**Version Date & Revision History**

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|---|---|
| Draft: | Portfolio # |
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## Convection Oven (Time of Sale)

**Official Measure Code (Measure Number:** X-X-X-X (Program name, End Use)

**Description**
Commercial convection ovens that are ENERGY STAR certified have higher heavy load cooking efficiencies, and lower idle energy rates making them on average about 20 percent more efficient than standard models. Energy savings estimates are for ovens using full size (18" x 36") sheet pans.

**Definition of Efficient Equipment**
The efficient equipment is assumed to be an ENERGY STAR qualified electric convection oven.

**Definition of Baseline Equipment**
The baseline equipment is assumed to be a standard convection oven with a heavy load efficiency of 65%.

**Deemed Savings for this Measure**

Annual kWh Savings = 3,235 kWh

Summer Coincident Peak kW Savings = 0.62 kW

**Deemed Lifetime of Efficient Equipment**
12 years[586]

**Deemed Measure Cost**
The incremental cost for commercial convection ovens is assumed to be $1,113[587]

**Deemed O&M Cost Adjustments**
n/a

**Coincidence Factor**
0.84[588]

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**REFERENCE SECTION**

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**Calculation of Savings**

**Energy Savings**

$$kWH = [LB \times E_{FOOD}/EFF + IDLE \times (HOURS_{DAY} - LB/PC - PRE_{TIME}/60) + PRE_{ENERGY}] \times DAYS$$
$$\Delta kWh = kWH_{base} - kWh_{eff}$$

Where:

$kWH_{base}$ = the annual energy usage of the baseline equipment calculated using baseline values
$kWH_{eff}$ = the annual energy usage of the efficient equipment calculated using efficient values
$HOURS_{DAY}$ = Daily operating hours
= 12[589]

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586 Food Service Technology Center (FSTC). Default value from life cycle cost calculator. http://www.fishnick.com/saveenergy/tools/calculators/ecombicalc.php
587 NYSERDA Deemed Savings Database
588 RLW Analytics. Coincidence Factor Study – Residential and Commercial Industrial Lighting Measures. Spring 2007.
589 Food Service Technology Center (FSTC), based on assumption that restaurant is open 12 hours a day, 365 days a year.

| | |
|---|---|
| DAYS | = Days per year of operation<br>= 365 |
| $PRE_{TIME}$ | = Preheat time (min/day), the amount of time it takes a steamer to reach operating temperature when turned on<br>= 15 min/day[590] |
| $E_{FOOD}$ | = ASTM Energy to Food (kWh/lb); the amount of energy absorbed by the food during cooking, per pound of food<br>= 0.0732[591] |
| LB | = Pounds of food cooked per day (lb/day)<br>= 100[592] |
| EFF | = Heavy load cooking energy efficiency (%). See table below. |
| IDLE | = Idle energy rate. See table below. |
| PC | = Production capacity (lbs/hr). See table below. |
| $PRE_{ENERGY}$ | = Preheat energy (kWh/day). See table below. |

Performance Metrics: Baseline and Efficient Values[593]

| Metric | Baseline Model | Energy Efficient Model |
|---|---|---|
| $PRE_{ENERGY}$ (kWh) | 1.5 | 1 |
| IDLE (kW) | 2 | 1.3[594] |
| EFF | 65% | 74%[595] |
| PC (lb/hr) | 70 | 80 |

**Summer Coincident Peak Demand Savings**

$$\Delta kW = (\Delta kWh / HOURS) \times CF$$

Where:

| | |
|---|---|
| ΔkWh | = Annual energy savings (kWh) |
| HOURS | = Equivalent full load hours<br>= 4380 |
| CF | = Summer Peak Coincidence Factor for measure<br>= 0.84 |

**Fossil Fuel Impact Descriptions and Calculation**
n/a

**Water Impact Descriptions and Calculation**
n/a

**Deemed O&M Cost Adjustment Calculation**
n/a

590 Food Service Technology Center (2002). *Commercial Cooking Appliance Technology Assessment.* Prepared by Don Fisher.. Chapter 7: Ovens.
591 American Society for Testing and Materials. Industry Standard for Commercial Ovens.
592 Food Service Technology Center (FSTC). Default value from life cycle cost calculator. http://www.fishnick.com/saveenergy/tools/calculators/ecombicalc.php
593 Ibid.
594 Calculated from list of Energy Star qualified models, http://www.energystar.gov/ia/products/prod_lists/comm_ovens_prod_list.xls
595 Ibid.

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# ENERGY STAR Griddle (Time of Sale)

**Official Measure Code (Measure Number: X-X-X-X (Program name, End Use)**

**Description**
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.

**Definition of Efficient Equipment**
The efficient equipment is assumed to be an ENERGY STAR qualified griddle that has a cooking energy efficiency greater than 70%

**Definition of Baseline Equipment**
The baseline equipment is assumed to be a conventional electric griddle with a cooking energy efficiency of 60%

**Deemed Calculations for this Measure**

Annual kWh Savings $= kWh_{base} - kWh_{eff}$

Summer Coincident Peak kW Savings = (Annual kWh Savings / HOURS) x CF

**Deemed Lifetime of Efficient Equipment**
12 years[596]

**Deemed Measure Cost**
The incremental cost of an ENERGY STAR griddle is assumed to be $2,090[597].

**Deemed O&M Cost Adjustments**
n/a

**Coincidence Factor**
0.84[598]

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**REFERENCE SECTION**

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**Calculation of Savings**

**Energy Savings**

$$kWh_i = [LB \times E_{FOOD} / EFF_i + IDLE_i \times (HOURS_{DAY} - LB / PC_i - PRE_{TIME} / 60) + PRE_{ENERGY,i}] \times DAYS$$

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

Where:

$kWh_{base}$ = the annual energy usage of the baseline equipment calculated using baseline values (where i = base for all instances of the subscript in the equation above).

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[596] Food Service Technology Center (FSTC). Default value from life cycle cost calculator. http://www.fishnick.com/saveenergy/tools/calculators/egridcalc.php
[597] New York State Energy Research and Development Agency (NYSERDA) Deemed Savings Database, Rev. 12, 2008.
[598] Verification of summer peak coincidence factor is pending further information from the utilities.

| | |
|---|---|
| $kWh_{eff}$ | = the annual energy usage of the efficient equipment calculated using efficient values (where i = eff for all instances of the subscript in the equation above). |
| LB | = Pounds of food cooked per day<br>= 100 |
| $E_{FOOD}$ | = ASTM Energy to Food (kWh/lb); the amount of energy absorbed by the food during cooking, per pound of food<br>= 0.139[599] |
| $EFF_i$ | = Heavy Load Cooking Energy Efficiency; see table below for baseline and efficient values. |
| $IDLE_i$ | = Idle Energy Rate; see table below for baseline and efficient values. |
| $HOURS_{DAY}$ | = Daily operating hours<br>= 12[600] |
| $PC_i$ | = Production Capacity; see table below for baseline and efficient values. |
| $PRE_{TIME}$ | = Preheat time (min/day), the amount of time it takes a steamer to reach operating temperature when turned on<br>= 15 min/day[601] |
| 60 | = minutes per hour |
| $PRE_{ENERGY,i}$ | = Preheat energy (kWh/day); see table below for baseline and efficient values. |
| DAYS | = Operating Days per year<br>= 365 |

**Efficient Griddle Performance Metrics: Baseline and Efficient Values**[602]

| Parameter | Baseline Model | Efficient Model |
|---|---|---|
| Idle Energy Rate (kW) | 2.4 | 0.92 |
| Production Capacity (lb/h) | 35 | 46 |
| $PRE_{ENERGY}$ | 4 | 2 |
| Heavy Load Cooking Energy Efficiency | 60% | 75% |

**Summer Coincident Peak Demand Savings**

$$\Delta kW = (\Delta kWh / HOURS) \times CF$$

Where:

| | |
|---|---|
| $\Delta kWh$ | = Annual energy savings (kWh) |
| HOURS | = annual operating hours<br>= $HOURS_{DAY}$ * DAYS = 12 * 365 =4380 |
| CF | = Summer Peak Coincidence Factor for measure<br>= 0.84 |

**Fossil Fuel Impact Descriptions and Calculation**
n/a

**Water Impact Descriptions and Calculation**
n/a

**Deemed O&M Cost Adjustment Calculation**
n/a

599 American Society for Testing and Materials. Industry Standard.
600 Food Service Technology Center (FSTC), based on assumption that restaurant is open 12 hours a day, 365 days a year.
601 FSTC (2002). *Commercial Cooking Appliance Technology Assessment*. Chapter 3: Griddles.
602 An average pan width of 3 ft has been assumed based on a survey of available equipment. Baseline values based on assumptions from FSTC life cycle cost calculator. Efficient values reflect averages from a list of qualifying models found on the ENERGY STAR website (accessed June 2010)

**Version Date & Revision History**

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## Spray Nozzles for Food Service (Retrofit)

**Official Measure Code (Measure Number: X-X-X-X (Program name, End Use)**

**Description**
All pre-rinse valves use a spray of water to remove food waste from dishes prior to cleaning in a dishwasher. They reduce water consumption, water heating cost, and waste water (sewer) charges. Pre-rinse spray valves include a nozzle, squeeze lever, and dish guard bumper. The spray valves usually have a clip to lock the handle in the "on" position. Pre-rinse valves are inexpensive and easily interchangeable with different manufacturers' assemblies. The primary impacts of this measure will be water savings. Energy savings depend on the facility's water heating fuel - if the facility does not have electric water heating, there are no electric savings for this measure; if the facility does not have fossil fuel water heating, there are no MMBtu savings for this measure.

