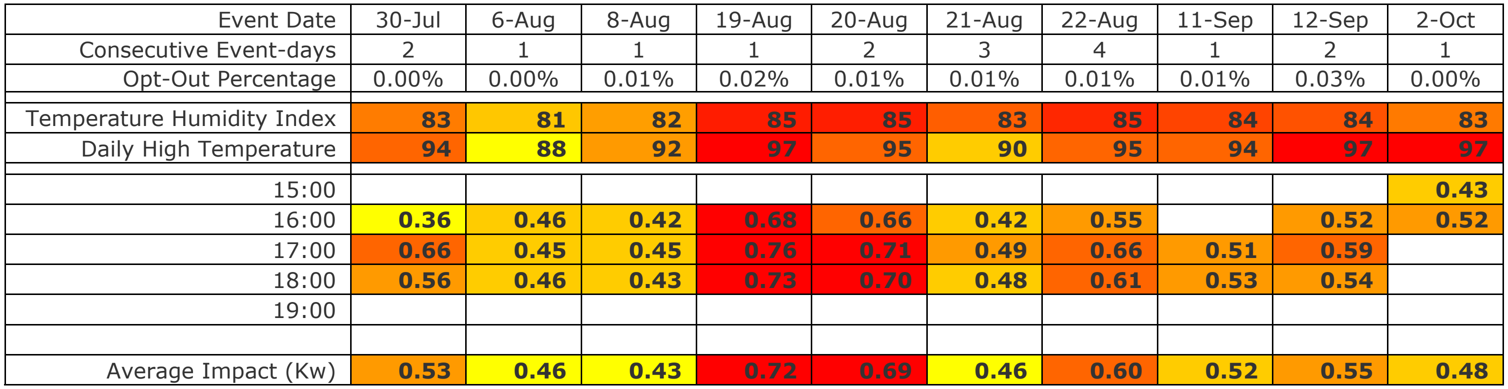
The highest average event impact occurred on August 19, and the lowest on August 8. The maximum impact for a single interval in 2019 was 0.76 kW on July 19 and August 19, the same event that is plotted in Figure 5-2. The average opt-out percentage for 2019 was 0.02% and the highest number of opt-outs for any given event was 44 out of 84,000 switches.

**Table 5-1. AC Cycling Impacts by Event-Day and Hour (June 25 through July 29, 2019)**



| Event Date | 25-Jun | 26-Jun | 27-Jun | 28-Jun | 2-Jul | 3-Jul | 12-Jul | 16-Jul | 17-Jul | 18-Jul | 19-Jul | 22-Jul | 29-Jul |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Consecutive Event-days | 1 | 2 | 3 | 4 | 1 | 2 | 1 | 1 | 2 | 3 | 4 | 1 | 1 |
| Opt Out Percentage | 0.00% | 0.02% | 0.02% | 0.05% | 0.03% | 0.03% | 0.01% | 0.02% | 0.02% | 0.02% | 0.04% | 0.02% | 0.00% |
| Temperature Humidity Index | 81 | 80 | 82 | 83 | 83 | 84 | 84 | 85 | 85 | 85 | 85 | 85 | 83 |
| Daily High Temperature | 89 | 93 | 95 | 92 | 95 | 97 | 90 | 93 | 97 | 95 | 94 | 97 | 94 |
| 15:00 | | | | | | | | | | | | 0.56 | |
| 16:00 | | | 0.50 | 0.65 | | 0.63 | | 0.64 | 0.68 | 0.58 | 0.61 | 0.71 | 0.56 |
| 17:00 | 0.51 | 0.52 | 0.54 | 0.67 | 0.49 | 0.68 | 0.52 | 0.73 | 0.70 | 0.61 | 0.76 | 0.72 | 0.63 |
| 18:00 | 0.49 | 0.51 | 0.57 | 0.57 | 0.60 | 0.72 | 0.51 | 0.69 | 0.71 | 0.63 | 0.69 | | 0.55 |
| 19:00 | | 0.48 | | | 0.64 | | | 0.70 | | | | | |
| | | | | | | | | | | | | | |
| Average Impact (Kw) | 0.50 | 0.50 | 0.54 | 0.63 | 0.58 | 0.68 | 0.52 | 0.69 | 0.70 | 0.60 | 0.69 | 0.66 | 0.58 |

**Table 5-2. AC Cycling Impacts by Event-Day and Hour (July 30 through October 2, 2019)**



| Event Date | 30-Jul | 6-Aug | 8-Aug | 19-Aug | 20-Aug | 21-Aug | 22-Aug | 11-Sep | 12-Sep | 2-Oct |
|---|---|---|---|---|---|---|---|---|---|---|
| Consecutive Event-days | 2 | 1 | 1 | 1 | 2 | 3 | 4 | 1 | 2 | 1 |
| Opt-Out Percentage | 0.00% | 0.00% | 0.01% | 0.02% | 0.01% | 0.01% | 0.01% | 0.01% | 0.03% | 0.00% |
| Temperature Humidity Index | 83 | 81 | 82 | 85 | 85 | 83 | 85 | 84 | 84 | 83 |
| Daily High Temperature | 94 | 88 | 92 | 97 | 95 | 90 | 95 | 94 | 97 | 97 |
| 15:00 | | | | | | | | | | 0.43 |
| 16:00 | 0.36 | 0.46 | 0.42 | 0.68 | 0.66 | 0.42 | 0.55 | | 0.52 | 0.52 |
| 17:00 | 0.66 | 0.45 | 0.45 | 0.76 | 0.71 | 0.49 | 0.66 | 0.51 | 0.59 | |
| 18:00 | 0.56 | 0.46 | 0.43 | 0.73 | 0.70 | 0.48 | 0.61 | 0.53 | 0.54 | |
| 19:00 | | | | | | | | | | |
| | | | | | | | | | | |
| Average Impact (Kw) | 0.53 | 0.46 | 0.43 | 0.72 | 0.69 | 0.46 | 0.60 | 0.52 | 0.55 | 0.48 |

## 5.3 Ex Ante Impacts

The primary metric of the impact analysis is the ex ante impact estimates for the program year. The ex ante analysis models event impacts for a range of THI values. A regression model was fit for each of the event hours ending 15, 16, 17, 18, and 19, with THI as a predictor variable. Like the 2018 model, the 2019 ex ante model was based solely on 2019 ex post impacts. The ex ante impact for the Company's peak planning conditions was 0.63 kW.

Table 5-3 shows the predicted values from the regression models, aggregated by whole-hour intervals and tabulated by hour and THI.

