9.4.2 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[109]

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

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

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

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

Where:

ΔkWh = gross annual electric energy savings
ΔkW = 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 in linear feet

Input Variables

Table 9-11: Input Values for Door Gasket Savings Calculations

Component	Type	Value	Unit	Source(s)
ΔkWh/ft	Variable	See Table 9-12	kWh/ft	Tennessee Valley Authority TRM 2017, p. 122.
ΔkW/ft	Variable	See Table 9-12	kW/ft	Tennessee Valley Authority TRM 2017, p. 122.
L	Variable	See customer application	feet	Customer application
		Default = 15		DNV GL engineering judgment

[109] Electric energy and demand savings for this measure are based on modeled results found in the Tennessee Valley Authority TRM 2017, 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 9-12: Door Gasket Gross Annual Electric Energy and Gross Coincident Demand Reduction (per Linear Foot) [110]

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.

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

$$\begin{aligned}\Delta kWh &= \frac{\Delta kWh}{ft} \times L \\ &= 3.4 \frac{kWh}{ft} \times 15\,ft \\ &= 51.0\,kWh\end{aligned}$$

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

$$\begin{aligned}\Delta kW &= \frac{\Delta kW}{ft} \times L \\ &= 0.0004\,kW/ft \times 15\,ft \\ &= 0.006\,kW\end{aligned}$$

Source(s)

The primary source for this deemed savings approach is the Tennessee Valley Authority TRM 2017, p. 121 - 122.

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[110] Tennessee Valley Authority 2017, p. 122. 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.

9.4.3 Commercial Freezers and Refrigerators – Solid Door

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

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

$$\Delta kWh = (kWh_{base} - kWh_{ee}) \times Qty \times Days$$

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

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

Where:

ΔkWh	=	gross annual electric energy savings
ΔkW	=	gross coincident demand reduction
kWh_{base}	=	daily energy consumption of the baseline equipment
kWh_{ee}	=	daily energy consumption of the efficient equipment
Qty	=	number of units installed
Days	=	days per year
FLH	=	annual equivalent full load hours of equipment
CF	=	demand coincidence factor

Input Variables

Table 9-13: Input Parameters for Commercial Freezers and Refrigerator Measure

Component	Type	Value	Units	Source(s)
kWh_{base}	Variable	See Table 9-14	kWh	Federal Standards, Energy Efficiency Program for Certain Commercial and Industrial Equipment, title 10, sec. 431.66 (2013)[111]
kWh_{ee}	Variable	See Table 9-15	kWh	ENERGY STAR® Certified-commercial-refrigerators-and-freezers[112]
Qty	Variable	See customer application	-	Customer application
Days	Fixed	365	days (annual)	constant
FLH	Fixed	5,858	hours (annual)	Mid-Atlantic TRM 2018, p.459 and 462[113]
CF	Fixed	0.772	-	Mid-Atlantic TRM 2018, p.459 and 462[114]

Table 9-14: Calculated Baseline Daily Energy Consumption from Volume[115]

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

111 The Mid-Atlantic TRM 2018 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.

112 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

113 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.

114 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.

115 Volume, V, is rated unit volume in ft^3

Table 9-15: Calculated Efficient Unit Daily Energy Consumption from Volume[116]

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
$15 \le V < 30\ ft^3$	=0.066 x V + 0.310	=0.120 x V + 2.248
$30 \le V < 50\ ft^3$	=0.040 x V + 1.090	=0.285 x V + 2.703
$V \ge 50\ ft^3$	=0.024 x V + 1.890	=0.142 x V + 4.445
Transparent Door		
$V < 15\ ft^3$	=0.095 x V + 0.445	=0.232 x V + 2.360
$15 \le V < 30\ ft^3$	=0.050 x V + 1.120	=0.232 x V + 2.360
$30 \le V < 50\ ft^3$	=0.076 x V + 0.340	=0.232 x V + 2.360
$V \ge 50\ ft^3$	=0.105 x V + 1.110	=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

The primary sources for this deemed savings approach is the Mid-Atlantic TRM 2018, p. 457 – 462.

[116] Volume, V, is rated unit volume in ft^3

9.4.4 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

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

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

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

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

Where:

ΔkWh	= gross annual electric energy savings
ΔkW	= gross coincident demand reduction
Qty	= number of ice makers installed
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 9-16: Input Parameters for Commercial Ice Maker

Component	Type	Value	Units	Source(s)
kWh_{base}	Variable	Batch-type: see Table 9-17 Continuous-type: see Table 9-18	kWh/ 100-lb of ice	Federal Standards 80 FR 4645[117]
kWh_{ee}	Variable	<u>Water-cooled:</u> CEE Tier 2 batch-type: see Table 9-19 CEE Tier 2 continuous-type: see Table 9-20 <u>Air-cooled:</u> ENERGY STAR batch-type: see Table 9-21 ENERGY STAR continuous-type: see Table 9-22	kWh/ 100-lb of ice	CEE Tier 2[118] and ENERGY STAR®[119] lists of qualifying equipment
Qty	Variable	See customer application	-	From application
H_{rated}	Variable	See customer application	lb (daily)	From application
DC	Fixed	0.5	-	Arkansas TRM 2017 Volume 2 p. 477[120]
Days	Fixed	365	days (annual)	Arkansas TRM 2017 Volume 2 p. 477
CF	Fixed	1.0	-	Arkansas TRM 2017 Volume 2 p. 478[121]

[117] 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.