**Definition of Efficient Equipment**
The efficient equipment is assumed to be a pre-rinse spray valve with a flow rate of 1.6 gallons per minute, and with a cleanability performance of 26 seconds per plate or less

**Definition of Baseline Equipment**
The baseline equipment is assumed to be a spray valve with a flow rate of 3 gallons per minute.

**Deemed Savings for this Measure**

Annual kWh Savings[603] $= \Delta Water \times HOT_{\%} \times 8.33 \times (\Delta T) \times (1/EFF) \times 10^{-6}$

Summer Coincident Peak kW Savings = 0

Annual MMBtu Savings[604] $= \Delta Water \times HOT_{\%} \times 8.33 \times (\Delta T) \times (1/EFF) \times 10^{-6}$

**Deemed Lifetime of Efficient Equipment**
5 years[605]

**Deemed Measure Cost**
The actual measure installation cost should be used (including material and labor).

**Deemed O&M Cost Adjustments**
n/a

**Coincidence Factor**
n/a[606]

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**REFERENCE SECTION**

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**Calculation of Savings**

603 If the facility does not have electric water heating, there are no electric savings for this measure.
604 If the facility does not have fossil fuel water heating, there are no MMBtu savings for this measure.
605 Federal Energy Management Program (2004), *How to Buy a Low-Flow Pre-Rinse Spray Valve*. Common assumption across efficiency programs.
606 No demand savings are claimed for this measure since there is insufficient peak coincident data.

**Energy Savings**
If water heating is electric-based:

$$\Delta kWh = \Delta Water \times HOT_{\%} \times 8.33 \times (\Delta T) \times (1/EFF) \times 10^{-6}$$

| | |
|---|---|
| ΔWater | = Water savings (gallons); see calculation in "Water Impact" section below. |
| $HOT_{\%}$ | = The percentage of water used by the pre-rinse spray valve that is heated<br>= 69%[607] |
| 8.33 | = The energy content of heated water (Btu/gallon/°F) |
| ΔT | = Temperature rise through water heater (°F)<br>= 70[608] |
| EFF | = Water heater thermal efficiency<br>= 0.97[609] |
| $10^{-6}$ | = Factor to convert Btu to MMBtu |

**Summer Coincident Peak Demand Savings**

$$\Delta kW = 0$$

**Fossil Fuel Impact Descriptions and Calculation**
If water heating is fossil fuel-based:

$$\Delta MMBtu = \Delta Water \times HOT_{\%} \times 8.33 \times (\Delta T) \times (1/EFF) \times 10^{-6}$$

| | |
|---|---|
| ΔWater | = Water savings (gallons); see calculation in "Water Impact" section below. |
| $HOT_{\%}$ | = The percentage of water used by the pre-rinse spray valve that is heated<br>= 69% |
| 8.33 | = The energy content of heated water (Btu/gallon/°F) |
| ΔT | = Temperature rise through water heater (°F)<br>= 70[610] |
| EFF | = Water heater thermal efficiency<br>= 0.58[611] |
| $10^{-6}$ | = Factor to convert Btu to MMBtu |

**Water Impact Descriptions and Calculation**

$$\Delta Water = (FLO_{base} - FLO_{eff}) \times 60 \times HOURS_{day} \times 365$$

| | |
|---|---|
| $FLO_{base}$ | = The flow rate of the baseline spray nozzle<br>= 3 gallons per minute |
| $FLO_{eff}$ | = The flow rate of the efficient equipment<br>= 1.6 gallons per minute |
| 60 | = minutes per hour |
| 365 | = days per year |
| HOURS | = Hours used per day – depends on facility type as below:[612] |

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607 Measures and Assumptions for DSM Planning (2009). Navigant Consulting. Prepared for the Ontario Energy Board. This factor is a candidate for future improvement through evaluation.
608 Engineering judgment; assumes typical supply water temperature of 70°F and a hot water storage tank temperature of 140°F.
609 IECC 2006. Performance requirement for electric resistance water heaters.
610 Engineering judgment; assumes typical supply water temperature of 70°F and a hot water storage tank temperature of 140°F.
611 Baseline gas water heater thermal efficiency. As submitted in the gas utilities' *Proposed predetermined values and protocols* – submitted to the OH PUC 2009. Case no. 09-512-GE-UNC.
612 Hours estimates based on *PG&E savings estimates, algorithms, sources* (2005). Food Service Pre-Rinse Spray Valves

| Facility Type | Hours of Pre-Rinse Spray Valve Use per Day (HOURS) |
|---|---|
| Full Service Restaurant | 4 |
| Other | 2 |
| Limited Service (Fast Food ) Restaurant | 1 |

**Deemed O&M Cost Adjustment Calculation**
n/a

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# Refrigerated Case Covers (Time of Sale, New Construction, Retrofit – New Equipment)

**Official Measure Code** (Measure Number: X-X-X-X (Program name, End Use)

**Description**
By covering refrigerated cases the heat gain due to the spilling of refrigerated air and convective mixing with room air is reduced at the case opening. Continuous curtains can be pulled down overnight while the store is closed, yielding significant energy savings.

**Definition of Efficient Equipment**
In order for this characterization to apply, the efficient equipment is assumed to be a refrigerated case with a continuous cover deployed during overnight periods. Characterization assumes covers are deployed for six hours daily.

**Definition of Baseline Equipment**
In order for this characterization to apply, the baseline equipment is assumed to be a refrigerated case without a cover.

**Deemed Calculation for this Measure**

Annual kWh Savings = 346.5 * FEET * COP

Summer Coincident Peak kW Savings = 0

**Deemed Lifetime of Efficient Equipment**
The expected measure life is assumed to be 5 years [613].

**Deemed Measure Cost**
The incremental capital cost for this measure is $42 per linear foot of cover installed including material and labor[614].

**Deemed O&M Cost Adjustments**
n/a

**Coincidence Factor**
The summer peak coincidence factor for this measure is assumed to be 0[615].

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**REFERENCE SECTION**

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**Calculation of Savings**

**Energy Savings**

$$\Delta kWh = (LOAD / 12{,}000) * FEET * (3.516) * COP * ESF * 8{,}760$$

Where:

[613] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008.
[614] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Cost Values and Summary Documentation", California Public Utilities Commission, December 16, 2008 <http://deeresources.com/deer0911planning/downloads/DEER2008_Costs_ValuesAndDocumentation_080530Rev1.zip>
[615] Assumed that the continuous covers are deployed at night; therefore no demand savings occur during the peak period.

LOAD = average refrigeration load per linear foot of refrigerated case without night covers deployed
= 1,500 Btu/h[616] per linear foot

FEET = linear (horzontal) feet of covered refrigerated case

12,000 = conversion factor - Btu per ton cooling.

3.516 = conversion factor – Coefficient of Performance (COP) to kW per ton.

COP = Coefficient of Performance of the refrigerated case.
= assume 2.2[617], if actual value is unknown.