**Table 5-3. Ex Ante Impacts by THI and Hour Ending Per Participant (2019)**

| | **Event Hour Ending** | | | | |
|---|---|---|---|---|---|
| **THI** | **15** | **16** | **17** | **18** | **19** |
| **79** | 0.36 | 0.49 | 0.58 | 0.57 | 0.53 |
| **80** | 0.40 | 0.51 | 0.59 | 0.58 | 0.57 |
| **81** | 0.43 | 0.53 | 0.60 | 0.59 | 0.61 |
| **82** | 0.47 | 0.56 | 0.61 | 0.60 | 0.64 |
| **83** | 0.50 | 0.58 | **0.62** | 0.60 | 0.68 |
| **84** | 0.53 | 0.61 | **0.63** | 0.61 | 0.71 |
| **85** | 0.57 | 0.63 | 0.64 | 0.62 | 0.75 |
| **86** | 0.60 | 0.65 | 0.65 | 0.63 | 0.78 |
| **87** | 0.64 | 0.68 | 0.66 | 0.64 | 0.82 |
| **88** | 0.67 | 0.70 | 0.67 | 0.65 | 0.85 |

# APPENDIX I: AC CYCLING EVALUATION DATA

## 5.4 AMI Data – Quality Control

Four sources of data are used in the impact analysis:

1. Half-hourly AMI customer consumption data
2. A record of controlled participants for each event
3. Program tracking data
4. Regional weather data

To prepare the AMI consumption data for the analysis, a series of QC procedures are performed on the AMI data and event control logs. This section describes these QC procedures, which for some procedures, rely on a cross-reference between the AMI consumption data, the event control logs, and business intelligence (BI) data.

The event control log lists all dispatched accounts and the start and stop times of the event. Only dispatched participants are included in the event control log. A participant will not be included if they opted out of an event or were not dispatched during a partial-dispatch event.

The AMI data undergoes QC tests to ensure that the AMI data is complete, and that only active participants are included in the analysis. The following specific conditions must be met for a participant to be included in the impact analysis:

- AMI accounts must include consumption data for May through October.
- An AMI account must be associated with a corresponding account in the event control log.
- An account in the event control log must be associated with a participant in the BI data.

Section 5.4.1 summarizes QC results for the AMI data.

### 5.4.1 QC Results

Half-hourly AMI consumption data for AC Cycling participants was delivered monthly to DNV GL from April through December 2019. Table 5-4 shows the stages of QC for the 2019 AMI data. Of the 10,000 AMI accounts delivered, 1,972 (20%) were not included in the analysis because they were no longer active participants.

**Table 5-4. Quality Test Results for the AMI Data (2019)**

| Quality Test | Number of Accounts Removed | Remaining Population |
|---|---|---|
| Number of AMI accounts delivered | | 10,000 |
| Number of account numbers without a match to participants in the BI data | 1,054 | 8,946 |
| Number of accounts that appeared in the AMI data only before or after the event season | 63 | 8,883 |
| Number of accounts in which an optimal reference temperature could not be generated for | 6 | 8,877 |

| Quality Test | Number of Accounts Removed | Remaining Population |
|---|---|---|
| Number of accounts that did not appear in the control logs | 849 | 8,028 |

# APPENDIX II: EXTRAPOLATING THE AMI-ENABLED ACCOUNT IMPACTS TO THE PROGRAM POPULATION

The distribution of the AMI-enabled participants among divisions and connected loads does not match the distribution of the population. To extrapolate the AMI account impacts to the participant population, the AMI-enabled accounts are assigned weights based on their division and connected load relative to all participants. The distribution of AMI enabled participants to all participants by division is shown in Table 5-5.

**Table 5-5. Total and AMI Participants by Division**[8]

| 2019 Division | # Total Participants by Division | # AMI Participants by Division |
|---:|---:|---:|
| Eastern | 32,624 | 111 |
| Northwest | 25,221 | 7,286 |
| Central | 19,000 | 311 |
| North Carolina | 3,041 | 85 |
| Total | 79,886 | 7,793 |

Due to the uneven distribution of AMI meters across divisions, the Company commissioned a customer load modeling analysis, a new recruit trend study, and a non-AMI comparison. In turn, all were included in the Final Order of the State Corporation Commission on April 19, 2016. The results of these studies are found in the 2016 evaluation of dispatch events.[9]

To create the weights, participants are categorized by division, connected load, and whether the account is AMI-enabled using the BI data, event control logs, and AMI consumption data.

The weights assigned to the AMI enabled group for the June 25 event are listed in Table 5-6. The weights are unique to each event to reflect slight differences in participation levels or larger variances that occur during partial-dispatch events. The weight can be understood as the number of program customers represented by each meter in the AMI group. The following steps were taken to build the 2019 weights:

1. Construct a list of all event participants by address, division, and connected load. The program tracking data, or BI data, is the source of the addresses and connected loads.
2. Stratify the participants based on state, division, and connected load.
3. Calculate weights based on the number of AMI participants for each event relative to all participants within each stratum.[10]

---

[8] Total and AMI participants in the first event on 25 June 2019. Although 8,028 AMI accounts are included in the overall analysis only 7,793 participated on 25 June 2019.

[9] Evaluation, Measurement, and Verification Report for Virginia Electric and Power Company, May 1, 2017, Appendix R-1: Impact Evaluation of 2016 Dispatch Events, Appendices A through C.

[10] The weight within each stratum is the population divided by the total number of AMI meters in the study group.

### Table 5-6. Weights by State, Division, and Connected Load for June 25, 2019

| State | Division | Load (kW) | # AMI meters | Population | Weight |
|---|---|---|---|---|---|
| VA | Northwest | Not Available | 2,538 | 9,995 | 4 |
| VA | Northwest | < 4kW | 2,629 | 8,047 | 3 |
| VA | Northwest | ≥4kW | 2,119 | 7,179 | 3 |
| | | | | | |
| VA | Eastern | Not Available | 30 | 9,660 | 322 |
| VA | Eastern | < 4 kW | 48 | 14,501 | 302 |
| VA | Eastern | >= 4 kW | 33 | 8,463 | 256 |
| | | | | | |
| VA | Central | Not Available | 87 | 5,527 | 64 |
| VA | Central | < 4kW | 136 | 8,160 | 60 |
| VA | Central | ≥4kW | 88 | 5,313 | 60 |
| | | | | | |
| NC | NC | Not Available | 22 | 512 | 23 |
| NC | NC | < 4kW | 25 | 1,461 | 58 |
| NC | NC | ≥4kW | 38 | 1,068 | 28 |
| | | | | | |
| | | **Total** | **7,793** | **79,886** | |

## About DNV GL

# Appendix S. Non-residential Distributed Generation Program EM&V Plan

# S. NON-RESIDENTIAL DISTRIBUTED GENERATION PROGRAM EM&V PLAN (VERSION 10.0)

## S.1 Program Summary

The Non-residential Distributed Generation Program provides qualifying commercial customers with an incentive to curtail load by operating backup generation at the request of the Company, up to a limited number of hours per year. Participants must have at least 200 kW demand to be eligible for this program. The program implementer is responsible for installing remote generation equipment controls, monitoring the customer's generators, and dispatching load under the direction of the Company. The program implementer is notified of a dispatch event 30 minutes in advance of the event either by e-mail or phone. Monthly average site-level load curtailment must be at least 95% of registered/enrolled kW to receive the incentive. Average monthly site level load curtailment must be at least 50% of registered/enrolled kW for continued program participation.

