

Illinois Statewide Technical Reference Manual for Energy Efficiency Version 5.0

Volume 2: Commercial and Industrial Measures

**Final
February 11th, 2016**

**Effective:
June 1st, 2016**

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TABLE OF CONTENTS

VOLUME 1: OVERVIEW AND USER GUIDE

VOLUME 2: COMMERCIAL AND INDUSTRIAL MEASURES7

4.1 Agricultural End Use 7

4.1.1 Engine Block Timer for Agricultural Equipment7

4.1.2 High Volume Low Speed Fans.....9

4.1.3 High Speed Fans11

4.1.4 Live Stock Waterer.....13

4.2 Food Service Equipment End Use..... 15

4.2.1 Combination Oven.....15

4.2.2 Commercial Solid and Glass Door Refrigerators & Freezers.....22

4.2.3 Commercial Steam Cooker25

4.2.4 Conveyor Oven33

4.2.5 ENERGY STAR Convection Oven35

4.2.6 ENERGY STAR Dishwasher38

4.2.7 ENERGY STAR Fryer.....48

4.2.8 ENERGY STAR Griddle51

4.2.9 ENERGY STAR Hot Food Holding Cabinets.....56

4.2.10 ENERGY STAR Ice Maker59

4.2.11 High Efficiency Pre-Rinse Spray Valve.....62

4.2.12 Infrared Charbroiler66

4.2.13 Infrared Rotisserie Oven68

4.2.14 Infrared Salamander Broiler70

4.2.15 Infrared Upright Broiler72

4.2.16 Kitchen Demand Ventilation Controls74

4.2.17 Pasta Cooker77

4.2.18 Rack Oven - Double Oven79

4.2.19 ENERGY STAR Electric Convection Oven81

4.3 Hot Water..... 86

4.3.1 Storage Water Heater.....86

4.3.2 Low Flow Faucet Aerators93

4.3.3 Low Flow Showerheads101

4.3.4 Commercial Pool Covers.....106

4.3.5 Tankless Water Heater109

4.3.6	Ozone Laundry.....	115
4.3.7	Multifamily Central Domestic Hot Water Plants.....	121
4.3.8	Controls for Central Domestic Hot Water.....	125
4.3.9	Heat Recovery Grease Trap Filter.....	127
4.4	HVAC End Use.....	131
4.4.1	Air Conditioner Tune-up.....	135
4.4.2	Space Heating Boiler Tune-up.....	138
4.4.3	Process Boiler Tune-up.....	141
4.4.4	Boiler Lockout/Reset Controls.....	144
4.4.5	Condensing Unit Heaters.....	146
4.4.6	Electric Chiller.....	148
4.4.7	ENERGY STAR and CEE Tier 1 Room Air Conditioner.....	154
4.4.8	Guest Room Energy Management (PTAC & PTHP).....	158
4.4.9	Heat Pump Systems.....	168
4.4.10	High Efficiency Boiler.....	176
4.4.11	High Efficiency Furnace.....	180
4.4.12	Infrared Heaters (all sizes), Low Intensity.....	186
4.4.13	Package Terminal Air Conditioner (PTAC) and Package Terminal Heat Pump (PTHP).....	188
4.4.14	Pipe Insulation.....	193
4.4.15	Single-Package and Split System Unitary Air Conditioners.....	213
4.4.16	Steam Trap Replacement or Repair.....	220
4.4.17	Variable Speed Drives for HVAC Pumps and Cooling Tower Fans.....	225
4.4.18	Small Commercial Programmable Thermostats.....	229
4.4.19	Demand Controlled Ventilation.....	235
4.4.20	High Turndown Burner for Space Heating Boilers.....	240
4.4.21	Linkageless Boiler Controls for Space Heating.....	243
4.4.22	Oxygen Trim Controls for Space Heating Boilers.....	245
4.4.23	Shut Off Damper for Space Heating Boilers or Furnaces.....	247
4.4.24	Small Pipe Insulation.....	249
4.4.25	Small Commercial Programmable Thermostat Adjustments.....	256
4.4.26	Variable Speed Drives for HVAC Supply and Return Fans.....	264
4.4.27	Energy Recovery Ventilator.....	271
4.4.28	Stack Economizer for Boilers Serving HVAC Loads.....	275
4.4.29	Stack Economizer for Boilers Serving Process Loads.....	278
4.4.30	Notched V Belts for HVAC Systems.....	281

4.4.31	Small Business Furnace Tune-Up	289
4.4.32	Combined Heat and Power	292
4.4.33	Industrial Air Curtain.....	300
4.4.34	Destratification Fan	311
4.4.35	Economizer Repair and Optimization	319
4.4.36	Multi-Family Space Heating Steam Boiler Averaging Controls	328
4.4.37	Unitary HVAC Condensing Furnace.....	330
4.5	Lighting End Use	340
4.5.1	Commercial ENERGY STAR Compact Fluorescent Lamp (CFL)	342
4.5.2	Fluorescent Delamping	349
4.5.3	High Performance and Reduced Wattage T8 Fixtures and Lamps	354
4.5.4	LED Bulbs and Fixtures.....	369
4.5.5	Commercial LED Exit Signs.....	384
4.5.6	LED Traffic and Pedestrian Signals.....	388
4.5.7	Lighting Power Density	392
4.5.8	Miscellaneous Commercial/Industrial Lighting	404
4.5.9	Multi-Level Lighting Switch.....	408
4.5.10	Occupancy Sensor Lighting Controls.....	411
4.5.11	Solar Light Tubes	415
4.5.12	T5 Fixtures and Lamps	418
4.5.13	Occupancy Controlled Bi-Level Lighting Fixtures	428
4.5.14	Commercial ENERGY STAR Specialty Compact Fluorescent Lamp (CFL).....	432
4.6	Refrigeration End Use	440
4.6.1	Automatic Door Closer for Walk-In Coolers and Freezers	440
4.6.2	Beverage and Snack Machine Controls	442
4.6.3	Door Heater Controls for Cooler or Freezer	445
4.6.4	Electronically Commutated Motors (ECM) for Walk-in and Reach-in Coolers / Freezers	448
4.6.5	ENERGY STAR Refrigerated Beverage Vending Machine	452
4.6.6	Evaporator Fan Control	454
4.6.7	Strip Curtain for Walk-in Coolers and Freezers	456
4.6.8	Refrigeration Economizers	458
4.6.9	Night Covers for Open Refrigerated Display Cases.....	462
4.7	Compressed Air	465
4.7.1	VSD Air Compressor.....	465

4.7.2	Compressed Air Low Pressure Drop Filters	468
4.7.3	Compressed Air No-Loss Condensate Drains.....	471
4.7.4	Efficient Compressed Air Nozzles	473
4.7.5	Efficient Refrigerated Compressed Air Dryer	476
4.8	Miscellaneous End Use	479
4.8.1	Pump Optimization.....	479
4.8.2	Roof Insulation for C&I Facilities	482
4.8.3	Computer Power Management Software	489
4.8.4	Modulating Commercial Gas Clothes Dryer	491
VOLUME 3: RESIDENTIAL MEASURES		
VOLUME 4: CROSS-CUTTING MEASURES AND ATTACHMENTS		
ATTACHMENT A: ILLINOIS STATEWIDE NET-TO-GROSS METHODOLOGIES		

Volume 2: Commercial and Industrial Measures

4.1 Agricultural End Use

4.1.1 Engine Block Timer for Agricultural Equipment

DESCRIPTION

The measure is a plug-in timer that is activated below a specific outdoor temperature to control an engine block heater in agricultural equipment. Engine block heaters are typically used during cold weather to pre-warm an engine prior to start, for convenience heaters are typically plugged in considerably longer than necessary to improve startup performance. A timer allows a user to preset the heater to come on for only the amount of time necessary to pre-warm the engine block, reducing unnecessary run time even if the baseline equipment has an engine block temperature sensor.

This measure was developed to be applicable to the following program types: RF. If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

The efficient measure is an engine block heater operated by an outdoor plug-in timer (15 amp or greater) that turns on the heater only when the outdoor temperature is below 25 °F.

DEFINITION OF BASELINE EQUIPMENT

The baseline scenario is an engine block heater that is manually plugged in by the farmer to facilitate equipment startup at a later time.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 3 years¹

DEEMED MEASURE COST

The incremental cost per installed plug-in timer is \$10.19².

COINCIDENCE FACTOR

Engine block timers only operate in the winter so the summer peak demand savings is zero.

¹Equipment life is expected to be longer, but measure life is more conservative to account for possible attrition in use over time.

²Based on bulk pricing reported by EnSave, which administers the rebate in Vermont

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\begin{aligned}\Delta\text{kWh} &= \text{ISR} * \text{Use Season} * \% \text{Days} * \text{HrSave/Day} * \text{kW}_{\text{heater}} - \text{ParaLd} \\ &= 78.39\% * 87 \text{ days} * 84.23\% * 7.765 \text{ Hr/Day} * 1.5 \text{ kW} - 5.46 \text{ kWh} \\ &= 664 \text{ kWh}\end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-APL-ESDH-V01-120601

4.1.2 High Volume Low Speed Fans

DESCRIPTION

The measure applies to 20-24 foot diameter horizontally mounted ceiling high volume low speed (HVLS) fans that are replacing multiple non HVLS fans that have reached the end of useful life in agricultural applications.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to be classified as HVLS and have a VFD³.

DEFINITION OF BASELINE EQUIPMENT

In order for this characterization to apply, the baseline condition is assumed to be multiple non HVLS existing fans that have reached the end of s useful life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 10 years⁴.

DEEMED MEASURE COST

The incremental capital cost for the fans are as follows⁵:

Fan Diameter Size (feet)	Incremental Cost
20	\$4150
22	\$4180
24	\$4225

LOADSHAPE

Loadshape C34 - Industrial Motor

COINCIDENCE FACTOR

The measure has deemed kW savings therefor a coincidence factor is not applied.

³ Act on Energy Commercial Technical Reference Manual No. 2010-4

⁴ Ibid.

⁵ Ibid.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS⁶

The annual electric savings from this measure are deemed values depending on fan size and apply to all building types:

Fan Diameter Size (feet)	kWh Savings
20	6577
22	8543
24	10018

SUMMER COINCIDENT PEAK DEMAND SAVINGS⁷

The annual kW savings from this measure are deemed values depending on fan size and apply to all building types:

Fan Diameter Size (feet)	kW Savings
20	2.4
22	3.1
24	3.7

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-AGE-HVSF-V01-120601

⁶ Ibid.

⁷ Ibid.

4.1.3 High Speed Fans

DESCRIPTION

The measure applies to high speed exhaust, ventilation and circulation fans that are replacing an existing unit that reached the end of its useful life in agricultural applications.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to be diffuser equipped and meet the following criteria⁸.

Diameter of Fan (inches)	Minimum Efficiency for Exhaust & Ventilation Fans	Minimum Efficiency for Circulation Fans
24 through 35	14.0 cfm/W at 0.10 static pressure	12.5 lbf/kW
36 through 47	17.1 cfm/W at 0.10 static pressure	18.2 lbf/kW
48 through 71	20.3 cfm/W at 0.10 static pressure	23.0 lbf/kW

DEFINITION OF BASELINE EQUIPMENT

In order for this characterization to apply, the baseline condition is assumed to be an existing fan that reached the end of its useful life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 7 years⁹.

DEEMED MEASURE COST

The incremental capital cost for all fan sizes is \$150¹⁰.

LOADSHAPE

Loadshape C34 - Industrial Motor

COINCIDENCE FACTOR

The measure has deemed kW savings therefor a coincidence factor is not applied.

⁸ Act on Energy Commercial Technical Reference Manual No. 2010-4

⁹ Ibid.

¹⁰ Ibid.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS ¹¹

The annual electric savings from this measure are deemed values depending on fan size and apply to all building types:

Diameter of Fan (inches)	kWh
24 through 35	372
36 through 47	625
48 through 71	1122

SUMMER COINCIDENT PEAK DEMAND SAVINGS¹²

The annual kW savings from this measure are deemed values depending on fan size and apply to all building types:

Diameter of Fan (inches)	kW
24 through 35	0.118
36 through 47	0.198
48 through 71	0.356

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-AGE-HSF_-V01-120601

¹¹ Ibid.

¹² Ibid.

4.1.4 Live Stock Waterer

DESCRIPTION

This measure applies to the replacement of electric open waterers with sinking or floating water heaters with equivalent herd size watering capacity of the old unit.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to an electrically heated thermally insulated waterer with minimum 2 inches of insulation. A thermostat is required on unit with heating element greater than or equal to 250 watts¹³.

DEFINITION OF BASELINE EQUIPMENT

In order for this characterization to apply, the baseline equipment is assumed to be an electric open waterer with sinking or floating water heaters that have reached the end of useful life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 10 years¹⁴.

DEEMED MEASURE COST

The incremental capital cost for the waters are \$787.50:¹⁵

LOADSHAPE

Loadshape C04 - Non-Residential Electric Heating

COINCIDENCE FACTOR

The measure has deemed kW savings therefor a coincidence factor is not applied

¹³ Act on Energy Commercial Technical Reference Manual No. 2010-4

¹⁴ Ibid.

¹⁵ Ibid.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS ¹⁶

The annual electric savings from this measure is a deemed value and assumed to be 1592.85 kWh.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

The annual kW savings from this measure is a deemed value and assumed to be 0.525 kW. ¹⁷

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-AGE-LSW1-V01-120601

¹⁶ Ibid.

¹⁷ Ibid.

4.2 Food Service Equipment End Use

4.2.1 Combination Oven

DESCRIPTION

This measure applies to both natural gas fired and electric high efficiency combination convection and steam ovens installed in a commercial kitchen.

This measure was developed to be applicable to the following program types: TOS, RF. If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure, the installed equipment must be a new natural gas or electric combination oven meeting the ENERGY STAR idle rate and cooking efficiency requirements as specified below.¹⁸

ENERGY STAR Requirements (Version 2.1, Effective January 1, 2014)

Fuel Type	Operation	Idle Rate (Btu/h for Gas, kW for Electric)	Cooking-Energy Efficiency, (%)
Natural Gas	Steam Mode	$\leq 200P+6,511$	≥ 41
	Convection Mode	$\leq 150P+5,425$	≥ 56
Electric	Steam Mode	$\leq 0.133P+0.6400$	≥ 55
	Convection Mode	$\leq 0.080P+0.4989$	≥ 76

Note: P = Pan capacity as defined in Section 1.S, of the Commercial Ovens Program Requirements Version 2.1¹⁹

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is a natural gas or electric combination oven that is not ENERGY STAR certified.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years.²⁰

DEEMED MEASURE COST

The costs vary based on the efficiency and make of the equipment. Actual costs should be used.

LOADSHAPE

Loadshape C01 - Commercial Electric Cooking

COINCIDENCE FACTOR

Summer Peak Coincidence Factor for measure is provided below for different building type²¹:

¹⁸ ENERGY STAR Commercial Ovens Key Product Criteria

http://www.energystar.gov/index.cfm?c=ovens.pr_crit_comm_ovens

¹⁹ Pan capacity is defined as the number of steam table pans the combination oven is able to accommodate as per the ASTM F-1495-05 standard specification.

<http://www.energystar.gov/products/specs/system/files/Commercial%20Ovens%20Program%20Requirements%20V2%201.pdf?965d-c5ec&3b06-d2f5>

²⁰ <http://www.fishnick.com/saveenergy/tools/calculators/gcombcalc.php>

²¹ Values taken from Minnesota Technical Reference Manual, 'Electric Oven and Range' measure and is based upon "Project on

Location	CF
Fast Food Limited Menu	0.32
Fast Food Expanded Menu	0.41
Pizza	0.46
Full Service Limited Menu	0.51
Full Service Expanded Menu	0.36
Cafeteria	0.36

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

The algorithm below applies to electric combination ovens only.²²

$$\Delta kWh = (\Delta CookingEnergy_{ConvElec} + \Delta CookingEnergy_{SteamElec} + \Delta IdleEnergy_{ConvElec} + \Delta IdleEnergy_{SteamElec}) * Days / 1,000$$

Where:

$\Delta CookingEnergy_{ConvElec}$ = Change in total daily cooking energy consumed by electric oven in convection mode

$$= LB_{Elec} * (E_{FOOD_{ConvElec}} / ElecEFF_{ConvBase} - E_{FOOD_{ConvElec}} / ElecEFF_{ConvEE}) * \%Conv$$

$\Delta CookingEnergy_{SteamElec}$ = Change in total daily cooking energy consumed by electric oven in steam mode

$$= LB_{Elec} * (E_{FOOD_{SteamElec}} / ElecEFF_{SteamBase} - E_{FOOD_{SteamElec}} / ElecEFF_{SteamEE}) * \%Steam$$

$\Delta IdleEnergy_{ConvElec}$ = Change in total daily idle energy consumed by electric oven in convection mode

$$= [(ElecIDLE_{ConvBase} * ((HOURS - LB_{Elec}/ElecPC_{ConvBase}) * \%Conv)) - (ElecIDLE_{ConvEE} * ((HOURS - LB_{Elec}/ElecPC_{ConvEE}) * \%Conv))]$$

$\Delta IdleEnergy_{SteamElec}$ = Change in total daily idle energy consumed by electric oven in convection mode

$$= [(ElecIDLE_{SteamBase} * ((HOURS - LB_{Elec}/ElecPC_{SteamBase}) * \%Steam)) - (ElecIDLE_{SteamEE} * ((HOURS - LB_{Elec}/ElecPC_{SteamEE}) * \%Steam))]$$

Where:

LB_{Elec} = Estimated mass of food cooked per day for electric oven (lbs/day)

= Custom, or if unknown, use 200 lbs (If P <15) or 250 lbs (If P >= 15)

$E_{FOOD_{ConvElec}}$ = Energy absorbed by food product for electric oven in convection mode

Restaurant Energy Performance-End-Use Monitoring and Analysis”, Appendixes I and II, Claar, et. al., May 1985

²² Algorithms and assumptions derived from ENERGY STAR Commercial Kitchen Equipment Savings Calculator https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx

= Custom or if unknown, use 73.2 Wh/lb

ElecEFF = Cooking energy efficiency of electric oven

= Custom or if unknown, use values from table below

	Base	EE
ElecEFF_{Conv}	72%	76%
ElecEFF_{Steam}	49%	55%

%Conv = Percentage of time in convection mode

= Custom or if unknown, use 50%

EFOOD_{SteamElec} = Energy absorbed by food product for electric oven in steam mode

= Custom or if unknown, use 30.8 Wh/lb

%steam = Percentage of time in steam mode

= 1 - %conv

ElecIDLE_{Base} = Idle energy rate (W) of baseline electric oven

= Custom or if unknown, use values from table below

Pan Capacity	Convection Mode (ElecIDLE_{ConvBase})	Steam Mode (ElecIDLE_{SteamBase})
< 15	1,320	5,260
> = 15	2,280	8,710

