16.1.2 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.

Baseline Description

The baseline equipment is assumed to be a typical standard efficiency electric combination oven.

Savings Estimation

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

$$kWh_{base} = kWh_{base_{convection}} + kWh_{base_{steam}}$$

$$kWh_{base_{convention}} = (kWh\ Cooking_{base_{convection}} + kWh\ Idle_{base_{convection}}) * Days$$

$$kWh\ Cooking_{base_{Cconvection}} = lb * \frac{E_{food_{convection}}}{Eff_{base\ convection}} * PCT_{convection}$$

$$kWh\ Idle_{base_{convection}} = Idle_{base_{convection}} * \left(Hours_{day} - \frac{lb}{PC_{base_{convection}}}\right) * PCT_{convection}$$

Therefore,

$$kWh_{base_{convection}} = \left(lb * \frac{E_{food_{convection}}}{Eff_{base\ convection}} + Idle_{base_{convection}} * \left(Hours_{day} - \frac{lb}{PC_{base_{convection}}}\right)\right) * PCT_{convection} * Days$$

Similarly,

$$kWh_{base_{steam}} = \left(lb * \frac{E_{food_{steam}}}{Eff_{base\ steam}} + Idle_{base_{steam}} * \left(Hours_{day} - \frac{lb}{PC_{base_{steam}}}\right)\right) * PCT_{steam} * Days$$

$$kWh_{base} = kWh_{base_{convection}} + kWh_{base_{steam}}$$

$$kWh_{eff} = kWh_{eff_{convectoin}} + kWh_{eff_{steam}}$$

$$kWh_{eff_{convection}} = (kWh\ Cooking_{eff_{convection}} + kWh\ Idle_{eff_{convection}}) * Days$$

$$kWh\ Cooking_{eff\,Cconvection} = lb * \frac{E_{food_{convection}}}{Eff_{eff\ convection}} * PCT_{convection}$$

$$kWh\ Idle_{eff_{convection}} = Idle_{eff_{convection}} * \left(Hours_{day} - \frac{lb}{PC_{eff_{convection}}}\right) * PCT_{convection}$$

Therefore,

$$kWh_{eff_{convection}} = \left(lb * \frac{E_{food_{convection}}}{Eff_{eff\ convection}} + Idle_{eff} * \left(Hours_{day} - \frac{lb}{PC_{eff_{convection}}}\right)\right) * PCT_{convection} * Days$$

Similarly,

$$kWh_{eff_{Steam}} = \left(lb * \frac{E_{food_{steam}}}{Eff_{eff\ steam}} + Idle_{eff_{steam}} * \left(Hours_{day} - \frac{lb}{PC_{ffe_{steam}}}\right)\right) * PCT_{steam} * Days$$

$$kWh_{eff} = kWh_{eff_{convectoin}} + kWh_{eff_{steam}}$$

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

Gross coincident demand reductions are calculated according to the following equation:

$$\Delta kW = \frac{\Delta kWh}{Hours_{day} * Days}$$

Where:

ΔkWh = gross annual electric energy savings, kWh

ΔkW = gross coincident demand reductions

kWh_{base} = the annual energy usage of the baseline equipment.

kWh_{ee} = the annual energy usage of the efficient equipment.

kWh $Cooking_{base}$ = Baseline daily cooking energy consumption (kWh).

kWh $Idle_{base}$ = Baseline daily idle energy consumption (kWh).

Days = Annual days of operation

lb = Pounds of food cooked per day (lb/day).

$E_{food\text{-}convection}$ = = ASTM Energy to Food (kWh/lb); the amount of energy absorbed by the food during convection mode cooking, per pound of food.

$Eff_{base\text{-}convection}$ = Baseline equipment cooking energy efficiency (%).

$PCT_{convection}$ = percent of food cooked in convection cooking mode.

$Idle_{base\text{-}convection}$ = Baseline equipment idle energy rate (kW) in convection model.

$Hours_{day}$ = Average daily operating hours.

$PC_{base\text{-}convection}$ = Baseline equipment production capacity (lb/hr) in steam mode.

$E_{food\text{-}steam}$ = = ASTM Energy to Food (kWh/lb); the amount of energy absorbed by the food during steam cooking mode, per pound of food.

$Eff_{base\text{-}steam}$ = Baseline equipment cooking energy efficiency (%) in steam mode.

PCT_{steam} = percent of food cooked in convection cooking mode.

$Idle_{base\text{-}steam}$ = Baseline equipment idle energy rate (kW) in steam mode.

PCT_{steam} = percent of food cooked in steam mode cooking.

$Eff_{eff\text{-}convection}$ = Efficienct equipment cooking energy efficiency (%) in convection mode.

$Eff_{eff\text{-}steam}$ = Efficienct equipment cooking energy efficiency (%) in steam mode.

Input Variables

Table 95: Input Parameters for Commercial Electric Combination Ovens

Component	Type	Value	Units	Source(s)
$Hours_{day}$	Variable	See customer application; Default: 12	hours/day	Mid-Atlantic TRM 2017, p. 452
Days	Variable	See customer application; Default: 365	day/year	Mid-Atlantic TRM 2017, p. 452
Lb	Variable	See customer application; Default: 200	lb/day	Mid-Atlantic TRM 2017, p. 452
$PCT_{convection}$	Variable	See customer application; Default: 0.5	Dimensionless	Mid-Atlantic TRM 2017, p. 452
PCT_{steam}	Variable	See customer application; Default: 0.5	Dimensionless	Mid-Atlantic TRM 2017, p. 453
$E_{food\text{-}convection}$	Fixed	0.0732	kWh/lb	Mid-Atlantic TRM 2017, p. 452
$E_{food\text{-}steam}$	Fixed	0.0308	kWh/lb	Mid-Atlantic TRM 2017, p. 452
$PC_{base\text{-}convection}$	Fixed	<15 pans:79 ≥15 pans: 166	lb/hr/ft^2	Mid-Atlantic TRM 2017, p. 453
$PC_{base\text{-}steam}$	Fixed	<15 pans:126 ≥15 pans: 295	lb/hr/ft^2	Mid-Atlantic TRM 2017, p. 453
$Eff_{base\text{-}convection}$	Fixed	All Pan Sizes: 0.72	Dimensionless	Mid-Atlantic TRM 2017, p. 453
$Eff_{base\text{-}steam}$	Fixed	All Pan Sizes: 0.49	Dimensionless	Mid-Atlantic TRM 2017, p. 453
$Idle_{base\text{-}convection}$	Fixed	<15 pans:1.32 ≥15 pans: 2.28	kW/ft^2	Mid-Atlantic TRM 2017, p. 449
$Idle_{base\text{-}steam}$	Fixed	<15 pans:5.26 >=15 pans: 8.71	kW/ft^2	Mid-Atlantic TRM 2017,p. 453
$Idle_{eff\text{-}convection}$	Variable	0.08 x Number of pans + 0.4989	kW/ft^2	Mid-Atlantic TRM 2017,p. 453
$Idle_{eff\text{-}steam}$	Variable	0.133 x Number of pans + 0.64	kW/ft^2	Mid-Atlantic TRM 2017,p. 453
$PC_{eff\text{-}convection}$	Fixed	<15 pans:119 ≥15 pans: 201	lb/hr/ft^2	Mid-Atlantic TRM 2017, p. 452
$PC_{eff\text{-}Steam}$	Fixed	<15 pans:177 ≥15 pans: 349	lb/hr/ft^2	Mid-Atlantic TRM 2017, p. 452
$Eff_{eff\text{-}convection}$	Fixed	All Pan Sizes: 0.76	Dimensionless	Mid-Atlantic TRM 2017, p. 453
$Eff_{eff\text{-}steam}$	Fixed	All Pan Sizes: 0.55	Dimensionless	Mid-Atlantic TRM 2017, p. 453

Source

The primary sources for this deemed savings approach is the Mid-Atlantic TRM 2017, p. 451-455.