ESF = Energy Savings Factor; reflects the percent reduction in refrigeration load due to the deployment of night covers.
= 9%[618]

8,760 = assumed annual operating hours of the refrigerated case

**Summer Coincident Peak Demand Savings**

$\Delta kW$ = 0[619]

**Fossil Fuel Impact Descriptions and Calculation**
n/a

**Water Impact Descriptions and Calculation**
n/a

**Deemed O&M Cost Adjustment Calculation**
n/a

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[616] Davis Energy Group, Analysis of Standard Options for Open Case Refrigerators and Freezers, May 11, 2004. Accessed on 7/7/10 < http://www.energy.ca.gov/appliances/2003rulemaking/documents/case_studies/CASE_Open_Case_Refrig.pdf>

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

[618] Effects of the Low Emissivity Shields on Performance and Power Use of a Refrigerated Display Case, Southern California Edison, August 8, 1997. Accessed on 7/7/10. <http://www.sce.com/NR/rdonlyres/2AAEFF0B-4CE5-49A5-8E2C-3CE23B81F266/0/AluminumShield_Report.pdf>; Characterization assumes covers are deployed for six hours daily.

[619] Assumed that the continuous covers are deployed at night; therefore no demand savings occur during the peak period.

# Door Heater Controls for Cooler or Freezer (Time of Sale)

**Official Measure Code** (Measure Number: X-X-X-X (Program name, End Use)

**Description**
By installing a control device to turn off door heaters when there is little or no risk of condensation, one can realize significant energy savings. There are two commercially available control strategies that achieve "on-off" control of door heaters based on either (1) the relative humidity of the air in the store or (2) the "conductivity" of the door (which drops when condensation appears). In the first strategy, the system activates your door heaters when the relative humidity in your store rises above a specific setpoint, and turns them off when the relative humidity falls below that setpoint. In the second strategy, the sensor activates the door heaters when the door conductivity falls below a certain setpoint, and turns them off when the conductivity rises above that setpoint.

**Definition of Efficient Equipment**
In order for this characterization to apply, the efficient equipment is assumed to be a door heater control on a commercial glass door cooler or refrigerator utilizing humidity or conductivity control.

**Definition of Baseline Equipment**
In order for this characterization to apply, the baseline condition is assumed to be a commercial glass door cooler or refrigerator with a standard heated door with no controls installed.

**Deemed Calculation for this Measure**

Annual kWh Savings = kWbase * NUMdoors * ESF * BF

Summer Coincident Peak kW Savings = 0

**Deemed Lifetime of Efficient Equipment**
The expected measure life is assumed to be 12 years [620].

**Deemed Measure Cost**
The incremental capital cost for a humidity-based control is $300 per circuit regardless of the number of doors controlled. The incremental cost for conductivity-based controls is $200[621].

**Deemed O&M Cost Adjustments**
n/a

**Coincidence Factor**
The summer peak coincidence factor for this measure is assumed to be 0%[622].

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**REFERENCE SECTION**

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**Calculation of Savings**

**Energy Savings**

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[620] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008.
[621] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010
[622] Based on the assumption that humidity levels will most likely be relatively high during the peak period, reducing the likelihood of demand savings from door heater controls.

ΔkWH = kWbase * NUMdoors * ESF * BF

Where:

kWbase[623] = connected load kW for typical reach-in refrigerator or freezer door and frame with a heater.
= If actual kWbase is unknown, assume 0.195 kW for freezers and 0.092 kW for coolers.

NUMdoors = number of reach-in refrigerator or freezer doors controlled by sensor
= Actual installed

ESF[624] = Energy Savings Factor; represents the percentage of hours annually that the door heater is powered off due to the controls.
= assume 55% for humidity-based controls, 70% for conductivity-based controls

BF[625] = Bonus Factor; represents the increased savings due to reduction in cooling load inside the cases, and the increase in cooling load in the building space to cool the additional heat generated by the door heaters.
= assume 1.36 for low-temp, 1.22 for medium-temp, and 1.15 for high-temp applications

**Summer Coincident Peak Demand Savings**

ΔkW[626] = 0

**Fossil Fuel Impact Descriptions and Calculation**
n/a

**Water Impact Descriptions and Calculation**
n/a

**Deemed O&M Cost Adjustment Calculation**
n/a

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[623] A review of TRM methodologies from Vermont, New York, Wisconsin, and Connecticut reveals several different sources for this factor. Connecticut requires site-specific information, whereas New York's characterization does not explicitly identify the kWbase. Connecticut and Vermont provide values that are very consistent, and the simple average of these two values has been used for the purposes of this characterization.

[624] A review of TRM methodologies from Vermont, New York, Wisconsin, and Connecticut reveals several different estimates of ESF. Vermont is the only TRM that provides savings estimates dependent on the control type. Additionally, these estimates are the most conservative of all TRMs reviewed. These values have been adopted for the purposes of this characterization.

[625] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

[626] Based on the assumption that humidity levels will most likely be relatively high during the peak period, reducing the likelihood of demand savings from door heater controls.

# ENERGY STAR Ice Machine (Time of Sale, New Construction)

**Official Measure Code** (Measure Number: X-X-X-X (Program name, End Use)

**Description**
This measure relates to the installation of a new ENERGY STAR qualified commercial ice machine. The ENERGY STAR label applied to air-cooled, cube-type machines including ice-making head, self-contained, and remote-condensing units. This measure could relate to the replacing of an existing unit at the end of its useful life, or the installation of a new system in a new or existing building.

**Definition of Efficient Equipment**
In order for this characterization to apply, the efficient equipment is assumed to be a commercial ice machine meeting the minimum ENERGY STAR efficiency level standards.

**Definition of Baseline Equipment**
In order for this characterization to apply, the baseline equipment is assumed to be a commercial ice machine meeting federal equipment standards established January 1, 2010.

**Deemed Calculation for this Measure**

Annual kWh Savings = [(kWhbase - kWhee) / 100] x (0.40 * H) x 365

Summer Coincident Peak kW Savings = Annual kWh Savings / (8760 x 0.40) x 0.772

**Deemed Lifetime of Efficient Equipment**
The expected measure life is assumed to be 9 years[627].

**Deemed Measure Cost**
The incremental capital cost for this measure is provided below.[628]

| Harvest Rate (H) | Incremental Cost |
|---|---|
| 100-200 lb ice machine | $296 |
| 201-300 lb ice machine | $312 |
| 301-400 lb ice machine | $559 |
| 401-500 lb ice machine | $981 |
| 501-1000 lb ice machine | $1,485 |
| 1001-1500 lb ice machine | $1,821 |
| >1500 lb ice machine | $2,194 |

**Deemed O&M Cost Adjustments**
n/a

**Coincidence Factor**
The summer peak coincidence factor for this measure is assumed to be 77.2%[629].

[627] The following report estimates life of a commercial ice-maker at 7-10 years: *Energy Savings Potential for Commercial Refrigeration Equipment*, Arthur D. Little, Inc., 1996.
[628] These values are from electronic work papers prepared in support of San Diego Gas & Electric's "Application for Approval of Electric and Gas Energy Efficiency Programs and Budgets for Years 2009-2011", SDGE, March 2, 2009. Accessed on 7/7/10 <http://www.sdge.com/regulatory/documents/ee2009-2011Workpapers/SW-ComB/Food%20Service/Food%20Service%20Electic%20Measure%20Workpapers%2011-08-05.DOC>.
[629] Assumes that the summer peak coincidence factor for commercial ice machines is consistent with that of general commercial refrigeration equipment. Characterization assumes a value of 77.2% adopted from the Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February. 19, 2010, until a region specific study is conducted.

## REFERENCE SECTION

**Calculation of Savings**

**Energy Savings**

$\Delta kWH = [(kWh_{base} - kWh_{ee}) / 100] * (DC * H) * 365$

Where:

$kWh_{base}$ = maximum kWh consumption per 100 pounds of ice for the baseline equipment
= calculated as shown in the table below using the actual Harvest Rate (H) of the efficient equipment.

$kWh_{ee}$ = maximum kWh consumption per 100 pounds of ice for the efficient equipment
= calculated as shown in the table below using the actual Harvest Rate (H) of the efficient equipment.

| Ice Machine Type | $kWh_{base}$[630] | $kWh_{ee}$[631] |
|---|---|---|
| Ice Making Head (H < 450) | 10.26 - 0.0086*H | 9.23 - 0.0077*H |
| Ice Making Head (H ≥ 450) | 6.89 – 0.0011*H | 6.20 - 0.0010*H |
| Remote Condensing Unit, without remote compressor (H < 1000) | 8.85 – 0.0038*H | 8.05 - 0.0035*H |
| Remote Condensing Unit, without remote compressor (H ≥ 1000) | 5.1 | 4.64 |
| Remote Condensing Unit, with remote compressor (H < 934) | 8.85 – 0.0038*H | 8.05 - 0.0035*H |
| Remote Condensing Unit, with remote compressor (H ≥ 934) | 5.3 | 4.82 |
| Self Contained Unit (H < 175) | 18 - 0.0469*H | 16.7 - 0.0436*H |
| Self Contained Unit (H ≥ 175) | 9.8 | 9.11 |

100 = conversion factor to convert kWhbase and kWhee into maximum kWh consumption per pound of ice.