HOURS = Average daily hours of operation

= Custom or if unknown, use 12 hours

ElecPC_{Base} = Production capacity (lbs/hr) of baseline electric oven

= Custom of if unknown, use values from table below

Pan Capacity	Convection Mode (ElecPC_{ConvBase})	Steam Mode (ElecPC_{SteamBase})
< 15	79	126
> = 15	166	295

ElecIDLE_{ConvEE} = Idle energy rate of ENERGY STAR electric oven in convection mode

= (0.08*P + 0.4989)*1000

ElecPCEE = Production capacity (lbs/hr) of ENERGY STAR electric oven

= Custom of if unknown, use values from table below

Pan Capacity	Convection Mode (ElecPC _{ConvEE})	Steam Mode (ElecPC _{SteamEE})
< 15	119	177
> = 15	201	349

ElecIDLE_{SteamEE} = Idle energy rate of ENERGY STAR electric oven in steam mode
 = (0.133* P+0.64)*1000

Days = Days of operation per year
 = Custom or if unknown, use 365 days per year

1,000 = Wh to kWh conversion factor

EXAMPLE

For example, a 10-pan capacity electric combination oven would save:

$$\Delta kWh = (\Delta CookingEnergy_{ConvElec} + \Delta CookingEnergy_{SteamElec} + \Delta IdleEnergy_{ConvElec} + \Delta IdleEnergy_{SteamElec}) * Days / 1,000$$

$$\Delta CookingEnergy_{ConvElec} = 200 * (73.2 / 0.72 - 73.2 / 0.76) * 0.50$$

$$= 535 \text{ Wh}$$

$$\Delta CookingEnergy_{SteamElec} = 200 * (30.8 / 0.49 - 30.8 / 0.55) * (1 - 0.50)$$

$$= 686 \text{ Wh}$$

$$\Delta IdleEnergy_{ConvElec} = [(1,320 * ((12 - 200/79) * 0.50)) - (1,299 * ((12 - 200/119) * 0.50))]$$

$$= -453 \text{ Wh}$$

$$\Delta IdleEnergy_{SteamElec} = [(5,260 * ((12 - 200/126) * (1 - 0.50))) - (1,970 * ((12 - 200/177) * (1 - 0.50)))]$$

$$= 16,678 \text{ Wh}$$

$$\Delta kWh = (535 + 686 + -453 + 16,678) * 365 / 1,000$$

$$= 6,368 \text{ kWh}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \Delta kWh / (\text{HOURS} * \text{DAYS}) * CF$$

Where:

CF = Summer peak coincidence factor is dependent on building type²³:

Location	CF
Fast Food Limited Menu	0.32
Fast Food Expanded Menu	0.41

²³Values taken from Minnesota Technical Reference Manual, ‘Electric Oven and Range’ measure and is based upon “Project on Restaurant Energy Performance-End-Use Monitoring and Analysis”, Appendixes I and II, Claar, et. al., May 1985

Pizza	0.46
Full Service Limited Menu	0.51
Full Service Expanded Menu	0.36
Cafeteria	0.36

All other variables as defined above.

EXAMPLE

For example, a 10-pan capacity electric combination oven in a Full Service Limited Menu restaurant would save:

$$\begin{aligned} \Delta kW &= \Delta kWh / (\text{HOURS} * \text{DAYS}) * CF \\ &= 6,368 / (12 * 365) * 0.51 \\ &= 0.74 \text{ kW} \end{aligned}$$

NATURAL GAS ENERGY SAVINGS

The algorithm below applies to natural gas combination ovens only.²⁴

$$\Delta \text{Therms} = (\Delta \text{CookingEnergy}_{\text{ConvGas}} + \Delta \text{CookingEnergy}_{\text{SteamGas}} + \Delta \text{IdleEnergy}_{\text{ConvGas}} + \Delta \text{IdleEnergy}_{\text{SteamGas}}) * \text{Days} / 100,000$$

Where:

$\Delta \text{CookingEnergy}_{\text{ConvGas}}$ = Change in total daily cooking energy consumed by gas oven in convection mode
 $= \text{LB}_{\text{Gas}} * (\text{EFOOD}_{\text{ConvGas}} / \text{GasEFF}_{\text{ConvBase}} - \text{EFOOD}_{\text{ConvGas}} / \text{GasEFF}_{\text{ConvEE}}) * \%_{\text{Conv}}$

$\Delta \text{CookingEnergy}_{\text{SteamGas}}$ = Change in total daily cooking energy consumed by gas oven in steam mode
 $= \text{LB}_{\text{Gas}} * (\text{EFOOD}_{\text{SteamGas}} / \text{GasEFF}_{\text{SteamBase}} - \text{EFOOD}_{\text{SteamGas}} / \text{GasEFF}_{\text{SteamEE}}) * \%_{\text{Steam}}$

$\Delta \text{IdleEnergy}_{\text{ConvGas}}$ = Change in total daily idle energy consumed by gas oven in convection mode
 $= [(\text{GasIDLE}_{\text{ConvBase}} * ((\text{HOURS} - \text{LB}_{\text{Gas}} / \text{GasPC}_{\text{ConvBase}}) * \%_{\text{Conv}})) - (\text{GasIDLE}_{\text{ConvEE}} * ((\text{HOURS} - \text{LB}_{\text{Gas}} / \text{GasPC}_{\text{ConvEE}}) * \%_{\text{Conv}}))]$

$\Delta \text{IdleEnergy}_{\text{SteamGas}}$ = Change in total daily idle energy consumed by gas oven in convection mode
 $= [(\text{GasIDLE}_{\text{SteamBase}} * ((\text{HOURS} - \text{LB}_{\text{Gas}} / \text{GasPC}_{\text{SteamBase}}) * \%_{\text{Steam}})) - (\text{GasIDLE}_{\text{SteamEE}} * ((\text{HOURS} - \text{LB}_{\text{Gas}} / \text{GasPC}_{\text{SteamEE}}) * \%_{\text{Steam}}))]$

Where:

LB_{Gas} = Estimated mass of food cooked per day for gas oven (lbs/day)

²⁴ Algorithms and assumptions derived from ENERGY STAR Commercial Kitchen Equipment Savings Calculator https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator.xlsx

= Custom, or if unknown, use 200 lbs (If P <15), 250 lbs (If 15 <= P 30), or 400 lbs (If P = >30)

EFOOD_{ConvGas} = Energy absorbed by food product for gas oven in convection mode

= Custom or if unknown, use 250 Btu/lb

GasEFF = Cooking energy efficiency of gas oven

= Custom or if unknown, use values from table below

	Base	EE
GasEFF _{Conv}	52%	56%
GasEFF _{Steam}	39%	41%

EFOOD_{SteamGas} = Energy absorbed by food product for gas oven in steam mode

= Custom or if unknown, use 105 Btu/lb

GasIDLE_{Base} = Idle energy rate (Btu/hr) of baseline gas oven

= Custom or if unknown, use values from table below

Pan Capacity	Convection Mode (GasIDLE _{ConvBase})	Steam Mode (GasIDLE _{SteamBase})
< 15	8,747	18,656
15-30	10,788	24,562
>30	13,000	43,300

GasPC_{Base} = Production capacity (lbs/hr) of baseline gas oven

= Custom of if unknown, use values from table below

Pan Capacity	Convection Mode (GasPC _{ConvBase})	Steam Mode (GasPC _{SteamBase})
< 15	125	195
15-30	176	211
>30	392	579

GasIDLE_{ConvEE} = Idle energy rate of ENERGY STAR gas oven in convection mode

= 150*P + 5,425

GasPC_{EE} = Production capacity (lbs/hr) of ENERGY STAR gas oven

= Custom of if unknown, use values from table below

Pan Capacity	Convection Mode (GasPC _{ConvEE})	Steam Mode (GasPC _{SteamEE})
< 15	124	172
15-30	210	277
>30	394	640

GasIDLE_{SteamEE} = Idle energy rate of ENERGY STAR gas oven in steam mode

$$= 200 * P + 6511$$

100,000

= Conversion factor from Btu to therms

All other variables as defined above.

EXAMPLE

For example, a 10-pan capacity gas combination oven would save:

$$\Delta\text{Therms} = (\Delta\text{CookingEnergy}_{\text{ConvGas}} + \Delta\text{CookingEnergy}_{\text{SteamGas}} + \Delta\text{IdleEnergy}_{\text{ConvGas}} + \Delta\text{IdleEnergy}_{\text{SteamGas}}) * \text{Days} / 100,000$$

$$\Delta\text{CookingEnergy}_{\text{ConvGas}} = 200 * (250 / 0.52 - 250 / 0.56) * 0.50$$

$$= 3,434 \text{ therms}$$

$$\Delta\text{CookingEnergy}_{\text{SteamGas}} = 200 * (105 / 0.39 - 105 / 0.41) * (1 - 0.50)$$

$$= 1,313 \text{ therms}$$

$$\Delta\text{IdleEnergy}_{\text{ConvGas}} = [(8,747 * ((12 - 200/125) * 0.50)) - (6,925 * ((12 - 200/124) * 0.50))]$$

$$= 9,519 \text{ therms}$$

$$\Delta\text{IdleEnergy}_{\text{SteamGas}} = [(18,658 * ((12 - 200/195) * (1 - 0.50))) - (8,511 * ((12 - 200/172) * (1 - 0.50)))]$$

$$= 56,251 \text{ therms}$$

$$\Delta\text{Therms} = (3,434 + 1,313 + 9,519 + 56,251) * 365 / 100,000$$

$$= 257 \text{ therms}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-CBOV-V02-160601

4.2.2 Commercial Solid and Glass Door Refrigerators & Freezers

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 was developed to be applicable to the following program types: TOS and NC. If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to be a new vertical solid or glass door refrigerator or freezer or vertical chest 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 an existing solid or glass door refrigerator or freezer meeting the minimum federal manufacturing standards as specified by the Energy Policy Act of 2005.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years²⁵.

DEEMED MEASURE COST

The incremental capital cost for this measure is provided below²⁶.

Type	Refrigerator incremental Cost, per unit	Freezer Incremental Cost, per unit
Solid or Glass Door		
0 < V < 15	\$143	\$142
15 ≤ V < 30	\$164	\$166
30 ≤ V < 50	\$164	\$166
V ≥ 50	\$249	\$407

LOADSHAPE

Loadshape C23 - Commercial Refrigeration

²⁵2008 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>

²⁶Estimates 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.

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is assumed to be 0.937.²⁷

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = (kWh_{base} - kWh_{ee}) * 365.25$$

Where:

kWh_{base}= 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	kWh _{base} ²⁸
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

kWh_{ee}²⁹ = 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	Freezer
	kWh _{ee}	kWh _{ee}
Refrigerator		
0 < V < 15	≤ 0.089V + 1.411	≤ 0.250V + 1.250
15 ≤ V < 30	≤ 0.037V + 2.200	≤ 0.400V – 1.000
30 ≤ V < 50	≤ 0.056V + 1.635	≤ 0.163V + 6.125
V ≥ 50	≤ 0.060V + 1.416	≤ 0.158V + 6.333
Glass Door		
0 < V < 15	≤ 0.118V + 1.382	≤ 0.607V + 0.893
15 ≤ V < 30	≤ 0.140V + 1.050	≤ 0.733V – 1.000
30 ≤ V < 50	≤ 0.088V + 2.625	≤ 0.250V + 13.500
V ≥ 50	≤ 0.110V + 1.500	≤ 0.450V + 3.500

V = the chilled or frozen compartment volume (ft³) (as defined in the Association of Home Appliance Manufacturers Standard HRF1–1979)

²⁷ The CF for Commercial Refrigeration was calculated based upon the Ameren provided eShapes

²⁸Energy Policy Act of 2005. Accessed on 7/7/10. <http://www.epa.gov/oust/fedlaws/publ_109-058.pdf>

²⁹ENERGY 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>

= Actual installed

365.25 = days per year

For example a solid door refrigerator with a volume of 15 would save

$$\begin{aligned} \Delta\text{kWh} &= (3.54 - 2.76) * 365.25 \\ &= 285 \text{ kWh} \end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta\text{kW} = \Delta\text{kWh} / \text{HOURS} * \text{CF}$$

Where:

HOURS = equipment is assumed to operate continuously, 24 hours per day, 365.25 days per year.

= 8766

CF = Summer Peak Coincidence Factor for measure

= 0.937

For example a solid door refrigerator with a volume of 15 would save

$$\begin{aligned} \Delta\text{kW} &= 285 / 8766 * .937 \\ &= 0.030 \text{ kW} \end{aligned}$$

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-CSDO-V01-120601

4.2.3 Commercial Steam Cooker

DESCRIPTION

To qualify for this measure the installed equipment must be an ENERGY STAR® steamer in place of a standard steamer in a commercial kitchen. Savings are presented dependent on the pan capacity and corresponding idle rate at heavy load cooking capacity and if the steamer is gas or electric.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be as follows:

Gas	Electric
ENERGY STAR® qualified with 38% minimum cooking energy efficiency at heavy load (potato) cooking capacity for gas steam cookers.	ENERGY STAR® qualified with 50% minimum cooking energy efficiency at heavy load (potato) cooking capacity for electric steam cookers.

DEFINITION OF BASELINE EQUIPMENT

The baseline condition is assumed to be a non-ENERGY STAR® commercial steamer at end of life. It is assumed that the efficient equipment and baseline equipment have the same number of pans.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years³⁰

DEEMED MEASURE COST

The incremental capital cost for this measure is \$998³¹ for a natural gas steam cooker or \$2490³² for an electric steam cooker.

LOADSHAPE

Loadshape C01 - Commercial Electric Cooking

COINCIDENCE FACTOR

Summer Peak Coincidence Factor for measure is provided below for different building type³³:

Location	CF
Fast Food Limited Menu	0.32
Fast Food Expanded Menu	0.41
Pizza	0.46
Full Service Limited Menu	0.51
Full Service Expanded Menu	0.36

³⁰California DEER 2008 which is also used by both the Food Service Technology Center and ENERGY STAR®.

³¹Source for incremental cost for efficient natural gas steamer is RSG Commercial Gas Steamer Workpaper, January 2012.

³²Source for efficient electric steamer incremental cost is \$2,490 per 2009 PG&E Workpaper - PGECOFST104.1 - Commercial Steam Cooker - Electric and Gas as reference by KEMA in the ComEd C & I TRM.

³³ Values taken from Minnesota Technical Reference Manual, ‘Electric Oven and Range’ measure and is based upon “Project on Restaurant Energy Performance-End-Use Monitoring and Analysis”, Appendixes I and II, Claar, et. al., May 1985. Unknown is an average of other location types

Location	CF
Cafeteria	0.36
Unknown	0.40

Algorithm

CALCULATION OF SAVINGS

Formulas below are applicable to both gas and electric steam cookers. Please use appropriate lookup values and identified flags.

ENERGY SAVINGS

$$\Delta\text{Savings} = (\Delta\text{Idle Energy} + \Delta\text{Preheat Energy} + \Delta\text{Cooking Energy}) * Z$$

For a gas cooker: $\Delta\text{Savings} = \Delta\text{Btu} * 1/100,000 * Z$

For an electric steam cooker: $\Delta\text{Savings} = \Delta\text{kWh} * Z$

Where:

Z = days/yr steamer operating (use 365.25 days/yr if heavy use restaurant and exact number unknown)

$$\Delta\text{Idle Energy} = (((1 - \text{CSM}\%_{\text{Baseline}}) * \text{IDLE}_{\text{BASE}} + \text{CSM}\%_{\text{Baseline}} * \text{PC}_{\text{BASE}} * E_{\text{FOOD}} / \text{EFF}_{\text{BASE}}) * (\text{HOURS}_{\text{Day}} - (F / \text{PC}_{\text{Base}}) - (\text{PRE}_{\text{number}} * 0.25))) - (((1 - \text{CSM}\%_{\text{ENERGYSTAR}}) * \text{IDLE}_{\text{ENERGYSTAR}} + \text{CSM}\%_{\text{ENERGYSTAR}} * \text{PC}_{\text{ENERGY}} * E_{\text{FOOD}} / \text{EFF}_{\text{ENERGYSTAR}}) * (\text{HOURS}_{\text{Day}} - (F / \text{PC}_{\text{ENERGY}}) - (\text{PRE}_{\text{number}} * 0.25))))$$

Where:

CSM%_{Baseline} = Baseline Steamer Time in Manual Steam Mode (% of time)
 = 90%³⁴

IDLE_{Base} = Idle Energy Rate of Base Steamer³⁵

Number of Pans	IDLE _{BASE} - Gas, Btu/hr	IDLE _{BASE} - Electric, kw
3	11,000	1.0
4	14,667	1.33
5	18,333	1.67
6	22,000	2.0

PC_{Base} = Production Capacity of Base Steamer³⁶

³⁴Food Service Technology Center 2011 Savings Calculator

³⁵Food Service Technology Center 2011 Savings Calculator

Number of Pans	PC _{BASE, gas} (lbs/hr)	PC _{BASE, electric} (lbs/hr)
3	65	70
4	87	93
5	108	117
6	130	140

E_{FOOD}= Amount of Energy Absorbed by the food during cooking known as ASTM Energy to Food (Btu/lb or kW/lb)

=105 Btu/lb³⁷ (gas steamers) or 0.0308⁸ (electric steamers)

EFF_{BASE} =Heavy Load Cooking Efficiency for Base Steamer

=15%³⁸ (gas steamers) or 26%⁹ (electric steamers)

HOURS_{day} = Average Daily Operation (hours)

Type of Food Service	Hours _{day} ³⁹
Fast Food, limited menu	4
Fast Food, expanded menu	5
Pizza	8
Full Service, limited menu	8
Full Service, expanded menu	7
Cafeteria	6
Unknown	6 ⁴⁰
Custom	Varies

F = Food cooked per day (lbs/day)

= custom or if unknown, use 100 lbs/day⁴¹

CSM_{%ENERGYSTAR} = ENERGY STAR Steamer's Time in Manual Steam Mode (% of time)⁴²

³⁶Production capacity per Food Service Technology Center 2011 Savings Calculator of 23.3333 lb/hr per pan for electric baseline steam cookers and 21.6667 lb/hr per pan for natural gas baseline steam cookers. ENERGY STAR[®] savings calculator uses 23.3 lb/hr per pan for both electric and natural gas baseline steamers.

³⁷Reference ENERGY STAR[®] savings calculator at http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COC.

³⁸Reference Food Service Technology Center 2011 Savings Calculator values as used by Consortium for Energy Efficiency, Inc. for baseline electric and natural gas steamer heavy cooking load energy efficiencies.

³⁹Values taken from Minnesota Technical Reference Manual, 'Electric Oven and Range' measure and is based upon "Project on Restaurant Energy Performance-End-Use Monitoring and Analysis", Appendixes I and II, Claar, et. al., May 1985.