16.1.3 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 burned 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.

Baseline Condition

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.[268]

Savings Estimation

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

$$kWh_{base} = (kWh\ Cooking_{base} + kWh\ Idle_{base}) * Days$$

$$kWh\ Cooking_{base} = lb * \frac{E_{food}}{Eff_{base}}$$

$$kWh\ Idle_{base} = Idle_{base} * \left(Hours_{day} - \frac{lb}{PC_{base}}\right)$$

Therefore,

$$kWh_{base} = \left[lb * \frac{E_{food}}{Eff_{base}} + Idle_{base} * \left(Hours_{day} - \frac{lb}{PC_{base}}\right)\right] * Days$$

$$kWh_{ee} = \left[lb * \frac{E_{food}}{Eff_{ee}} + Idle_{ee} * \left(Hours_{day} - \frac{lb}{PC_{ee}}\right)\right] * Days$$

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

Gross coincident demand reductions are calculated according to the following equation:

$$\Delta kW = \frac{\Delta kWh}{(Hours_{day} * Days)}$$

Where:

ΔkWh/year = gross annual electric energy savings

[268] 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.

ΔkW = gross coincident demand reductions

kWh_{base} = the annual energy usage of the baseline equipment

kWh_{ee} = the annual energy usage of the efficient equipment

$KWh\ Cooking_{base}$ = Baseline daily cooking energy consumption (kWh).

$KWh\ Idle_{base}$ = Baseline daily idle energy consumption (kWh).

$Hours_{day}$ = Average daily operating hours.

E_{food} = ASTM Energy to Food (kWh/lb); the amount of energy absorbed by the food during cooking, per pound of food.

lb = Pounds of food cooked per day (lb/day).

Days = Annual days of operation

Eff_{base} = Baseline equipment cooking energy efficiency (%).

Eff_{eff} = Efficienct equipment cooking energy efficiency (%).

$Idle_{base}$ = Baseline equipment idle energy rate (kW).

$Idle_{ee}$ = Efficient equipment idle energy rate (kW).

PC_{base} = Baseline equipment production capacity (lb/hr).

PC_{ee} = Efficient equipment production capacity (lb/hr).

Input Variables

Table 96: Input Parameters for Electric Commercial Fryer Measure

Component	Type	Value	Units	Source(s)
$Hours_{day}$	Variable	See customer application. Default: 16 for Standard Fryers and 12 for large VAT fryers	hours/day	Mid- Atlantic 2017, p. 432
E_{food}	Fixed	0.167	kWh/lb	Mid- Atlantic 2017, p. 432
lb	Variable	See customer application. Default: 150	lbs/day	Mid- Atlantic 2017, p. 432
Days	Variable	See custumer application. Default: 365	days	Mid- Atlantic 2017, p. 432
Eff_{base}	Fixed	Standard Size: 75% Large Vat: 70%	Dimensionless	Mid- Atlantic 2017, p. 433
$Idle_{base}$	Fixed	Standard Size: 1.05 Large Vat: 1.35	kW	Mid- Atlantic 2017, p. 433
PC_{base}	Fixed	Standard Size: 65 Large Vat: 100	Lb/hr	Mid- Atlantic 2017, p. 433
Eff_{ee}	Fixed	Standard Size: 83% Large Vat: 80%	Dimensionless	Mid- Atlantic 2017, p. 433
$Idle_{ee}$	Fixed	Standard Size: 0.80 Large Vat: 1.10	kW	Mid- Atlantic 2017, p. 433
PC_{ee}	Fixed	Standard Size: 70 Large Vat: 110	Lb/hr	Mid- Atlantic 2017, p. 433

Source

The primary sources for this deemed savings approach is the Mid Atlantic TRM 2017, p. 431-434.

16.1.4 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 program requirement by Dominion.

Baseline Condition

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

Savings Estimation

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

$$kWh_{base} = \left[lb * \frac{E_{food}}{Eff_{base}} + Idle_{base} * Size * \left(Hours_{day} - \frac{lb}{PC_{base} * Size}\right)\right] * Days$$

$$kWh_{eff} = \left[lb * \frac{E_{food}}{Eff_{eff}} + Idle_{eff} * Size * \left(Hours_{day} - \frac{lb}{PC_{eff} * Size}\right)\right] * Days$$

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

Gross coincident demand reductions are calculated according to the following equation:

$$\Delta kW = \frac{\Delta kWh}{Hours_{day} * Days}$$

Where:

ΔkWh/year = gross annual electric energy savings
ΔkW = gross coincident demand reductions
kWh_{base} = the annual energy usage of the baseline equipment (kWh)
kWh_{ee} = the annual energy usage of the efficient equipment (kWh)
Size = size of the griddle surface (sq. ft.)
$Hours_{day}$ = Average daily operating hours
E_{food} = ASTM Energy to Food (kWh/lb); the amount of energy absorbed by the food during cooking, per pound of food.

lb = Pounds of food cooked per day (lb/day).
Days = Annual days of operation
Eff_{base} = Baseline equipment cooking energy efficiency (%).
Eff_{base} = Efficient equipment cooking energy efficiency (%).
$Idle_{base}$ = Baseline equipment idle energy rate (kW/ft2).
$Idle_{eff}$ = Efficient equipment equipment idle energy rate (kW/ft2).
PC_{base} = Baseline equipment production capacity (lb/hr).
PC_{eff} = Efficient equipment production capacity (lb/hr).