## S.2 Measures

On-site generation capacity.

## S.3 Evaluation, Measurement & Verification Overview

International Performance Measurement and Verification Protocol (IPMVP - Option B): Because impacts are calculated from metered energy consumption, IPMVP Option B is the appropriate EM&V method. Program participants are known, and the load curtailment will be metered directly.

Baseline estimation approach: The baseline for this program is 0 kW because the power generators are considered non-operational at the beginning of each event.

Deemed savings approach: Deemed savings values based on evaluated impacts are incorporated into the DNV GL Energy Standard Tracking and Engineering Protocols (STEP).

Measured savings approach: The program participants are known, generated kW is metered, and impacts are calculated using regression models.

## S.4 Deemed Savings Approach

## S.5 Evaluated Savings Approach

Customer data regarding backup generation equipment will be collected prior to enrollment and will be used to determine customer eligibility. Metered generation data is collected from the implementer using Company and implementer owned equipment.

Impacts are evaluated on the census of participants.

### S.5.1 Sample design considerations

A census of participant data will be evaluated since electrical output from 100% of enrolled generators will be metered, the event times are known, and the load and run time hours will be directly metered and reported. Missing meter data will be replaced to the extent possible with redundant meter data.

## S.6 Lost Revenue Methodology

Not applicable.

## S.7 Timeline and Scope of Work

Analysis of program tracking and metered data: Annual Report (May 15th of each year following program launch).

Semi-annual program tracking summary table (ending July 2015). 2015 will be final year of semi-annual reporting, as North Carolina submissions will be changing next year to line up with Virginia. Semi-annual program tracking summary table (July of each year).

Annual event season report (November of each year).

Annual updates to DNV GL Energy Standard Tracking and Engineering Protocols (STEP) for updates that occurred to its referenced sources.

Develop baseline, measure savings, and efficient load shapes.

Provide regulatory support as necessary.

## S.8 Non-residential Distributed Generation Program EM&V Plan Document Revision History

| Version | Notes |
|---|---|
| **Version 1.0** | Added semi-annual program tracking summary table in the "Frequency of EM&V Measurement & Timeline" section. |
| **Version 2.0** | No material changes to the content.<br>Added semi-annual program tracking summary table in the "Frequency of EM&V Measurement & Timeline" section. |
| **Version 3.0** | No material changes to the content. |
| **Version 4.0** | Updated program requirements with more details, as shown below:<br>Added minimum kW demand requirement of 200 kW to be eligible for this program to the "Program Summary" section.<br>Added customer notification process of each DG event through e-mail or phone 30 minutes in advance.<br>Added compliance requirement that participants must be within +/- 5% of committed peak shaving enrolled kW.<br>Changed "KEMA" to "DNV KEMA."<br>Changed "Program Penetration & Initial Baseline Assumptions" section title to "Program Penetration" and removed initial baseline assumptions.<br>Updated program penetrations and added "Source" column to the "Program Penetration" table.<br>Changed "Revision History" section title to "Document Revision History."<br>Updated planned penetration table based on 2013 IRP. |
| **Version 5.0** | Removed 2013 planned customer penetration numbers. |

| | |
|---|---|
| | Added sentence on PJM requirements to end of "EM&V Method."<br>Updated program requirements with more details, as shown below:<br>Added minimum kW demand requirement of 200 kW to be eligible for this program to the "Program Summary" section.<br>Added customer notification process of each DG event through e-mail or phone 30 minutes in advance.<br>Added compliance requirement that participants must be within +/- 5% of committed peak shaving enrolled kW.<br>Changed "KEMA" to "DNV KEMA."<br>Changed "Program Penetration & Initial Baseline Assumptions" section title to "Program Penetration" and removed initial baseline assumptions.<br>Updated program penetrations and added "Source" column to the "Program Penetration" table.<br>Changed "Revision History" section title to "Document Revision History."<br>Updated planned penetration table based on 2013 IRP. |
| **Version 6.0** | Updated DNV KEMA to DNV GL Energy.<br>Clarified that compliance is defined by total monthly average load curtailment that is at least 95% of committed peak shaving enrolled kW (rather than +/- 5% of enrolled kW).<br>Renamed "Frequency of EM&V Measurement and Timeline" section title to "EM&V Measurement, Timeline and Scope of Work" to more accurately reflect the content in that section.<br>Added on-going scope that was not explicitly mentioned to "EM&V Measurement, Timeline and Scope of Work" section.<br>Deleted program penetrations section.<br>Removed 2013 planned customer penetration numbers.<br>Added sentence on PJM requirements to end of "EM&V Method." |
| **Version 7.0** | Clarified that compliance for program participation is 50% of enrolled, but compliance for payments is 95% of enrolled kW. Updated bullet "Semi-annual program tracking summary table (as required)." to "Semi-annual program tracking summary table (ending July 2015). 2015 will be final year of semi-annual reporting, as North Carolina submissions will be changing next year to line up with Virginia.<br>Updated DNV KEMA to DNV GL Energy.<br>Clarified that compliance is defined by total monthly average load curtailment that is at least 95% of committed peak shaving enrolled kW (rather than +/- 5% of enrolled kW).<br>Renamed "Frequency of EM&V Measurement and Timeline" section title to "EM&V Measurement, Timeline and Scope of Work" to more accurately reflect the content in that section.<br>Added on-going scope that was not explicitly mentioned to "EM&V Measurement, Timeline and Scope of Work" section.<br>Deleted program penetrations section.<br>Updated bullet "Semi-annual program tracking summary table (as required)." to "Semi-annual program tracking summary table (ending July 2015). 2015 will be final year of semi-annual reporting, as North Carolina submissions will be changing next year to line up with Virginia."<br>Clarified difference between payment compliance (95% of enrolled load) and program participation compliance (50% of enrolled load). |

| | |
|---|---|
| **Version 8.0** | Updated "April 1" report date to "May 1" in "EM&V Measurement, Timeline, and Scope of Work" section. |
| **Version 9.0** | Minor edits.<br>Formatting updates.<br>Updated from DNV GL Energy to DNV GL Energy Insights. |
| **Version 10.0** | Formatting updates. |