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

[119] 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.

[120] 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.

[121] 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 9-17: Batch-Type Ice Machine Baseline Efficiencies

Ice Machine Type	Type of Cooling	Harvest Rate (lb/day)	kWhbase (kWh/100-lb ice)
Ice-Making Head	Water	< 300	6.88 – 0.0055 x H
		≥ 300 and < 850	5.80 – 0.00191 x H
		≥ 850 and < 1500	4.42 – 0.00028 x H
		≥ 1500 and < 2500	4.00
		≥ 2500 and < 4000	4.00
	Air	< 300	10.00 – 0.01233 x H
		≥ 300 and < 800	7.055 – 0.0025 x H
		≥ 800 and < 1500	5.55 - 0.0003342 x H
		≥ 1500 and < 4000	4.61
Remote-Condensing w/o Remote Compressor	Air	≥ 50 and < 1000	7.97 - 0.00342 x H
		≥ 1000 and < 4000	4.55
Remote-Condensing w/ Remote Compressor	Air	< 942	7.97 - 0.00342 x H
		≥ 942 and < 4000	4.75
Self-Contained	Water	< 200	9.50 –0.00342x H
		≥ 200 and < 2500	5.70
		≥ 2500 and < 4000	5.70
	Air	< 110	14.79 – 0.0469 x H
		≥ 110 and < 200	12.42 – 0.02533 x H
		≥ 200 and < 4000	7.35

Table 9-18: Continuous-Type Ice Machine Baseline Efficiencies

Ice Machine Type	Type of Cooling	Harvest Rate (lb/day)	kWh_{base} (kWh/100-lb ice)
Ice-Making Head	Water	< 801	6.48 - 0.00267 x *H*
		≥ 801 and < 2,500	4.34
		≥ 2,500 and < 4,000	4.34
	Air	< 310	9.19 - 0.00629 x *H*
		≥ 310 and < 820	8.23 - 0.00320 x *H*
		≥ 820 and < 4,000	5.61
Remote-Condensing w/o remote compressor	Air	< 800	9.70 - 0.00580 x *H*
		≥ 800 and < 4,000	5.06
Remote-Condensing w/ remote compressor	Air	< 800	9.90 - 0.00580 x *H*
		≥ 800 and < 4,000	5.26

Ice Machine Type	Type of Cooling	Harvest Rate (lb/day)	kWh_{base} (kWh/100-lb ice)
Self-Contained	Water	< 900	7.60 – 0.00302 x *H*
		≥ 900 and < 2,500	4.88
		≥ 2,500 and < 4,000	4.88
	Air	< 200	14.22 – 0.03000 x *H*
		≥ 200 and < 700	9.47 – 0.00624 x *H*
		≥ 700 and < 4,000	5.10

Table 9-19: Batch-Type CEE Tier 2 Ice Machine Qualifying Efficiencies[122]

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*
		≥ 175 and < 450	7.1 – 0.0062 x *H*
		≥ 450 and < 1,000	4.7 – 0.0011 x *H*
		≥ 1,000	3.7 – 0.0002 x *H*

Table 9-20: Continuous-Type CEE Tier 2 Ice Machine Qualifying Efficiencies[123]

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*
		≥ 1,000	3.2

[122] 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

[123] Ibid

Table 9-21: Batch-Type ENERGY STAR® Ice Machine Qualifying Efficiencies[124]

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*
		≥ 300 and < 800	6.49 – 0.0023 x *H*
		≥ 800 and < 1,500	5.11 – 0.00058 x *H*
		≥ 1,500 and ≤ 4,000	4.24
Remote-Condensing	Air	< 988	7.17 – 0.00308 x *H*
		≥ 988 and ≤ 4,000	4.13
Self-Contained	Air	< 110	12.57 – 0.0399 x *H*
		≥ 110 and < 200	10.56 – 0.0215 x *H*
		≥ 200 and ≤ 4,000	6.25

Table 9-22: Continuous-Type ENERGY STAR® Ice Machine Qualifying Efficiencies[125]

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*
		≥ 310 and < 820	7.08 – 0.002752 x *H*
		≥ 820 and ≤ 4,000	4.82
Remote-Condensing	Air	< 800	7.76 – 0.00464 x *H*
		≥ 800 and ≤ 4,000	4.05
Self-Contained	Air	< 200	12.37 – 0.0261 x *H*
		≥ 200 and < 700	8.24 – 0.005429 x *H*
		≥ 700 and ≤ 4,000	4.44

Source

The primary source for this deemed savings approach is the Arkansas TRM 2017 Version 7.0, p.475 – p.478.

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[124] 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

[125] Ibid

9.4.5 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

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

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

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

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

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 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 9-23—are to be used.