Input Variables

Table 97: Input Parameters for Commercial Griddle Measure

Component	Type	Value	Units	Source(s)
lb	Variable	See customer application; Default: 100	lb/day	Mid-Atlantic TRM 2017, p. 444
$Hours_{day}$	Variable	See customer application; Default: 12	hour/day	Mid- Atlantic 2017, p. 444
Days	Variable	See customer application; Default: 365	days	Mid- Atlantic 2017, p. 444
E_{food}	Fixed	Default: 0.139	kWh/lb	Mid-Atlantic TRM 2017, p. 444
PC_{base}	Fixed	Default: 5.83	lb/hr/sq.ft.	Mid-Atlantic TRM 2017, p. 445
Eff_{base}	Fixed	65%	Dimensionless	Mid-Atlantic TRM 2017, p. 445
$Idle_{base}$	Fixed	0.40	kW/sq.ft.	Mid-Atlantic TRM 2017, p. 445
$Idle_{ee}$	Fixed	0.32	kW/sq.ft.	Mid-Atlantic TRM 2017,p. 445
PC_{ee}	Fixed	6.67	lb/hr/sq.ft.	Mid-Atlantic TRM 2017, p. 445
Eff_{ee}	Fixed	70%	Dimensionless	Mid-Atlantic TRM 2017, p. 445
Size	Variable	See customer application.	sq.ft.	Mid-Atlantic TRM 2017, p. 444

Source

The primary source for this deemed savings approach is the Mid-Atlantic TRM 2017, p. 443-446.

16.1.5 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.

Baseline Description

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

Savings Estimation

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

$$\Delta kWh = \frac{\left(Idle_{base} - Idle_{eff}\right)}{1000} * Hours_{day} * Days$$

Gross coincident demand reductions are calculated according to the following equation:

$$\Delta kW = \frac{\left(Idle_{base} - Idle_{eff}\right)}{1000}$$

Where:

ΔkWh/year = gross annual electric energy savings
ΔkW = gross coincident demand reductions
$Idle_{base}$ = the idle energy rate of the baseline equipment (W).
$Idle_{eff}$ = the idle energy rate of the efficient equipment (W).
1,000 = conversion of W to kW.$Hours_{day}$ = average daily operating hours.
Days = Annual days of operation

Where:

$Idle_{base}$ = the idle energy rate of the baseline equipment (W).
$Idle_{eff}$ = the idle energy rate of the efficient equipment (W).
1,000 = conversion of W to kW.

Input Variables

Table 98: Input Parameters for Hot Food Holding Cabinet

Component	Type	Value	Units	Source(s)
$Idle_{base}$	Variable	40 x Volume	watts	Mid-Atlantic TRM 2017, p. 441
$Idle_{eff}$	Variable	0<Volume<13: 21.5 x Volume 13≤Volume<28: 2.0 x Volume + 254 Volume>=28: 3.8 x Volume + 203.5	watts	Mid-Atlantic TRM 2017, p. 441
Days	Variable	See customer application; Default: 365	days	Mid-Atlantic TRM 2017, p. 440
$Hours_{day}$	Variable	See customer application; Default: 15	hours/day	Mid-Atlantic TRM 2017, p. 440

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

Source

The primary sources for this deemed savings approach is the Mid-Atlantic TRM 2017, p. 440-442.

16.1.6 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 more efficient steam delivery system.

Baseline Description

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

Savings Estimation

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

$$kWh_{base} = (kWh\ Cooking_{base} + kWh\ Idle_{base}) * Days$$

$$kWh\ Cooking_{base} = lb * \frac{E_{food}}{Eff_{base}}$$

$$kWh\ Idle_{base} = (1 - PCT_{steam}) * Idle_{base} + PCT_{steam} * PC_{base} * Pans * \frac{E_{food}}{Eff_{base}} * \left(Hours_{day} - \frac{lb}{(Pans * PC_{base})}\right)$$

Therefore,

$$kWh_{base} = \left(lb * \frac{E_{food}}{Eff_{base}} + (1 - PCT_{steam}) * Idle_{base} + PCT_{steam} * PC_{base} * Pans * \frac{E_{food}}{Eff_{base}} * \left(Hours_{day} - \frac{lb}{(Pans * PC_{base})}\right)\right) * Days$$

$$kWh_{eff} = (kWh\ Cooking_{eff} + kWh\ Idle_{eff}) * Days$$

$$kWh\ Cooking_{eff} = lb * \frac{E_{food}}{Eff_{beff}}$$

$$kWh\ Idle_{eff} = (1 - PCT_{steam}) * Idle_{eff} + PCT_{steam} * PC_{eff} * Pans * \frac{E_{food}}{Eff_{eff}} * \left(Hours_{day} - \frac{lb}{(Pans * PC_{eff})}\right)$$

Therefore,

$$kWh_{eff} = \left(lb * \frac{E_{food}}{Eff_{eff}} + (1 - PCT_{steam}) * Idle_{eff} + PCT_{steam} * PC_{eff} * Pans * \frac{E_{food}}{Eff_{eff}} * \left(Hours_{day} - \frac{lb}{(Pans * PC_{eff})}\right)\right) * Days$$

$$\Delta kWh/_{year} = kWh_{base} - kWh_{ee}$$

Where:

ΔkWh = gross annual electric energy savings, kWh/year
ΔkW = gross coincident demand reductions
kWh_{base} = the annual energy usage of the baseline equipment.
kWh_{ee} = the annual energy usage of the efficient equipment.
kWh $Cooking_{base}$ = Baseline daily cooking energy consumption (kWh).
kWh $Idle_{base}$ = Baseline daily idle energy consumption (kWh).
$Hours_{day}$ = Average daily operating hours.
E_{food} = ASTM Energy to Food (kWh/lb); the amount of energy absorbed by the food during cooking, per pound of food.
lb = Pounds of food cooked per day (lb/day).
Days = Annual days of operation
PCT_{steam} = percent of time in constant steam mode (%).
Pans = number of pans per unit.
Eff_{base} = Baseline equipment cooking energy efficiency (%).
Eff_{eff} = Efficienct equipment cooking energy efficiency (%).
$Idle_{base}$ = Baseline equipment idle energy rate (kW).
$Idle_{ee}$ = Efficient equipment idle energy rate (kW).
PC_{base} = Baseline equipment production capacity (lb/hr).
PC_{ee} = Efficient equipment production capacity (lb/hr).

Input Variables

Table 99: Input Parameters for Commercial Steam Cooker Measure

Component	Type	Value	Units	Source(s)
$Hours_{day}$	Variable	See customer application; Default: 12	hours/day	Mid-Atlantic TRM 2017, p. 436
Days	Variable	See customer application; Default: 365	day/year	Mid-Atlantic TRM 2017, p. 436
lb	Variable	See customer application; Default: 100	lbs/day	Mid-Atlantic TRM 2017, p. 436
Pans	Variable	See customer application.	Dimensionless	Mid-Atlantic TRM 2017, p. 436
E_{food}	Fixed	0.0308	kWh/lb	Mid-Atlantic TRM 2017, p. 436
PC_{base}	Fixed	23.3	lb/hr/sq.ft.	Mid-Atlantic TRM 2017, p. 436
Eff_{base}	Fixed	Steam Generator: 0.3 Boiler based: 0.26	Dimensionless	Mid-Atlantic TRM 2017, p. 437
$Idle_{base}$	Fixed	Steam Generator: 1.2 Boiler based: 1.0	kW	Mid-Atlantic TRM 2017, p. 437
$Idle_{ee}$	Fixed	3 pans: 0.4 4 pans: 0.53 5 pans: 0.67 6+ pans: 0.8	kW	Mid-Atlantic TRM 2017,p. 437
PC_{ee}	Fixed	16.9	lb/hr/sq.ft.	Mid-Atlantic TRM 2017, p. 436
Eff_{ee}	Fixed	0.5	Dimensionless	Mid-Atlantic TRM 2017, p. 437

Source

The primary sources for this deemed savings approach is the 2017 Mid-Atlantic TRM p. 437-439.