⁴⁰Unknown is average of other locations

⁴¹Reference amount used by both Food Service Technology Center and ENERGY STAR[®] savings calculator

⁴²Reference information from the Food Service Technology Center citing that ENERGY STAR[®] steamers are not typically

= 0%

$IDLE_{ENERGYSTAR}$ = Idle Energy Rate of ENERGY STAR⁴³

Number of Pans	$IDLE_{ENERGY STAR} - \text{gas, (Btu/hr)}$	$IDLE_{ENERGY STAR} - \text{electric, (kW)}$
3	6250	0.40
4	8333	0.53
5	10417	0.67
6	12500	0.80

PC_{ENERGY} = Production Capacity of ENERGY STAR⁴⁴ Steamer

Number of Pans	$PC_{ENERGY} - \text{gas (lbs/hr)}$	$PC_{ENERGY} - \text{electric (lbs/hr)}$
3	55	50
4	73	67
5	92	83
6	110	100

$EFF_{ENERGYSTAR}$ = Heavy Load Cooking Efficiency for ENERGY STAR⁴⁵ Steamer(%)

=38%⁴⁵ (gas steamer) or 50%¹⁵ (electric steamer)

PRE_{number} = Number of preheats per day

=1⁴⁶ (if unknown, use 1)

$$\Delta \text{Preheat Energy} = (PRE_{number} * \Delta \text{Preheat})$$

Where:

PRE_{number} = Number of Preheats per Day

operated in constant steam mode, but rather are used in timed mode. Reference ENERGY STAR⁴³ savings calculator at http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COC for efficient steamer. Both baseline & efficient steamer mode values should be considered for users in Illinois market.

⁴³Food Service Technology Center 2011 Savings Calculator

⁴⁴Production capacity per Food Service Technology Center 2011 Savings Calculator of 18.3333 lb/hr per pan for gas ENERGY STAR⁴⁵ steam cookers and 16.6667 lb/hr per pan for electric ENERGY STAR⁴⁵ steam cookers. ENERGY STAR⁴⁵ savings calculator uses 16.7 lb/hr per pan for electric and 20 lb/hr for natural gas ENERGY STAR⁴⁵ steamers.

⁴⁵Reference Food Service Technology Center 2011 Savings Calculator values as used by Consortium for Energy Efficiency, Inc. for Tier 1A and Tier 1B qualified electric and natural gas steamer heavy cooking load energy efficiencies and http://www.energystar.gov/ia/partners/product_specs/program_reqs/Commercial_Steam_Cookers_Program_Requirements.pdf?7010-36eb

⁴⁶Reference ENERGY STAR⁴⁵ savings calculator at http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COC and Food

=1⁴⁷(if unknown, use 1)

PRE_{heat} = Preheat energy savings per preheat
 = 11,000 Btu/preheat⁴⁸ (gas steamer) or 0.5 kWh/preheat⁴⁹ (electric steamer)

$$\Delta\text{Cooking Energy} = ((1/ \text{EFF}_{\text{BASE}}) - (1/ \text{EFF}_{\text{ENERGY STAR}})) * F * E_{\text{FOOD}}$$

Where:

- EFF_{BASE} =Heavy Load Cooking Efficiency for Base Steamer
 =15%⁵⁰ (gas steamer) or 26%²⁸ (electric steamer)
- EFF_{ENERGY STAR} =Heavy Load Cooking Efficiency for ENERGY STAR® Steamer
 =38%⁵¹ (gas steamer) or 50%²³ (electric steamer)
- F = Food cooked per day (lbs/day)
 = custom or if unknown, use 100 lbs/day⁵²
- E_{FOOD} = Amount of Energy Absorbed by the food during cooking known as ASTM Energy to Food⁵³

E _{FOOD} - gas(Btu/lb)	E _{FOOD} (kWh/lb)
105 ⁵⁴	0.0308 ⁵⁵

⁴⁷Reference ENERGY STAR® savings calculator at

http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COC and Food

⁴⁸Ohio TRM which references 2002 Food Service Technology Center "Commercial Cooking Appliance Technology Assessment" Chapter 8: Steamers. This is time also used by ENERGY STAR® savings calculator at

http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COC. 11,000 Btu/preheat is from 72,000 Btu/hr * 15 min/hr /60 min/hr for gas steamers and 0.5 kWh/preheat is from 6 kW/preheat * 15 min/hr / 60 min/hr

⁴⁹Reference Food Service Technology Center 2011 Savings Calculator values for Baseline Preheat Energy.

⁵⁰Reference Food Service Technology Center 2011 Savings Calculator values as used by Consortium for Energy Efficiency, Inc. for baseline electric and natural gas steamer heavy cooking load energy efficiencies.

⁵¹Ibid.

⁵²Amount used by both Food Service Technology Center and ENERGY STAR® savings calculator

⁵³Reference ENERGY STAR® savings calculator at

http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COC.

⁵⁴Ibid.

⁵⁵Ibid.

EXAMPLE

For a gas steam cooker: A 3 pan steamer in a full service restaurant

$$\begin{aligned} \Delta\text{Savings} &= (\Delta\text{Idle Energy} + \Delta\text{Preheat Energy} + \Delta\text{Cooking Energy}) * Z * 1/100.000 \\ \Delta\text{Idle Energy} &= (((1-0.9) * 11000 + 0.9 * 65 * 105 / 0.15) * (7 - (100 / 65) - (1 * 0.25))) - (((1-0) * 6250 + 0 * 55 * 105 / 0.38) * (7 - (100 / 55) - (1 * 0.25))) \\ &= 188,321 \\ \Delta\text{Preheat Energy} &= (1 * 11,000) \\ &= 11,000 \\ \Delta\text{Cooking Energy} &= (((1/0.15) - (1/0.38)) * (100 \text{ lb/day} * 105 \text{ btu/lb})) \\ &= 42368 \\ \Delta\text{Therms} &= (188321 + 11000 + 42368) * 365.25 * 1/100,000 \\ &= 883 \text{ therms} \end{aligned}$$

For an electric steam cooker: A 3 pan steamer in a cafeteria:

$$\begin{aligned} \Delta\text{Savings} &= (\Delta\text{Idle Energy} + \Delta\text{Preheat Energy} + \Delta\text{Cooking Energy}) * Z \\ \Delta\text{Idle Energy} &= (((1-.9) * 1.0 + .9 * 70 * 0.0308 / 0.26) * (6 - (100 / 70) - (1 * .25))) - (((1-0) * 0.4 + 0 * 50 * 0.0308 / 0.50) * (6 - (100 / 50) - (1 * 0.25))) \\ &= 31.18 \\ \Delta\text{Preheat Energy} &= (1 * 0.5) \\ &= 0.5 \\ \Delta\text{Cooking Energy} &= (((1/0.26) - (1/0.5)) * (100 * 0.0308)) \\ &= 5.69 \\ \Delta\text{kWh} &= (31.18 + 0.5 + 5.69) * 365.25 \text{ days} \\ &= 13,649 \text{ kWh} \end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

This is only applicable to the electric steam cooker.

$$\Delta kW = (\Delta kWh / (\text{HOURS}_{\text{Day}} * \text{Days}_{\text{Year}})) * CF$$

Where:

CF = Summer Peak Coincidence Factor for measure is provided below for different locations⁵⁶:

Location	CF
Fast Food Limited Menu	0.32
Fast Food Expanded Menu	0.41
Pizza	0.46
Full Service Limited Menu	0.51
Full Service Expanded Menu	0.36
Cafeteria	0.36

Days_{Year} = Annual Days of Operation
 = custom or 365.25 days a year
 Other values as defined above

EXAMPLE

For 3 pan electric steam cooker located in a cafeteria:

$$\begin{aligned} \Delta kW &= (\Delta kWh / (\text{HOURS}_{\text{Day}} * \text{Days}_{\text{Year}})) * CF \\ &= (13,649 / (6 * 365.25)) * 0.36 \\ &= 2.24 \text{ kW} \end{aligned}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

This is applicable to both gas and electric steam cookers.

$$\Delta \text{Water} = (W_{\text{BASE}} - W_{\text{ENERGYSTAR}}) * \text{HOURS}_{\text{Day}} * \text{Days}_{\text{Year}}$$

Where

W_{BASE} = Water Consumption Rate of Base Steamer (gal/hr)
 = 40⁵⁷

W_{ENERGYSTAR} = Water Consumption Rate of ENERGY STAR® Steamer look up⁵⁸

⁵⁶Values taken from Minnesota Technical Reference Manual, ‘Electric Oven and Range’ measure and is based upon “Project on Restaurant Energy Performance-End-Use Monitoring and Analysis”, Appendixes I and II, Claar, et. al., May 1985.

⁵⁷FSTC (2002). Commercial Cooking Appliance Technology Assessment. Chapter 8: Steamers.

⁵⁸Source Consortium for Energy Efficiency, Inc. September 2010 "Program Design Guidance for Steamers" for Tier 1A and Tier 1B water requirements. Ohio Technical Reference Manual 2010 for 10 gal/hr water consumption which can be used when Tier level is not known.

CEE Tier	gal/hr
Tier 1A	15
Tier 1B	4
Avg Efficient	10
Avg Most Efficient	3

Days_{Year} =Annual Days of Operation
 =custom or 365.25 days a year⁵⁹

EXAMPLE

For example, an electric 3 pan steamer with average efficiency in a full service restaurant

$$\Delta\text{Water} = (40 - 10) * 7 * 365.25$$

$$= 76,703 \text{ gallons}$$

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-STMC-V04-160601

⁵⁹Source for 365.25 days/yr is ENERGY STAR® savings calculator which references Food Service Technology research on average use, 2009.

4.2.4 Conveyor Oven

DESCRIPTION

This measure applies to natural gas fired high efficiency conveyor ovens installed in commercial kitchens replacing existing natural gas units with conveyor width greater than 25 inches.

Conveyor ovens are available using four different heating processes: infrared, natural convection with a ceramic baking hearth, forced convection or air impingement, or a combination of infrared and forced convection. Conveyor ovens are typically used for producing a limited number of products with similar cooking requirements at high production rates. They are highly flexible and can be used to bake or roast a wide variety of products including pizza, casseroles, meats, breads, and pastries.

Some manufacturers offer an air-curtain feature at either end of the cooking chamber that helps to keep the heated air inside the conveyor oven. The air curtain operates as a virtual oven wall and helps reduce both the idle energy of the oven and the resultant heat gain to the kitchen.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a natural gas conveyor oven with a tested baking energy efficiency > 42% and an idle energy consumption rate < 57,000 Btu/hr utilizing ASTM standard F1817.

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is an existing pizza deck oven at end of life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 17 years.⁶⁰

DEEMED MEASURE COST

The incremental capital cost for this measure is \$1800⁶¹.

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

⁶⁰Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011

⁶¹Ibid.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

The annual natural gas energy savings from this measure is a deemed value equaling 733 Therms⁶².

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-CVOV-V01-120601

⁶²Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011. These deemed values should be compared to PY evaluation and revised as necessary

4.2.5 ENERGY STAR Convection Oven

DESCRIPTION

This measure applies to natural gas fired ENERGY STAR convection ovens installed in a commercial kitchen.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a natural gas convection oven with a cooking efficiency $\geq 44\%$ utilizing ASTM standard 1496 and an idle energy consumption rate $< 13,000$ Btu/hr

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is a natural gas convection oven that is not ENERGY STAR certified and is at end of life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years⁶³

DEEMED MEASURE COST

The incremental capital cost for this measure is \$50⁶⁴

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

Custom calculation below, otherwise use deemed value of 306 therms. ⁶⁵

⁶³ Lifetime from ENERGY STAR commercial griddle which cites reference as "FSTC research on available models, 2009"
http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

⁶⁴Measure cost from ENERGY STAR which cites reference as "EPA research on available models using AutoQuotes, 2010"
http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

⁶⁵ Algorithms and assumptions derived from ENERGY STAR Oven Commercial Kitchen Equipment Savings Calculator.
http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

$$\Delta\text{Therms} = (\Delta\text{DailyIdle Energy} + \Delta\text{DailyPreheat Energy} + \Delta\text{DailyCooking Energy}) * \text{Days} / 100000$$

Where:

$$\Delta\text{DailyIdleEnergy} = (\text{IdleBase} * \text{IdleBaseTime}) - (\text{IdleENERGYSTAR} * \text{IdleENERGYSTARTime})$$

$$\Delta\text{DailyPreheatEnergy} = (\text{PreHeatNumberBase} * \text{PreheatTimeBase} / 60 * \text{PreheatRateBase}) - (\text{PreheatNumberENERGYSTAR} * \text{PreheatTimeENERGYSTAR} / 60 * \text{PreheatRateENERGYSTAR})$$

$$\Delta\text{DailyCookingEnergy} = (\text{LB} * \text{EFOOD} / \text{EffBase}) - (\text{LB} * \text{EFOOD} / \text{EffENERGYSTAR})$$

Where:

HOURLSday = Average Daily Operation
 = custom or if unknown, use 12 hours

Days = Annual days of operation
 = custom or if unknown, use 365.25 days a year

LB = Food cooked per day
 = custom or if unknown, use 100 pounds

EffENERGYSTAR = Cooking Efficiency ENERGY STAR
 = custom or if unknown, use 44%

EffBase = Cooking Efficiency Baseline
 = custom or if unknown, use 30%

PCENERGYSTAR = Production Capacity ENERGY STAR
 = custom or if unknown, use 80 pounds/hr

PCBase = Production Capacity base
 = custom or if unknown, use 70 pounds/hr

PreheatNumberENERGYSTAR = Number of preheats per day
 = custom or if unknown, use 1

PreheatNumberBase = Number of preheats per day
 = custom or if unknown, use 1

PreheatTimeENERGYSTAR = preheat length
 = custom or if unknown, use 15 minutes

PreheatTimeBase = preheat length
 = custom or if unknown, use 15 minutes

PreheatRateENERGYSTAR = preheat energy rate high efficiency
 = custom or if unknown, use 44000 btu/h

PreheatRateBase = preheat energy rate baseline
 = custom or if unknown, use 76000 btu/h

IdleENERGYSTAR = Idle energy rate

	= custom or if unknown, use 13000 btu/h
IdleBase	= Idle energy rate
	= custom or if unknown, use 18000 btu/h
IdleENERGYSTARTTime	= ENERGY STAR Idle Time
	=HOURSday-LB/PCENERGYSTAR –PreHeatTimeENERGYSTAR/60
	=12 – 100/80 – 15/60
	=10.5 hours
IdleBaseTime	= BASE Idle Time
	= HOURSday-LB/PCbase –PreHeatTimeBase/60
	=Custom or if unknown, use
	=12 – 100/70-15/60
	=10.3 hours
EFOOD	= ASTM energy to food
	= 250 btu/pound

EXAMPLE

For example, an ENERGY STAR Oven with a cooking energy efficiency of 44% and default values from above would save.

$$\Delta\text{Therms} = (\Delta\text{Idle Energy} + \Delta\text{Preheat Energy} + \Delta\text{Cooking Energy}) * \text{Days} / 100000$$

Where:

$$\begin{aligned} \Delta\text{DailyIdleEnergy} &= (18000 * 10.3) - (13000 * 10.5) \\ &= 49286 \text{ btu} \\ \Delta\text{DailyPreheatEnergy} &= (1 * 15 / 60 * 76000) - (1 * 15 / 60 * 44000) \\ &= 8000 \text{ btu} \\ \Delta\text{DailyCookingEnergy} &= (100 * 250 / .30) - (100 * 250 / .44) \\ &= 26515 \text{ btu} \\ \Delta\text{Therms} &= (49286 + 8000 + 26515) * 365.25 / 100000 \\ &= 306 \text{ therms} \end{aligned}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-ESCV-V01-120601

4.2.6 ENERGY STAR Dishwasher

DESCRIPTION

This measure applies to ENERGY STAR high and low temp under counter, stationary single tank door type, single tank conveyor, and multiple tank conveyor dishwashers, as well as high temp pot, pan, and utensil dishwashers installed in a commercial kitchen.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be an ENERGY STAR certified dishwasher meeting idle energy rate (kW) and water consumption (gallons/rack) limits, as determined by both machine type and sanitation approach (chemical/low temp versus high temp).

ENERGY STAR Requirements (Effective February 1, 2013)

Dishwasher Type	High Temp Efficiency Requirements		Low Temp Efficiency Requirements	
	Idle Energy Rate	Water Consumption	Idle Energy Rate	Water Consumption
Under Counter	≤ 0.50 kW	≤ 0.86 GPR	≤ 0.50 kW	≤ 1.19 GPR
Stationary Single Tank Door	≤ 0.70 kW	≤ 0.89 GPR	≤ 0.60 kW	≤ 1.18 GPR
Pot, Pan, and Utensil	≤ 1.20 kW	≤ 0.58 GPSF	≤ 1.00 kW	≤ 0.58 GPSF
Single Tank Conveyor	≤ 1.50 kW	≤ 0.70 GPR	≤ 1.50 kW	≤ 0.79 GPR
Multiple Tank Conveyor	≤ 2.25 kW	≤ 0.54 GPR	≤ 2.00 kW	≤ 0.54 GPR

DEFINITION OF BASELINE EQUIPMENT

THE BASELINE EQUIPMENT IS A NEW DISHWASHER THAT IS NOT ENERGY STAR CERTIFIED. DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be⁶⁶

Dishwasher Type		Equipment Life
Low Temp	Under Counter	10
	Stationary Single Tank Door	15
	Single Tank Conveyor	20
	Multi Tank Conveyor	20
High Temp	Under Counter	10
	Stationary Single Tank Door	15
	Single Tank Conveyor	20
	Multi Tank Conveyor	20
	Pot, Pan, and Utensil	10

⁶⁶ Lifetime from ENERGY STAR Commercial Kitchen Equipment Savings Calculator which cites reference as "EPA/FSTC research on available models, 2013"

http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

DEEMED MEASURE COST

The incremental capital cost for this measure is provided below:⁶⁷

Dishwasher Type		Incremental Cost
Low Temp	Under Counter	\$50
	Stationary Single Tank Door	\$0
	Single Tank Conveyor	\$0
	Multi Tank Conveyor	\$970
High Temp	Under Counter	\$120
	Stationary Single Tank Door	\$770
	Single Tank Conveyor	\$2,050
	Multi Tank Conveyor	\$970
	Pot, Pan, and Utensil	\$1,710

LOADSHAPE

Loadshape C01 - Commercial Electric Cooking

COINCIDENCE FACTOR

Summer Peak Coincidence Factor for measure is provided below for different restaurant types⁶⁸:

Location	CF
Fast Food Limited Menu	0.32
Fast Food Expanded Menu	0.41
Pizza	0.46
Full Service Limited Menu	0.51
Full Service Expanded Menu	0.36
Cafeteria	0.36

⁶⁷ Measure cost from ENERGY STAR Commercial Kitchen Equipment Savings Calculator which cites reference as “EPA research on available models using AutoQuotes, 2012”

⁶⁸ Values taken from Minnesota Technical Reference Manual, ‘Electric Oven and Range’ measure and is based upon “Project on Restaurant Energy Performance-End-Use Monitoring and Analysis”, Appendixes I and II, Claar, et. al., May 1985

Algorithm

CALCULATION OF SAVINGS

ENERGY STAR dishwashers save energy in three categories: building water heating, booster water heating and idle energy. Building water heating and booster water heating could be either electric or natural gas.