Where:

ΔkWh = gross annual electric energy savings
ΔkW = gross coincident demand reduction
Qty = number of motors replaced
$watts_{base}$ = rated wattage of existing/baseline evaporator fan motor
$watts_{ee}$ = rated wattage of electronically commutated evaporator fan motor
CW_{rated} = conversion factor of rated wattage to connected-load wattage
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 Coincidence Factor

Input Variables

Table 9-23: Input Values for ECM Evaporator Savings Calculations

Component	Type	Value	Unit	Source(s)
Qty	Variable	See customer application	-	Customer application
		Default = 1		Per unit savings
$watts_{base}$	Variable	See customer application	watts	Customer application
		Defaults: Walk-in: 128 Reach-in: 31 Unknown: 31		Mid-Atlantic TRM 2018, p. 470[126]
$watts_{ee}$	Variable	See customer application	watts	Customer application
		Defaults: Walk-in: 50 Reach-in: 12 Unknown: 12		Commercial Refrigeration Loadshape Project 2015, NEEP, p. 5[127]
CW_{rated}	Fixed	1.02	-	Commercial Refrigeration Loadshape Project NEEP 2015, p. 6[128]
DC_{evap}	Fixed	0.978	-	Mid-Atlantic TRM 2018, p. 470
HOU	Variable	8,760	hours (annual)	Mid-Atlantic TRM 2018, p. 470
WHF_e	Fixed	Low Temp (-35°F - -1°F): 1.76 Med Temp (0°F - 30°F): 1.76 High Temp (31°F - 55°F): 1.38	-	Mid-Atlantic TRM 2018, p. 470
WHF_d	Fixed	Low Temp (-35°F - -1°F): 1.76 Med Temp (0°F - 30°F): 1.76 High Temp (31°F - 55°F): 1.38	-	Mid-Atlantic TRM 2018, p. 470

[126] 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.

[127] 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 watts.

[128] The Commercial Refrigeration Loadshape Project NEEP 2015, p. 6[128] provides normalized ECM motor watts by rated horsepower based on measurement data from 66 sites. The values collected on application are in rated wattage instead of rated horsepower. Therefore, the 758 W/hp is converted to 1.02 connected-watts/rated-watts (758 W/hp divided by 746 W/hp).

Component	Type	Value	Unit	Source(s)
CF	Fixed	1.53[129]	-	Mid-Atlantic TRM 2018, p. 470

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:

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

$$= 1\ unit \times \frac{(31\ W - 12\ W)}{1{,}000\ W/kW} \times 1.02 \times 0.978 \times 8{,}760\ hours \times 1.38$$

$$= 229\ kWh$$

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

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

$$= 1\ unit \times \frac{(31\ W - 12\ W)}{1{,}000\ W/kW} \times 1.02 \times 1.38 \times 1.53$$

$$= 0.041\ \mathrm{kW}$$

Source(s)

The primary source for this deemed savings approach is the Mid-Atlantic TRM 2018, p. 469 to 471.

[129] 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 is greater than one because it is calculated relative to the wattage of the post-retrofit ECM motor as opposed to the existing SP motor.

9.4.6 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

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

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

Gross coincident demand reduction is calculated using the following equation:

$$\Delta kW = Qty_{fan} \times hp_{fan} \times \frac{kW}{hp} \times WHF_d \times CF$$

Where:

ΔkWh = gross annual electric energy savings
ΔkW = gross coincident demand reduction
Qty_{fan} = number of evaporator fan motors
hp_{fan} = 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 = Summer Peak Coincidence Factor

Input Variables

Table 9-24: Input Values for Freezer and Cooler Evaporator Fan Controls Saving Calculations

Component	Type	Value	Unit	Source(s)
Qty_{fan}	Variable	See customer application	-	Customer application
		Default = 1		Per unit savings
hp_{fan}	Variable	See customer application	hp	Customer application
		Default = 1/15 hp		Mid-Atlantic TRM 2018, p. 473[130]
kW/hp	fixed	Single-speed: 2.088 kW/hp Multi-speed: 0.758 kW/hp	kW/hp	Mid-Atlantic TRM 2018, p. 473
$\%On_{base}$	Fixed	97.8%	percent	Mid-Atlantic TRM 2018, p. 473
$\%On_{ee}$	Fixed	Single-speed: 63.6% Multi-speed: 69.2%	percent	Mid-Atlantic TRM 2018, p. 473
HOU	Fixed	8,760	hours (annual)	Mid-Atlantic TRM 2018, p. 473
WHF_e	Fixed	Low Temp (-35°F to -1°F): 1.76 Med Temp (0°F - 30°F): 1.76 High Temp (31°F - 55°F): 1.38	-	Mid-Atlantic TRM 2018, p. 473
WHF_d	Fixed	Low Temp (-35°F - -1°F): 1.76 Med Temp (0°F - 30°F): 1.76 High Temp (31°F - 55°F): 1.38	-	Mid-Atlantic TRM 2018, p. 473
CF	Fixed	0.26	percent	Mid-Atlantic TRM 2018, p. 473

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

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

$$= 1 \times \frac{1}{15} hp \times 0.758 \frac{kW}{hp} \times (97.8\% - 69.2\%) \times 8{,}760\ hours \times 1.38$$

[130] 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.

$$= 175 \text{ kWh}$$

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

$$\Delta kW = Qty_{fan} \times hp_{fan} \times \frac{kW}{hp} \times WHF_d \times CF$$

$$= 1 \times \frac{1}{15} hp \times 0.758 \frac{kW}{hp} \times 1.38 \times 0.26 = 0.018 \text{ kW}$$

Source(s)

The primary source for this deemed savings approach is the Mid-Atlantic TRM 2018, p. 472 to 474.