16.2 Heating Ventilation and Air Conditioning (HVAC) End Use

16.2.1 Duct Testing and Sealing

This measure is also provided by two other programs: Non-Residential Small Business Improvement Program and Non-Residential Duct Testing and Sealing Program. The savings are to be determined using the methodology described in Section 15.2.1.

16.2.2 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-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.

Savings Estimation

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

$$\Delta kWh/year = \Delta kWh/year_{cool} + \Delta kWh/year_{heat}$$

Cooling Energy Savings

For air-source heat pumps and AC units <=65,000 kBtuh:

$$\Delta kWh/year_{cool,<5\ tons} = Tons_{cool} \times \frac{12}{SEER} \times FLH_{cool} \times TUF$$

For air-source heat pumps and AC units >65,000 kBtuh, and all ground-source heat pumps:

$$\Delta kWh/year_{cool,\geq 5\ tons} = Tons_{cool} \times \frac{12}{IEER} \times FLH_{cool} \times TUF$$

For air-cooled chillers:

$$\Delta kWh/year = Tons_{cool} \times IPLV \times FLH_{cool} \times TUF$$

Heating Energy Savings

For air-source heat pumps <=65,000 kBtuh:

$$\Delta kWh/year_{heat,<5\ tons} = kBtu/h_{heat} \times \frac{1}{HSPF} \times FLH_{heat} \times TUF$$

For air-source heat pumps >65,000 kBtuh, and all ground-source heat pumps:

$$\Delta kWh/year_{heat,\geq 5\ tons} = kBtu/h_{heat} \times \frac{1}{COP} \times FLH_{heat} \times TUF$$

For AC units and air-cooled chillers:

$$\Delta kWh/year_{heat} = 0$$

Gross coincident demand reductions are calculated according to the following equation:

$$\Delta kW = Tons_{cool} \times \frac{12}{EER} \times CF \times TUF$$

Where:

$\Delta kWh/year$ = gross annual electric energy savings

ΔkW = gross coincident demand reductions

$\Delta kWh/year_{cool,<5\ tons}$ = gross annual electric cooling energy savings for systems that are less than 5 tons

$\Delta kWh/year_{cool,\geq 5\ tons}$ = gross annual electric cooling energy savings for systems that are greater than or equal to 5 tons

$\Delta kWh/year_{heat,<5\ tons}$ = gross annual electric heating energy savings for systems that are less than 5 tons

$\Delta kWh/year_{heat,\geq 5\ tons}$ = gross annual electric heating energy savings for systems that are greater than or equal to 5 tons

$Tons_{cool}$ = tons of cooling capacity of equipment

$kBtu/h_{heat}$ = heating capacity of equipment in kBtu/h, if applicable. (For heat pumps, $kBtu/h_{heat}$ = 12 x $Tons_{cool}$.)

SEER = seasonal energy efficiency ratio (SEER) of the existing air conditioning equipment. SEER is used when calculating savings for heat pumps and AC units that are up to 5 tons in size.

FLH_{cool} = annual full load cooling hours

FLH_{heat} = annual full load heating hours

IPLV = integrated part load value of air-cooled chiller

TUF = rate of energy efficiency improvement due to tune-up; value depends upon whether an optional component, refrigeration charge adjustment (RCA), was also performed

EER = energy efficiency ratio (EER) of existing air conditioning equipment. EER is used to analyze performance of air source heat pumps and AC units that are ≥ 5 tons in size. Ground source heat pumps use EER to determine cooling.

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 (COP) of existing heating equipment. Ground source heat pumps use COP to determine heating savings.

CF = summer peak coincidence factor

Input Variables

Table 100: Input Variables for AC/HP/Chiller Tune-up Measure

Component	Type	Value	Units	Source(s)
$Tons_{cool}$	Variable	See customer application.	Tons of refrigeration	Customer application
$kBtu/h_{heat}$	Variable	See customer application.	kBtu/h	Customer application
FLH_{heat}	Fixed	See Table 139.	hours/year	Mid-Atlantic TRM 2017 p. 351-353
FLH_{cool}	Fixed	For AC/HP, see Table 138. For chillers, see Table 42.	hours/year	Mid-Atlantic TRM 2017 p. 351-353
HSPF/SEER/ EER/COP	Variable	See Table 37 and Table 38.	k/kW-hour (except COP is dimensionless)	ASHRAE 90.1-2010 Table 6.8.1A and Table 6.8.1B
IPLV	Variable	See customer application.	kW/ton	
RCA_Done[269]	Variable	See customer application.	True/False	Customer application
TUF	Fixed	If RCA was not done: For AC units: 0.023 For HP units: 0.027 If RCA was done: For AC units: 0.050 For HP units: 0.050 For chillers: 0.050	-	Mid-Atlantic TRM 2016 p. 398, California 2013-14 Evaluation Report[270], and Wisconsin Focus on Energy TRM, p. 154.
CF	Fixed	Use system capacity to assign CF: $<$ 11.5 tons = 0.588 $\geq$ 11.5 tons = 0.874	-	Mid-Atlantic TRM 2017 p. 396

Source

The primary sources for this deemed savings approach include the 2017 Mid-Atlantic TRM, p. 394-397, the California 2013-14 Impact Evaluation Report, and the Wisconsin Focus on Energy TRM.

[269] RCA_Done is only relevant to the Non-Residential Prescriptive Program; it is not collected nor used for the Small Business Improvement Program.

[270] California Public Utilities Commission (2016). Impact Evaluation of 2013-14 Commercial Quality Maintenance Programs (HVAC3): www.calmac.org/publications/HVAC3ImpactReport_0401ES.pdf.

16.2.3 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 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 baseline condition is the manual on/off switch and magnetic relay or motor starter for the commercial kitchen hoods.