# Appendix S-1. Distributed Generation Program, Impact Evaluation of 2019 Dispatch Events

DNV·GL

## DISTRIBUTED GENERATION PROGRAM

# Appendix S-1
# Impact Evaluation of 2019 Dispatch Events

### Dominion Energy

Date: May 15, 2020

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## List of figures

# 1 EXECUTIVE SUMMARY

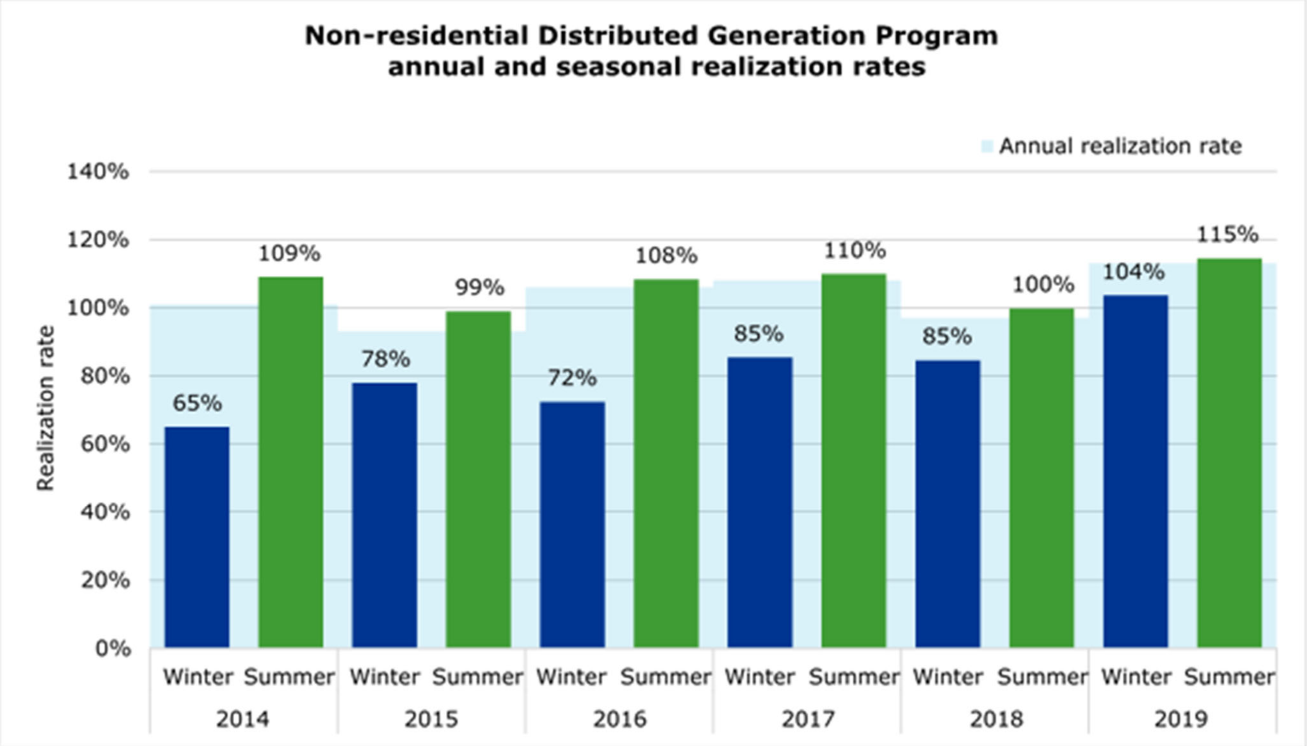
This report presents the results of the annual impact analysis of Dominion Energy's (hereafter referred to as the Company) Non-residential Distributed Generation (DG) Program for 2019.

The program began in June 2012 with the objective of curtailing peak load. During periods when demand for electricity is particularly high, the Company calls upon participating large non-residential customers to provide a supply resource to the Company by operating backup power to curtail load on the Company's grid. Customers must meet specific eligibility requirements to participate in the program and receive an incentive from the Company in exchange for their participation.

***In 2019 the program achieved an overall realization rate of 113%, the highest since its inception in 2013***

For the non-residential DG program, dispatched generation is the amount of load curtailment, in kilowatts (kW), requested by the Company, per event-hour interval, aggregated to the day, month, season, or year. Measured generation is site-metered generation and is the amount of load delivered to the Company per event-hour interval, aggregated to the day, month, season, or year. Both dispatched and measured generation are presented in total (cumulative) and average (mean) aggregates. The realization rate is calculated by dividing the measured generation by the dispatched generation for participating sites.

**Figure 1-1. Annual and seasonal realization rate 2014-2019**



Summer realization rates exceed winter realization rates every year. Since most events are called in the summer, annual realization rates are driven more by summer than winter events.

The three objectives of the impact analysis are to:

- Compute the aggregate and site-level curtailed load, in kW for each event-hour and event-day
- Compute program realization rates annually, seasonally, and for each event interval by comparing dispatched generation to measured generation
- Report monthly program performance and planned values

From January 1, 2019 to December 31, 2019 the program achieved an overall realization rate of 113% and substantially exceeded its planned realization rate of 95%. The 2019 monthly realization rates range from 73% in January to 118% in August. The realization rate for summer events averaged 115%, and winter events averaged 104%. Summer events typically have higher realization rates than winter events. However, the winter event that occurred on October 2, 2019 performed more like a summer event and raised the average winter realization rate. Figure 1-1 illustrates the typical difference between summer and winter realization rates and highlights the notably higher winter realization rate of 104% in 2019.

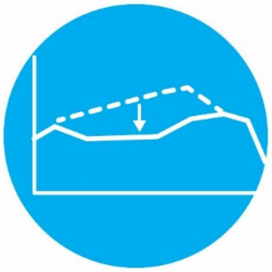
Table 1-1 shows DG Program performance and planned values for 2019. The table provides the planned and actual participants in megawatts (MW) and the average dispatched and measured generation in kW.

**Table 1-1. DG Program Performance (2019)**

| 2019 | Planned (MW) | Enrolled (MW) | Net kW Planned | Net kW Enrolled | Event Days | Average Dispatched (kW) | Average Generation (kW) | Average Realization Rate |
|---|---|---|---|---|---|---|---|---|
| **Jan** | 7.59 | 5.95 | 7,592 | 6,130 | 1 | 5,950 | 4,335 | 73% |
| **Feb** | | | No events | | | | | |
| **March** | | | No events | | | | | |
| **April** | | | No events | | | | | |
| **May** | | | No events | | | | | |
| **June** | 7.59 | 6.13 | 7,592 | 6,130 | 5 | 5,883 | 6,476 | 110% |
| **July** | 7.59 | 6.13 | 7,592 | 6,130 | 11 | 5,202 | 5,964 | 115% |
| **August** | 7.59 | 5.94 | 7,592 | 6,130 | 6 | 5,910 | 6,960 | 118% |
| **Sept** | 7.59 | 6.13 | 7,592 | 6,130 | 1 | 6,130 | 7,077 | 115% |
| **Oct** | 7.59 | 6.13 | 7,592 | 6,130 | 1 | 6,130 | 6,958 | 114% |
| **Nov** | | | No events | | | | | |
| **Dec** | | | No events | | | | | |

# INTRODUCTION AND BACKGROUND

During periods when demand for electricity is particularly high, the Company calls upon participating large non-residential customers to provide a supply resource to the Company by operating backup power to curtail load on the Company's grid. Customers must meet specific eligibility requirements to participate in the program and receive an incentive from the Company in exchange for their participation.