ELECTRIC ENERGY SAVINGS

Custom calculation below, otherwise use deemed values found within the tables that follow.

$$\Delta kWh^{69} = \Delta BuildingEnergy + \Delta BoosterEnergy^{70} + \Delta IdleEnergy$$

Where:

$$\begin{aligned} \Delta BuildingEnergy &= \text{Change in annual electric energy consumption of building water heater} \\ &= [(WaterUse_{Base} * RacksWashed * Days) * (\Delta T_{in} * 1.0 * 8.2 \div Eff_{Heater} \div 3,413)] - \\ &\quad [(WaterUse_{ESTAR} * RacksWashed * Days) * (\Delta T_{in} * 1.0 * 8.2 \div Eff_{Heater} \div 3,413)] \\ \Delta BoosterEnergy &= \text{Annual electric energy consumption of booster water heater} \\ &= [(WaterUse_{Base} * RacksWashed * Days) * (\Delta T_{in} * 1.0 * 8.2 \div Eff_{Heater} \div 3,413)] - \\ &\quad [(WaterUse_{ESTAR} * RacksWashed * Days) * (\Delta T_{in} * 1.0 * 8.2 \div Eff_{Heater} \div 3,413)] \\ \Delta IdleEnergy &= \text{Annual idle electric energy consumption of dishwasher} \\ &= [IdleDraw_{Base} * (Hours * Days - Days * RacksWashed * WashTime \div 60)] - \\ &\quad [IdleDraw_{ESTAR} * (Hours * Days - Days * RacksWashed * WashTime \div 60)] \end{aligned}$$

Where:

- WaterUse_{Base} = Water use per rack (gal) of baseline dishwasher
= Custom or if unknown, use value from table below as determined by machine type and sanitation method
- WaterUse_{ESTAR} = Water use per rack (gal) of ENERGY STAR dishwasher
= Custom or if unknown, use value from table below as determined by machine type and sanitation method
- RacksWashed = Number of racks washed per day
= Custom or if unknown, use value from table below as determined by machine type and sanitation method
- Days = Annual days of dishwasher operation
= Custom or if unknown, use 365.25 days per year
- ΔT_{in} = Inlet water temperature increase (°F)
= Custom or if unknown, use 70 °F for building water heaters and 40 °F for booster water heaters
- 1.0 = Specific heat of water (Btu/lb/°F)
- 8.2 = Density of water (lb/gal)

⁶⁹Algorithms and assumptions derived from ENERGY STAR Commercial Kitchen Equipment Savings Calculator. http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

⁷⁰ Booster water heater energy only applies to high-temperature dishwashers.

- Eff_{Heater} = Efficiency of water heater
= Custom or if unknown, use 98% for electric building and booster water heaters
- 3,413 = kWh to Btu conversion factor
- IdleDraw_{Base} = Idle power draw (kW) of baseline dishwasher
= Custom or if unknown, use value from table below as determined by machine type and sanitation method
- IdleDraw_{ESTAR} = Idle power draw (kW) of ENERGY STAR dishwasher
= Custom or if unknown, use value from table below as determined by machine type and sanitation method
- Hours = Average daily hours of dishwasher operation
= Custom or if unknown, use 18 hours per day
- WashTime = Typical wash time (min)
= Custom or if unknown, use value from table below as determined by machine type and sanitation method
- 60 = Minutes to hours conversion factor

EXAMPLE

For example, an ENERGY STAR high-temperature, under counter dishwasher with electric building and electric booster water heating with defaults from the calculation above and the table below would save:

$$\Delta kWh = \Delta BuildingEnergy + \Delta BoosterEnergy + \Delta IdleEnergy$$

Where:

$$\begin{aligned} \Delta BuildingEnergy &= [(1.09 * 75 * 365.25) * (70 * 1.0 * 8.2 \div 0.98 \div 3,413)] - [(0.86 * 75 * 365.25) * (70 * 1.0 * 8.2 \div 0.98 \div 3,413)] \\ &= 1,081 \text{ kWh} \\ \Delta BoosterEnergy &= [(1.09 * 75 * 365.25) * (40 * 1.0 * 8.2 \div 0.98 \div 3,413)] - [(0.86 * 75 * 365.25) * (40 * 1.0 * 8.2 \div 0.98 \div 3,413)] \\ &= 618 \text{ kWh} \\ \Delta IdleEnergy &= [0.76 * (18 * 365.25 - 365.25 * 75 * 2.0 \div 60)] - \\ &\quad [0.50 * (18 * 365.25 - 365.25 * 75 * 2.0 \div 60)] \\ &= 1,472 \text{ Wh} \\ \Delta kWh &= 1,081 + 618 + 1,472 \\ &= 3,171 \text{ kWh} \end{aligned}$$

Default values for WaterUse, RacksWashed, kW_{Idle}, and WashTime are presented in the table below.

	RacksWashed		WashTime		WaterUse		IdleDraw	
	All Dishwashers	All Dishwashers	Conventional	ENERGY STAR	Conventional	ENERGY STAR	Conventional	ENERGY STAR
Low Temperature Under Counter	75	2.0	1.73	1.19	0.50	0.50		
Stationary Single Tank Door	280	1.5	2.10	1.18	0.60	0.60		
Single Tank Conveyor	400	0.3	1.31	0.79	1.60	1.50		

Multi Tank Conveyor	600	0.3	1.04	0.54	2.00	2.00
High Temperature	All Dishwashers	All Dishwashers	Conventional	ENERGY STAR	Conventional	ENERGY STAR
Under Counter	75	2.0	1.09	0.86	0.76	0.50
Stationary Single Tank Door	280	1.0	1.29	0.89	0.87	0.70
Single Tank Conveyor	400	0.3	0.87	0.70	1.93	1.50
Multi Tank Conveyor	600	0.2	0.97	0.54	2.59	2.25
Pot, Pan, and Utensil	280	3.0 3.0	0.70	0.58	1.20	1.20

Savings for all water heating combinations are presented in the tables below (calculated without rounding variables as provided above).

Electric building and electric booster water heating

Dishwasher type		kWh _{Base}	kWh _{ESTAR}	ΔkWh
Low Temp	Under Counter	10,972	8,431	2,541
	Stationary Single Tank Door	39,306	23,142	16,164
	Single Tank Conveyor	42,230	28,594	13,636
	Multi Tank Conveyor	50,112	31,288	18,824
High Temp	Under Counter	12,363	9,191	3,173
	Stationary Single Tank Door	39,852	27,981	11,871
	Single Tank Conveyor	45,593	36,375	9,218
	Multi Tank Conveyor	72,523	45,096	27,426
	Pot, Pan, and Utensil	21,079	17,766	3,313

Electric building and natural gas booster water heating

Dishwasher type		kWh _{Base}	kWh _{ESTAR}	ΔkWh
Low Temp	Under Counter	10,972	8,431	2,541
	Stationary Single Tank Door	39,306	23,142	16,164
	Single Tank Conveyor	42,230	28,594	13,636
	Multi Tank Conveyor	50,112	31,288	18,824
High Temp	Under Counter	9,432	6,878	2,554
	Stationary Single Tank Door	26,901	19,046	7,856
	Single Tank Conveyor	33,115	26,335	6,780
	Multi Tank Conveyor	51,655	33,479	18,176
	Pot, Pan, and Utensil	14,052	11,943	2,108

Natural gas building and electric booster water heating

Dishwasher type	kWh _{Base}	kWh _{ESTAR}	ΔkWh
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Dishwasher type		kWh _{Base}	kWh _{ESTAR}	ΔkWh
Low Temp	Under Counter	2,831	2,831	0
	Stationary Single Tank Door	2,411	2,411	0
	Single Tank Conveyor	9,350	8,766	584
	Multi Tank Conveyor	10,958	10,958	0
High Temp	Under Counter	7,234	5,143	2,090
	Stationary Single Tank Door	17,188	12,344	4,844
	Single Tank Conveyor	23,757	18,806	4,951
	Multi Tank Conveyor	36,004	24,766	11,238
	Pot, Pan, and Utensil	8,781	7,576	1,205

Natural gas building and natural gas booster water heating

Dishwasher type		kWh _{Base}	kWh _{ESTAR}	ΔkWh
Low Temp	Under Counter	2,831	2,831	0
	Stationary Single Tank Door	2,411	2,411	0
	Single Tank Conveyor	9,350	8,766	584
	Multi Tank Conveyor	10,958	10,958	0
High Temp	Under Counter	4,303	2,831	1,472
	Stationary Single Tank Door	4,237	3,409	828
	Single Tank Conveyor	11,279	8,766	2,513
	Multi Tank Conveyor	15,136	13,149	1,987
	Pot, Pan, and Utensil	1,753	1,753	0

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \Delta kWh / \text{AnnualHours}$$

Where:

$$\begin{aligned} \text{AnnualHours} &= \text{Hours} * \text{Days} \\ &= 18 * 365.25 \\ &= 6575 \text{ annual hours} \end{aligned}$$

Example:

A low temperature undercounter dishwasher with electric building and booster water heaters would save:

$$\begin{aligned} \Delta kW &= \Delta kWh / \text{AnnualHours} \\ &= 2541 / 6575 \\ &= 0.386 \text{ kW} \end{aligned}$$

NATURAL GAS ENERGY SAVINGS

$$\Delta \text{Therms}^{71} = \Delta \text{BuildingEnergy} + \Delta \text{BoosterEnergy}$$

Where:

$$\begin{aligned} \Delta \text{BuildingEnergy} &= \text{Change in annual natural gas consumption of building water heater} \\ &= [(\text{WaterUse}_{\text{Base}} * \text{RacksWashed} * \text{Days}) * (\Delta T_{\text{in}} * 1.0 * 8.2 \div \text{Eff}_{\text{Heater}} \div 100,000)] - \\ &\quad [(\text{WaterUse}_{\text{ESTAR}} * \text{RacksWashed} * \text{Days}) * (\Delta T_{\text{in}} * 1.0 * 8.2 \div \text{Eff}_{\text{Heater}} \div 100,000)] \\ \Delta \text{BoosterEnergy} &= \text{Change in annual natural gas consumption of booster water heater} \\ &= [(\text{WaterUse}_{\text{Base}} * \text{RacksWashed} * \text{Days}) * (\Delta T_{\text{in}} * 1.0 * 8.2 \div \text{Eff}_{\text{Heater}} \div 100,000)] - \\ &\quad [(\text{WaterUse}_{\text{ESTAR}} * \text{RacksWashed} * \text{Days}) * (\Delta T_{\text{in}} * 1.0 * 8.2 \div \text{Eff}_{\text{Heater}} \div 100,000)] \end{aligned}$$

Where:

- $\text{WaterUse}_{\text{Base}}$ = Water use per rack (gal) of baseline dishwasher
= Custom or if unknown, use value from table within the electric energy savings characterization as determined by machine type and sanitation method
- $\text{WaterUse}_{\text{ESTAR}}$ = Water use per rack (gal) of ENERGY STAR dishwasher
= Custom or if unknown, use value from table within the electric energy savings characterization as determined by machine type and sanitation method
- RacksWashed = Number of racks washed per day
= Custom or if unknown, use value from table within the electric energy savings characterization as determined by machine type and sanitation method
- Days = Annual days of dishwasher operation
= Custom or if unknown, use 365 days per year
- ΔT_{in} = Inlet water temperature increase (°F)
= Custom or if unknown, use 70 °F for building water heaters and 40 °F for booster water heaters
- 1.0 = Specific heat of water (Btu/lb/°F)
- 8.2 = Density of water (lb/gal)
- $\text{Eff}_{\text{Heater}}$ = Efficiency of water heater
= Custom or 80% for gas building and booster water heaters
- 100,000 = Therms to Btu conversion factor

⁷¹ Algorithms and assumptions derived from ENERGY STAR Commercial Kitchen Equipment Savings Calculator

EXAMPLE

For example, an ENERGY STAR high-temperature, under counter dishwasher with gas building and gas booster water heating with defaults from the calculation above and the table within the electric energy savings characterization would save:

$$\Delta\text{Therms} = \Delta\text{BuildingEnergy} + \Delta\text{BoosterEnergy}$$

Where:

$$\begin{aligned} \Delta\text{BuildingEnergy} &= [(1.09 * 75 * 365.25) * (70 * 1.0 * 8.2 \div 0.80 \div 100,000)] - [(0.86 * 75 * 365.25) * (70 * 1.0 * 8.2 \div 0.80 \div 100,000)] \\ &= 45 \text{ therms} \end{aligned}$$

$$\begin{aligned} \Delta\text{BoosterEnergy} &= [(1.09 * 75 * 365.25) * (40 * 1.0 * 8.2 \div 0.80 \div 100,000)] - [(0.86 * 75 * 365.25) * (40 * 1.0 * 8.2 \div 0.80 \div 100,000)] \\ &= 26 \text{ therms} \end{aligned}$$

$$\begin{aligned} \Delta\text{Therms} &= 45 + 26 \\ &= 71 \text{ therms} \end{aligned}$$

Savings for all water heating combinations are presented in the tables below.

Electric building and natural gas booster water heating

Dishwasher type		Therms _{Base}	Therms _{ESTAR}	ΔTherms
Low Temp	Under Counter	NA	NA	NA
	Stationary Single Tank Door	NA	NA	NA
	Single Tank Conveyor	NA	NA	NA
	Multi Tank Conveyor	NA	NA	NA
High Temp	Under Counter	123	97	26
	Stationary Single Tank Door	541	374	168
	Single Tank Conveyor	522	420	102
	Stationary Single Tank Door	872	486	387
	Pot, Pan, and Utensil	294	243	50

Natural gas building and natural gas booster water heating

Dishwasher type		Therms _{Base}	Therms _{ESTAR}	ΔTherms
Low Temp	Under Counter	340	234	106
	Stationary Single Tank Door	1,543	867	676
	Single Tank Conveyor	1,375	829	546
	Multi Tank Conveyor	1,637	850	787
High	Under Counter	337	266	71

Dishwasher type		Therms _{Base}	Therms _{ESTAR}	ΔTherms
Temp	Stationary Single Tank Door	1,489	1,027	462
	Single Tank Conveyor	1,435	1,154	280
	Multi Tank Conveyor	2,399	1,336	1,064
	Pot, Pan, and Utensil	808	669	139

Natural gas building and electric booster water heating

Dishwasher type		Therms _{Base}	Therms _{ESTAR}	ΔTherms
Low Temp	Under Counter	340	234	106
	Stationary Single Tank Door	1,543	867	676
	Single Tank Conveyor	1,375	829	546
	Multi Tank Conveyor	1,637	850	787
High Temp	Under Counter	214	169	45
	Stationary Single Tank Door	948	654	294
	Single Tank Conveyor	913	735	178
	Multi Tank Conveyor	1,527	850	677
	Pot, Pan, and Utensil	514	426	88

WATER IMPACT DESCRIPTIONS AND CALCULATION

$$\Delta\text{Water} = (\text{WaterUse}_{\text{Base}} * \text{RacksWashed} * \text{Days}) - (\text{WaterUse}_{\text{ESTAR}} * \text{RacksWashed} * \text{Days})$$

Where:

- WaterUse_{Base} = Water use per rack (gal) of baseline dishwasher
= Custom or if unknown, use value from table within the electric energy savings characterization as determined by machine type and sanitation method
- WaterUse_{ESTAR} = Water use per rack (gal) of ENERGY STAR dishwasher
= Custom or if unknown, use value from table within the electric energy savings characterization as determined by machine type and sanitation method
- RacksWashed = Number of racks washed per day
= Custom or if unknown, use value from table within the electric energy savings characterization as determined by machine type and sanitation method
- Days = Annual days of dishwasher operation
= Custom or if unknown, use 365 days per year

EXAMPLE

For example, an ENERGY STAR low-temperature, under counter dishwasher with defaults from the calculation above and the table within the electric energy savings characterization would save:

$$\Delta\text{Water} = (\text{WaterUse}_{\text{Base}} * \text{RacksWashed} * \text{Days}) - (\text{WaterUse}_{\text{ESTAR}} * \text{RacksWashed} * \text{Days})$$

$$\begin{aligned} \Delta\text{Water} &= (1.73 * 75 * 365.25) - (1.19 * 75 * 365.25) \\ &= 14,793 \text{ gallons} \end{aligned}$$

Savings for all dishwasher types are presented in the table below.

	Annual Water Consumption (gallons)		
	Baseline	ENERGY STAR	Savings
Low Temperature			
Under Counter	47,391	32,599	14,793
Stationary Single Tank Door	214,767	120,679	94,088
Single Tank Conveyor	191,391	115,419	75,972
Multi Tank Conveyor	227,916	118,341	109,575
High Temperature			
Under Counter	29,859	23,559	6,301
Stationary Single Tank Door	131,928	91,020	40,908
Single Tank Conveyor	127,107	102,270	24,837
Multi Tank Conveyor	212,576	118,341	94,235
Pot, Pan, and Utensil	71,589	59,317	12,272

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-ESDW-V02-160601

4.2.7 ENERGY STAR Fryer

DESCRIPTION

This measure applies to natural gas fired ENERGY STAR fryer installed in a commercial kitchen.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a natural gas fryer with a heavy load cooking efficiency $\geq 50\%$ utilizing ASTM standard F1361 or F2144.