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

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

$$\Delta kWh/year_{EF} = hp_{EF} \times LF_{EF} \times \frac{0.746}{Eff_{EF}} \times Hours \times \Delta Power_{EF}$$

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

$$\Delta kWh/year_{cooling} = SqFt_{Kitchen} \times \frac{cfm}{SqFt} \times OF_{EF} \times \Delta cfm_{EF} \times CDD \times \frac{24 \times 1.08}{3{,}412 \times COP_{MUA_{cooling}}}$$

$$\Delta kWh/year_{heating} = SqFt_{Kitchen} \times \frac{cfm}{SqFt} \times OF_{EF} \times \Delta cfm_{EF} \times HDD \times \frac{24 \times 1.08}{3{,}412 \times COP_{MUA_{heating}}}$$

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

$$\Delta kWh/year_{cooling} = \Delta kWh/year_{heating} = 0$$

The total annual electric energy savings for this measure are calculated as follows:

$$\Delta kWh/year = \Delta kWh/year_{EF} + \Delta kWh/year_{cooling} + \Delta kWh/year_{heating}$$

Gross coincident demand reductions are calculated according to the following equation:

$$\Delta kW = \frac{\Delta kWh/year}{Hours}$$

Where:

$\Delta kWh/year_{\ EF}$ = gross annual electric energy savings for the exhaust fan

$\Delta kWh/year_{\ cooling}$ = gross annual electric energy savings for cooling the make-up air

$\Delta kWh/year_{\ heating}$ = gross annual electric energy savings for heating the make-up air

ΔkWh/year = gross annual electric energy savings

ΔkW = gross coincident demand reductions

hp_{EF} = total motor horsepower of exhaust fan(s)

LF_{EF} = load factor of exhaust fan motor(s)

Eff_{EF} = efficiency of exhaust fan motor(s)

Hours = annual run hours of exhaust fan(s)

$\Delta Power_{EF}$ = proportional exhaust fan power reduction due to VFD

$SqFt_{Kitchen}$ = floor area of kitchen

$\frac{cfm}{SqFt}$ = exhaust airflow rate per square foot of kitchen floor area

OF_{EF} = oversize ratio of exhaust fan system

Δcfm_{EF} = proportional exhaust fan airflow reduction due to VFD

CDD = cooling degree days

$COP_{MUA_{cooling}}$= coefficient of performance of cooling component of make-up air system

HDD = heating degree days

$COP_{MUA_{heating}}$= 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 101: Input Parameters for VSD on Kitchen Fan(s)

Component	Type	Value	Units	Source(s)
hp_{EF}	Variable	See customer application.	hp	Customer application
LF_{EF}	Fixed	Default: 90%	dimensionless	
Eff_{EF}	Variable	See customer application; Default: See Table 45.	dimensionless	Customer application
Hours	Variable	Default: 4,926	hours	Customer application
$\Delta Power_{EF}$	Variable	See Table 102.	dimensionless	California
$SqFt_{Kitchen}$	Variable	See customer application.	sq.ft.	Customer application
$\frac{cfm}{SqFt}$	Fixed	Default: 0.7	cfm/sq.ft.	ASHRAE 62.1-2010
OF_{EF}	Fixed	Default: 1.4	dimensionless	New Jersey Clean Energy Program Protocols to Measure Resource Savings: Revisions to FY2016 Protocols, pg. 90
Δcfm_{EF}	Variable	See Table 102	dimensionless	
CDD	Variable	See Appendix A.	Cooling Degree Days	
HDD	Variable	See Appendix A.	Heating Degree Days	
$MUA_{cooling}$	Flag	See customer application.	True/False	Customer application
$COP_{MUA_{cooling}}$	Variable	Default: 3.0	dimensionless	Customer application
$MUA_{electric\_heating}$	Flag	See customer application.	True/False	Customer application
$COP_{MUA_{heating}}$	Variable	Default: 3.0	dimensionless	Customer application

Table 102: Power and Airflow Reductions due to VSD[271]

Facility Type	Proportion of Power Reduction ($\Delta Power_{EF}$)	Proportion of Airflow Reduction (Δcfm_{EF})
Campus	0.568	0.295
Lodging	0.618	0.330
Restaurant	0.552	0.295

[271] New Jersey Clean Energy Program Protocols to Measure Resource Savings: Revisions to FY2016 Protocols, pg. 90: http://www.njcleanenergy.com/files/file/NJCEP%20Protocols%20to%20Measure%20Resource%20Savings%20FY17_FINAL.pdf.

Facility Type	Proportion of Power Reduction ($\Delta Power_{EF}$)	Proportion of Airflow Reduction (Δcfm_{EF})
Supermarket	0.597	0.320
Other	0.584	0.310

Source

The primary sources for this deemed savings approach include the New Jersey Clean Energy Program Protocols to Measure Resource Savings 2016, pages 88-91, and the SCE workpaper SCE13CC008, Revision 2, Jan 21, 2016 regarding Commercial Kitchen Exhaust Hoods Demand Controlled Ventilation.

16.3 Plug Load End-Use

16.3.1 Smart Strip

Measure Description

This measure realizes energy savings by installing a "smart-strip" plug outlet in place of a standard "power strip." A smart strip has the ability to minimize energy losses caused by phantom loads when the devices plugged into the smart strip are not in use.

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

Gross annual electric energy savings are assigned per unit as follows:

$$\Delta kWh/year = 26.9\ kWh/year$$[272]

Gross coincident demand reductions are assigned as follows:

$$\Delta kW = 0\ kW$$

Where:

ΔkWh/year = gross annual electric energy savings
ΔkW = gross coincident demand reductions

Source(s)

The primary source for this deemed savings approach is the Mid-Atlantic TRM 2017, p. 429-430.

[272] 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.

16.4 Refrigeration End-Use

16.4.1 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.[273] To simulate the reduction, the main door open time is reduced by 40%. For walk-in coolers and freezers, savings are calculated with the assumption that strip curtains that are 100% effective are installed on the doorway.

This measure is offered in the Non-Residential Energy Audit program as well as the Non-Residential Small Business Improvement program, described in Section 15, and the Non-Residential Prescription program, described in Section 16.

Savings Estimation Approach

Gross annual electric energy savings are assigned according to the refrigeration unit type and temperature setting:

Cooler Doors

$$\Delta kWh/year = \Delta kWh/year_{cooler}$$

Freezer Doors

$$\Delta kWh/year = \Delta kWh/year_{freezer}$$

Gross coincident demand reductions are assigned according to the refrigeration unit type and temperature setting:

Cooler Doors

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

Freezer Doors

[273] Tennessee Valley Authority TRM 2017, p. 126. 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"

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

Where:

ΔkWh/year = gross annual electric energy savings
ΔkW = gross coincident demand reductions
$\Delta kWh/year_{cooler}$ = annual kWh savings for main cooler doors
ΔkW_{cooler} = summer peak kW savings for main cooler doors
$\Delta kWh_{freezer}$ = annual kWh savings for main freezer doors
ΔkWfreezer = summer peak kW savings for main freezer doors

Input Variables

Table 103: Door Closer Gross Annual Electric Energy and Gross Coincident Demand Reductions (per Closer)[274]

Refrigeration Unit Type	Location	Walk-In		Reach-In	
		ΔkWh/ year	ΔkW	ΔkWh/ year	ΔkW
Cooler (High Temperature, 31°F to 55°F)	Richmond, VA	44	0.0050	102	0.0116
	Charlotte, NC	44	0.0050	101	0.0116
Freezer (Medium Temperature, -35°F to 30 °F)	Richmond, VA	173	0.0196	439	0.0501
	Charlotte, NC	171	0.0195	435	0.0497

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 2017, p. 125-127.