The Virginia State Corporation Commission approved the Non-residential DG Pilot on January 17, 2008. The Non-residential DG Pilot subsequently achieved program status on April 30, 2012, and the pilot ran through the end of 2014. In June 2017, the DG program was extended for an additional five years through May 31, 2022.[1]

As of December 31, 2019, there were 21 enrolled sites representing a resource potential of 6.1 MW to the Company. Large non-residential customers with least 200 kW of demand and enough generation capacity are eligible to participate in the program.

Details of the DG Program are as follows:

- A participant is defined by its enrolled capacity, and one participant equals 1,000 kW of enrolled generation. The level of incentive also corresponds with the kW of enrolled generation capacity, so a customer with greater than 1,000 kW of enrolled capacity is counted as more than one participant.[2]
- Participating customers are compensated if the average measured on-site generation is at least 95% of the dispatched target generation for each event day.
- The Company has the right to adjust the incentive paid to customers based on historical performance if the average realization rate falls below the 95% target.

## 1.1 Program Terminology and Metrics

Any day on which an event is called is an event day. An event day may include multiple events. The length of each event varies by event and events are reported in one-hour intervals and the end of each hour. For example, the interval hour ending 17 corresponds to event performance between 16:00 and 17:00. The number of dispatched sites during a given event day also varies.

For the non-residential DG program, total and average dispatched generation is the amount of load curtailment, in kW, requested by the Company, per event-hour interval, aggregated and reported at the daily, monthly, seasonally and yearly level. Total and average measured generation is metered on-site and is the amount of load delivered by the participants per event-hour interval, aggregated and reported at the same level of detail as average dispatched generation.

### 1.1.1 Realization Rate

The reporting metric of interest in the DG program is the realization rate. The realization rate is calculated by dividing the average monthly measured generation by the average monthly dispatched generation for

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[1] Case No. PUE-2016-00111. Commonwealth of Virginia, State Corporation Commission, "Final Order" on the subject "For approval to implement new, and to extend existing, demand-side management programs and for approval of two updated rate adjustment clauses pursuant to § 56-585.1 A 5 of the Code of Virginia." June 1, 2017.

[2] Customers who do not have exact multiples of 1,000 kW of on-site generation are credited with fractional levels of participation and incentive, e.g., 1,500 kW is considered 1.5 participants.

participating sites. If there is measured generation at a site prior to or following a dispatched event, the measured generation is not attributed to the Program.

From January 1, 2019, to December 31, 2019, the program achieved an overall realization rate of 113% and substantially exceeded its planned realization rate of 95%. The 2019 monthly realization rates shown in Table 1-1 range from 73% in January to 118% in August. The realization rate for summer events averaged 115%, and winter events averaged 104%. Summer events typically have higher realization rates than winter events. However, one of two winter events that occurred on October 2 performed more like a summer event and raised the overall winter realization rate.

Performance indicators for DG Pilot participants were reported through the end of the pilot (2014). Therefore, results reported in 2015–2019 are not directly comparable to the results of combined pilot and program reported in 2013 and 2014.

# 2 IMPACT ANALYSIS METHODOLOGY

## 2.1 Data

The company provides measured generation data to DNV GL on a quarterly basis. If a site is not dispatched for a given event, it is not recorded. Each record includes the enrolled (dispatchable) generation for every site called for the event, as well as the measured generation for each hour ending during the event duration (in kW). Observations are recorded at the event-hour level for each site called on a given event day.

## 2.2 Evaluation Metrics

The key performance indicator used to measure program performance is the realization rate. The site-level realization rate for a given event interval is the on-site measured generation during that interval divided by the dispatched generation for the interval. The program realization rate during an event interval is the total measured generation divided by the total dispatched generation for all sites. For participants indexed by i, and for an event interval j,

$$Realization\ Rate_j = \frac{\sum_i Measured\ Generation\ (kW_{i,j})}{\sum_i Dispatched\ Generation\ (kW_{i,j})}$$

The aggregate dispatched and measured generation across the program is calculated by event interval and day.

Results are reported seasonally for some parts of the analysis. The winter season spans October–March, and the summer season spans April–September.

# 3 RESULTS

This section summarizes program performance from 2013 to 2019 and presents a detailed impact analysis for the 2019 events.

A total of 25 events were called in 2019, with only one event per event-day. Two events were called in the winter season (January and October) and the remaining 23 events were called between June and September. Table 3-1 presents an annual summary of the number of event days, average dispatched generation, average measured generation, and realization rates for event days through December 31, 2019.

**Table 3-1. Program Participant Impacts and Realization Rates per Year**

| Year | Number of Event Days | Average Dispatched (kW) | Average Measured Generation (kW) | Realization Rate |
|---|---|---|---|---|
| **2013** | 12 | 6,239 | 6,306 | 102% |
| **2014** | 23 | 5,862 | 5,978 | 101% |
| **2015** | 26 | 5,899 | 5,457 | 93% |
| **2016** | 37 | 5,215 | 5,524 | 106% |
| **2017** | 27 | 5,603 | 6,054 | 108% |
| **2018** | 31 | 5,296 | 5,140 | 97% |
| **2019** | 25 | 5,619 | 6,368 | 113% |

Table 3-2 presents an overview of yearly DG program impacts broken out by season. In 2019, winter's 104% realization rate and summer's 115% realization rate surpassed all prior year's seasonal rates. Both rates met the 95% target for 2019.

**Table 3-2. DG Performance Indicators for Winter and Summer (2014–2019)**

| | Number of Event Days | | Average Dispatched (kW) | | Average Generation (kW) | | Realization Rate | |
|---|---|---|---|---|---|---|---|---|
| **Year** | **Summer** | **Winter** | **Summer** | **Winter** | **Summer** | **Winter** | **Summer** | **Winter** |
| **2014** | 14 | 9 | 5,798 | 6,060 | 6,305 | 3,954 | 109% | 65% |
| **2015** | 20 | 6 | 5,958 | 5,846 | 5,903 | 4,515 | 99% | 78% |
| **2016** | 34 | 3 | 5,171 | 5,911 | 5,602 | 4,281 | 108% | 72% |
| **2017** | 24 | 3 | 5,564 | 6,130 | 6,114 | 5,234 | 110% | 85% |
| **2018** | 27 | 4 | 5,438 | 4,757 | 5,432 | 4,026 | 100% | 85% |
| **2019** | 23 | 2 | 5,565 | 6,085 | 6,376 | 6,302 | 115% | 104% |

Section 3.1 describes dispatched and measured generation by event-hour and day. Section 3.2 reports realization rates by event-hour and day. Section 3.3 provides site-level realization rate details by event day and month.

## 3.1 Program Event Impacts

The total dispatched generation for all DG participants during the 2019 winter and summer event intervals are shown in Table 3-3 and Table 3-4. The total and average dispatched generation is summarized by event day. The total hourly dispatched capacity ranged from 5,950 kW to 6,130 in winter (two events) and between 320 and 6,130 in summer (23 events). The fully enrolled program capacity is 6,130 kW.