DC = Duty Cycle of the ice machine
= 0.40[632]

H = Harvest Rate (pounds of ice made per day)
= Actual installed

365 = days per year

**Summer Coincident Peak Demand Savings**

$\Delta kW = \Delta kWh / (HOURS * DC) * CF$

[630] Baseline reflects federal standards which apply to units manufactured on or after January 1, 2010 <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&rgn=div6&view=text&node=10:3.0.1.4.17.8&idno=10>.

[631] ENERGY STAR Program Requirements for Commercial Ice Machines, Partner Commitments, U.S. Environmental Protection Agency, Accessed on 7/7/10 <http://www.energystar.gov/ia/partners/product_specs/program_reqs/ice_machine_prog_req.pdf>

[632] Duty cycle varies considerably from one installation to the next. TRM assumptions from Vermont, Wisconsin, and New York vary from 40 to 57%, whereas the ENERGY STAR Commercial Ice Machine Savings Calculator < http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_Ice_Machines.xls> assumes a value of 75%. A field study of eight ice machines in California indicated an average duty cycle of 57% ("A Field Study to Characterize Water and Energy Use of Commercial Ice-Cube Machines and Quantify Saving Potential", Food Service Technology Center, December 2007). Furthermore, a report prepared by ACEEE assumed a value of 40% (Nadel, S., Packaged Commercial Refrigeration Equipment: A Briefing Report for Program Planners and Implementers, ACEEE, December 2002). For conservatism, this characterization assumed a value of 40%.

Where:

| | |
|---|---|
| HOURS | = annual operating hours |
| | = 8760[633] |
| CF | = Summer Peak Coincidence Factor for measure |
| | = 0.772 [634] |

**Fossil Fuel Impact Descriptions and Calculation**
n/a

**Water Impact Descriptions and Calculation**
While the ENERGY STAR labeling criteria require that certified commercial ice machines meet certain "maximum potable water use per 100 pounds of ice made" requirements, such requirements are intended to prevent equipment manufacturers from gaining energy efficiency at the cost of water consumptions. A review of the AHRI Certification Directory[635] indicates that approximately 81% of air-cooled, cube-type machines meet the ENERGY STAR potable water use requirement. Therefore, there are no assumed water impacts for this measure.

**Deemed O&M Cost Adjustment Calculation**
n/a

**Version Date & Revision History**

| | |
|---|---|
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[633] Unit is assumed to be connected to power 24 hours per day, 365 days per year.
[634] Assumes that the summer peak coincidence factor for commercial ice machines is consistent with that of general commercial refrigeration equipment. Characterization assumes a value of 77.2% adopted from the Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010, until a region specific study is conducted.
[635] AHRI Certification Directory, Accessed on 7/7/10. <http://www.ahridirectory.org/ahridirectory/pages/home.aspx>

# Commercial Solid Door Refrigerators & Freezers (Time of Sale, New Construction)

**Official Measure Code** (Measure Number: X-X-X-X (Program name, End Use)

**Description**
This measure relates to the installation of a new reach-in commercial refrigerator or freezer meeting ENERGY STAR efficiency standards. ENERGY STAR labeled commercial refrigerators and freezers are more energy efficient because they are designed with components such as ECM evaporator and condenser fan motors, hot gas anti-sweat heaters, or high-efficiency compressors, which will significantly reduce energy consumption. This measure could relate to the replacing of an existing unit at the end of its useful life, or the installation of a new system in a new or existing building.

**Definition of Efficient Equipment**
In order for this characterization to apply, the efficient equipment is assumed to be a solid or glass door refrigerator or freezer meeting the minimum ENERGY STAR efficiency level standards.

**Definition of Baseline Equipment**
In order for this characterization to apply, the baseline equipment is assumed to be a solid or glass door refrigerator or freezer meeting the minimum federal manufacturing standards as specified by the Energy Policy Act of 2005.

**Deemed Calculation for this Measure**

Annual kWh Savings = (kWhbase – kWhee) * 365

Summer Coincident Peak kW Savings = Annual kWh Savings / HOURS * CF

**Deemed Lifetime of Efficient Equipment**
The expected measure life is assumed to be 12 years [636].

**Deemed Measure Cost**
The incremental capital cost for this measure is provided below[637].

| Type | Refrigerator Incremental Cost | Freezer Incremental Cost |
|---|---|---|
| **Solid or Glass Door** | | |
| 0 < V < 15 | $143 | $142 |
| 15 ≤ V < 30 | $164 | $166 |
| 30 ≤ V < 50 | $164 | $166 |
| V ≥ 50 | $249 | $407 |

[636] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008. http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf

[637] Estimates of the incremental cost of commercial refrigerators and freezers varies widely by source. Nadel, S., Packaged Commercial Refrigeration Equipment: A Briefing Report for Program Planners and Implementers, ACEEE, December 2002, indicates that incremental cost is approximately zero. Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010, assumed incremental cost ranging from $75 to $125 depending on equipment volume. ACEEE notes that incremental cost ranges from 0 to 10% of the baseline unit cost <http://www.aceee.org/ogeece/ch5_reach.htm>. For the purposes of this characterization, assume and incremental cost adder of 5% on the full unit costs presented in Goldberg et al, State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs: Incremental Cost Study, KEMA, October 28, 2009.

**Deemed O&M Cost Adjustments**
n/a

**Coincidence Factor**
The summer peak coincidence factor for this measure is assumed to be 100%[638].

## REFERENCE SECTION

**Calculation of Savings**

**Energy Savings**

$$\Delta kWh = (kWhbase - kWhee) * 365$$

Where:

kWhbase = baseline maximum daily energy consumption in kWh
= calculated using actual chilled or frozen compartment volume (V) of the efficient unit as shown in the table below.

| Type | kWhbase[639] |
|---|---|
| Solid Door Refrigerator | 0.10 * V + 2.04 |
| Glass Door Refrigerator | 0.12 * V + 3.34 |
| Solid Door Freezer | 0.40 * V + 1.38 |
| Glass Door Freezer | 0.75 * V + 4.10 |

kWhee[640] = efficient maximum daily energy consumption in kWh
= calculated using actual chilled or frozen compartment volume (V) of the efficient unit as shown in the table below.

| Type | Refrigerator kWhee | Freezer kWhee |
|---|---|---|
| **Solid Door** | | |
| $0 < V < 15$ | $\leq 0.089V + 1.411$ | $\leq 0.250V + 1.250$ |
| $15 \leq V < 30$ | $\leq 0.037V + 2.200$ | $\leq 0.400V - 1.000$ |
| $30 \leq V < 50$ | $\leq 0.056V + 1.635$ | $\leq 0.163V + 6.125$ |
| $V \geq 50$ | $\leq 0.060V + 1.416$ | $\leq 0.158V + 6.333$ |
| **Glass Door** | | |
| $0 < V < 15$ | $\leq 0.118V + 1.382$ | $\leq 0.607V + 0.893$ |
| $15 \leq V < 30$ | $\leq 0.140V + 1.050$ | $\leq 0.733V - 1.000$ |
| $30 \leq V < 50$ | $\leq 0.088V + 2.625$ | $\leq 0.250V + 13.500$ |
| $V \geq 50$ | $\leq 0.110V + 1.500$ | $\leq 0.450V + 3.500$ |

V = the chilled or frozen compartment volume ($ft^3$) (as defined in the Association of Home Appliance Manufacturers Standard HRF1–1979)
= Actual installed

365 = days per year

[638] The Summer Peak Coincidence Factor is assumed to equal 1.0, since the annual kWh savings is divided by the total annual hours (8760), effectively resulting in the average kW reduction during the peak period.
[639] Energy Policy Act of 2005. Accessed on 7/7/10. <http://www.epa.gov/oust/fedlaws/publ_109-058.pdf>
[640] ENERGY STAR Program Requirements for Commercial Refrigerators and Freezers Partner Commitments Version 2.0, U.S. Environmental Protection Agency, Accessed on 7/7/10. <http://www.energystar.gov/ia/partners/product_specs/program_reqs/commer_refrig_glass_prog_req.pdf>

**Summer Coincident Peak Demand Savings**

$$\Delta kW = \Delta kW / HOURS * CF$$

Where:

HOURS = equipment is assumed to operate continuously, 24 hours per day, 365 days per year.
= 8760

CF = Summer Peak Coincidence Factor for measure
= 1.0 [641]

**Fossil Fuel Impact Descriptions and Calculation**
n/a

**Water Impact Descriptions and Calculation**
n/a

**Deemed O&M Cost Adjustment Calculation**
n/a

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[641] The Summer Peak Coincidence Factor is assumed to equal 1.0, since the annual kWh savings is divided by the total annual hours (8760), effectively resulting in the average kW reduction during the peak period.