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is a natural gas fryer that is not ENERGY STAR certified at end of life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 15 years.⁷²

DEEMED MEASURE COST

The incremental capital cost for this measure is \$1200.⁷³

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS⁷⁴

Custom calculation below, otherwise use deemed value of 505 Therms.

$$\Delta\text{Therms} = (\Delta\text{DailyIdle Energy} + \Delta\text{DailyPreheat Energy} + \Delta\text{DailyCooking Energy}) * \text{Days} / 100000$$

⁷²Lifetime from ENERGY STAR commercial griddle which cites reference as “FSTC research on available models, 2009” http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

⁷³Measure cost from ENERGY STAR which cites reference as “EPA research on available models using AutoQuotes, 2010” http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

⁷⁴ Algorithms and assumptions derived from ENERGY STAR fryer Commercial Kitchen Equipment Savings Calculator. http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

Where:

$$\Delta\text{DailyIdleEnergy} = (\text{IdleBase} * \text{IdleBaseTime}) - (\text{IdleENERGYSTAR} * \text{IdleENERGYSTARTime})$$

$$\Delta\text{DailyPreheatEnergy} = (\text{PreHeatNumberBase} * \text{PreheatTimeBase} / 60 * \text{PreheatRateBase}) - (\text{PreheatNumberENERGYSTAR} * \text{PreheatTimeENERGYSTAR} / 60 * \text{PreheatRateENERGYSTAR})$$

$$\Delta\text{DailyCookingEnergy} = (\text{LB} * \text{EFOOD} / \text{EffBase}) - (\text{LB} * \text{EFOOD} / \text{EffENERGYSTAR})$$

Where:

HOURSday	= Average Daily Operation = custom or if unknown, use 16 hours
Days	= Annual days of operation = custom or if unknown, use 365.25 days a year
LB	= Food cooked per day = custom or if unknown, use 150 pounds
EffENERGYSTAR	= Cooking Efficiency ENERGY STAR = custom or if unknown, use 50%
EffBase	= Cooking Efficiency Baseline = custom or if unknown, use 35%
PCENERGYSTAR	= Production Capacity ENERGY STAR = custom or if unknown, use 65 pounds/hr
PCBase	= Production Capacity base = custom or if unknown, use 60 pounds/hr
PreheatNumberENERGYSTAR	= Number of preheats per day = custom or if unknown, use 1
PreheatNumberBase	= Number of preheats per day = custom or if unknown, use 1
PreheatTimeENERGYSTAR	= preheat length = custom or if unknown, use 15 minutes
PreheatTimeBase	= preheat length = custom or if unknown, use 15 minutes
PreheatRateENERGYSTAR	= preheat energy rate high efficiency = custom or if unknown, use 62000 btu/h
PreheatRateBase	= preheat energy rate baseline = custom or if unknown, use 64000 btu/h
IdleENERGYSTAR	= Idle energy rate = custom or if unknown, use 9000 btu/h
IdleBase	= Idle energy rate

	= custom or if unknown, use 14000 btu/h
IdleENERGYSTARTime	= ENERGY STAR Idle Time = HOURSday-LB/PCENERGYSTAR –PreHeatTimeENERGYSTAR/60 =Custom or if unknown, use =16 – 150/65-15/60 =13.44 hours
IdleBaseTime	= BASE Idle Time = HOURSday-LB/PCbase –PreHeatTimeBase/60 =Custom or if unknown, use =16 – 150/60-15/60 =13.25 hours
EFOOD	= ASTM energy to food = 570 btu/pound

EXAMPLE

For example, an ENERGY STAR fryer with a tested heavy load cooking energy efficiency of 50% and an idle energy rate of 120,981 btu and an Idle Energy Consumption Rate 9000 btu would save.

$$\Delta\text{Therms} = (\Delta\text{Idle Energy} + \Delta\text{Preheat Energy} + \Delta\text{Cooking Energy}) * \text{Days} / 100000$$

Where:

$\Delta\text{DailyIdleEnergy}$	$= (18550 * 13.25) - (120981 * 13.44)$ $= 64519 \text{ btu}$
$\Delta\text{DailyPreheatEnergy}$	$= (1 * 15 / 60 * 64000) - (1 * 15 / 60 * 62000)$ $= 500 \text{ btu}$
$\Delta\text{DailyCookingEnergy}$	$= (150 * 570 / .35) - (150 * 570 / .5)$ $= 73286 \text{ btu}$
ΔTherms	$= (64519 + 500 + 73286) * 365.25 / 100000$ $= 508 \text{ therms}$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-ESFR-V01-120601

4.2.8 ENERGY STAR Griddle

DESCRIPTION

This measure applies to electric and natural gas fired high efficiency griddle installed in a commercial kitchen.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be an ENERGY STAR natural gas or electric griddle with a tested heavy load cooking energy efficiency of 70 percent (electric) 38 percent (gas) or greater and an idle energy rate of 2,650 Btu/hr per square foot of cooking surface or less, utilizing ASTM F1275. The griddle must have an Idle Energy Consumption Rate < 2,600 Btu/hr per square foot of cooking surface.

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is an existing natural gas or electric griddle that's not ENERGY STAR certified and is at end of use.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years⁷⁵

DEEMED MEASURE COST

The incremental capital cost for this measure is \$0 for an electric griddle and \$60 for a gas griddle.⁷⁶

LOADSHAPE

Loadshape C01 - Commercial Electric Cooking

COINCIDENCE FACTOR

Summer Peak Coincidence Factor for measure is provided below for different building type⁷⁷:

Location	CF
Fast Food Limited Menu	0.32
Fast Food Expanded Menu	0.41
Pizza	0.46
Full Service Limited Menu	0.51
Full Service Expanded Menu	0.36
Cafeteria	0.36

⁷⁵ Lifetime from ENERGY STAR commercial griddle which cites reference as "FSTC research on available models, 2009" http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

⁷⁶ Measure cost from ENERGY STAR which cites reference as "EPA research on available models using AutoQuotes, 2010" http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

⁷⁷ Values taken from Minnesota Technical Reference Manual, 'Electric Oven and Range' measure and is based upon "Project on Restaurant Energy Performance-End-Use Monitoring and Analysis", Appendixes I and II, Claar, et. al., May 1985

Algorithm

CALCULATION OF SAVINGS⁷⁸

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = (\Delta \text{Idle Energy} + \Delta \text{Preheat Energy} + \Delta \text{Cooking Energy}) * \text{Days} / 1000$$

Where:

$$\begin{aligned} \Delta \text{DailyIdleEnergy} &= [(\text{IdleBase} * \text{Width} * \text{Depth} * (\text{HOURSday} - (\text{LB}/(\text{PCBase} * \text{Width} * \text{Depth}))) - (\text{PreheatNumberBase} * \text{PreheatTimeBase}/60)] - [(\text{IdleENERGYSTAR} * \text{Width} * \text{Depth} * (\text{HOURSday} - (\text{LB}/(\text{PCENERGYSTAR} * \text{Width} * \text{Depth}))) - (\text{PreheatNumberENERGYSTAR} * \text{PreheatTimeENERGYSTAR}/60)] \\ \Delta \text{DailyPreheatEnergy} &= (\text{PreHeatNumberBase} * \text{PreheatTimeBase} / 60 * \text{PreheatRateBase} * \text{Width} * \text{Depth}) - (\text{PreheatNumberENERGYSTAR} * \text{PreheatTimeENERGYSTAR}/60 * \text{PreheatRateENERGYSTAR} * \text{Width} * \text{Depth}) \\ \Delta \text{DailyCookingEnergy} &= (\text{LB} * \text{EFOOD} / \text{EffBase}) - (\text{LB} * \text{EFOOD} / \text{EffENERGYSTAR}) \end{aligned}$$

Where:

- HOURSday = Average Daily Operation
= custom or if unknown, use 12 hours
- Days = Annual days of operation
= custom or if unknown, use 365.25 days a year
- LB = Food cooked per day
= custom or if unknown, use 100 pounds
- Width = Griddle Width
= custom or if unknown, use 3 feet
- Depth = Griddle Depth
= custom or if unknown, use 2 feet
- EffENERGYSTAR = Cooking Efficiency ENERGY STAR
= custom or if unknown, use 70%
- EffBase = Cooking Efficiency Baseline
= custom or if unknown, use 65%
- PCENERGYSTAR = Production Capacity ENERGY STAR
= custom or if unknown, use 40/6 = 6.67 pounds/hr/sq ft
- PCBase = Production Capacity base
= custom or if unknown, use 35/6 = 5.83 pounds/hr/sq ft
- PreheatNumberENERGYSTAR = Number of preheats per day

⁷⁸ Algorithms and assumptions derived from ENERGY STAR Griddle Commercial Kitchen Equipment Savings Calculator. http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

	= custom or if unknown, use 1
PreheatNumberBase	= Number of preheats per day
	= custom or if unknown, use 1
PreheatTimeENERGYSTAR	= preheat length
	= custom or if unknown, use 15 minutes
PreheatTimeBase	= preheat length
	= custom or if unknown, use 15 minutes
PreheatRateENERGYSTAR	= preheat energy rate high efficiency
	= custom or if unknown, use 8000/6 = 1333 W/sq ft
PreheatRateBase	= preheat energy rate baseline
	= custom or if unknown, use 16000/6 = 2667 W/sq ft
IdleENERGYSTAR	= Idle energy rate
	= custom or if unknown, use 320 W/sq ft
IdleBase	= Idle energy rate
	= custom or if unknown, use 400 W/sq ft
EFOOD	= ASTM energy to food
	= 139 w/pound

For example, an ENERGY STAR griddle with a tested heavy load cooking energy efficiency of 70 percent or greater and an idle energy rate of 320 W per square foot of cooking surface or less would save.

$$\begin{aligned} \Delta \text{DailyIdleEnergy} &= [400 * 3 * 2 * (12 - (100/(35/6 * 3 * 2)) - (1 * 15/60)) - [320 * 3 * 2 * (12 - (100/(40/6 * 3 * 2)) - (1 * 15/60))] \\ &= 3583 \text{ W} \\ \Delta \text{DailyPreheatEnergy} &= (1 * 15 / 60 * 16000/6 * 3 * 2) - (1 * 15/60 * 8000/6 * 3 * 2) \\ &= 2000 \text{ W} \\ \Delta \text{DailyCookingEnergy} &= (100 * 139 / 0.65) - (100 * 139 / 0.70) \\ &= 1527 \text{ W} \\ \Delta \text{kWh} &= (2000+1527+3583) * 365.25 / 1000 \\ &= 2597 \text{ kWh} \end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\text{kW} = \Delta \text{kWh/Hours} * \text{CF}$$

For example, an ENERGY STAR griddle in a cafeteria with a tested heavy load cooking energy efficiency of 70 percent or greater and an idle energy rate of 320 W per square foot of cooking surface or less would save

$$= 2597 \text{ kWh}/4308 * 0.36$$

$$= 0.22 \text{ kW}$$

NATURAL GAS ENERGY SAVINGS

Custom calculation below, otherwise use deemed value of 149 therms.

$$\Delta \text{Therms} = (\Delta \text{Idle Energy} + \Delta \text{Preheat Energy} + \Delta \text{Cooking Energy}) * \text{Days} / 100000$$

Where:

$$\Delta \text{DailyIdleEnergy} = [(\text{IdleBase} * \text{Width} * \text{Depth} * (\text{HOURSday} - \text{LB}/(\text{PCBase} * \text{Width} * \text{Depth})) - (\text{PreheatNumberBase} * \text{PreheatTimeBase}/60)] - [(\text{IdleENERGYSTAR} * \text{Width} * \text{Depth} * (\text{HOURSday} - (\text{LB}/(\text{PCENERGYSTAR} * \text{Width} * \text{Depth})) - (\text{PreheatNumberENERGYSTAR} * \text{PreheatTimeENERGYSTAR}/60)]$$

$$\Delta \text{DailyPreheatEnergy} = (\text{PreHeatNumberBase} * \text{PreheatTimeBase} / 60 * \text{PreheatRateBase} * \text{Width} * \text{Depth}) - (\text{PreheatNumberENERGYSTAR} * \text{PreheatTimeENERGYSTAR}/60 * \text{PreheatRateENERGYSTAR} * \text{Width} * \text{Depth})$$

$$\Delta \text{DailyCookingEnergy} = (\text{LB} * \text{EFOOD}/ \text{EffBase}) - (\text{LB} * \text{EFOOD}/ \text{EffENERGYSTAR})$$

Where (new variables only):

- EffENERGYSTAR = Cooking Efficiency ENERGY STAR
= custom or if unknown, use 38%
- EffBase = Cooking Efficiency Baseline
= custom or if unknown, use 32%
- PCENERGYSTAR = Production Capacity ENERGY STAR
= custom or if unknown, use 45/6 = 7.5 pounds/hr/sq ft
- PCBase = Production Capacity base
= custom or if unknown, use 25/6 = 4.17 pounds/hr/sq ft
- PreheatRateENERGYSTAR = preheat energy rate high efficiency
= custom or if unknown, use 60000/6 = 10000 btu/h/sq ft
- PreheatRateBase = preheat energy rate baseline
= custom or if unknown, use 84000/6 = 14000 btu/h/sq ft
- IdleENERGYSTAR = Idle energy rate
= custom or if unknown, use 15900/6 = 2650 btu/h/sq ft
- IdleBase = Idle energy rate
= custom or if unknown, use 21000/6 = 3500 btu/h/sq ft

EFOOD = ASTM energy to food
 = 475 btu/pound

For example, an ENERGY STAR griddle with a tested heavy load cooking energy efficiency of 38 percent or greater and an idle energy rate of 2,650 Btu/h per square foot of cooking surface or less and an Idle Energy Consumption Rate < 2,600 Btu/h per square foot of cooking surface would save.

$$\begin{aligned} \Delta \text{DailyIdleEnergy} &= [3500 * 3 * 2 * (12 - 100 / (25 / 6 * 3 * 2)) - (1 * 15 / 60)] - [(2650 * 3 * 2 * (12 - (100 / (45 / 6 * 3 * 2)) - (1 * 15 / 60)))] \\ &= 11258 \text{ Btu} \\ \Delta \text{DailyPreheatEnergy} &= (1 * 15 / 60 * 14,000 * 3 * 2) - (1 * 15 / 60 * 10000 * 3 * 2) \\ &= 6000 \text{ btu} \\ \Delta \text{DailyCookingEnergy} &= (100 * 475 / 0.32) - (100 * 475 / 0.38) \\ &= 23438 \text{ btu} \\ \Delta \text{Therms} &= (11258 + 6000 + 23438) * 365.25 / 100000 \\ &= 149 \text{ therms} \end{aligned}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-ESGR-V02-160601

4.2.9 ENERGY STAR Hot Food Holding Cabinets

DESCRIPTION

This measure applies to electric ENERGY STAR hot food holding cabinets (HFHC) installed in a commercial kitchen.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be an ENERGY STAR certified HFHC.

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is an electric HFHC that's not ENERGY STAR certified and at end of life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years⁷⁹

DEEMED MEASURE COST

The incremental capital cost for this measure is⁸⁰

HFHC Size	Incremental Cost
Full Size (20 cubic feet)	\$1200
¾ Size (12 cubic feet)	\$1800
½ Size (8 cubic feet)	\$1500

LOADSHAPE

Loadshape C01 - Commercial Electric Cooking

⁷⁹ Lifetime from ENERGY STAR HFHC which cites reference as "FSTC research on available models, 2009"
http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

⁸⁰ Measure cost from ENERGY STAR which cites reference as "EPA research on available models using AutoQuotes, 2010"
http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

COINCIDENCE FACTOR

Summer Peak Coincidence Factor for measure is provided below for different building type⁸¹:

Location	CF
Fast Food Limited Menu	0.32
Fast Food Expanded Menu	0.41
Pizza	0.46
Full Service Limited Menu	0.51
Full Service Expanded Menu	0.36
Cafeteria	0.36

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Custom calculation below, otherwise use deemed values depending on HFHC size⁸²

Cabinet Size	Savings (kWh)
Full Size HFHC	9308
¾ Size HFHC	3942
½ Size HFHC	2628

$$\Delta kWh = HFHC_{Baseline} kWh - HFHC_{ENERGYSTAR} kWh$$

Where:

$$HFHC_{Baseline} kWh = Power_{Baseline} * HOURS_{day} * Days / 1000$$

Power_{Baseline} = Custom, otherwise

Cabinet Size	Power (W)
Full Size HFHC	2500
¾ Size HFHC	1200
½ Size HFHC	800

- HOURS_{day} = Average Daily Operation
- = custom or if unknown, use 15 hours
- Days = Annual days of operation

⁸¹Values taken from Minnesota Technical Reference Manual, ‘Electric Oven and Range’ measure and is based upon “Project on Restaurant Energy Performance-End-Use Monitoring and Analysis”, Appendixes I and II, Claar, et. al., May 1985

⁸² Algorithms and assumptions derived from ENERGY STAR Commercial Kitchen Equipment Savings Calculator. http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COG

$\text{HFHCENERGYSTAR kWh} = \text{PowerENERGYSTAR} * \text{HOURSday} * \text{Days}/1000$
 = custom or if unknown, use 365.25 days a year
 $\text{PowerENERGYSTAR} = \text{Custom, otherwise}$

Cabinet Size	Power (W)
Full Size HFHC	800
¾ Size HFHC	480
½ Size HFHC	320

$\text{HOURSday} = \text{Average Daily Operation}$
 = custom or if unknown, use 15 hours
 $\text{Days} = \text{Annual days of operation}$
 = custom or if unknown, use 365.25 days a year

For example, if a full size HFHC is installed the measure would save:

$$\begin{aligned} \Delta \text{kWh} &= (\text{PowerBaseline} * \text{HOURSday} * \text{Days})/1000 - (\text{PowerENERGYSTAR} * \text{HOURSday} * \text{Days})/1000 \\ &= (2500 * 15 * 365.25)/1000 - (800 * 15 * 365.25)/1000 \\ &= 9,314 \text{ kWh} \end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta \text{kW} = \Delta \text{kWh}/\text{Hours} * \text{CF}$
 Where: $\text{Hours} = \text{Hoursday} * \text{Days}$

For example, if a full size HFHC is installed in a cafeteria the measure would save:

$$\begin{aligned} &= 9,314 \text{ kWh} / (15 * 365.25) * .36 \\ &= 0.61 \text{ kW} \end{aligned}$$

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-ESHH-V02-160601

4.2.10 ENERGY STAR Ice Maker

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 excludes flake and nugget type ice machines. 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.

This measure was developed to be applicable to the following program types: TOS and NC. If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to be a new 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 LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 10 years⁸³.

DEEMED MEASURE COST

The incremental capital cost for this measure is provided below.⁸⁴

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

LOADSHAPE

Loadshape C23 - Commercial Refrigeration

⁸³DEER 2008

⁸⁴These 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%20Electric%20Measure%20Workpapers%2011-08-05.DOC>>.

COINCIDENCE FACTOR

The Summer Peak Coincidence Factor is assumed to equal 0.937

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta \text{kWh} = [(\text{kWh}_{\text{base}} - \text{kWh}_{\text{ee}}) / 100] * (\text{DC} * \text{H}) * 365.25$$

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	$\text{kWh}_{\text{base}}^{85}$	$\text{kWh}_{\text{ee}}^{86}$
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 kWh_{base} and kWh_{ee} into maximum kWh consumption per pound of ice.

DC = Duty Cycle of the ice machine
 = 0.57⁸⁷

⁸⁵Baseline 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>>.