9.4.7 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

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

$$\Delta kWh = \frac{kWh}{hp} \times hp_{comp}$$

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

$$\Delta kW^{131} = 0$$

Where:

ΔkWh = gross annual electric energy savings
ΔkW = 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 9-25: Input Values for Floating Head Pressure Control Savings Calculations

Component	Type	Value	Unit	Source(s)
kWh/hp	Variable	See Table 9-26	kWh/ horsepower/ year	Maine Commercial TRM 2018, p. 81
		Default = 509 (High Temperature, Scroll Compressor)		
hp_{comp}	Variable	See customer application.	horsepower	Customer application
		Default = 5		Vermont TRM 2015, p. 132[132]

[131] Gross coincident demand savings are zero since savings are realized during off-peak periods. No demand reduction is expected from this measure.

[132] Vermont TRM 2015, p. 132. Assumes "5 HP compressor data used, based on average compressor size."

Table 9-26: Floating-head Pressure Control Gross Annual Electric Energy Savings (per Horsepower)[133]

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:

$$\Delta kW = 0\ kW$$

Source(s)

The primary source for this deemed savings approach is the Maine Commercial TRM 2018, p. 80-81. Additonally, the Vermont TRM 2015, p. 132 was used to estimate the default compressor size.

[133] Efficiency Maine Commercial TRM 2016, Table 12 – Floating Head Perssure Control kWh Savings per Horsepower, p. 81.

9.4.8 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.[134] 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

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

$$\Delta kWh = Qty \times kW_{ASDH} \times DC \times HOU \times WHF_e$$

The gross coincident demand reduction is assigned as follows:

$$\Delta kW = Qty \times kW_{ASDH} \times DC \times WHF_d \times CF$$

Where:

ΔkWh	= gross annual electric energy savings
ΔkW	= 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
Qty	= number of reach-in refrigerator or freezer doors with film installed
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

134 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 9-27: Input Parameters for Low/No-Sweat Door Film

Component	Type	Value	Units	Source(s)
kW_{ASDH}	Variable	See customer application.	kW	Customer application
		Default: 0.13		Mid-Atlantic TRM 2018, p. 467[135]
Qty	Variable	See customer application.	-	Customer application
		Default = 1		Per unit savings
DC	Variable	No controls: 0.907 On/Off controls: 0.589 Micropulse controls: 0.428	-	Mid-Atlantic TRM 2018, p. 467
		Default: 0.428	-	Mid-Atlantic TRM 2018, p. 467
HOU	Fixed	8,760	hours (annual)	Mid-Atlantic TRM 2018, p. 467
WHF_e	Fixed	Low Temp (-35°F - -1°F): 1.50 Med Temp (0°F - 30°F): 1.50 High Temp (31°F - 55°F): 1.25	-	Mid-Atlantic TRM 2018, p. 467
WHF_d	Fixed	Med Temp (0°F - 30°F): 1.50 High Temp (31°F - 55°F): 1.25	-	Mid-Atlantic TRM 2018, p. 467
CF[136]	Variable	Freezer case: On/Off controls: 0.21 Micropulse: 0.30	-	Mid-Atlantic TRM 2018, pp. 467–468
		Refrigerated case: On/Off controls: 0.25 Micropulse: 0.36		Mid-Atlantic TRM 2018, pp. 467–468
		No controls: 1.0		Assumed uniform load throughout the year

Default Savings

When the application does not have information about the baseline ASDH control, it is assumed to be an ASDH with micropulse controls. When the temperature range and the case type are also unknown, the case is assumed to be a high-temperature refrigerated case having ASDH with micropulse controls.

135 Mid-Atlantic TRM 2018, p. 467. Original source Cadmus. 2015. Commercial Refrigeration Loadshape Project. Lexington, MA.

136 Mid-Atlantic TRM 2018, p. 467. Coincidence factors developed by dividing the PJM Summer Peak Savings for ASDH Controls from Table 52 by the product of the average wattage of ASDH per connected door (0.13 kW) and the Waste Heat Factor for Demand.

Accordingly, the default annual energy savings are as follows:

$$\Delta kWh = Qty \times kW_{ASDH} \times DC \times HOU \times WHF_e$$

$$= 1\,x\,0.13\,kW \times 0.428 \times 8{,}760\,hours \times 1.25$$

$$= 609.3\,kWh$$

And the default demand reduction is:

$$\Delta kW = Qty \times kW_{ASDH} \times DC \times WHF_d \times CF$$

$$= 1 \times 0.13\,kW \times 0.428 \times 1.25 \times 0.36$$

$$= 0.025\,kW$$

Source

The primary sources for this deemed savings approach is the Mid-Atlantic TRM 2018 p. 466 – p. 468. The method was adapted from the ASDH controls methodology.