## Strip Curtain for Walk-in Coolers and Freezers (New Construction, Retrofit – New Equipment, Retrofit – Early Replacement)

**Official Measure Code (Measure Number: X-X-X-X (Program name, End Use)**

**Description**
This commercial measure pertains to the installation of infiltration barriers (strip curtains) on walk-in coolers or freezers. Strip curtains impede heat transfer from adjacent warm and humid spaces into walk-ins when the main door is opened, thereby reducing the cooling load. As a result, compressor run time and energy consumption are reduced. The engineering assumption is that walk-in door is open 2.5 hours per day every day, and the strip curtain covers the entire door frame. Eligible applications include new construction and retrofit.

**Definition of Efficient Equipment**
The efficient equipment is a polyethylene strip curtain added to a walk-in cooler or freezer.

**Definition of Baseline Equipment**
The baseline assumption is a walk-in cooler or freezer that previously had either no strip curtain installed or an old, ineffective strip curtain installed.

**Deemed Savings for this Measure**

| | |
|---|---|
| Annual kWh Savings[642] | = 2,974 for freezers<br>= 422 for coolers |
| Summer Coincident Peak kW Savings | = 0.34 for freezers<br>= 0.05 for coolers |

**Deemed Lifetime of Efficient Equipment**
The expected measure life is assumed to be 6 years[643].

**Deemed Measure Cost**
The incremental capital cost for this measure is $10.22 per square foot of door opening (includes material and labor)[644].

**Deemed O&M Cost Adjustments**
n/a

**Coincidence Factor**
The summer peak coincidence factor for this measure is 100%[645].

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[642] Values based on analysis prepared by ADM for FirstEnergy utilities in Pennsylvania, provided via personal communication with Diane Rapp of FirstEnergy on June 4, 2010. Based on a review of deemed savings assumptions and methodologies from Oregon and California, the values from Pennsylvania appear reasonable and are the most applicable to the Ohio climate.
[643] M. Goldberg, J. Ryan Barry, B. Dunn, M. Ackley, J. Robinson, and D. Deangelo-Woolsey, KEMA. "Focus on Energy: Business Programs – Measure Life Study", August 2009.
[644] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Cost Values and Summary Documentation", California Public Utilities Commission, December 16, 2008
[645] The summer coincident peak demand reduction is assumed as the total annual savings divided by the total number of hours per year, effectively assuming the average demand reduction is realized during the peak period. This is a reasonable assumption for refrigeration savings.

## REFERENCE SECTION

**Calculation of Savings**

**Energy Savings**

ΔkWh = 2,974 for freezers
= 422 for coolers

**Summer Coincident Peak Demand Savings**

ΔkW = ΔkWh / 8760 * CF
= 0.35 for freezers
= 0.05 for coolers

Where:

8760 = hours per year
CF = Summer Peak Coincidence Factor for the measure
= 1.0

**Fossil Fuel Impact Descriptions and Calculation**
n/a

**Water Impact Descriptions and Calculation**
n/a

**Deemed O&M Cost Adjustment Calculation**
n/a

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# Motors (Time of Sale)

**Official Measure Code (Measure Number: X-X-X-X (Program name, End Use)**

**Description**
Three phase Open Drip Proof (ODP) and Totally Enclosed Fan-Cooled (TEFC) motors of at least 1 horsepower (HP) and less than or equal to 200 HP.

**Definition of Efficient Equipment**
The efficient equipment is motors meeting the minimum efficiency levels of NEMA premium efficiency motors.

**Definition of Baseline Equipment**
For 2010, the baseline equipment assumes motors that meet the minimum efficiency allowed under the Federal Energy Policy Act of 1992 (EPACT). While EPACT generally reflects the floor of efficiencies available, most manufacturers produce models just meeting EPACT, and these are the most commonly purchased among customers not choosing high efficiency. Refer to the table of Baseline Motor Efficiencies in the reference table section.

For 2011, NEMA premium efficiency motors are becoming the new baseline. The Energy Independence and Security Act of 2007 (EISA) requires that general purpose motors (subtype I) manufactured after Dec. 19, 2010, from 1 to 200 HP, inclusive, shall have a nominal full-load efficiency that is not less than as defined in NEMA MG 1-2006 Table 12-12 ("NEMA Premium" efficiency levels)[646], Therefore, , it is not anticipated that time-of-sale NEMA premium efficient motors will provide savings in 2011.

**Deemed Savings for this Measure**

Annual kWh Savings $= 0.746 \times [(hp_{base} \times RLF_{base})/\eta_{base} - (hp_{ee} \times RLF_{ee})/\eta_{ee}]$

Summer Coincident Peak kW Savings $= \Delta kW \times CF$

**Deemed Lifetime of Efficient Equipment**
16 years[647]

**Deemed Measure Cost**
See 'Incremental Costs for Efficient Motors' in the Reference Table section below

**Deemed O&M Cost Adjustments**
n/a

**Coincidence Factor**
0.38

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**REFERENCE SECTION**

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**Calculation of Savings**

**Energy Savings**

$$\Delta kWh = \Delta kW \times EFLH$$

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[646] *NEMA Premium Efficiency Levels Adopted as Federal Motor Efficiency Performance Standards*, NEMA press release , March 27, 2008, http://www.nema.org/media/pr/20080327a.cfm, accessed on August 5, 2010.
[647] PA Consulting Group, Inc. (2009). *Business Programs: Measure Life Study*. Prepared for State of Wisconsin Public Service Commission

Where:

EFLH = Equivalent Full Load Hours
= site specific variable, either collected on a per unit basis, or calculated using building type and location

**Summer Coincident Peak Demand Savings**

$\Delta kW = 0.746 \times [(hp_{base} \times RLF_{base})/\eta_{base} - (hp_{ee} \times RLF_{ee})/\eta_{ee}]$

$kW = \Delta kW \times CF$

Where:

$hp_{ee}$ = Rated horsepower of the efficient motor
= Nameplate

$hp_{base}$ = Rated horsepower of baseline motor
= same as the efficient motor

$RLF_{base}$ = Rated load factor of baseline motor
= 0.75[648]

$RLF_{ee}$ = Rated load factor of efficient motor
= Nameplate

$\eta_{base}$ = Efficiency of baseline motor
= see 'Baseline Motor Efficiencies (EPACT)' below

$\eta_{eff}$ = Efficiency of efficient motor
= nameplate, must meet or exceed efficiency levels in table 'Efficient Motor Efficiencies (NEMA Premium)' found below

0.746 = the conversion factor kW/hp

CF = Peak coincidence factor
= 0.38[649]

**Fossil Fuel Impact Descriptions and Calculation**
n/a

**Water Impact Descriptions and Calculation**
n/a

**Deemed O&M Cost Adjustment Calculation**
n/a

**Reference Tables**

Baseline Motor Efficiencies (EPACT)

| Size HP | Open Drip Proof (ODP) # of Poles | | | Totally Enclosed Fan-Cooled (TEFC) | | |
|---|---|---|---|---|---|---|
| | 6 | 4 | 2 | 6 | 4 | 2 |
| | Speed (RPM) | | | Speed (RPM) | | |
| | 1200 | 1800 | 3600 | 1200 | 1800 | 3600 |
| 1 | 80.0% | 82.5% | 75.5% | 80.0% | 82.5% | 75.5% |
| 1.5 | 84.0% | 84.0% | 82.5% | 85.5% | 84.0% | 82.5% |
| 2 | 85.5% | 84.0% | 84.0% | 86.5% | 84.0% | 84.0% |
| 3 | 86.5% | 86.5% | 84.0% | 87.5% | 87.5% | 85.5% |
| 5 | 87.5% | 87.5% | 85.5% | 87.5% | 87.5% | 87.5% |
| 7.5 | 88.5% | 88.5% | 87.5% | 89.5% | 89.5% | 88.5% |
| 10 | 90.2% | 89.5% | 88.5% | 89.5% | 89.5% | 89.5% |