⁸⁶ENERGY 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>

⁸⁷Duty cycle varies considerably from one installation to the next. TRM assumptions from Vermont, Wisconsin, and New York

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

For example an ice machine with an ice making head producing 450 pounds of ice would save

$$\Delta \text{kWh} = [(6.4 - 5.8) / 100] * (0.57 * 450) * 365.25$$

$$= 562 \text{ kWh}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

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

Where:

HOURS = annual operating hours
 = 8766⁸⁸
 CF = 0.937

For example an ice machine with an ice making head producing 450 pounds of ice would save

$$\Delta \text{kW} = 562 / (8766 * 0.57) * .937$$

$$= 0.105 \text{ kW}$$

NATURAL GAS ENERGY SAVINGS

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 Directory⁸⁹ 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

MEASURE CODE: CI-FSE-ESIM-V01-120601

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). The value of 57% was utilized since it appears to represent a high quality data source.

⁸⁸Unit is assumed to be connected to power 24 hours per day, 365.25 days per year.

⁸⁹AHRI Certification Directory, Accessed on 7/7/10. <<http://www.ahridirectory.org/ahridirectory/pages/home.aspx>>

4.2.11 High Efficiency Pre-Rinse Spray Valve

DESCRIPTION

Pre-rinse valves use a spray of water to remove food waste from dishes prior to cleaning in a dishwasher. More efficient spray valves use less water thereby reducing water consumption, water heating cost, and waste water (sewer) charges. Pre-rinse spray valves include a nozzle, squeeze lever, and dish guard bumper. The primary impacts of this measure are water savings. Reduced hot water consumption saves either natural gas or electricity, depending on the type of energy the hot water heater uses.

This measure was developed to be applicable to the following program types: TOS, RF, and DI. If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure, the new or replacement pre-rinse spray nozzle must use less than 1.6 gallons per minute with a cleanability performance of 26 seconds per plate or less.

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment will vary based on the delivery method and is defined below:

Time of Sale	Retrofit, Direct Install
The baseline equipment is assumed to be 1.6 gallons per minute. The Energy Policy Act (EPAAct) of 2005 sets the maximum flow rate for pre-rinse spray valves at 1.6 gallons per minute at 60 pounds per square inch of water pressure when tested in accordance with ASTM F2324-03. This performance standard went into effect January 1, 2006.	The baseline equipment is assumed to be an existing pre-rinse spray valve with a flow rate of 1.9 gallons per minute. ⁹⁰ If existing pre-rinse spray valve flow rate is unknown, then existing pre-rinse spray valve must have been installed prior to 2006. The Energy Policy Act (EPAAct) of 2005 sets the maximum flow rate for pre-rinse spray valves at 1.6 gallons per minute at 60 pounds per square inch of water pressure when tested in accordance with ASTM F2324-03. This performance standard went into effect January 1, 2006. However, field data shows that not all nozzles in use have been replaced with the newer flow rate nozzle. Products predating this standard can use up to five gallons per minute

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 5 years⁹¹

DEEMED MEASURE COST

The cost of this measure is assumed to be \$100⁹²

LOADSHAPE

Loadshape C01 - Commercial Electric Cooking

COINCIDENCE FACTOR

N/A

⁹⁰ Verification measurements taken at 195 installations showed average pre and post flowrates of 2.23 and 1.12 gallon per minute, respectively." from IMPACT AND PROCESS EVALUATION FINAL REPORT for CALIFORNIA URBAN WATER CONSERVATION COUNCIL 2004-5 PRE-RINSE SPRAY VALVE INSTALLATION PROGRAM (PHASE 2) (PG&E Program # 1198-04; SoCalGas Program 1200-04) ("CUWCC Report", Feb 2007)

⁹¹Reference 2010 Ohio Technical Reference Manual, Act on Energy Business Program Technical Reference Manual Rev05, and Federal Energy Management Program (2004), "How to Buy a Low-Flow Pre-Rinse Spray Valve."

⁹²Costs range from \$60 Chicagoland (Integrus for North Shore & People's Gas) to \$150 referenced by Nicor's CLEARresultWorkpaper WPRSGCCODHW102 "Pre-Rinse Spray Valve." Act on Energy references \$100.

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS (NOTE WATER SAVINGS MUST FIRST BE CALCULATED)

$$\Delta kWh = \Delta Gallons * 8.33 * 1 * (T_{out} - T_{in}) * (1/EFF_Elec) / 3,413 * FLAG$$

Where:

- $\Delta Gallons$ = amount of water saved as calculated below
- 8.33 = specific mass in pounds of one gallon of water (lbm/gal)
- 1 = Specific heat of water: 1 Btu/lbm/°F
- T_{out} = Water Heater Outlet Water Temperature
= custom, otherwise assume $T_{in} + 70^{\circ}F$ temperature rise from T_{in} ⁹³
- T_{in} = Inlet Water Temperature
= custom, otherwise assume $54.1^{\circ}F$ ⁹⁴
- EFF_Elec = Efficiency of electric water heater supplying hot water to pre-rinse spray valve
= custom, otherwise assume 97%⁹⁵
- Flag = 1 if electric or 0 if gas

EXAMPLE

Time of Sale: For example, a new spray nozzle with 1.06 gal/min flow replacing a nozzle with 1.6 gal/min flow at a large institutional establishments with a cafeteria with 70 degree temperature rise of water used by the pre-rinse spray valve that is heated by electric hot water saves annually :

$$\begin{aligned} \Delta kWh &= 30,326 \times 8.33 \times 1 \times ((70+54.1) - 54.1) \times (1/.97) / 3,413 \times 1 \\ &= 5,341 kWh \end{aligned}$$

Retrofit: For example, a new spray nozzle with 1.06 gal/min flow replacing a nozzle with 1.9 gal/min flow at a large institutional establishments with a cafeteria with 70 degree temperature rise of water used by the pre-rinse spray valve that is heated by electric hot water equals:

$$\begin{aligned} \Delta kWh &= 47,175 \times 8.33 \times 1 \times ((70+ 54.1) - 54.1) \times (1/.97) / 3,413 \times 1 \\ &= 8309 kWh \end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

⁹³If unknown, assume a 70 degree temperature rise from T_{in} per Food Service Technology Center calculator assumptions to account for variations in mixing and water heater efficiencies

⁹⁴August 31, 2011 Memo of Savings for Hot Water Savings Measures to Nicor Gas from Navigant states that $54.1^{\circ}F$ was calculated from the weighted average of monthly water mains temperatures reported in the 2010 Building America Benchmark Study for Chicago-Waukegan, Illinois.

⁹⁵This efficiency value is based on IECC 2012/2015 performance requirement for electric resistant water heaters rounded without the slight adjustment allowing for reduction based on size of storage tank.

NATURAL GAS ENERGY SAVINGS

$$\Delta\text{Therms} = \Delta\text{Gallons} * 8.33 * 1 * (\text{Tout} - \text{Tin}) * (1/\text{EFF_Gas}) / 100,000 * (1 - \text{FLAG})$$

Where (new variables only):

$$\begin{aligned} \text{EFF_Gas} &= \text{Efficiency of gas water heater supplying hot water to pre-rinse spray valve} \\ &= \text{custom, otherwise assume } 80\%^{96} \end{aligned}$$

EXAMPLE

Time of Sale: For example, a new spray nozzle with 1.06 gal/min flow replacing a nozzle with 1.6 gal/min flow at a large institutional establishments with a cafeteria with 70 degree temperature of water used by the pre-rinse spray valve that is heated by fossil fuel hot water saves annually:

$$\begin{aligned} \Delta\text{Therms} &= 30,326 * 8.33 * 1 * ((70+54.1) - 54.1) * (1/.80) / 100,000 * (1-0) \\ &= 221 \text{ Therms} \end{aligned}$$

Retrofit: For example, a new spray nozzle with 1.06 gal/min flow replacing a nozzle with 1.9 gal/min flow at a busy large institutional establishments with a cafeteria with 70 degree temperature rise of water used by the pre-rinse spray valve that is heated by fossil fuel hot water saves annually:

$$\begin{aligned} \Delta\text{Therms} &= 47,175 * 8.33 * 1 * ((70+54.1) - 54.1) * (1/.80) / 100,000 * (1-0) \\ &= 344 \text{ Therms} \end{aligned}$$

WATER IMPACT CALCULATION⁹⁷

$$\Delta\text{Gallons} = (\text{FLObase} - \text{FLOeff}) * 60 * \text{HOURSday} * \text{DAYYear}$$

Where:

$$\text{FLObase} = \text{Base case flow in gallons per minute, or custom (Gal/min)}$$

Time of Sale	Retrofit, Direct Install
1.6 gal/min ⁹⁸	1.9 gal/min ⁹⁹

$$\text{FLOeff} = \text{Efficient case flow in gallons per minute or custom (Gal/min)}$$

Time of Sale	Retrofit, Direct Install
1.06 gal/min ¹⁰⁰	1.06 gal/min ¹⁰¹

⁹⁶ IECC 2012/2015, Table C404.2, Minimum Performance of Water-Heating Equipment

⁹⁷In order to calculate energy savings, water savings must first be calculated

⁹⁸The baseline equipment is assumed to be 1.6 gallons per minute. The Energy Policy Act (EPAct) of 2005 sets the maximum flow rate for pre-rinse spray valves at 1.6 gallons per minute at 60 pounds per square inch of water pressure when tested in accordance with ASTM F2324-03. This performance standard went into effect January 1, 2006.

www1.eere.energy.gov/femp/pdfs/spec_prerinsesprayvavles.pdf.

⁹⁹ Verification measurements taken at 195 installations showed average pre and post flowrates of 2.23 and 1.12 gallon per minute, respectively." from IMPACT AND PROCESS EVALUATION FINAL REPORT for CALIFORNIA URBAN WATER CONSERVATION COUNCIL 2004-5 PRE-RINSE SPRAY VALVE INSTALLATION PROGRAM (PHASE 2) (PG&E Program # 1198-04; SoCalGas Program 1200-04) ("CUWCC Report", Feb 2007)

¹⁰⁰1.6 gallons per minute used to be the high efficiency flow, but more efficient spray valves are available ranging down to 0.64 gallons per minute per Federal Energy Management Program which references the Food Services Technology Center web site with the added note that even more efficient models may be available since publishing the data. The average of the nozzles

60 = Minutes per hour

HOURS_{day} = Hours per day that the pre-rinse spray valve is used at the site, custom, otherwise¹⁰²:

Application	Hours/day
Small, quick- service restaurants	1
Medium-sized casual dining restaurants	1.5
Large institutional establishments with cafeteria	3

DAYS_{year} = Days per year pre-rinse spray valve is used at the site, custom, otherwise 312 days/yr based on assumed 6 days/wk x 52 wk/yr = 312 day/yr.

EXAMPLE

Time of Sale: For example, a new spray nozzle with 1.06 gal/min flow replacing a nozzle with 1.6 gal/min flow at a large institutional establishment with a cafeteria equals

$$= (1.6 - 1.06) * 60 * 3 * 312$$

$$= 30,326 \text{ gal/yr}$$

Retrofit: For example, a new spray nozzle with 1.06 gal/min flow replacing a nozzle with 1.9 gal/min flow at a large institutional establishments with a cafeteria equals

$$= (1.9 - 1.06) * 60 * 3 * 312$$

$$= 47,175 \text{ gal/yr}$$

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-SPRY-V03-160601

listed on the FSTC website is 1.06.

¹⁰¹1.6 gallons per minute used to be the high efficiency flow, but more efficient spray valves are available ranging down to 0.64 gallons per minute per Federal Energy Management Program which references the Food Services Technology Center web site with the added note that even more efficient models may be available since publishing the data. The average of the nozzles listed on the FSTC website is 1.06.

¹⁰² Hours primarily based on PG& E savings estimates, algorithms, sources (2005), Food Service Pre-Rinse Spray Valves with review of 2010 Ohio Technical Reference Manual and Act on Energy Business Program Technical Resource Manual Rev05.

4.2.12 Infrared Charbroiler

DESCRIPTION

This measure applies to natural gas fired charbroilers that utilize infrared burners installed in a commercial kitchen. This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a new natural gas charbroiler with infrared burners.

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is an existing natural gas charbroiler without infrared burners.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years¹⁰³

DEEMED MEASURE COST

The incremental capital cost for this measure is \$2200¹⁰⁴

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

The annual natural gas energy savings from this measure is a deemed value equaling 661 Therms.¹⁰⁵

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

¹⁰³Food Service Technology Center, ENERGY STAR and CEE do not currently provide calculators for this type of equipment therefore deemed values from Nicor Gas were used. Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011

¹⁰⁴Ibid.

¹⁰⁵ Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011. These deemed values should be compared to PY evaluation and revised as necessary.

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-IRCB-V01-120601

4.2.13 Infrared Rotisserie Oven

DESCRIPTION

This measure applies to natural gas fired high efficiency rotisserie ovens utilizing infrared burners and installed in a commercial kitchen.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a new natural gas rotisserie oven with infrared burners.

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is an existing natural gas rotisserie oven without infrared burners.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years¹⁰⁶

DEEMED MEASURE COST

The incremental capital cost for this measure is \$2700¹⁰⁷

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

The annual natural gas energy savings from this measure is a deemed value equaling 554 Therms¹⁰⁸

¹⁰⁶Food Service Technology Center, ENERGY STAR and CEE do not currently provide calculators for this type of equipment therefore deemed values from Nicor Gas were used. Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011

¹⁰⁷Ibid.

¹⁰⁸Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011. These deemed values should be compared to PY evaluation and revised as necessary.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-IROV-V01-120601

4.2.14 Infrared Salamander Broiler

DESCRIPTION

This measure applies to natural gas fired high efficiency salamander broilers utilizing infrared burners installed in a commercial kitchen.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a new natural gas salamander broiler with infrared burners

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is an existing natural gas salamander broiler without infrared burners

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years¹⁰⁹

DEEMED MEASURE COST

The incremental capital cost for this measure is \$1000¹¹⁰

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

The annual natural gas energy savings from this measure is a deemed value equaling 239 therms¹¹¹

¹⁰⁹Food Service Technology Center, ENERGY STAR and CEE do not currently provide calculators for this type of equipment therefore deemed values from Nicor Gas were used. Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011

¹¹⁰Ibid.

¹¹¹ Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011. These deemed values should be compared to PY evaluation and revised as necessary.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-IRBL-V01-120601

4.2.15 Infrared Upright Broiler

DESCRIPTION

This measure applies to natural gas fired high efficiency upright broilers utilizing infrared burners and installed in a commercial kitchen.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a new natural gas upright broiler with infrared burners.

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is an existing natural gas upright broiler without infrared burners.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 10 years¹¹²

DEEMED MEASURE COST

The incremental capital cost for this measure is \$5900¹¹³

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

The annual natural gas energy savings from this measure is a deemed value equaling 1089 therms¹¹⁴.

¹¹²Food Service Technology Center, ENERGY STAR and CEE do not currently provide calculators for this type of equipment therefore deemed values from Nicor Gas were used. Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011

¹¹³ibid.

¹¹⁴ Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011. These deemed values should be compared to PY evaluation and revised as necessary

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-IRUB-V01-120601

4.2.16 Kitchen Demand Ventilation Controls

DESCRIPTION

Installation of commercial kitchen demand ventilation controls that vary the ventilation based on cooking load and/or time of day.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a control system that varies the exhaust rate of kitchen ventilation (exhaust and/or makeup air fans) based on the energy and effluent output from the cooking appliances (i.e., the more heat and smoke/vapors generated, the more ventilation needed). This involves installing a new temperature sensor in the hood exhaust collar and/or an optic sensor on the end of the hood that sense cooking conditions which allows the system to automatically vary the rate of exhaust to what is needed by adjusting the fan speed accordingly.

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is kitchen ventilation that has constant speed ventilation motor.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 15 years.¹¹⁵

DEEMED MEASURE COST

The incremental capital cost for this measure is¹¹⁶

Measure Category	Incremental Cost , \$/fan
DVC Control Retrofit	\$1,988
DVC Control New	\$1,000

LOADSHAPE

Loadshape C23 - Commercial Ventilation

COINCIDENCE FACTOR

The measure has deemed peak kW savings therefore a coincidence factor does not apply

¹¹⁵ PG&E Workpaper: Commercial Kitchen Demand Ventilation Controls-Electric, 2004 - 2005

¹¹⁶ Ibid.

Algorithm

CALCULATION OF SAVINGS

Annual energy use was based on monitoring results from five different types of sites, as summarized in PG&E Food Service Equipment work paper.

ELECTRIC ENERGY SAVINGS

The following table provides the kWh savings

Measure Name	Annual Energy Savings Per Unit (kWh/fan)
DVC Control Retrofit	4,486
DVC Control New	4,486

SUMMER COINCIDENT PEAK DEMAND SAVINGS

The following table provides the kW savings

Measure Name	Coincident Peak Demand Reduction (kW)
DVC Control Retrofit	0.76
DVC Control New	0.76

NATURAL GAS ENERGY SAVINGS

$$\Delta\text{Therms} = \text{CFM} * \text{HP} * \text{Annual Heating Load} / (\text{Eff}(\text{heat}) * 100,000)$$

Where:

CFM = the average airflow reduction with ventilation controls per hood

$$= 611 \text{ cfm/HP}^{117}$$

HP = actual if known, otherwise assume 7.75 HP

Annual Heating Load = Annual heating energy required to heat fan exhaust make-up air, Btu/cfm dependent on location¹¹⁸:

Zone	Annual Heating Load, Btu/cfm
1 (Rockford)	154,000

¹¹⁷ PGE Workpaper, Commercial Kitchen Demand Ventilation Controls, PGECOFST116, June 1, 2009, 4,734 cfm reduction on average, with 7.75 fan horsepower on average.

¹¹⁸ Food Service Technology Center Outside Air Load Calculator, <http://www.fishnick.com/ventilation/oalc/oalc.php>, with inputs of one cfm, and hours from Commercial Kitchen Demand Ventilation Controls (Average 17.8 hours a day 4.45 am to 10.30 pm). Savings for Rockford, Chicago, and Springfield were obtained from the calculator; values for Belleview and Marion were obtained by using the average savings per HDD from the other values.

Zone	Annual Heating Load, Btu/cfm
2-(Chicago)	144,000
3 (Springfield)	132,000
4-(Belleville)	102,000
5-(Marion)	104,000

Eff(heat) = Heating Efficiency
 = actual if known, otherwise assume 80%¹¹⁹
 100,000 = conversion from Btu to Therm

EXAMPLE

For example, a kitchen hood in Rockford, IL with a 7.75 HP ventilation motor

$$\Delta\text{Therms} = 611 * 7.75 * 154,000 / (0.80 * 100,000)$$

$$= 9,115 \text{ Therms}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-VENT-V02-140601

¹¹⁹Work Paper WPRRSGNGRO301 CLEAResult "Boiler Tune-Up" which cites Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0, PA Consulting, KEMA, March 22, 2010

4.2.17 Pasta Cooker

DESCRIPTION

This measure applies to natural gas fired dedicated pasta cookers as determined by the manufacturer and installed in a commercial kitchen.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a new natural gas fired pasta cooker.