9.4.9 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

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

$$\Delta kWh = \frac{load}{\frac{12{,}000\, Btu/hour}{ton}} \times \frac{3.516\, kW/ton}{COP} \times L \times ESF \times HOU$$

Gross coincident demand reduction is assigned as follows:

$$\Delta kW^{137} = 0$$

Where:

ΔkWh	= gross annual electric energy savings
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 9-28: 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 2018, p. 463[138]

[137] Mid-Atlantic TRM 2018, p. 463. Assumed that continuous covers are deployed at night; therefore, no demand savings occur during the peak period.

[138] Mid-Atlantic 2018, p. 463. 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.

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Component	Type	Value	Unit	Source(s)
L	Variable	See customer application.	feet	Customer application
		Default = 6		DNV GL judgment
COP[139]	Fixed	2.2	-	Mid-Atlantic TRM 2018, p. 464
ESF[140]	Fixed	0.09	-	Mid-Atlantic TRM 2018, p. 464
HOU	Variable	Default = 8,760	hours (annual)	Mid-Atlantic TRM 2018, p. 464

Default Savings

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

The default gross annual electric energy savings will be assigned according to the following calculation:

$$\Delta kWh = \frac{load}{\frac{12{,}000\,Btu/hour}{ton}} \times L \times \frac{3.516\,kW/ton}{COP} \times ESF \times HOU$$

$$= \frac{1{,}500\,Btu/hour/feet}{12{,}000\,Btu/hour/ton} \times \frac{3.516\,kW/ton}{2.2} \times 6\,feet \times 0.09 \times 8{,}760\,hours$$

$$= 945.0\,kWh$$

The default gross coincident demand reduction will be assigned as follows:

$$\Delta kW = 0$$

Source(s)

The primary source for this deemed savings approach is the Mid-Atlantic TRM 2018, p. 463 - 464.

[139] Kuiken et al, Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0, KEMA, March 22, 2010.

[140] Mid-Atlantic TRM 2018, p. 464. 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.

9.4.10 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

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

$$\Delta kWh = load \times \frac{3.156\ kW/ton}{COP} \times HOU \times ESF$$

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

$$\Delta kW = load \times \frac{3.156\ kW/ton}{COP} \times DRF$$

Where:

ΔkWh = gross annual energy savings
ΔkW = gross coincident demand reduction
load = total capacity of condensers
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 9-29: Input Values for Refrigeration Coil Cleaning Savings Calculations

Component	Type	Value	Unit	Source(s)
load	Variable	See customer application	tons of cooling	Customer application
COP	Fixed	Low Temp (-35°F - -1°F): 1.3 Med Temp (0°F – 30°F): 1.3 High Temp (31°F - 55°F): 2.5	-	Pennsylvania TRM 2016.1, p. 391

Component	Type	Value	Unit	Source(s)
HOU	Fixed	Low Temp (-35°F - -1°F): 6,370 Med Temp (0°F - 30°F): 6,370 High Temp (31°F - 55°F): 6,173	hours (annual)	Calculated duty cycle using weather factor, defrost factor, and capacity factor[141]
ESF[142]	Fixed	0.048	-	Qureshi and Zubair (2011)
DRF[143]	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*.

[141] 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.

[142] 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.

[143] Ibid.

9.4.11 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

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

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

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

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

Where:

ΔkWh = gross annual electric energy savings
ΔkW = 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 9-30: Input Values for Suction Pipe Insulation Savings Calculations

Component	Type	Value	Unit	Source(s)
ΔkWh/ft	Variable	See Table 9-31	kWh/feet	Pennsylvania TRM 2016, p. 418
ΔkW/ft	Variable	See Table 9-31	kW/feet	Pennsylvania TRM 2016, p. 418
L	Variable	See customer application	feet	Customer application
		Default = 1		Per unit savings

Table 9-31: Suction Pipe Insulation Gross Annual Electric Energy Savings and Gross Coincident Demand Reduction (per Linear Foot)[144]

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 gross annual electric energy savings will be assigned according to the following calculation:

$$\Delta kWh = \frac{\Delta kWh/year}{ft} \times L$$

$$= 11.3\, kWh/ft \times 1\, foot$$

$$= 11.3\, kWh$$

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

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

$$= 0.00219\, kW/ft \times 1 ft$$

$$= 0.00219\, kW$$

Source(s)

The primary source for this deemed savings approach is the Pennsylvania TRM 2016, p. 417 – 418.

144 Pennsylvania TRM 2016, p. 418, original source: Southern California Edison Company, "Insulation of Bare Refrigeration Suction Lines", Work Paper WPSCNRRN0003.