Dispatched kW is the amount of load curtailment requested (called) by the Company during an event. It is not a measure of participants' committed load and can vary by event.

**Table 3-3. Dispatched Generation by Event Day and Hour Ending–Winter**

| Dispatched Generation by Event Day and Hour Ending (kW) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Hour Ending | | | | | | | | | |
| **Event Day** | **7** | **8** | **14** | **15** | **16** | **17** | **18** | **19** | **Total** | **Average** |
| **31-Jan-19** | 5,950 | 5,950 | | | | | | | 11,900 | 5,950 |
| **2-Oct-19** | | | 6,130 | 6,130 | 6,130 | 6,130 | 6,130 | 6,130 | 36,780 | 6,130 |

**Table 3-4. Dispatched Generation by Event Day and Hour Ending–Summer**

| | Dispatched Generation by Event Day and Hour Ending (kW) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Hour Ending | | | | | | |
| Event Day | 15 | 16 | 17 | 18 | 19 | Total | Average |
| 25-Jun-19 | | | 5,330 | 5,330 | | 10,660 | 5,330 |
| 26-Jun-19 | | | 5,810 | 5,810 | 5,810 | 17,430 | 5,810 |
| 27-Jun-19 | | 6,130 | 6,130 | 6,130 | | 18,390 | 6,130 |
| 28-Jun-19 | | 6,130 | 6,130 | 6,130 | | 18,390 | 6,130 |
| 29-Jun-19 | | 5,830 | 5,830 | 5,830 | | 17,490 | 5,830 |
| 2-Jul-19 | | | 5,700 | 5,700 | 5,700 | 17,100 | 5,700 |
| 3-Jul-19 | | 6,130 | 6,130 | 6,130 | 320 | 18,710 | 4,678 |
| 12-Jul-19 | | | 5,690 | 5,690 | | 11,380 | 5,690 |
| 15-Jul-19 | | | 5,610 | 5,610 | 5,610 | 16,830 | 5,610 |
| 16-Jul-19 | | 5,940 | 5,940 | 5,940 | 5,940 | 23,760 | 5,940 |
| 17-Jul-19 | | 6,010 | 6,010 | 6,010 | | 18,030 | 6,010 |
| 18-Jul-19 | | 4,040 | 4,040 | 4,040 | | 12,120 | 4,040 |
| 19-Jul-19 | | 5,820 | 5,820 | 5,820 | | 17,460 | 5,820 |
| 22-Jul-19 | 3,850 | 3,850 | 3,850 | | | 11,550 | 3,850 |
| 29-Jul-19 | | 4,040 | 4,040 | 4,040 | | 12,120 | 4,040 |
| 30-Jul-19 | | 5,940 | 5,940 | 5,940 | | 17,820 | 5,940 |
| 6-Aug-19 | | 5,760 | 5,760 | 5,760 | | 17,280 | 5,760 |
| 8-Aug-19 | | 5,940 | 5,940 | 5,940 | | 17,820 | 5,940 |
| 19-Aug-19 | | 5,940 | 5,940 | 5,940 | | 17,820 | 5,940 |
| 20-Aug-19 | | 5,940 | 5,940 | 5,940 | | 17,820 | 5,940 |
| 21-Aug-19 | | 5,940 | 5,940 | 5,940 | | 17,820 | 5,940 |
| 22-Aug-19 | | 5,940 | 5,940 | 5,940 | | 17,820 | 5,940 |
| 12-Sep-19 | | 6,130 | 6,130 | 6,130 | | 18,390 | 6,130 |

Table 3-5 and Table 3-6 report the program level measured generation by event day and interval for winter and summer events, respectively.

Total and average measured generation are given across all events during each event day. The average measured generation was higher in the summer (6,376 kW) than in the winter (6,302 kW). This is consistent with program expectations. Dispatched kW per site reflects the Company's higher summer peak since winter heating demands are also served by oil and gas end-uses.

**Table 3-5. Measured Generation by Event Day and Hour Ending–Winter**

| Measured Generation by Event Day and Hour Ending (kW) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Hour Ending | | | | | | | | | | |
| Event Day | 7 | 8 | 14 | 15 | 16 | 17 | 18 | 19 | Total | Average |
| 31-Jan-19 | 3,951 | 4,719 | | | | | | | 8,670 | 4,335 |
| 2-Oct-19 | | | 7,118 | 7,173 | 6,961 | 6,826 | 6,769 | 6,901 | 41,749 | 6,958 |

**Table 3-6. Measured Generation by Event Day and Hour Ending–Summer**

| Measured Generation by Event Day and Hour Ending (kW) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Hour Ending | | | | | | | |
| **Event Day** | **15** | **16** | **17** | **18** | **19** | **Total** | **Average** |
| **25-Jun-19** | | | 6,027 | 6,005 | | 12,032 | 6,016 |
| **26-Jun-19** | | | 6,265 | 6,321 | 6,271 | 18,857 | 6,286 |
| **27-Jun-19** | | 6,722 | 7,034 | 6,660 | | 20,416 | 6,805 |
| **28-Jun-19** | | 6,793 | 6,431 | 6,342 | | 19,567 | 6,522 |
| **29-Jun-19** | | 6,646 | 6,646 | 6,508 | | 19,800 | 6,600 |
| **2-Jul-19** | | | 6,556 | 6,548 | 6,446 | 19,550 | 6,517 |
| **3-Jul-19** | | 7,508 | 7,448 | 7,357 | 134 | 22,446 | 5,612 |
| **12-Jul-19** | | | 6,561 | 6,263 | | 12,824 | 6,412 |
| **15-Jul-19** | | | 6,045 | 6,061 | 6,015 | 18,121 | 6,040 |
| **16-Jul-19** | | 7,074 | 6,969 | 6,846 | 6,854 | 27,743 | 6,936 |
| **17-Jul-19** | | 7,364 | 7,361 | 7,262 | | 21,987 | 7,329 |
| **18-Jul-19** | | 5,305 | 5,198 | 5,206 | | 15,709 | 5,236 |
| **19-Jul-19** | | 4,967 | 4,974 | 4,930 | | 14,871 | 4,957 |
| **22-Jul-19** | 5,053 | 5,050 | 5,050 | | | 15,153 | 5,051 |
| **29-Jul-19** | | 5,008 | 4,721 | 4,432 | | 14,160 | 4,720 |
| **30-Jul-19** | | 6,611 | 6,783 | 6,806 | | 20,199 | 6,733 |
| **6-Aug-19** | | 6,475 | 6,454 | 6,511 | | 19,439 | 6,480 |
| **8-Aug-19** | | 6,755 | 6,718 | 6,599 | | 20,071 | 6,690 |
| **19-Aug-19** | | 7,092 | 7,107 | 7,312 | | 21,511 | 7,170 |
| **20-Aug-19** | | 7,515 | 7,291 | 7,069 | | 21,874 | 7,291 |
| **21-Aug-19** | | 6,882 | 6,919 | 6,938 | | 20,738 | 6,913 |
| **22-Aug-19** | | 7,374 | 7,216 | 7,048 | | 21,638 | 7,213 |
| **12-Sep-19** | | 7,151 | 7,045 | 7,034 | | 21,230 | 7,077 |

## 3.2 Realization Rates

The average realization rates for winter and summer are provided in Table 3-7 and Table 3-8. Both show measured generation as a percentage of the dispatched generation for each event interval.