[274] Methodology from Tennessee Valley Authority TRM 2017, p. 125-127 was used. Savings were revised using the TMY3 weather data for Richmond, VA and Charlotte, NC.

16.4.2 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.

This measure is offered in the Non-Residential Energy Audit program as well as the Non-Residential Small Business Improvement program, described in Section 15, and the Non-Residential Prescription program, described in Section 16.

Savings Estimation Approach[275]

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

$$\Delta kWh/year = \Delta kWh/ft \times L$$

Gross coincident demand reductions are calculated according to the following equation:

$$\Delta kW = \Delta kW/ft \times L$$

Where:

ΔkWh/year = gross annual electric energy savings
ΔkW = gross coincident demand reductions
ΔkWh/ft = gross annual electric energy savings per linear foot
ΔkW/ft = gross coincident demand reductions per linear foot
L = length of gasket applied in linear feet

Input Variables

Table 104: Input Values for Door Gasket Savings Calculations

Component	Type	Value	Unit	Source(s)
ΔkWh/ft	Variable	See Table 62	kWh/feet	Tennessee Valley Authority TRM 2017, p. 122.
ΔkW/ft	Variable	See Table 62	kW/feet	Tennessee Valley Authority TRM 2017, p. 122.
L	Variable	See customer application	feet	Customer application
		Default = 15		DNV GL judgment

275 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 105: Door Gasket Gross Annual Electric Energy and Gross Coincident Demand Reductions (per Linear Foot) [276]

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:

$$\Delta kWh/year = \Delta kWh/ft \times L$$

$$= 3.4\ kWh/ft \times 15\ ft$$

$$= 51.0\ kWh/year$$

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

$$\Delta kW = \Delta kW/ft \times L$$

$$= 0.0004\ kW/ft \times 15\ ft$$

$$= 0.006\ kW$$

Source(s)

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

[276] 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.

16.4.3 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:

$$\Delta kWh/_{year} = (kWh_{base} - kWh_{ee}) \times n \times days$$

Gross coincident demand reductions are calculated according to the following equation:

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

Where:

ΔkWh = gross annual electric energy savings, kWh
ΔkW = gross coincident demand reductions, kW
kWh_{base} = daily energy consumption of the baseline equipment, kWh
kWh_{ee} = daily energy consumption of the efficient equipment, kWh
n = number of units installed, dimensionless
days = days in year, days/year
FLH = annual equivalent full load hours of equipment, hrs/year
CF = demand coincidence factor, dimensionless

Input Variables

Table 106: Input Parameters for Commercial Freezers and Refrigerator Measure

Component	Type	Value	Units	Source(s)
kWh_{base}	Variable	See Table 107.	kWh/year	Federal Standards, Energy Efficiency Program for Certain Commercial and Industrial Equipment, title 10, sec. 431.66 (2013)[277]
kWh_{ee}	Variable	See Table 108.	kWh/year	ENERGY STAR® Certified-commercial-refrigerators-and-freezers[278]
n	Variable	See customer application.	Dimensionless	Customer application
days	Fixed	365	day/year	constant
FLH	Fixed	5,858	hour/year	Mid-Atlantic TRM 2017, p.403[279]
CF	Fixed	0.772	Dimensionless	Mid-Atlantic TRM 2017, p.403[280]

Table 107: Calculated Baseline Daily Energy Consumption from Volume[281], kWh

Equipment Type	Refrigerator kWh	Freezer kWh
Vertical Closed		
Solid Door	$= 0.05 \times V + 1.36$	$= 0.22 \times V + 1.38$
Transparent	$= 0.10 \times V + 0.86$	$= 0.29 \times V + 2.95$
Horizontal Closed		
Solid Door	$= 0.05 \times V + 0.91$	$= 0.06 \times V + 1.12$
Transparent	$= 0.06 \times V + 0.37$	$= 0.08 \times V + 1.23$

Table 108: Calculated Efficient Unit Daily Energy Consupmtion from Volume[282], kWh

Equipment Type and Volume (ft^3)	Refrigerator (kWh)	Freezer (kWh)
Vertical Closed		
Solid Door		

277 New Federal Standards take effect in 2018.

278 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

279 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.

280 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.

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

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

Equipment Type and Volume (ft^3)	Refrigerator (kWh)	Freezer (kWh)
0<V<15	$= 0.022 \times V + 0.97$	$= 0.21 \times V + 0.90$
15≤V<30	$= 0.066 \times V + 0.31$	$= 0.12 \times V + 2.248$
30≤V<50	$= 0.04 \times V + 1.09$	$= 0.285 \times V + 2.703$
50≤V	$= 0.024 \times V + 1.89$	$= 0.142 \times V + 4.445$
Transparent Door		
0<V<15	$= 0.095 \times V + 0.445$	$= 0.232 \times V + 2.36$
15≤V<30	$= 0.05 \times V + 1.12$	$= 0.232 \times V + 2.36$
30≤V<50	$= 0.076 \times V + 0.34$	$= 0.232 \times V + 2.36$
50≤V	$= 0.105 \times V + 1.11$	$= 0.232 \times V + 2.36$
Horizontal Closed		
Solid or Transparent Door		
All Volumes	$= 0.05 \times V + 0.28$	$= 0.057 \times V + 0.55$

Default Savings

This measure does not have default savings.

Source

The primary sources for this deemed savings approach is the Mid-Atlantic TRM 2017, p. 398 – 403.

16.4.4 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, and is not applicable to refrigerated warehouses or other industrial refrigeration applications.[283]

Savings Estimation Approach[284]

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

$$\Delta kWh/year = n \times hp_{evap} \times kW_{hp} \times (\%On_{uncontrolled} - \%On_{controlled}) \times HOU \times WHF_e$$

Gross coincident demand reductions are calculated according to the following equation:

$$\Delta kW = hp_{evap} \times kW_{evap} \times (\%On_{uncontrolled} - \%On_{controlled}) \times WHF_d \times CF$$

Where:

ΔkWh/year = gross annual electric energy savings, kWh/year
ΔkW = gross coincident demand reductions, kW
n = number of evaporator fan motors, dimensionless
hp_{evap} = rated hp of evaporator fans attached to control, hp
kW_{hp} = evaporative fan connected load per rated hp, kW/hp
$\%On_{uncontrolled}$ = duty cycle of the uncontrolled evaporator fan, dimensionless
$\%On_{controled}$ = duty cycle of the controlled evaporator fan, dimensionless
HOU = annual hours of use, hrs/year
WHFe = Waste Heat Factor for Energy; represents the increased savings due to reduced waste heat from motors that must be rejected by the refrigeration equipment, dimensionless
WHFd = Waste Heat Factor for Demand; represents the increased savings due to reduced waste heat from motors that must be rejected by the refrigeration equipment, dimensionless
CF = Summer Peak Coincidence Factor, dimensionless

[283] This approach does not apply to industrial refrigeration warehouse type applications, where circulating fans may be installed.