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is an existing natural gas fired stove where pasta is cooked in a pan.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12¹²⁰.

DEEMED MEASURE COST

The incremental capital cost for this measure is \$2400¹²¹.

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

The annual natural gas energy savings from this measure is a deemed value equaling 1380 Therms¹²².

¹²⁰Food Service Technology Center, ENERGY STAR and CEE do not currently provide calculators for this type of equipment therefore deemed values from Nicor Gas were used. Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011

¹²¹Ibid.

¹²²Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011. These deemed values should be compared to PY evaluation and revised as necessary.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-PCOK-V01-120601

4.2.18 Rack Oven - Double Oven

DESCRIPTION

This measure applies to natural gas fired high efficiency rack oven - double oven installed in a commercial kitchen.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a new natural gas rack oven –double oven with a baking efficiency \geq 50% utilizing ASTM standard 2093

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is an existing natural gas rack oven – double oven with a baking efficiency $<$ 50%.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years.¹²³

DEEMED MEASURE COST

The incremental capital cost for this measure is \$8646.¹²⁴

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

The annual natural gas energy savings from this measure is a deemed value equaling 2064 therms¹²⁵

¹²³Food Service Technology Center, ENERGY STAR and CEE do not currently provide calculators for this type of equipment therefore deemed values from Nicor Gas were used. Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011

¹²⁴Ibid.

¹²⁵Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011. These deemed values should be compared to PY evaluation and revised as necessary

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE CI-FSE-RKOV-VO1-120601

4.2.19 ENERGY STAR Electric Convection Oven

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.

This measure was developed to be applicable to the following program types; TOS.

If applied to other program types, the measure savings should be verified.

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 LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years.¹²⁶

DEEMED MEASURE COST

The incremental cost for this measure is assumed to be \$800 for half size units and \$1000 for full size¹²⁷

LOADSHAPE

Loadshape C01 - Commercial Electric Cooking

COINCIDENCE FACTOR

Summer Peak Coincidence Factor for measure is provided below for different building type¹²⁸:

Location	CF
Fast Food Limited Menu	0.32
Fast Food Expanded Menu	0.41
Pizza	0.46
Full Service Limited Menu	0.51
Full Service Expanded Menu	0.36
Cafeteria	0.36
Unknown	0.40

¹²⁶ Food Service Technology Center (FSTC). Default value from life cycle cost calculator.

<http://www.fishnick.com/saveenergy/tools/calculators/eovencalc.php>

¹²⁷ Based on data from the Regional Technical Forum for the Northwest Council

(http://rtf.nwcouncil.org/measures/com/ComCookingConvectionOven_v2_0.xlsm) using actual list prices for 23 units from 2012, see "ComCookingConvectionOven_v2_0.xlsm".

¹²⁸Minnesota 2012 Technical Reference Manual, [Electric Food Service_v03.2.xls](#),

<http://mn.gov/commerce/energy/topics/conservation/Design-Resources/Deemed-Savings.jspech>. Unknown is an average of other location types

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

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

$$kWh = [(LB * E_{FOOD}/EFF) + (IDLE * (HOURS_{DAY} - LB/PC - PRE_{TIME}/60)) + PRE_{ENERGY}] * DAYS$$

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

= Actual, defaults:

Type of Food Service	$HOURS_{DAY}$ ¹²⁹
Fast Food, limited menu	4
Fast Food, expanded menu	5
Pizza	8
Full Service, limited menu	8
Full Service, expanded menu	7
Cafeteria	6
Unknown	6 ¹³⁰
Custom	Varies

$DAYS$ = Days per year of operation

= Actual, default = 365¹³¹

PRE_{TIME} = Preheat time (min/day), the amount of time it takes a steamer to reach operating temperature when turned on

= 15 min/day¹³²

¹²⁹Minnesota 2012 Technical Reference Manual, Electric Food Service_v03.2.xls, <http://mn.gov/commerce/energy/topics/conservation/Design-Resources/Deemed-Savings.jspech>

¹³⁰Unknown is average of other locations

¹³¹ Food Service Technology Center (FSTC). Default value from life cycle cost calculator.

<http://www.fishnick.com/saveenergy/tools/calculators/eovencalc.php>

¹³² Food Service Technology Center (2002). *Commercial Cooking Appliance Technology Assessment*. Prepared by Don Fisher. Chapter 7: Ovens

- E_{FOOD} = ASTM Energy to Food (kWh/lb); the amount of energy absorbed by the food during cooking, per pound of food
= 0.0732¹³³
- LB = pounds of food cooked per day (lb/day)
= Actual, default = 100¹³⁴
- 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

Metric	Baseline Model ¹³⁵	Energy Efficient Model ¹³⁶
PRE _{ENERGY} (kWh)	1.5	1
IDLE (kW)	2	Actual, default = 1.0
EFF	65%	Actual, default = 74%
PC (lb/hr)	70	Actual, default = 79

¹³³ American Society for Testing and Materials. Industry standard for Commercial Ovens

¹³⁴ Food Service Technology Center (FSTC). Default value from life cycle cost calculator.
<http://www.fishnick.com/saveenergy/tools/calculators/eovencalc.php>

¹³⁵ Food Service Technology Center (FSTC). Default values from life cycle cost calculator.
<http://www.fishnick.com/saveenergy/tools/calculators/eovencalc.php>

¹³⁶ Average ratings of units on ENERGY STAR qualified list as of 10/2014. Preheat energy is not provided so default is provided based on FSTC life cycle cost calculator.

EXAMPLE

Using defaults provided above, the savings for a ENERGY STAR Electric Convection Oven in unknown location are:

$$\begin{aligned}
 \text{kWh}_{\text{base}} &= [(100 * 0.0732/0.65) + (2 * (6 - 100/70 - 15/60)) + 1.5] * 365 \\
 &= 7,813 \text{ kWh} \\
 \text{kWh}_{\text{eff}} &= [(100 * 0.0732/0.74) + (1 * (6 - 100/79 - 15/60)) + 1.0] * 365 \\
 &= 5,612 \text{ kWh} \\
 \Delta\text{kWh} &= \text{kWh}_{\text{base}} - \text{kWh}_{\text{eff}} \\
 &= 7,813 - 5,612 \\
 &= 2200 \text{ kWh}
 \end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta\text{kW} = (\Delta\text{kWh} / (\text{HOURS}_{\text{DAY}} * \text{DAYS})) * \text{CF}$$

Where:

ΔkWh = Annual energy savings (kWh)

CF = Summer Peak Coincidence Factor for measure is provided below for different building type¹³⁷:

Location	CF
Fast Food Limited Menu	0.32
Fast Food Expanded Menu	0.41
Pizza	0.46
Full Service Limited Menu	0.51
Full Service Expanded Menu	0.36
Cafeteria	0.36
Unknown	0.40

EXAMPLE

Using defaults provided above, the savings for a ENERGY STAR Electric Convection Oven in unknown location are:

$$\begin{aligned}
 \Delta\text{kW} &= (2200 / (6 * 365)) * 0.40 \\
 &= 0.40
 \end{aligned}$$

¹³⁷Minnesota 2012 Technical Reference Manual, [Electric Food Service v03.2.xls](http://mn.gov/commerce/energy/topics/conservation/Design-Resources/Deemed-Savings.ispech), <http://mn.gov/commerce/energy/topics/conservation/Design-Resources/Deemed-Savings.ispech>. Unknown is an average of other location types

FOSSIL FUEL IMPACT DESCRIPTIONS AND CALCULATION

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE CI-FSE-ECON-VO1-150601

4.3 Hot Water

4.3.1 Storage Water Heater

DESCRIPTION

This measure is for upgrading from minimum code to a high efficiency storage-type water heater. Storage water heaters are used to supply hot water for a variety of commercial building types. Storage capacities vary greatly depending on the application. Large consumers of hot water include (but not limited to) industries, hotels/motels and restaurants.

This measure was developed to be applicable to the following program types: TOS.

If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

The minimum specifications of the high efficiency equipment should be defined by the programs.

DEFINITION OF BASELINE EQUIPMENT

The baseline condition is assumed to be a new standard water heater of same type as existing, meeting the Federal Standard for <75,000 Btuh units and IECC 2015 for all others. If existing type is unknown, assume Gas Storage Water Heater.

Equipment Type	Sub Category	Federal Standard Minimum Efficiency ¹³⁸
Gas Storage Water Heaters ≤ 75,000 Btu/h	≤55 gallon tanks	0.675 – (0.0015 * Rated Storage Volume in Gallons) EF
	>55 gallon tanks	0.8012 – (0.00078 * Rated Storage Volume in Gallons) EF
Gas Storage Water Heaters > 75,000 Btu/h	< 4000 Btu/h/gal	80% E _t Standby Loss: (Q/800 + 110vV)
Electric Water Heaters ≤ 75,000 Btu/h	≤55 gallon tanks	0.96 – (0.0003 * rated volume in gallons) EF
	>55 gallon tanks ¹³⁹	2.057 – (0.00113 * rated volume in gallons) EF
Electric Water Heaters > 75,000 Btu/h	≤12 kW	0.97 – (0.00132 * rated volume in gallons) EF
	> 12kW	Standby Loss: 0.30 + 27/V _m (%/hr)

V= Rated volume in gallons, V_m = measured volume in gallons.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 15 Years¹⁴⁰

DEEMED MEASURE COST

The full install cost and incremental cost assumptions are provided below. Actual costs should be used where available¹⁴¹:

¹³⁸ ≤75,000 Btu/h Storage Water Heater and <200,000 Btu/h Tankless Water Heater Federal Standard is DOE Standard 10 CFR 430.32(d). All other standards are from 10 CFR 431.110.

¹³⁹ It is assumed that tanks <75,000Btu/h and >55 gallons will not be eligible measures due to the high baseline.

¹⁴⁰ DEER 08, EUL_Summary_10-1-08.xls.

¹⁴¹ Cost information is based upon data from “2010-2012 WA017 Ex Ante Measure Cost Study Draft Report”, Itron, February 28, 2014. See “NR HW Heater_WA017_MCS Results Matrix - Volume I.xls” for more information.

Equipment Type	Category	Install Cost	Incremental Cost
Gas Storage Water Heaters ≤ 75,000 Btu/h, ≤55 Gallons	Baseline	\$616	N/A
	Efficient	\$1,055	\$440
Gas Storage Water Heaters > 75,000 Btu/h	0.80 Et	\$4,886	N/A
	0.83 Et	\$5,106	\$220
	0.84 Et	\$5,299	\$413
	0.85 Et	\$5,415	\$529
	0.86 Et	\$5,532	\$646
	0.87 Et	\$5,648	\$762
	0.88 Et	\$5,765	\$879
	0.89 Et	\$5,882	\$996
	0.90 Et	\$6,021	\$1,135

For electric water heaters the incremental capital cost for this measure is assumed to be¹⁴²

Tank Size	Incremental Cost
50 gallons	\$1050
80 gallons	\$1050
100 gallons	\$1950

LOADSHAPE

For electric hot water heaters, use Loadshape C02 - Non-Residential Electric DHW.

COINCIDENCE FACTOR

The coincidence factor is assumed to be 0.925¹⁴³.

¹⁴² Act on Energy Commercial Technical Reference Manual, Table 9.6.1-4

¹⁴³ Coincidence factor based on Average W in peak period/Max W from Itron eShape data for Missouri, calibrated to Illinois loads,

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Electric energy savings are calculated for electric storage water heaters per the equations given below.

Electric units ≤12 kW:

$$\Delta kWh = \frac{(T_{out} - T_{in}) * HotWaterUse_{Gallon} * \gamma_{Water} * 1 * \left(\frac{1}{EF_{elecbase}} - \frac{1}{EF_{Eff}} \right)}{3412}$$

Where:

T_{OUT} = Tank temperature
 = 125°F

T_{IN} = Incoming water temperature from well or municiple system
 = 54°F¹⁴⁴

HotWaterUse_{Gallon} = Estimated annual hot water consumption (gallons)
 = Actual if possible to provide reasonable custom estimate. If not, two methodologies are provided to develop an estimate:

1. Consumption per water heater capacity
 = Consumption/cap * Capacity

Where:

Consumption/cap = Estimate of consumption per gallon of tank capacity, dependent on building type:¹⁴⁵

Building Type	Consumption/cap
Grocery, Convenience Store, and Restaurant	803
Lodging, Hospital, and Multifamily	630
Health Clinic, Church, Warehouse	433
Education, Office, and Retail	594
Industrial	558
Agriculture	558

¹⁴⁴ US DOE Building America Program. Building America Analysis Spreadsheet. For Chicago, IL http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html

¹⁴⁵ Based on Cadmus analysis. Annual hot water usage in gallons based on CBECS (2003) consumption data of West North Central (removed outliers of 1,000 kBtu/h or less) to calculate hot water usage. Annual hot water gallons per tank size gallons based on the tank sizing methodology found in ASHRAE 2011 HVAC Applications. Chapter 50 Service Water Heating. Demand assumptions (gallons per day) for each building type based on ASHRAE Chapter 50 and to LBNL White Paper. LBL-37398 Technology Data Characterizing Water Heating in Commercial Buildings: Application to End Use Forecasting. VEIC consider these relatively conservative estimates and consider this may be a good variable for future evaluation.

Building Type	Consumption/cap
Average Non Residential	558

Capacity = Capacity of hot water heater in gallons
 = Actual¹⁴⁶

2. Consumption by Facility Size¹⁴⁷

Building Type	Gallons hot water per unit per day	Unit	Units/1000 ft ²	Days per year	Gallons/1000 ft ² floor area
Small Office	1	person	2.3	250	575
Large Office	1	person	2.3	250	575
Fast Food Rest	0.7	meal/day	784.6	365	200,458
Sit-Down Rest	2.4	meal/day	340	365	297,840
Retail	2	employee	1	365	730
Grocery	2	employee	1.1	365	803
Warehouse	2	employee	0.5	250	250
Elementary School	0.6	person	9.5	200	1,140
Jr High/High School	1.8	person	9.5	200	3,420
Health	90	patient	3.8	365	124,830
Motel	20	room	5	365	36,500
Hotel	14	room	2.2	365	11,242
Other	1	employee	0.7	250	175

γ_{Water} = Specific weight capacity of water (lb/gal)
 = 8.33 lbs/gal

1 = Specific heat of water (Btu/lb.°F)

EF_{elecbase} = Rated efficiency of baseline water heater expressed as Energy Factor (EF);

Equipment Type	Sub Category	Federal Standard Minimum Efficiency ¹⁴⁸
Electric Water Heaters ≤ 75,000 Btu/h	≤55 gallon tanks	0.96 – (0.0003 * rated volume in gallons) EF
	>55 gallon tanks ¹⁴⁹	2.057 – (0.00113 * rated volume in gallons) EF
Electric Water Heaters > 75,000 Btu/h	≤12 kW	0.97 – (0.00132 * rated volume in gallons) EF
	> 12kW	N/A (For >12 kW Units see below)

¹⁴⁶ If the replaced unit is a tankless water heater, an estimate will need to be made of the required storage tank for the application.

¹⁴⁷ Osman Sezgen and Jonathan G. Koomey. Lawrence Berkeley National Laboratory 1995; “Technology Data Characterizing Water Heating in Commercial Buildings: Application to End-Use Forecasting”. December 1995.

¹⁴⁸ ≤75,000 Btu/h Storage Water Heater and <200,000 Btu/h Tankless Water Heater Federal Standard is DOE Standard 10 CFR 430.32(d). All other standards are from 10 CFR 431.110.

¹⁴⁹ It is assumed that tanks <75,000Btu/h and >55 gallons will not be eligible measures due to the high baseline.

- EF_{eff} = Rated efficiency of efficient water heater expressed as Energy Factor (EF) or Thermal Efficiency (E_t)
- = Actual
- 3412 = Converts Btu to kWh

For example, for a 200,000 Btu/h, 150 gallon, 90% Thermal Efficiency storage unit with rated standby loss of 1029 BTU/h installed in a 1500 ft² restaurant:

$$\begin{aligned} \Delta kWh &= ((125 - 54) * (297,840 * 1.5) * 8.33 * 1 * (1/0.8 - 1/0.9))/3412 \\ &= 10,756 \text{ kWh} \end{aligned}$$

Electric units > 12kW:

$$\Delta kWh = \frac{(T_{out} - T_{air}) * V * \gamma_{Water} * 1 * (SL_{elecbase} - SL_{eff}) * 8766}{3412}$$

- T_{air} = Ambient Air Temperature
- = 70°F
- V = Rated tank volume in gallons
- = Actual
- SL_{elecbase} = Standby loss of electric baseline unit (%/hr)
- = 0.30 + 27/V
- SL_{eff} = Nameplate standby loss of new water heater, in BTU/h
- 8766 = Hours per year

For example, >12kW, 100 gallon storage unit with rated standby loss of 0.5 %/hr:

$$\begin{aligned} SL_{base} &= 0.3 + (27 / 100) \\ &= 0.57\%/hr \\ \Delta kWh &= (((125 - 70) * 100 * 8.33 * 1 * (0.57 - 0.5)) * 8766)/3412 \\ &= 8,239 \text{ kWh} \end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \frac{\Delta kWh}{Hours} * CF$$

Where:

- Hours = Full load hours of water heater
- = 6461¹⁵⁰

¹⁵⁰ Full load hours assumption based on Wh/Max W Ratio from Itron eShape data for Missouri, calibrated to Illinois loads,

CF = Summer Peak Coincidence Factor for measure
 = 0.925¹⁵¹

For example, >12kW, 100 gallon storage unit with rated standby loss of 0.5 %/hr:

$\Delta kW = 8,239 / 6,461 * 0.925$
 $= 1.18 \text{ kW}$

NATURAL GAS ENERGY SAVINGS

Natural gas energy savings are calculated for natural gas storage water heaters per the equations given below.

$$\Delta Therms = \frac{(T_{out} - T_{in}) * HotWaterUse_{Gallon} * \gamma_{Water} * 1 * \left(\frac{1}{EF_{gasbase}} - \frac{1}{EF_{Eff}} \right)}{100,000}$$

Where:

100,000 = Converts Btu to Therms

EF_{gasbase} = Rated efficiency of baseline water heater expressed as Energy Factor (EF) or Thermal Efficiency (E_t);

Equipment Type	Sub Category	Federal Standard Minimum Efficiency ¹⁵²
Gas Storage Water Heaters ≤ 75,000 Btu/h	≤55 gallon tanks	0.675 – (0.0015 * Rated Storage Volume in Gallons) EF
	>55 gallon tanks	0.8012 – (0.00078 * Rated Storage Volume in Gallons) EF
Gas Storage Water Heaters > 75,000 Btu/h	< 4000 Btu/h/gal	80% E _t

Additional Standby Loss Savings

Gas Storage Water Heaters >75,000 Btu/h can claim additional savings due to lower standby losses.

$$\Delta Therms_{Standby} = \frac{(SL_{gasbase} - SL_{eff}) * 8766}{100,000}$$

Where:

SL_{gasbase} = Standby loss of gas baseline unit (Btu/h)

$$= Q/800 + 110\sqrt{V}$$

Q = Nameplate input rating in Btu/h

V = Rated volume in gallons

SL_{eff} = Nameplate standby loss of new water heater, in Btu/h

8766 = Hours per year

¹⁵¹ Coincidence factor based on Average W in peak period/Max W from Itron eShape data for Missouri, calibrated to Illinois loads,

¹⁵² ≤75,000 Btu/h Storage Water Heater and <200,000 Btu/h Tankless Water Heater Federal Standard is DOE Standard 10 CFR 430.32(d). All other standards are from 10 CFR 431.110.