One of the winter event days met the 95% realization rate target (Table 3-7). This event was called on October 2. Lasting six hours, it was the longest event of the year. Although it was called during the winter season, this event performed more like a summer event than a typical winter event. It was called in the afternoon presumably as load associated with air conditioning approached. Typical winter events are shorter and often occur in the morning (e.g., the January 31 event lasted two hours and ended at 8 a.m.).

22 of 23 summer event days (96%) met or exceeded the 95% target (Table 3-8). The highest performing summer event day occurred July 22, generating 131% of the dispatched load on that day. The lowest performing summer event day occurred on July 19, yielding a realization rate of 85%. Average realization rates that meet or exceed the 95% target are bolded in Table 3-7 and Table 3-8.

**Table 3-7. Realization Rates by Event Day and Hour Ending–Winter**

| Realization Rate by Event Day and Hour Ending-Winter | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Hour Ending | | | | | | | | |
| **Event Day** | **7** | **8** | **14** | **15** | **16** | **17** | **18** | **19** | **Average** |
| **31-Jan-19** | 66% | 79% | | | | | | | 73% |
| **2-Oct-19** | | | 116% | 117% | 114% | 111% | 110% | 113% | **114%** |

**Table 3-8. Realization Rates by Event Day and Hour Ending–Summer**

| Realization Rate by Event Day and Hour Ending–Summer | | | | | | |
|---|---|---|---|---|---|---|
| | Hour Ending | | | | | |
| **Event Day** | **15** | **16** | **17** | **18** | **19** | **Average** |
| **25-Jun-19** | | | 113% | 113% | | **113%** |
| **26-Jun-19** | | | 108% | 109% | 108% | **108%** |
| **27-Jun-19** | | 110% | 115% | 109% | | **111%** |
| **28-Jun-19** | | 111% | 105% | 103% | | **106%** |
| **29-Jun-19** | | 114% | 114% | 112% | | **113%** |
| **2-Jul-19** | | | 115% | 115% | 113% | **114%** |
| **3-Jul-19** | | 122% | 122% | 120% | 42% | **101%** |
| **12-Jul-19** | | | 115% | 110% | | **113%** |
| **15-Jul-19** | | | 108% | 108% | 107% | **108%** |
| **16-Jul-19** | | 119% | 117% | 115% | 115% | **117%** |
| **17-Jul-19** | | 123% | 122% | 121% | | **122%** |
| **18-Jul-19** | | 131% | 129% | 129% | | **130%** |
| **19-Jul-19** | | 85% | 85% | 85% | | 85% |
| **22-Jul-19** | 131% | 131% | 131% | | | **131%** |
| **29-Jul-19** | | 124% | 117% | 110% | | **117%** |
| **30-Jul-19** | | 111% | 114% | 115% | | **113%** |
| **6-Aug-19** | | 112% | 112% | 113% | | **112%** |
| **8-Aug-19** | | 114% | 113% | 111% | | **113%** |
| **19-Aug-19** | | 119% | 120% | 123% | | **121%** |
| **20-Aug-19** | | 127% | 123% | 119% | | **123%** |
| **21-Aug-19** | | 116% | 116% | 117% | | **116%** |
| **22-Aug-19** | | 124% | 121% | 119% | | **121%** |
| **12-Sep-19** | | 117% | 115% | 115% | | **115%** |

## 3.3 Site-Level Detail

Table 3-9 and Table 3-10 show the average realization rates by participant site for each event day. Each site is assigned a unique identifier. If a participant site was not dispatched during an event, the corresponding cell is blank. Realization rates greater than or equal to 95% are highlighted green, less than 95% and greater than or equal to 50% are purple, and rates less than 50% are highlighted in red.

Site IDs 8, 9, 10, 11, 13, and 20 met or exceeded the 95% target in every 2019 event. Table 3-11 shows the monthly average realization rate for each site. Ten sites achieved or exceeded the program target of 95% every month. Site 5 was the only site that did not reach the target of 95% in any month.

**Table 3-9. Average Realization Rates by Site and Event Day (January 1–July 30, 2019)**

| Site ID | Jan | June | | | | | July | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 25 | 26 | 27 | 28 | 29 | 2 | 3 | 12 | 15 | 16 | 17 | 18 | 19 | 22 | 29 | 30 |
| 1 | 44% | 88% | 83% | 92% | 89% | 97% | 90% | 98% | 96% | 83% | 99% | 104% | | 0% | | | 94% |
| 2 | 57% | 98% | 102% | 104% | 101% | 105% | 105% | 107% | 103% | 103% | 107% | 107% | 105% | 109% | 112% | 107% | 106% |
| 3 | 70% | 104% | 103% | 118% | 112% | 117% | 116% | 116% | 114% | 115% | 119% | 119% | 117% | 117% | 119% | 52% | 119% |
| 4 | 49% | 98% | 100% | 109% | 93% | 110% | 105% | 111% | 107% | 106% | 110% | 109% | 110% | 112% | 112% | 102% | 104% |
| 5 | 50% | | | 84% | 85% | 85% | 83% | 82% | 85% | 92% | 88% | 94% | 94% | 93% | 98% | 80% | 92% |
| 6 | 62% | 114% | 110% | 117% | 117% | 118% | | 122% | 116% | 112% | 113% | 124% | 112% | 115% | 120% | 114% | 115% |
| 7 | 71% | | 102% | 114% | 117% | 119% | 117% | 118% | 115% | 115% | 113% | 124% | 120% | 121% | 126% | 113% | 105% |
| 8 | 132% | 126% | 128% | 133% | 118% | 137% | 135% | 143% | 139% | 135% | 147% | 144% | 138% | 140% | 146% | 138% | 138% |
| 9 | 129% | 106% | 101% | 104% | 113% | 110% | 106% | 120% | 109% | 106% | 104% | 119% | 135% | 134% | 138% | 140% | 139% |
| 10 | 132% | 129% | 120% | 123% | 128% | 132% | 125% | 127% | 127% | 135% | 139% | 134% | 130% | 139% | 133% | 127% | 126% |
| 11 | 168% | 221% | 221% | 232% | 229% | 238% | 237% | 242% | 227% | 220% | 214% | 241% | 241% | 235% | 244% | 234% | 224% |
| 12 | 78% | 93% | 91% | 98% | 94% | 103% | 100% | 104% | 97% | 97% | 100% | 106% | 106% | 105% | 102% | 99% | 94% |
| 13 | 114% | 136% | 137% | 142% | 134% | 141% | 143% | 150% | 138% | 140% | 142% | 142% | 141% | 146% | 148% | 142% | 140% |
| 14 | 97% | 93% | 96% | 102% | 103% | 93% | 100% | 105% | 98% | 99% | 101% | 111% | 110% | 114% | 105% | 105% | 106% |
| 15 | 90% | 121% | 121% | 131% | 101% | 148% | 156% | 159% | 151% | | 157% | 135% | 144% | 159% | 151% | 136% | 134% |
| 16 | 77% | | 81% | 95% | 92% | 95% | 95% | 100% | 97% | 95% | 92% | 115% | 106% | 106% | 115% | 104% | 103% |
| 17 | 51% | 94% | 90% | 93% | 103% | 103% | 104% | 107% | | 98% | 97% | 104% | 108% | 103% | 108% | 102% | 102% |
| 18 | 109% | 162% | 153% | 160% | 157% | 146% | | 148% | 74% | | | 168% | 166% | | | 73% | |
| 19 | 144% | 237% | 230% | 242% | 242% | | 244% | 250% | 255% | 242% | 240% | | | | | | 129% |
| 20 | 114% | 201% | 193% | 204% | 199% | 212% | 214% | 220% | 214% | 209% | 200% | 217% | 218% | 208% | 222% | 201% | 198% |
| 21 | | 179% | 182% | 67% | 0% | | 193% | 199% | | | 190% | 206% | 199% | 197% | 202% | 194% | 190% |