[284] The savings estimation approach for this measure, herein, differs from that used for the same measure in the Nonresidential Energy Audit Program.

Input Variables

Table 109: Input Values for Freezer and Cooler Evaporator Fan Controls Saving Calculations

Component	Type	Value	Unit	Source(s)
n	Variable	See customer application.	motor	Customer application
		Default = 1		Per unit savings
hp_{evap}	Variable	See customer application.	hp	Customer application
		Default = 1/15 hp		Mid-Atlantic TRM 2017, p. 414[285]
kW_{hp}	fixed	ECM:0.758 kW/hp SP: 2.088 kW/hp	kW/hp	Mid-Atlantic TRM 2017, p. 414
$\%On_{uncontrolled}$	Fixed	97.8%	-	Mid-Atlantic TRM 2017, p. 414
$\%On_{controlled}$	Fixed	On/Off: 63.6% Multi-speed: 69.2%	-	Mid-Atlantic TRM 2017, p. 414
HOU	Fixed	8,760	hour/year	Mid-Atlantic TRM 2017, p. 414
WHFe	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 2017, p. 414
WHFd	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 2017, p. 414
CF	Fixed	0.26	-	Mid-Atlantic TRM 2017, p. 414

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:

$$\frac{\Delta kWh}{year} = n \times hp_{evap} \times kW_{hp} \times (\%On_{uncontrolled} - \%On_{controlled}) \times HOU \times WHF_e$$
$$= 1 \times \frac{1}{15} \times 0.758\, kW/hp \times (97.8\% - 69.2\%) \times 8{,}760 \times 1.38$$
$$= 753\, kWh/year$$

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

[285] Reference cited by Mid-Atlantic TRM: Cadmus. 2015. *Commercial Refrigeration Loadshape Projects.* Lexington, MA.

$$\Delta kW = kW_{evap} \times n_{fans} \times (1 - DC_{comp}) \times DC_{evap} \times BF$$

$$= 0.123\ kW \times 1 \times (1 - 0.5) \times 1.00 \times 1.40$$
$$= 0.086\ kW$$

Source(s)

The primary source for this deemed savings approach is the Mid-Atlantic TRM 2017, p. 413 to 415.

16.4.5 Floating Head Pressure Control

Measure Description

This measure realizes energy savings by controlling condenser fans in the refrigeration system to change condensing temperatures in response to different outdoor temperatures. This is accomplished by the condensing fan controller through fan staging (e.g., turning certain fans ON or OFF as necessary based on the condenser head pressure) or through varying the fan speed. As the outdoor temperature drops, the compressor will not have to work as hard to reject heat from the cooler or freezer.

Savings Estimation Approach

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

$$\Delta kWh/year = kWh_{HP} \times HP_{\text{comp.}}$$

Gross coincident demand reductions are calculated according to the following equation:

$$\Delta kW^{286} = 0$$

Where:

ΔkWh/year = gross annual electric energy savings
ΔkW = gross coincident demand reductions
kWh_{HP} = Floating head pressure control gross annual electric energy savings (kWh) per compressor horsepower (HP)
$HP_{comp.}$ = compressor HP

FLH = annual full load hours

Input Variables

Table 110: Input Values for Floating Head Pressure Control Savings Calculations

Component	Type	Value	Unit	Source(s)
kWh_{HP}	Variable	See Table 66.	kWh/ horsepower /year	Maine Commercial TRM 2017, p. 78
		Default = 509 (High Temperature, Scroll Compressor)		
$HP_{comp.}$	Variable	See customer application.	horsepower	Customer application
		Default = 5		Vermont TRM 2015, p. 132[287]
FLH	Fixed	7,221	hours/year	Efficiency Maine Commercial TRM 2017, p. 77

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

Table 111: Floating Head Pressure Control Gross Annual Electric Energy Savings (per Horsepower)[288]

Compressor Type	Electric Savings (kWh/hp/year)		
	Low Temperature (-35°F to -1°F) (Ref. Temp. -20°F SST)	Medium Temperature (0°F to 30°F) (Ref. Temp. 20°F SST)	High Temperature (31°F to 55°F) (Ref. Temp. 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:

$$\Delta kWh/year = kWh/year_{HP} \times HP_{\text{comp.}}$$

$$= 509\, kWh/HP/year \times 5\, HP$$

$$= 2{,}545\, kWh/year$$

The default gross coincident demand reductions 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 2017, p. 77-78.

[288] Efficiency Maine Commercial TRM 2016, Table 10 – Floating Head Perssure Control kWh Savings per Horsepower, p. 67.

16.4.6 Commercial Ice Maker

Measure Description

This measure involves high-efficiency ice makers meeting ENERGY STAR[289] or CEE Tier 2[290] ice maker requirements. The measure applies to batch type and continuous 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 qualifying ice makers include both air and water-cooled units.

Savings Estimation

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

$$\Delta kWh = \frac{(kWh_{base} - kWh_{ee})}{100\ lbs} \times n \times H \times DC \times 365\ days/year$$

Gross coincident demand reductions are calculated according to the following equation:

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

Where:

ΔkWh = gross annual electric energy savings, kWh

ΔkW = gross coincident demand reductions, kW

kWh_{base} = energy consumption per 100 lb of ice produced by the baseline equipment, kWh/100 lb

kWh_{ee} = energy consumption per 100 lb of ice produced by the new equipment, kWh/100 lb

n = number of ice makers installed, dimensionless

H= rated harvest rate of equipment, lb/day

DC = duty cycle of ice machine, dimensionless

Days = number of days per year, day/year

CF = demand coincidence factor, dimensionless

289 Currently qualifying ice makers meet ENERGY STAR Verision 2.0 program requirments effective Feburary 1, 2013. The list of qualifying equipment can be found here: https://www.energystar.gov/productfinder/product/certified-commercial-ice-machines/results

290 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

Input Variables

Table 112: Input Parameters for Commercial Ice Maker

Component	Type	Value	Units	Source(s)
kWh_{base}	variable	Batch-type see: Table 113: Batch-Type Ice Machine Baseline Efficiencies Continuous type see:Table 114: Continuous-Type Ice Machine Baseline Efficiencies	kWh/100-lb ice	Federal Standards 42 U.S.C. 6313(d)[291]
kWh_{ee}	variable	CEE Tier 2 batch-type see: CEE Tier 2 continuous-type: ENERGY STAR batch-type see: ENERGY STAR continuous-type see:	kWh/100-lb ice	CEE Tier 2 list of qualifying equipment and ENERGY STAR List of qualifying equipment
n	variable	See customer application.	dimensionless	From application
H	variable	See customer application.	lb/day	From application
DC	Fixed	0.5	dimensionless	Arkansas TRM 2016 Volume 2 p. 469[292]
CF	Fixed	1.0	dimensionless	Arkansas TRM 2016 Volume 2 p. 470[293]

Table 113: Batch-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	< 500	7.8 – 0.0055 x *H*
	Water	≥ 500 and < 1,436	5.58 – 0.0011 x *H*
	Water	≥ 1,436	4.0
	Air	< 450	10.26 – 0.0086 x *H*
	Air	≥ 450	6.98 – 0.0011 x *H*
Remote-Condensing without remote compressor	Air	< 1,000	8.85 – 0.0038 x *H*
	Air	≥ 1,000	5.1
Remote-Condensing with remote compressor	Air	< 34	8.85 – 0.0038 x *H*
	Air	≥ 934	5.1
Self-Contained	Water	< 200	11.4 – 0.019 x *H*
	Water	≥ 200	7.6
	Air	< 175	18.0 – 0.0469 x *H*

291 The standards are available here: https://www.regulations.gov/document?D=EERE-2010-BT-STD-0037-0136. Batch type ice maker efficiencies are on p. 5-4 and continuous type baseline efficiency levels are on p. 5-9.