[648] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

[649] JCP&L metered data

| Size HP | Open Drip Proof (ODP) # of Poles | | | Totally Enclosed Fan-Cooled (TEFC) | | |
|---|---|---|---|---|---|---|
| | 6 | 4 | 2 | 6 | 4 | 2 |
| | Speed (RPM) | | | Speed (RPM) | | |
| | 1200 | 1800 | 3600 | 1200 | 1800 | 3600 |
| 15 | 90.2% | 91.0% | 89.5% | 90.2% | 91.0% | 90.2% |
| 20 | 91.0% | 91.0% | 90.2% | 90.2% | 91.0% | 90.2% |
| 25 | 91.7% | 91.7% | 91.0% | 91.7% | 92.4% | 91.0% |
| 30 | 92.4% | 92.4% | 91.0% | 91.7% | 92.4% | 91.0% |
| 40 | 93.0% | 93.0% | 91.7% | 93.0% | 93.0% | 91.7% |
| 50 | 93.0% | 93.0% | 92.4% | 93.0% | 93.0% | 92.4% |
| 60 | 93.6% | 93.6% | 93.0% | 93.6% | 93.6% | 93.0% |
| 75 | 93.6% | 94.1% | 93.0% | 93.6% | 94.1% | 93.0% |
| 100 | 94.1% | 94.1% | 93.0% | 94.1% | 94.5% | 93.6% |
| 125 | 94.1% | 94.5% | 93.6% | 94.1% | 94.5% | 94.5% |
| 150 | 94.5% | 95.0% | 93.6% | 95.0% | 95.0% | 94.5% |
| 200 | 94.5% | 95.0% | 94.5% | 95.0% | 95.0% | 95.0% |

Efficient Motor Efficiencies (NEMA Premium)

| Size HP | Open Drip Proof (ODP) | | | Totally Enclosed Fan-Cooled (TEFC) | | |
|---|---|---|---|---|---|---|
| | # of Poles | | | # of Poles | | |
| | 2 | 4 | 6 | 2 | 4 | 6 |
| | Speed (RPM) | | | Speed (RPM) | | |
| | 1200 | 1800 | 3600 | 1200 | 1800 | 3600 |
| 1 | 82.50% | 85.50% | 77.00% | 82.50% | 85.50% | 77.00% |
| 1.5 | 86.50% | 86.50% | 84.00% | 87.50% | 86.50% | 84.00% |
| 2 | 87.50% | 86.50% | 85.50% | 88.50% | 86.50% | 85.50% |
| 3 | 88.50% | 89.50% | 85.50% | 89.50% | 89.50% | 86.50% |
| 5 | 89.50% | 89.50% | 86.50% | 89.50% | 89.50% | 88.50% |
| 7.5 | 90.20% | 91.00% | 88.50% | 91.00% | 91.70% | 89.50% |
| 10 | 91.70% | 91.70% | 89.50% | 91.00% | 91.70% | 90.20% |
| 15 | 91.70% | 93.00% | 90.20% | 91.70% | 92.40% | 91.00% |
| 20 | 92.40% | 93.00% | 91.00% | 91.70% | 93.00% | 91.00% |
| 25 | 93.00% | 93.60% | 91.70% | 93.00% | 93.60% | 91.70% |
| 30 | 93.60% | 94.10% | 91.70% | 93.00% | 93.60% | 91.70% |
| 40 | 94.10% | 94.10% | 92.40% | 94.10% | 94.10% | 92.40% |
| 50 | 94.10% | 94.50% | 93.00% | 94.10% | 94.50% | 93.00% |
| 60 | 94.50% | 95.00% | 93.60% | 94.50% | 95.00% | 93.60% |
| 75 | 94.50% | 95.00% | 93.60% | 94.50% | 95.40% | 93.60% |
| 100 | 95.00% | 95.40% | 93.60% | 95.00% | 95.40% | 94.10% |
| 125 | 95.00% | 95.40% | 94.10% | 95.00% | 95.40% | 95.00% |
| 150 | 95.40% | 95.80% | 94.10% | 95.80% | 95.80% | 95.00% |
| 200 | 95.40% | 95.80% | 95.00% | 95.80% | 96.20% | 95.40% |

**Incremental Costs for Efficient Motors**[650]

| Size HP | Open Drip-Proof (ODP) Incremental Cost | Totally Enclosed Fan-Cooled (TEFC) Incremental Cost |
|---|---|---|
| 1 | $52 | $52 |
| 1.5 | $60 | $60 |
| 2 | $61 | $61 |
| 3 | $54 | $54 |
| 5 | $63 | $63 |
| 7.5 | $123 | $123 |
| 10 | $116 | $116 |
| 15 | $115 | $115 |
| 20 | $115 | $115 |
| 25 | $201 | $201 |
| 30 | $231 | $231 |
| 40 | $249 | $249 |
| 50 | $273 | $273 |
| 60 | $431 | $431 |
| 75 | $554 | $554 |
| 100 | $658 | $658 |
| 125 | $841 | $841 |
| 150 | $908 | $908 |
| 200 | $964 | $964 |

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[650] Xenergy (2001). *Motor Up! Program Evaluation and Market Assessment*

# High Efficiency Pumps and Pumping Efficiency Improvements (Retrofit)

**Official Measure Code (Measure Number:** X-X-X-X (Program name, End Use)

**Description**
Pump improvements can be done to optimize the design and control of water pumping systems. The measurement of energy and demand savings for commercial and industrial applications will vary with the type of pumping technology, operating hours, efficiency and current and proposed controls. Depending on the specific application, slowing the pump, trimming or replacing the impeller, or replacing the pump may suitable options for improving pumping efficiency.

**Definition of Efficient Equipment**
In order for this characterization to apply, the efficient equipment is assumed to be an optimized pumping system meeting applicable program efficiency requirements.

**Definition of Baseline Equipment**
In order for this characterization to apply, the baseline equipment is assumed to be a non-optimized existing pumping system.

**Deemed Calculation for this Measure**

Annual kWh Savings[651] $= (HP_{motor} * LF * 0.746 / \eta_{motor}) * HOURS * (ESF/\eta_{pump})$

Summer Coincident Peak kW Savings $= (HP_{motor} * LF * 0.746 / \eta_{motor}) * (ESF/\eta_{pump}) * CF$

**Deemed Lifetime of Efficient Equipment**
The expected measure life is assumed to be 10 years[652].

**Deemed Measure Cost**
The incremental capital cost for this measure can vary considerably depending upon the strategy employed to achieve the required efficiency levels and should be determined on a site-specific basis.

**Deemed O&M Cost Adjustments**
n/a

**Coincidence Factor**
The summer peak coincidence factor for this measure is assumed to be 38%[653].

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**REFERENCE SECTION**

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**Calculation of Savings**

**Energy Savings**

$\Delta kWh = (HP_{motor} * LF * 0.746 / \eta_{motor}) * HOURS * (ESF/\eta_{pump})$

Where:

[651] Improving Pumping System Performance: A Sourcebook for Industry, Second Edition, U.S. Department of Energy, May 2006
[652] Martin, N. et al., Emerging Energy-Efficient Industrial Technologies: New York State Edition, American Council for an Energy Efficient Economy (ACEEE), March 2001
[653] Summer Peak Coincidence Factor has been preserved from the "Technical Reference Manual (TRM) for Ohio Senate Bill 221 Energy Efficiency and Conservation Program and 09-512-GE-UNC", October 15, 2009. This is likely a conservative estimate, but is recommended for further study.

$HP_{motor}$ = nameplate motor horsepower
= Actual installed

LF = Load Factor; Ratio of the peak running load to the nameplate rating of the motor. If unknown, assume a value of 80%[654].

0.746 = conversion factor from horse-power to kW (kW/hp)

$\eta_{motor}$ = Motor efficiency; if actual motor efficiency at typical pump operating conditions is unknown, assume the federal minimum efficiency requirements as below:

| Size HP | Open Drip Proof (ODP) # of Poles | | | Totally Enclosed Fan-Cooled (TEFC) | | |
|---|---|---|---|---|---|---|
| | *6* | *4* | *2* | *6* | *4* | *2* |
| | Speed (RPM) | | | Speed (RPM) | | |
| | *1200* | *1800* | *3600* | *1200* | *1800* | *3600* |
| 1 | 80.0% | 82.5% | 75.5% | 80.0% | 82.5% | 75.5% |
| 1.5 | 84.0% | 84.0% | 82.5% | 85.5% | 84.0% | 82.5% |
| 2 | 85.5% | 84.0% | 84.0% | 86.5% | 84.0% | 84.0% |
| 3 | 86.5% | 86.5% | 84.0% | 87.5% | 87.5% | 85.5% |
| 5 | 87.5% | 87.5% | 85.5% | 87.5% | 87.5% | 87.5% |
| 7.5 | 88.5% | 88.5% | 87.5% | 89.5% | 89.5% | 88.5% |
| 10 | 90.2% | 89.5% | 88.5% | 89.5% | 89.5% | 89.5% |
| 15 | 90.2% | 91.0% | 89.5% | 90.2% | 91.0% | 90.2% |
| 20 | 91.0% | 91.0% | 90.2% | 90.2% | 91.0% | 90.2% |

HOURS = annual operating hours of the pump
= Actual installed

ESF = Energy Savings Factor; assume a value of 15%[655].