9.4.12 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

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

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

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

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

Where:

ΔkWh	= gross annual electric energy Δkoincident demand reductions
Qty	= number of openings/doors
kWh/ft^2	= average annual kilowatt hour savings per square foot of infiltration barrier
Area	= area of doorway where strip curtains are installed
HOU	= annual hours of use

Input Variables

Table 9-32: Input Values for Strip Curtain Savings Calculations

Component	Type	Value	Unit	Source(s)
Qty	Variable	See customer application	-	See customer application
kWh/ft^2	Variable	See Table 9-33	kWh/ft^2	Pennsylvania TRM 2016, p. 397 (Table 3-107)
Area	Variable	Supermarkets: 35 Convenience Store: 21 Restaurant: 21 Refr. Warehouse: 80	ft^2	Supermarkets[145] Convenience Stores[146] Restaurant[147] Refr. Warehouse[148]
		Default = 21		Assume convenience store

[145] Pennsylvania TRM 2016, Table 3-108, p. 398.
[146] Pennsylvania TRM 2016, Table 3-109, p. 399.
[147] Pennsylvania TRM 2016, Table 3-110, p. 400.
[148] Pennsylvania TRM 2016, Table 3-111, p. 401.

Component	Type	Value	Unit	Source(s)
HOU	Fixed	8,760	hours	Pennsylvania TRM 2016, p. 395

Table 9-33: Strip Curtain Gross Annual Electric Energy Savings (per sq. ft.)[149]

Type	Baseline Curtain	Gross 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[150]	Yes	5
	No	20
	Unknown	11

[149] 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]."

[150] Assigned most conservative savings and reductions values for a known building subcategory.

Type	Baseline Curtain	Gross Annual Electric Energy Savings per Square Foot ($\Delta kWh/ft^2$)
Not applicable	Yes	0
	No	0
	Unknown	0

Default Savings

If the proper values are not supplied, a default savings may be applied using conservative input values. However, per Table 9-33, the gross annual electric energy savings per square foot varies widely based on the space type, therefore the default savings must be calculated for individual space types obtained from the application.

The default gross annual electric energy savings for the Convenience Store – Cooler, for example, will be assigned according to the following calculation:

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

$$= 5\ kWh/ft^2 \times\ 21\ ft^2$$

$$= 105.0\ kWh$$

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

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

$$= \frac{105\ kWh}{8{,}760\ hours}$$

$$= 0.012\ kW$$

Source(s)

The primary source for this deemed savings approach is the Pennsylvania TRM 2016, p. 394 - 402.

9.4.13 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

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

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

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

$$\Delta kW = \frac{\Delta kWh}{8{,}760}$$

Where:

ΔkWh = gross annual electric energy savings
ΔkW = gross coincident demand reduction
kW_{rated} = rated kilowatts of connected equipment
HOU = annual hours of use
ESF = energy savings factor

Input Variables

Table 9-34: 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 9-35)		Massachusetts TRM 2015, p. 268
ESF	Variable	See Table 9-35	-	Massachusetts TRM 2015, p. 268
HOU	Fixed	8,760	hours (annual)	Massachusetts TRM 2015, p. 268

Table 9-35: Vending Miser Rated Kilowatts and Energy Savings Factors[151]

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 gross annual electric energy savings will be applied according to the following calculation:

$$\Delta kWh = kW_{rated} \times HOU \times ESF$$
$$= 0.085\ kW \times 8{,}760\ hours \times 0.46$$
$$= 343\ kWh/year$$

The default gross coincident demand reduction will be applied according to the following calculation:

$$\Delta kW = \frac{\Delta kWh}{HOU}$$
$$= 343\ kWh/8{,}760\ hours$$
$$= 0.039\ kW$$

Source(s)

The primary source for this deemed savings approach is the Massachusetts TRM 2015 , p. 268-270.

[151] 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.).

10 NON-RESIDENTIAL DISTRIBUTED GENERATION PROGRAM

The Non-Residential Distributed Generation (DG) 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 10-1.

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.

$$Realization\ Rate_j = \frac{\sum_i Measured\ Generation\ (kW)}{\sum_i Dispatched\ Generation\ (kW)}$$

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 10-1: Input Values for the Non-Residential DG 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.[152]

[152] Miriam L. Goldberg & G. Kennedy Agnew. Measurement and Verification for Demand Response, National Forum on the National Action Plan on Demand Response, https://www.ferc.gov/industries/electric/indus-act/demand-response/dr-potential/napdr-mv.pdf.

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12 SUB-APPENDICES

12.1 Sub-appendix I: Reference Cooling and Heating Degree Days

Table 12-1 provides the reference cooling degree days (CDD-65°F) and heating degree days (HDD-65°F) using TMY3 data found in the National Solar Radiation Data Base, 1991 - 2005 Update: Typical Meteorological Year 3 produced by the Renewable Resource Data Center (RRDC) of the National Renewable Energy Laboratory (NREL) for weather stations at Baltimore BLT-Washington International AP (Weather station number 724060), Richmond International AP (Weather station number 724010), and Charlotte Douglas International Airport. (Weather station number 723140).

Weather station identification codes can be found at https://www.google.com/fusiontables/DataSource?docid=1EsB07O-9SiqyJDlzl69GO8jTHsomsNIpkA1SLL8#rows:id=1.

TMY3 data can be found at http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3.

TMY3 data spans a base time period between 1976 to 2005 wherever they are available (out of 1020 locations) and from 1991 to 2005 for the remaining locations. The TMY data set provides a reasonably sized annual data set that holds hourly meteorological values that typify conditions at a specific location over a longer period of time. It represents a typical climatic condition for a location and does not provide extremes. For the purposes of this document, DNV GL determined that it is more appropriate to use weather data that represents typical climatic conditions. Also, DNV GL uses actual temperatures from USAF stations in modeling consumption in post-installation evaluations. The corresponding temperatures from TMY3 are then used to predict a weather-adjusted or normalized consumption. The goal is that models and predictions based on temperature data are using data from the same stations.