| Legend |
|---|
| 🟩 > 95% |
| 🟦 < 95% ≥50% |
| 🟥 < 50% |
| ⬜ No event called |

**Table 3-10. Average Realization Rates by Site and Event Day (August 6–October 2, 2019)**

| Site ID | August | | | | | | September | October |
|---|---|---|---|---|---|---|---|---|
| | 6 | 8 | 19 | 20 | 21 | 22 | 12 | 2 |
| 1 | 96% | 93% | 107% | 109% | 100% | 108% | 101% | 94% |
| 2 | 104% | 103% | 110% | 105% | 109% | 108% | 110% | 110% |
| 3 | 113% | 108% | 109% | 105% | 107% | 112% | 109% | 108% |
| 4 | 103% | 103% | 115% | 112% | 111% | 110% | 112% | 111% |
| 5 | 88% | 90% | 93% | 91% | 87% | 91% | 0% | 88% |
| 6 | 110% | 110% | 50% | 115% | 105% | 107% | 114% | 110% |
| 7 | 117% | 117% | 122% | 118% | 115% | 117% | 118% | 121% |
| 8 | 138% | 133% | 144% | 146% | 133% | 142% | 138% | 136% |
| 9 | 115% | 115% | 124% | 133% | 132% | 116% | 128% | 120% |
| 10 | 126% | 121% | 134% | 131% | 131% | 130% | 133% | 134% |
| 11 | 223% | 236% | 243% | 236% | 228% | 238% | 237% | 232% |
| 12 | 95% | 90% | 101% | 103% | 99% | 94% | 103% | 94% |
| 13 | 141% | 125% | 140% | 135% | 135% | 139% | 138% | 129% |
| 14 | 103% | 103% | 106% | 97% | 101% | 103% | 107% | 102% |
| 15 | 144% | 131% | 156% | 150% | 131% | 149% | 155% | 120% |
| 16 | 93% | 97% | 107% | 103% | 92% | 105% | 99% | 95% |
| 17 | 98% | 102% | 106% | 107% | 101% | 104% | 103% | 108% |
| 18 | | | | | | | 136% | 128% |
| 19 | 238% | 246% | 257% | 254% | 250% | 253% | 250% | 147% |
| 20 | 197% | 198% | 204% | 214% | 190% | 211% | 196% | 211% |
| 21 | | 185% | 205% | 199% | 190% | 198% | 192% | 187% |

| **Legend** |
|---|
| > 95% |
| < 95% ≥50% |
| < 50% |
| No event called |

### Table 3-11. Average Realization Rates by Site and Event Month (2019)

| Site ID | January | June | July | August | September | October |
|---|---|---|---|---|---|---|
| **1** | 44% | 90% | 83% | 102% | 101% | 94% |
| **2** | 57% | 102% | 106% | 107% | 110% | 110% |
| **3** | 70% | 111% | 111% | 109% | 109% | 108% |
| **4** | 49% | 102% | 108% | 109% | 112% | 111% |
| **5** | 50% | 85% | 89% | 90% | 0% | 88% |
| **6** | 62% | 115% | 116% | 100% | 114% | 110% |
| **7** | 71% | 113% | 117% | 118% | 118% | 121% |
| **8** | 132% | 129% | 140% | 139% | 138% | 136% |
| **9** | 129% | 107% | 123% | 123% | 128% | 120% |
| **10** | 132% | 126% | 132% | 129% | 133% | 134% |
| **11** | 168% | 229% | 232% | 234% | 237% | 232% |
| **12** | 78% | 96% | 101% | 97% | 103% | 94% |
| **13** | 114% | 138% | 143% | 136% | 138% | 129% |
| **14** | 97% | 98% | 105% | 102% | 107% | 102% |
| **15** | 90% | 125% | 148% | 144% | 155% | 120% |
| **16** | 77% | 91% | 103% | 99% | 99% | 95% |
| **17** | 51% | 97% | 103% | 103% | 103% | 108% |
| **18** | 109% | 155% | 129% |  | 136% | 128% |
| **19** | 144% | 238% | 226% | 250% | 250% | 147% |
| **20** | 114% | 202% | 211% | 202% | 196% | 211% |
| **21** |  | 100% | 196% | 195% | 192% | 187% |

| **Legend** |
|---|
| > 95% |
| < 95% ≥50% |
| < 50% |
| No event called |

# 4 CONCLUSIONS

The objective of each DG event is to provide the Company with a supply resource during periods of high demand. The goal of the DG program is that measured generation be at least 95% of dispatched load. In 2019, the DG Program met its target 95% realization rate. The annual realization rate was 113%, 18 percentage points higher than the program target of 95%. Summer events achieved a realization rate of 115%, while winter events achieved a 104% realization rate.

# 5 RECOMMENDATIONS

The purpose of the Company's annual Non-residential DG program evaluation of dispatch events is to assess program progress towards planned goals, while providing actionable information for program managers to calibrate program operation to align with these goals.

DNV GL recommends that enrolled and dispatched load be reviewed and adjusted on a seasonal basis to account for changes in site-level demand for electricity and any changes in corresponding generation capacity. Since participants are generating electricity based on their demand only, and provide this amount of capacity to the grid, commitments based on maximum capacity calculated from summer peaks are not attainable in the winter. The Company would need to establish site-level estimates of the monthly peak kW based on historical and/or seasonal site-level measured demand to make this change. The benefits of doing so would be:

- Improved ability to predict the peak shaving capability of the program in aggregate throughout the year
- Improved ability to track site-level performance with realization rates comparable across all months

## About DNV GL