$\eta_{pump}$ = Pump efficiency at design point; if actual pump efficiency is unknown, assume program compliance efficiency as below:

| HP | Minimum Pump Efficiency at Design Point ($\eta_{pump}$) |
|---|---|
| 1.5 | 65% |
| 2 | 65% |
| 3 | 67% |
| 5 | 70% |
| 7.5 | 73% |
| 10 | 75% |
| 15 | 77% |
| 20 | 77% |

**Summer Coincident Peak Demand Savings**

$$\Delta kW = (HP_{motor} * LF * 0.746 / \eta_{motor}) * (ESF/\eta_{pump}) * CF$$

Where:

CF = Summer Peak Coincidence Factor for measure
= 0.38[656]

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[654] In many applications, the pump/motor assembly is oversized. For analysis purposes, a typical 80% load factor is assumed; however, this assumption should be verified through evaluation if significant savings are realized through prescriptive pumping efficiency improvements.

[655] Published estimates of typical pumping efficiency improvements range from 10 to 20%. For analysis purposes, assume 15%. Martin, N. et al., Emerging Energy-Efficient Industrial Technologies: New York State Edition, American Council for an Energy Efficient Economy (ACEEE), March 2001.

[656] Summer Peak Coincidence Factor has been preserved from the "Technical Reference Manual (TRM) for Ohio Senate Bill 221 Energy Efficiency and Conservation Program and 09-512-GE-UNC", October 15, 2009. This is likely a conservative estimate, but is recommended for further study.

**Fossil Fuel Impact Descriptions and Calculation**
n/a

**Water Impact Descriptions and Calculation**
n/a

**Deemed O&M Cost Adjustment Calculation**
n/a

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# Efficient Air Compressors (Time of Sale)

**Official Measure Code (Measure Number:** X-X-X-X (Program name, End Use)

**Description**
This measure relates to the installation of an air compressor with a variable frequency drive, load/no load controls, or variable displacement controls. Baseline compressors choke off the inlet air to modulate the compressor output, which is not efficient. Efficient compressors use less energy at part load conditions. Demand curves are as per DOE data for a Variable Speed compressor versus a Modulating compressor. This measure could relate to the replacing of an existing unit at the end of its useful life, or the installation of a new system in a new building (i.e. time of sale).

**Definition of Efficient Equipment**
In order for this characterization to apply, the efficient equipment is assumed to be an air compressor with a variable frequency drive, load/no load controls[657], or variable displacement controls.

**Definition of Baseline Equipment**
In order for this characterization to apply, the baseline equipment is assumed to be a modulating air compressor with blow down.

**Deemed Calculation for this Measure**

Annual kWh Savings = BHP * 0.746 / $\eta_{motor}$ x HOURS x ESF

Summer Coincident Peak kW Savings = Annual kWh Savings / HOURS * CF

**Deemed Lifetime of Efficient Equipment**
The expected measure life is assumed to be 15 years[658].

**Deemed Measure Cost**
The incremental capital costs for this measure should be determined on a case-by-case basis. For analysis purposes, assume the incremental costs specified below:

| Compressor Type | Incremental Cost[659] |
|---|---|
| Load/No Load | $200/hp |
| Variable Displacement | $250/hp |
| Variable Frequency Drive | $300/hp |

**Deemed O&M Cost Adjustments**
n/a

**Coincidence Factor**
The summer peak coincidence factor for this measure is assumed to be 38%[660].

[657] For analysis purposes, it is assumed that the compressed air system with load / no load controls utilizes an air receiver with a storage capacity of 5 gallons per cubic foot per minute of compressor capacity.
[658] Based on a review of TRM assumptions from Vermont, New Hampshire, Massachusetts, and Wisconsin. Estimates range from 10 to 15 years.
[659] Incremental cost estimates have been maintained from the "Technical Reference Manual (TRM) for Ohio Senate Bill 221 Energy Efficiency and Conservation Program and 09-512-GE-UNC", October 15, 2009, and appear reasonable. However, future study of these estimates is recommended as published estimates of incremental costs for efficient air compressors are scarce.
[660] Summer Peak Coincidence Factor has been preserved from the "Technical Reference Manual (TRM) for Ohio Senate Bill 221 Energy Efficiency and Conservation Program and 09-512-GE-UNC", October 15, 2009. This is likely a conservative estimate, but is recommended for further study.

## REFERENCE SECTION

**Calculation of Savings**

**Energy Savings**

$\Delta kWh = BHP * 0.746 / \eta_{motor} \times HOURS \times ESF$

Where:

BHP = compressor motor full load brake horse-power
= Actual installed

0.746 = conversion factor from horse-power to kW (kW/hp)

$\eta_{motor}$ = compressor motor nameplate efficiency
= Actual installed (if actual efficiency in unknown, assume 90%[661])

HOURS = compressor total hours of operation
= Actual installed

ESF = Energy Savings Factor; dependent on compressor control type as below:

| Control Type | Energy Savings Factor (ESF)[662] |
|---|---|
| Load/No Load | 10% |
| Variable Displacement | 17% |
| Variable Frequency Drive | 26% |

**Summer Coincident Peak Demand Savings**

$\Delta kW = \Delta kWh / HOURS * CF$

Where:

CF = Summer Peak Coincidence Factor for measure
= 0.38 [663]

**Fossil Fuel Impact Descriptions and Calculation**
n/a

**Water Impact Descriptions and Calculation**
n/a

**Deemed O&M Cost Adjustment Calculation**
n/a

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**Referenced Documents:** "BHP Weighted Compressed Air Load Profiles – OH TRM.xls"

[661] Improving Compressed Air System Performance: A Sourcebook for Industry, U.S. Department of Energy, November 2003.
[662] Energy Savings Factors were developed using U.S. Department of Energy part load data for different compressor control types as well as load profiles from 50 facilities employing air compressors. See "BHP Weighted Compressed Air Load Profiles – OH TRM.xls" for source data and calculations.
[663] Summer Peak Coincidence Factor has been preserved from the "Technical Reference Manual (TRM) for Ohio Senate Bill 221 Energy Efficiency and Conservation Program and 09-512-GE-UNC", October 15, 2009. This is likely a conservative estimate, but is recommended for further study.

# Vending Machine Occupancy Sensors (Time of Sale, New Construction, Retrofit – New Equipment)

**Official Measure Code** (Measure Number: X-X-X-X (Program name, End Use)

**Description**
This measure relates to the installation of new controls on refrigerated beverage vending machines, non-refrigerated snack vending machines, and glass front refrigerated coolers. Controls can significantly reduce the energy consumption of vending machine and refrigeration systems. Qualifying controls must power down these systems during periods of inactivity but, in the case of refrigerated machines, must always maintain a cool product that meets customer expectations. This measure relates to the installation of a new control on a new or existing unit. This measure should not be applied to ENERGY STAR qualified vending machines, as they already have built-in controls.

**Definition of Efficient Equipment**
In order for this characterization to apply, the efficient equipment is assumed to be a standard efficiency refrigerated beverage vending machine, non-refrigerated snack vending machine, or glass front refrigerated cooler with a control system capable of powering down lighting and refrigeration systems during periods of inactivity.

**Definition of Baseline Equipment**
In order for this characterization to apply, the baseline equipment is assumed to be a standard efficiency refrigerated beverage vending machine, non-refrigerated snack vending machine, or glass front refrigerated cooler without a control system capable of powering down lighting and refrigeration systems during periods of inactivity.