292 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.

293 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.

Ice Machine Type	Type of Cooling	Harvest Rate (lb/day)	kWh_{base} (kWh/100-lb ice)
	Air	≥ 175	9.8

Table 114: 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	< 900	8.1– 0.00333 x *H*
	Water	≥ 900	5.1
	Air	< 700	11.0 – 0.00629 x *H*
	Air	≥ 700	6.6 6.6
Remote-Condensing without remote compressor	Air	< 850	10.0 – 0.00459 x *H*
	Air	≥ 850	6.1
Remote-Condensing with remote compressor	Air	< 850	10.2 – 0.00459 x *H*
	Air	≥ 850	6.3
Self-Contained	Water	< 900	9.5 – 0.00378 x *H*
	Water	≥ 900	6.1
	Air	< 200	16.3 – 0.03 x *H*
	Air	≥ 200 and < 700	11.84 – 0.0078 x *H*
	Air	≥ 700	6.38

Table 115: Batch-Type CEE Tier 2 Qualifying Efficiencies

Ice Machine Type	Type of Cooling	Harvest Rate (lb/day)	kWh_{ee} (kWh/100-lb ice)
Any	Air	< 175	14 – 0.0347 x *H*
	Air	≥ 175 and < 450	9.6 – 0.0098 x *H*
	Air	≥ 450 and < 1,000	5.9 – 0.0016 x *H*
	Air	≥ 1,000	4.5 – 0.0002 x *H*
Remote-Condensing with remote compressor	Water	< 175	10.6 – 0.03241 x *H*
	Water	≥ 175 and < 450	7.1 – 0.0062 x *H*
	Water	≥ 450 and < 1,000	4.7 – 0.0011 x *H*
	Water	≥ 1,000	3.7 – 0.0002 x *H*

Table 116: Continuous-Type CEE Tier 2 Qualifying Efficiencies

Ice Machine Type	Type of Cooling	Harvest Rate (lb/day)	kWh_{ee} (kWh/100-lb ice)
Any	Air	< 1,000	6.5 – 0.0033 x *H*
	Air	≥ 1,000	3.2
	Water	< 1,000	4.8 – 0.0017 x *H*

Ice Machine Type	Type of Cooling	Harvest Rate (lb/day)	kWh_{ee} (kWh/100-lb ice)
Remote-Condensing with remote compressor	Water	≥ 1,000	3.2

Table 117: Batch Type ENERGY STAR Qualifying Efficiencies

Ice Machine Type	Type of Cooling	Harvest Rate (lb/day)	kWh_{ee} (kWh/100-lb ice)
Ice-Making Head	Air	≥ 200 and < 1,600	$37.72 \times H^{-0.2998}$
Remote-Condensing with remote compressor	Air	≥ 400 and < 1,600	$1.0 - 22.95 \times H^{-0.258}$
	Air	≥ 1,600 and ≤ 4,000	$4.6 - 0.00011 \times H$
Self-Contained	Air	≥ 50 and ≤ 450	$0.08 - 48.66 \times H^{0.08}$

Table 118: Continuous Type ENERGY STAR Qualifying Efficiencies

Ice Machine Type	Type of Cooling	Harvest Rate (lb/day)	kWh_{ee} (kWh/100-lb ice)
Ice-Making Head	Air	All	$9.18 \times H^{-0.057}$
Remote-Condensing	Air	All	$3.5 + 6.0 \times H^{-0.162}$
Self-Contained	Air	All	$0.08 + 59.45 \times H^{0.349}$

Source

The primary source for this deemed savings approach is the Arkansas TRM 2016 Volume 2, p.467 – p.470.

16.4.7 Low/No-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 no/low sweat door film elimates the need for these heaters[294]. Note that this measure does not effect frame heaters.

The baseline condition for this measure is the refrigerated case doors with operational ASDH. The baseline ASDH may have controls or without any control. The measure allows different savings values for both types of refrigerated case doors; ASDH with or without control. The 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:

$$\Delta kWh = kW_{ASDH} \times DC \times n \times HOU \times WHFe$$

Gross coincident demand reductions are assigned as follows:

$$\Delta kW = kW_{ASDH} \times DC \times n \, X \, WHFd \times CF$$

Where:

kWh_{ASDH} =rated power of the existing ASDH, kW
DC = duty cycle (effective run time) of the existing ASDH based on existing controls, dimensionless
n = number of reach-in refrigerator or freezer doors with film installed, dimensionless
HOU = annual operating hours, hrs/yr
WHF = Waste Heat Factor; represents the increased savings due to reduced heat from ASDH that must be rejected by the refrigeration equipment.
CF = Summer Peak Coincidence Factor

[294] In some cases ASDHs may not be deactivated, however ASDH controls are modified to drastically reduce the dew point setpoint, reducing the time heaters operate. In these cases it is assumed that the time heaters operate is negligible.

Input Variables

Table 119: 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 2017, p. 408[295]
n	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 2017, p. 408
		Default: 0.428	-	Mid-Atlantic TRM 2017, p. 408
HOU	Fixed	8,760	hour/year	Mid-Atlantic TRM 2016, p. 446
WHFe	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	dimensionless	Mid-Atlantic TRM 2017, p. 408
WHFd	Fixed	Med Temp (0°F - 30°F): 1.50 High Temp (31°F - 55°F): 1.25	dimensionless	Mid-Atlantic TRM 2017, p. 408
CF[296]	Variable	Freezers: On/Off controls: 0.21 Micropulse: 0.30	dimensionless	Mid-Atlantic TRM 2017, p. 408 – p.409
		Refrigerators: On/Off controls: 0.25 Micropulse: 0.36		Mid-Atlantic TRM 2017, p. 408 – p.409
		No Controls: 1.0		Assumed uniform load throughout the year
		Default: 0.36		No controls

Default Savings

Default energy savings for ASDH with controls:

$$\Delta kWh = kW_{ASDH} \times DC \times n \times HOU \times WHF$$

[295] Mid-Atlantic TRM 2017, p. 408. Original source Cadmus. 2015. Commercial Refrigeration Loadshape Project. Lexington, MA.

[296] Mid-Atlantic TRM 2016, p. 446. 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.