The TMY3 hourly data are available for 1,020 USAF stations. For each station, DNV GL calculates the average hourly temperature for each day. The CDD and HDD are calculated using a range of cooling and heating base temperature. If the average daily temperature is greater than the cooling base temperature, CDD is the deviation in degrees Fahrenheit from the average daily temperature with respect to a cooling base temperature and zero otherwise. If the average daily temperature is less than the heating base temperature, HDD is the deviation in degrees Fahrenheit from the average daily temperature with respect to a heating base temperature and zero otherwise. Daily CDD and HDD are summed up for each station to come up with an annual estimate of CDD and HDD shown in this section, based on a typical meteorological year.

Table 12-1: Reference Cooling Degree Days/Hours and Heating Degree Days

Weather Station Number	Location	Cooling Degree Days (CDD – 65 °F)[153]	Cooling Degree Hours (CDH - 65 °F)[154]	Heating Degree Days (HDD – 65 °F)[155]
724010	Richmond International Airport	1,448	7,786	3,849
723140	Charlotte Douglas International Airport	1,598	8,040	3,140
724060	Baltimore -Washington International Airport	1,233	5,684	4,600

[153] National Solar Radiation Data Base. 1991-2005 Update: Typical Meteorological Year 3. Accessed June, 2017. http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3

[154] For consistency across all measures, DNV GL calculated cooling degree hours at the base 65 °F temperature to be used in the attic insulation measure.

[155] Ibid.

12.2 Sub-appendix II: Full Load Hours for HVAC Equipment

Table 12-2 provides the full load heating and cooling hours that are used as defaults for the Residential Home Energy Check-Up and Residential Income and Age Qualifying Home Improvement Programs. The Richmond, VA and Charlotte, 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 2018 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 Charlotte 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 Charlotte 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:

$$\textit{Mid-Atlantic TRM Baltimore } FLH_{cool} = 744 \textit{ hours/year}$$

$$\textit{ENERGY STAR® Baltimore } FLH_{cool} = 1{,}050 \textit{ hours/year}$$

$$\textit{ENERGY STAR® Richmond } FLH_{cool} = 1{,}188 \textit{ hours/year}$$

$$\textit{STEP Richmond } FLH_{cool} = \textit{ENERGY STAR® Richmond } FLH_{cool} \times \frac{\textit{Mid-Atlantic TRM Baltimore } FLH_{cool}}{\textit{ENERGY STAR® Baltimore } FLH_{cool}}$$

$$= 1{,}188 \; hours/year \times \frac{774 \; hours/year}{1{,}050 \; hours/year}$$

$$= 842 \textit{ hours/year}$$

Table 12-2: Full Load Heating and Cooling Hours for Residential Buildings

System Type	Location	ENERGY STAR® Annual Full Load Cooling Hours[156]	ENERGY STAR® Annual Full Load Heating Hours[157]	FLH_{cool}	FLH_{heat}
Air Source Heat Pump	Baltimore, MD – Reference city from Mid-Atlantic TRM	1,050	2,172	744 [158]	866 [159]
	Richmond, VA	1,188	1,980	842	789
	Charlotte, NC	1,325	1,865	939	744
Central AC	Baltimore, MD – Reference city from Mid-Atlantic TRM	1,050	-	542 [160]	-
	Richmond, VA	1,188	-	613	-
	Charlotte, NC	1,325	-	684	-
Window Unit or Room AC	Baltimore, MD – Reference city from Mid-Atlantic TRM	-	-	326 [161]	-
	Richmond, VA	-	-	368 [162]	-
	Charlotte, NC	-	-	411 [163]	-

[156] ENERGY STAR®. Heat Pumps savings calculator, annual full load cooling hours for Baltimore, Richmond and Charlotte https://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_ASHP_bulk.xls; and ENERGY STAR® Central Air Conditioner savings calculator, annual full load cooling hours for Baltimore, Richmond and Charlotte https://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC_bulk.xls. Accessed July 5, 2018.

[157] Ibid, annual full load heating hours for Baltimore, Richmond and Charlotte.

[158] Mid-Atlantic TRM 2018, p. 91. Based on average of 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.

[159] Mid-Atlantic TRM 2018, p. 93. Based on average of 5 utilities, two program years, 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.

[160] Mid-Atlantic TRM 2018, p. 83. Based on average of 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.