**Deemed Calculation for this Measure**

Annual kWh Savings = 8760 x WATTSbase / 1000 x ESF

Summer Coincident Peak kW Savings = 0

**Deemed Lifetime of Efficient Equipment**
The expected measure life is assumed to be 5 years [664].

**Deemed Measure Cost**
The actual measure installation cost should be used (including material and labor), but the following can be assumed for analysis purposes[665]:

Refrigerated Vending Machine: $215.50
Non-Refrigerated Vending Machine: $108.00

**Deemed O&M Cost Adjustments**
n/a

**Coincidence Factor**
The summer peak coincidence factor for this measure is assumed to be 0[666].

[664] Measure Life Study, prepared for the Massachusetts Joint Utilities, Energy & Resource Solutions, November 2005.
[665] 2005 Database for Energy-Efficiency Resources (DEER), Version 2005.21. "Cost Data for Supporting Documents."
[666] Assumed that the peak period is coincident with periods of high traffic diminishing the demand reduction potential of occupancy based controls.

## REFERENCE SECTION

**Calculation of Savings**

**Energy Savings**

ΔkWh = WATTSbase / 1000 * HOURS * ESF

Where:

WATTSbase = connected kW of the controlled equipment; see table below for default values by connected equipment type:

| Equipment Type | WATTSbase[667] |
|---|---|
| Refrigerated Beverage Vending Machines | 400 |
| Non-Refrigerated Snack Vending Machines | 85 |
| Glass Front Refrigerated Coolers | 460 |

1000 = conversion factor (W/kW)

HOURS = operating hours of the connected equipment; assumed that the equipment operates 24 hours per day, 365 days per year
= 8760

ESF = Energy Savings Factor; represents the percent reduction in annual kWh consumption of the equipment controlled; see table below for default values:

| Equipment Type | Energy Savings Factor (ESF)[668] |
|---|---|
| Refrigerated Beverage Vending Machines | 46% |
| Non-Refrigerated Snack Vending Machines | 46% |
| Glass Front Refrigerated Coolers | 30% |

**Summer Coincident Peak Demand Savings**

ΔkW[669] = 0

**Fossil Fuel Impact Descriptions and Calculation**
n/a

**Water Impact Descriptions and Calculation**
n/a

**Deemed O&M Cost Adjustment Calculation**
n/a

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[667] USA Technologies Energy Management Product Sheets, July 2006; cited September 2009. <http://http://www.usatech.com/energy_management/energy_productsheets.php>
[668] Ibid.
[669] Assumed that the peak period is coincident with periods of high traffic diminishing the demand reduction potential of occupancy based controls.

# Heat Pump Water Heaters (New Construction, Retrofit)

**Official Measure Code (Measure Number: X-X-X-X (Program name, End Use)**

**Description**
This measure relates to the installation of a heat pump water heater (HPWH) in place of a standard electric water heater. HPWHs can be added to existing domestic hot water (DHW) systems to improve the overall efficiency. HPWHs utilize refrigerants (like an air source heat pump) and have much higher coefficients of performance (COP) than standard electric water heaters. HPWHs remove waste heat from surrounding air sources and preheat the DHW supply system. HPWHs come in a variety of sizes and the size of HPWH will depend on the desired temperature output and amount of hot water needed by application. The savings from water heater heat pumps will depend on the design, size (capacity), water heating requirements, building application and climate. This measure could relate to either a retrofit or a new installation.

**Definition of Efficient Equipment**
In order for this characterization to apply, the efficient equipment is assumed to be a heat pump water heater with or without an auxiliary water heating system.

**Definition of Baseline Equipment**
In order for this characterization to apply, the baseline equipment is assumed to be a standard electric storage tank-type water heater with a thermal efficiency of 98%. This measure does not apply to natural gas-fired water heaters.

**Deemed Calculation for this Measure**

Annual kWh Savings $= (GPD * 365 * 8.33 * \Delta T_s\ ) / (3413\ ) * [(1/E_{t,base}) - (1/COP)]$

Summer Peak Coincident kW Savings $= (GPH * 8.33 * \Delta T_s\ ) / (3413) * [(1/E_{t,base}) - (1/COP)] * CF$

**Deemed Lifetime of Efficient Equipment**
The expected measure life is assumed to be 10 years[670].

**Deemed Measure Cost**
Due to the complexity of heat pump water heater systems, incremental capital costs should be determined on a case-by-case basis. High capacity heat pump water heaters will typically have a supplemental heating source such as an electric resistance heater. For new construction applications, the incremental capital cost for this measure should be calculated as the difference in installed cost of the entire heat pump water heater system including any auxiliary heating systems and a standard electric storage tank water heater of comparable capacity. For retrofit applications, the total installed cost of heat pump water heater should be used.

**Deemed O&M Cost Adjustments**
n/a

**Coincidence Factor**
The summer peak coincidence factor for this measure is assumed to be 6%[671].

[670] Estimates of measure life from utilities in the Northeast and the U.S. Department of Energy vary from 10 to 15 years. Assume 10 years as a conservative estimate.
http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf
[671] "Technical Reference Manual (TRM) for Ohio Senate Bill 221 Energy Efficiency and Conservation Program and 09-512-GE-UNC", October 15, 2009. Based on Ohio utility supply profiles.

## REFERENCE SECTION

**Calculation of Savings**

**Energy Savings**

$\Delta kWH = (GPD * 365 * 8.33 * \Delta T_s) / (3413) * [(1/E_{t,base}) - (1/COP)]$

Where:

GDP = average daily water consumption (gallons/day); determined from site-specific data.
365 = conversion factor (days/year)
8.33 = conversion factor (Btu/gallon-°F)
$\Delta T_s$ = average temperature difference between the supply cold water temperature and the hot water delivery temperature (°F); determined from site-specific data.
3413 = conversion factor (Btu/kWh)
$E_{t,base}$ = baseline water heater thermal efficiency; characterization assumes a value of 98%.
COP = Coefficient of Performance of the heat pump water heater system, including any auxiliary water heating systems.
= Actual installed

**Summer Coincident Peak Demand Savings**

$\Delta kW = (GPH * 8.33 * \Delta T_s) / (3413) * [(1/E_{t,base}) - (1/COP)] * CF$

Where:

GPH = hourly water consumption (gallons/day); determined from site-specific data.
CF = Summer Peak Coincidence Factor for measure
= 0.06[672]

**Fossil Fuel Impact Descriptions and Calculation**
n/a[673]

**Water Impact Descriptions and Calculation**
n/a

**Deemed O&M Cost Adjustment Calculation**
n/a

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[672] "Technical Reference Manual (TRM) for Ohio Senate Bill 221 Energy Efficiency and Conservation Program and 09-512-GE-UNC", October 15, 2009. Based on Ohio utility supply profiles.
[673] The interactive effects between space heating and cooling requirements and heat pump water heaters have been neglected for this characterization but are candidates for future study. Heat pumps remove waste heat from surrounding air sources which can reduce cooling loads and increase heating loads if the heat pump water heater is located within a conditioned space.

# Commercial Clothes Washer (Time of Sale)

**Official Measure Code (Measure Number: X-X-X-X (Program name, End Use)**

**Description**
High-efficiency commercial washers are intended for purchase and installation in laundromats, multi-family buildings and institutions. These high-efficiency washers are nearly identical to residential models available in retail outlets, with minor engineering changes, such as the addition of a coin box. High-efficiency commercial washers typically save up to 50 percent of energy costs and use about 30 percent less water.

**Definition of Efficient Equipment**
The efficient equipment is defined as a commercial-grade clothes washer meeting the minimum efficiency standards for ENERGY STAR (MEF ≥1.8)[674]. Also, for this characterization to apply the facility where the equipment is installed must have an electric water heater.

**Definition of Baseline Equipment**
The baseline equipment for this measure is a commercial grade clothes washer that meets federal manufacturing standards (MEF ≥ 1.26).

**Deemed Calculations for this Measure**

Annual kWh Savings = $\Delta kWh_{Load}$ x 950

Summer Coincident Peak kW Savings = n/a

**Deemed Lifetime of Efficient Equipment**
The effective measure life for commercial-grade clothes washers is 10 years[675]

**Deemed Measure Cost**
$347 per unit ENERGY STAR/CEE Tier1, $475 per unit CEE Tier 2, $604 per unit CEE Tier 3[676]

**Deemed O&M Cost Adjustments**
n/a

**Coincidence Factor**
n/a

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**REFERENCE SECTION**

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**Calculation of Savings**

**Energy Savings**

$$\Delta kWh = \Delta kWh_{Load} \times Loads_{Year}$$

Where:

$\Delta kWh_{Load}$ = The difference in electricity consumption per load of laundry between baseline equipment and efficient equipment
= Dependent on energy source for washer[677]:

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[674] Beginning in 2011 the criteria will be raised to MEF > 2.0
[675] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values",
[676] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Cost Values and Summary Documentation",