[161] Mid-Atlantic TRM 2018, p. 78. "VEIC calculated the average ratio of FLH for Room AC (provided in RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008) to FLH for Central Cooling (provided by AHRI: http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls) at 31%. Applying this to the FLH for Central Cooling provided for Baltimore (1050) we get 325 FLH for Room AC." DNV GL replicated the equation and calculated 325.5 FLH_{cool} and rounded to 326 FLH_{cool}

[162] Used the same approach as Mid-Atlantic TRM, and multiplied Richmond full load cooling hours (1,188) by 31% and calculated 368 FLH_{cool}

[163] Used the same approach as Mid-Atlantic TRM, and multiplied Charolette full load cooling hours (1,325) by 31% and calculated 410.75 FLH_{cool} and rounded to 411 FLH_{cool}

Table 12-3: Heat pump, Unitary AC, VRF, and Mini Split Full-Load Cooling Hours for Non-Residential Buildings[164]

Building Type	Baltimore, MD	Richmond, VA	Charlotte, NC
Education – Elementary and Middle School	295	347	382
Education – High School	340	399	441
Education – College and University[165]	756	888	979
Food Sales - Grocery	678	796	879
Food Sales – Convenience Store	923	1,084	1,196
Food Sales – Gas Station Convenience Store	923	1,084	1,196
Food Service - Full Service	768	902	996
Food Service - Fast Food	730	858	946
Health Care - Inpatient	1,223	1,437	1,585
Health Care - Outpatient	650	764	843
Lodging – (Hotel, Motel and Dormitory)	1,831	2,151	2,373
Mercantile (mall)	887	1,042	1,150
Mercantile (Retail, not mall)	911	1,070	1,181
Office – Small (<40,000 sq ft)	634	745	822
Office – Large (>= 40,000 sq ft)	733	861	950
Other[166]	245	288	318
Public Assembly	945	1,110	1,225
Public Order and Safety (Police and Fire Station)	245	288	318
Religious Worship	245	288	318
Service (Beauty, Auto Repair Workshop)	923	1,084	1,196
Warehouse and Storage[167]	2,081	2,445	2,697

164 Baltimore, MD full load cooling hours taken from Mid-Atlantic TRM 2018 p.528 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 International Airport (Weather station number 723140; CDD=1,598), and Baltimore BLT – Washington International Airport (Weather station number 724060; CDD=1,233). See Appendix I for CDD and HDD.

165 "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-Atlantirc TRM 2018, p.528

166 "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."

167 "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

Table 12-4: Heat Pump, VRF, and Mini-split Full Load Heating Hours for Non-Residential Buildings[168]

Building Type	Baltimore, MD	Richmond, VA	Charlotte, NC
Education – Elementary and Middle School	668	559	456
Education – High School	719	602	491
Education – College and University	622	520	424
Food Sales - Grocery	980	820	669
Food Sales – Convenience Store	623	521	425
Food Sales – Gas Station Convenience Store	623	521	425
Food Service - Full Service	1,131	947	772
Food Service - Fast Food	1,226	1,026	837
Health Care-inpatient	214	179	146
Health Care-outpatient	932	780	636
Lodging – (Hotel, Motel and Dormitory)	2,242	1,876	1,531
Mercantile (mall)	591	495	404
Mercantile (Retail, not mall)	739	618	505
Office – Small (<40,000 sq ft)	440	368	300
Office – Large (>= 40,000 sq ft)	221	185	151
Other	146	715	583
Public Assembly[169]	1,114	932	761
Public Order and Safety (Police and Fire Station)[170]	146	715	583
Religious Worship	146	715	583
Service (Beauty, Auto Repair Workshop)	623	521	425
Warehouse and Storage	598	500	408

168 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 Appendix I for CDD and HDD.

169 "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."

170 "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."

Table 12-5: Annual Chiller Full Load Cooling Hours at Non-Residential Buildings[171]

Building Type	Baltimore, MD	Richmond, VA	Chorlette, NC
Education – Elementary and Middle School	743	873	963
Education – High School	369	433	478
Education – College and University[172]	780	916	1,010
Food Sales - Grocery	928	1,090	1,203
Food Sales – Convenience Store	928	1,090	1,203
Food Sales – Gas Station Convenience Store	928	1,090	1,203
Food Service - Full Service	928	1,090	1,203
Food Service - Fast Food	928	1,090	1,203
Health Care-inpatient	1,570	1,844	2,035
Health Care-outpatient	601	706	779
Lodging – (Hotel, Motel and Dormitory)	1,801	2,116	2,335
Mercantile (mall)	928	1,090	1,203
Mercantile (Retail, not mall)	928	1,090	1,203
Office – Small (<40,000 sq ft)	559	657	725
Office – Large (>= 40,000 sq ft)	603	708	782
Other	369	433	478
Public Assembly	369	433	478
Public Order and Safety (Police and Fire Station)	369	433	478
Religious Worship	369	433	478
Service (Beauty, Auto Repair Workshop)	928	1,090	1,203
Warehouse and Storage	810	952	1,050

[171] 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 Appendix I for CDD and HDD.

[172] "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.

12.3 Sub-appendix III: Annual Equivalent Hours, Coincidence Factors and Waste Heat Factors by Non-Residential Facility/Lighting Types

For the purposes of this STEP Manual, Table 12-7 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 X 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 12-6 and Table 12-7, 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. Fxture 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 12-7.

All fixtures that contain the phrase "24/7" in the fixture name, from the tracking data provided to DNV GL, should assign variables for "LED Exit Sign" in . All fixtures that do not specify "exterior" in the fixture name are assumed to be for interior use and should assign variables based on the building type as shown in Table 12-6.

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