For example, for a 200,000 Btu/h, 150 gallon, 90% Thermal Efficiency storage unit with rated standby loss of 1029 BTU/h installed in a 1500 ft² restaurant:

$$\begin{aligned} \Delta\text{Therms} &= ((125 - 54) * (297,840 * 1.5) * 8.33 * 1 * (1/0.8 - 1/0.9))/100,000 \\ &= 367.0 \text{ Therms} \end{aligned}$$

$$\begin{aligned} \Delta\text{Therms}_{\text{Standby}} &= (((200000/800 + 110 * \sqrt{150}) - 1079) * 8766)/100,000 \\ &= 49.8 \text{ Therms} \end{aligned}$$

$$\begin{aligned} \Delta\text{Therms}_{\text{Total}} &= 367.0 + 49.8 \\ &= 416.8 \text{ Therms} \end{aligned}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HW_-STWH-V02-160601

4.3.2 Low Flow Faucet Aerators

DESCRIPTION

This measure relates to the direct installation of a low flow faucet aerator in a commercial building. Expected applications include small business, office, restaurant, or motel. For multifamily or senior housing, the residential low flow faucet aerator should be used.

This measure was developed to be applicable to the following program types, DI.

If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be an energy efficient faucet aerator, for bathrooms rated at 1.5 gallons per minute (GPM) or less, or for kitchens rated at 2.2 GPM or less. Savings are calculated on an average savings per faucet fixture basis.

DEFINITION OF BASELINE EQUIPMENT

The baseline condition is assumed to be a standard bathroom faucet aerator rated at 2.25 GPM or more, or a standard kitchen faucet aerator rated at 2.75 GPM or more. Note if flow rates are measured, for example through a Direct Install program, then actual baseline flow rates should be used as opposed to the deemed values.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 9 years.¹⁵³

DEEMED MEASURE COST

The incremental cost for this measure is \$8¹⁵⁴ or program actual.

LOADSHAPE

Loadshape CO2 - Commercial Electric DHW

COINCIDENCE FACTOR

The coincidence factor for this measure is dependent on building type as presented below.

¹⁵³ Table C-6, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. "http://neep.org/Assets/uploads/files/emv/emv-library/measure_life_GDS%5B1%5D.pdf"

¹⁵⁴ Direct-install price per faucet assumes cost of aerator and install time. (2011, Market research average of \$3 and assess and install time of \$5 (20min @ \$15/hr)

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

NOTE THESE SAVINGS ARE PER FAUCET RETROFITTED¹⁵⁵.

$$\Delta kWh = \%ElectricDHW * ((GPM_base - GPM_low)/GPM_base) * Usage * EPG_electric * ISR$$

Where:

%ElectricDHW = proportion of water heating supplied by electric resistance heating

DHW fuel	%Electric_DHW
Electric	100%
Fossil Fuel	0%

GPM_base = Average flow rate, in gallons per minute, of the baseline faucet “as-used”
 = 1.39¹⁵⁶ or custom based on metering studies¹⁵⁷ or if measured during DI:
 = Measured full throttle flow * 0.83 throttling factor¹⁵⁸

GPM_low = Average flow rate, in gallons per minute, of the low-flow faucet aerator “as-used”
 = 0.94¹⁵⁹ or custom based on metering studies¹⁶⁰ or if measured during DI:
 = Rated full throttle flow * 0.95 throttling factor¹⁶¹

¹⁵⁵ This algorithm calculates the amount of energy saved per aerator by determining the fraction of water consumption savings for the upgraded fixture. Due to the distribution of water consumption by fixture type, as well as the different number of fixtures in a building, several variables must be incorporated.

¹⁵⁶ DeOreo, B., and P. Mayer. Residential End Uses of Water Study Update. Forthcoming. ©2015 Water Research Foundation. Reprinted With Permission.

¹⁵⁷ Measurement should be based on actual average flow consumed over a period of time rather than a onetime spot measurement for maximum flow. Studies have shown maximum flow rates do not correspond well to average flow rate due to occupant behavior which does not always use maximum flow.

¹⁵⁸ 2008, Schultdt, Marc, and Debra Tachibana. Energy related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes. 2008 ACEEE Summer Study on Energy Efficiency in Buildings. Page 1-265. www.seattle.gov/light/Conserve/Reports/paper_10.pdf

¹⁵⁹ Average retrofit flow rate for kitchen and bathroom faucet aerators from sources 2, 4, 5, and 7. This accounts for all throttling and differences from rated flow rates. Assumes all kitchen aerators at 2.2 gpm or less and all bathroom aerators at 1.5 gpm or less. The most comprehensive available studies did not disaggregate kitchen use from bathroom use, but instead looked at total flow and length of use for all faucets. This makes it difficult to reliably separate kitchen water use from bathroom water use. It is possible that programs installing low flow aerators lower than the 2.2 gpm for kitchens and 1.5 gpm for bathrooms will see a lower overall average retrofit flow rate.

¹⁶⁰ Measurement should be based on actual average flow consumed over a period of time rather than a onetime spot measurement for maximum flow. Studies have shown maximum flow rates do not correspond well to average flow rate due to occupant behavior which does not always use maximum flow.

¹⁶¹ 2008, Schultdt, Marc, and Debra Tachibana. Energy related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes. 2008 ACEEE Summer Study on Energy Efficiency in Buildings. Page 1-265. www.seattle.gov/light/Conserve/Reports/paper_10.pdf

Usage = Estimated usage of mixed water (mixture of hot water from water heater line and cold water line) per faucet (gallons per year)

= If data is available to provide a reasonable custom estimate it should be used, if not use the following defaults (or substitute custom information in to the calculation):

Building Type	Gallons hot water per unit per day ¹⁶² (A)	Unit	Estimated % hot water from Faucets ¹⁶³ (B)	Multiplier ¹⁶⁴ (C)	Unit	Days per year (D)	Annual gallons mixed water per faucet (A*B*C*D)
Small Office	1	person	100%	10	employees per faucet	250	2,500
Large Office	1	person	100%	45	employees per faucet	250	11,250
Fast Food Rest	0.7	meal/day	50%	75	meals per faucet	365	9,581
Sit-Down Rest	2.4	meal/day	50%	36	meals per faucet	365	15,768
Retail	2	employee	100%	5	employees per faucet	365	3,650
Grocery	2	employee	100%	5	employees per faucet	365	3,650
Warehouse	2	employee	100%	5	employees per faucet	250	2,500
Elementary School	0.6	person	50%	50	students per faucet	200	3,000
Jr High/High School	1.8	person	50%	50	students per faucet	200	9,000
Health	90	patient	25%	2	Patients per faucet	365	16,425
Motel	20	room	25%	1	faucet per room	365	1,825
Hotel	14	room	25%	1	faucet per room	365	1,278
Other	1	employee	100%	20	employees per faucet	250	5,000

EPG_electric = Energy per gallon of mixed water used by faucet (electric water heater)
 = $(8.33 * 1.0 * (\text{WaterTemp} - \text{SupplyTemp})) / (\text{RE_electric} * 3412)$
 = 0.0795 kWh/gal for Bath, 0.0969 kWh/gal for Kitchen, 0.0919 kWh/gal for unknown

8.33 = Specific weight of water (lbs/gallon)

1.0 = Heat Capacity of water (btu/lb-°F)

WaterTemp = Assumed temperature of mixed water
 = 86F for Bath, 93F for Kitchen 91F for Unknown¹⁶⁵

SupplyTemp = Assumed temperature of water entering building
 = 54.1°F ¹⁶⁶

¹⁶² Table 2-45 Chapter 49, Service Water Heating, 2007 ASHRAE Handbook, HVAC Applications.

¹⁶³ Estimated based on data provided in Appendix E; "Waste Not, Want Not: The Potential for Urban Water Conservation in California"; http://www.pacinst.org/reports/urban_usage/appendix_e.pdf

¹⁶⁴ Based on review of the Illinois plumbing code (Employees and students per faucet). Retail, grocery, warehouse and health are estimates. Meals per faucet estimated as 4 bathroom and 3 kitchen faucets and average meals per day of 250 (based on California study above) – 250/7 = 36. Fast food assumption estimated.

¹⁶⁵ Cadmus and Opinion Dynamics Showerhead and Faucet Aerator Meter Study Memorandum dated June 2013, directed to Michigan Evaluation Working Group. If the aerator location is unknown an average of 91% should be used which is based on the assumption that 70% of household water runs through the kitchen faucet and 30% through the bathroom $(0.7*93)+(0.3*86)=0.91$.

¹⁶⁶ US DOE Building America Program. Building America Analysis Spreadsheet. For Chicago, IL

RE_electric = Recovery efficiency of electric water heater
 = 98%¹⁶⁷

3412 = Converts Btu to kWh (Btu/kWh)

ISR = In service rate of faucet aerators dependant on install method as listed in table below¹⁶⁸

Selection	ISR
Direct Install - Deemed	0.95

5

EXAMPLE

For example, a direct installed kitchen faucet in a large office with electric DHW:

$$\Delta kWh = 1 * ((1.39 - 0.94)/1.39) * 11,250 * 0.0969 * 0.95$$

$$= 335.3 \text{ kWh}$$

For example, a direct installed bathroom faucet in an Elementary School with electric DHW:

$$\Delta kWh = 1 * ((1.39 - 0.94)/1.39) * 3,000 * 0.0795 * 0.95$$

$$= 73.4 \text{ kWh}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = (\Delta kWh / \text{Hours}) * CF$$

Where:

ΔkWh = calculated value above on a per faucet basis

Hours = Annual electric DHW recovery hours for faucet use

$$= (\text{Usage} * 0.545^{169}) / \text{GPH}$$

= Calculate if usage is custom, if using default usage use:

Building Type	Annual Recovery Hours
Small Office	24
Large Office	109
Fast Food Rest	93
Sit-Down Rest	153
Retail	36
Grocery	36

http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html.

¹⁶⁷ Electric water heaters have recovery efficiency of 98%: <http://www.ahridirectory.org/ahridirectory/pages/home.aspx>

¹⁶⁸ ComEd Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: All Electric Single Family Home Energy Performance Tune-Up Program Table 3-8

http://ilsagfiles.org/SAG_files/Evaluation_Documents/ComEd/ComEd%20EPY2%20Evaluation%20Reports/ComEd_All_Electric_Single_Family_HEP_PY2_Evaluation_Report_Final.pdf

¹⁶⁹ 54.5% is the proportion of hot 120F water mixed with 54.1F supply water to give 90°F mixed faucet water.

Building Type	Annual Recovery Hours
Warehouse	24
Elementary School	29
Jr High/High School	88
Health	160
Motel	18
Hotel	12
Other	49

Where:

GPH = Gallons per hour recovery of electric water heater calculated for 85.9F temp rise (140-54.1), 98% recovery efficiency, and typical 12kW electric resistance storage tank.

= 56

CF = Coincidence Factor for electric load reduction

= Dependent on building type¹⁷⁰

Building Type	Coincidence Factor
Small Office	0.0064
Large Office	0.0288
Fast Food Rest	0.0084
Sit-Down Rest	0.0184
Retail	0.0043
Grocery	0.0043
Warehouse	0.0064
Elementary School	0.0096
Jr High/High School	0.0288
Health	0.0144
Motel	0.0006
Hotel	0.0004
Other	0.0128

¹⁷⁰ Calculated as follows: Assumptions for percentage of usage during peak period (1-5pm) were made and then multiplied by 65/365 (65 being the number of days in peak period) and by the number of total annual recovery hours to give an estimate of the number of hours of recovery during peak periods. There are 260 hours in the peak period so the probability you will see savings during the peak period is calculated as the number of hours of recovery during peak divided by 260. See 'C&I Faucet Aerator.xls' for details.

EXAMPLE

For example, a direct installed kitchen faucet in a large office with electric DHW:

$$\begin{aligned} \Delta kW &= 335.3/109 * 0.0288 \\ &= 0.0886 \text{ kW} \end{aligned}$$

For example, a direct installed bathroom faucet in an Elementary School with electric DHW:

$$\begin{aligned} \Delta kW &= 73.4/29 * 0.0096 \\ &= 0.0243 \text{ kW} \end{aligned}$$

FOSSIL FUEL IMPACT DESCRIPTIONS AND CALCULATION

$$\Delta \text{Therms} = \% \text{FossilDHW} * ((\text{GPM}_{\text{base}} - \text{GPM}_{\text{low}}) / \text{GPM}_{\text{base}}) * \text{Usage} * \text{EPG}_{\text{gas}} * \text{ISR}$$

Where:

$\% \text{FossilDHW}$ = proportion of water heating supplied by fossil fuel heating

DHW fuel	$\% \text{Fossil_DHW}$
Electric	0%
Fossil Fuel	100%

EPG_{gas} = Energy per gallon of mixed water used by faucet (gas water heater)

$$= (8.33 * 1.0 * (\text{WaterTemp} - \text{SupplyTemp})) / (\text{RE}_{\text{gas}} * 100,000)$$

= 0.00397 Therm/gal for Bath, 0.00484 Therm/gal for Kitchen, 0.00459 Therm/gal for unknown

Where:

RE_{gas} = Recovery efficiency of gas water heater

$$= 67\%^{171}$$

100,000 = Converts Btus to Therms (Btu/Therm)

Other variables as defined above.

¹⁷¹ Review of AHRI Directory suggests range of recovery efficiency ratings for new Gas DHW units of 70-87%. Average of existing units is estimated at 75%. Commercial properties are more similar to MF homes than SF homes. MF hot water is often provided by a larger commercial boiler. This suggests that the average recovery efficiency is somewhere between a typical central boiler efficiency of .59 and the .75 for single family home. An average is used for this analysis by default.

EXAMPLE

For example, a direct installed kitchen faucet in a large office with gas DHW:

$$\begin{aligned} \Delta\text{Therms} &= 1 * ((1.39 - 0.94)/1.39) * 11,250 * 0.00484 * 0.95 \\ &= 16.7 \text{ Therms} \end{aligned}$$

For example, a direct installed bathroom faucet in an Elementary School with gas DHW:

$$\begin{aligned} \Delta\text{Therms} &= 1 * ((1.39 - 0.94)/1.39) * 3,000 * 0.00397 * 0.95 \\ &= 3.66 \text{ Therms} \end{aligned}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

$$\Delta\text{gallons} = ((\text{GPM}_{\text{base}} - \text{GPM}_{\text{low}})/\text{GPM}_{\text{base}}) * \text{Usage} * \text{ISR}$$

Variables as defined above

EXAMPLE

For example, a direct installed faucet in a large office:

$$\begin{aligned} \Delta\text{gallons} &= ((1.39 - 0.94)/1.39) * 11,250 * 0.95 \\ &= 3,640 \text{ gallons} \end{aligned}$$

For example, a direct installed faucet in a Elementary School:

$$\begin{aligned} \Delta\text{gallons} &= ((1.39 - 0.94)/1.39) * 3,000 * 0.95 \\ &= 971 \text{ gallons} \end{aligned}$$

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

SOURCES USED FOR GPM ASSUMPTIONS

Source ID	Reference
1	2011, DeOreo, William. California Single Family Water Use Efficiency Study. April 20, 2011.
2	2000, Mayer, Peter, William DeOreo, and David Lewis. Seattle Home Water Conservation Study. December 2000.
3	1999, Mayer, Peter, William DeOreo. Residential End Uses of Water. Published by AWWA Research Foundation and American Water Works Association. 1999.
4	2003, Mayer, Peter, William DeOreo. Residential Indoor Water Conservation Study. Aquacraft, Inc. Water Engineering and Management. Prepared for East Bay Municipal Utility District and the US EPA. July 2003.
5	2011, DeOreo, William. Analysis of Water Use in New Single Family Homes. By Aquacraft. For Salt Lake City Corporation and US EPA. July 20, 2011.
6	2011, Aquacraft. Albuquerque Single Family Water Use Efficiency and Retrofit Study. For Albuquerque Bernalillo County Water Utility Authority. December 1, 2011.
7	2008, Schultdt, Marc, and Debra Tachibana. Energy related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes. 2008 ACEEE Summer Study on Energy Efficiency in Buildings.

MEASURE CODE: CI-HWE-LFFA-V06-160601

4.3.3 Low Flow Showerheads

DESCRIPTION

This measure relates to the direct installation of a low flow showerhead in a commercial building. Expected applications include small business, office, restaurant, or small motel. For multifamily or senior housing, the residential low flow showerhead should be used.

This measure was developed to be applicable to the following program types: DI.

If applied to other program types, the measure savings should be verified

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be an energy efficient showerhead rated at 2.0 gallons per minute (GPM) or less. Savings are calculated on a per showerhead fixture basis.

DEFINITION OF BASELINE EQUIPMENT

The baseline condition is assumed to be a standard showerhead rated at 2.5 GPM.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 10 years.¹⁷²

DEEMED MEASURE COST

The incremental cost for this measure is \$12¹⁷³ or program actual.

LOADSHAPE

Loadshape CO2 - Commercial Electric DHW

COINCIDENCE FACTOR

The coincidence factor for this measure is assumed to be 2.78%¹⁷⁴.

¹⁷² Table C-6, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. Evaluations indicate that consumer dissatisfaction may lead to reductions in persistence, particularly in Multi-Family, "http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf"

¹⁷³ Direct-install price per showerhead assumes cost of showerhead (Market research average of \$7 and assess and install time of \$5 (20min @ \$15/hr)

¹⁷⁴ Calculated as follows: Assume 11% showers take place during peak hours (based on: <http://www.aquacraft.com/sites/default/files/pub/DeOreo-%282001%29-Disaggregated-Hot-Water-Use-in-Single-Family-Homes-Using-Flow-Trace-Analysis.pdf>). There are 65 days in the summer peak period, so the percentage of total annual aerator use in peak period is $0.11 * 65 / 365 = 1.96\%$. The number of hours of recovery during peak periods is therefore assumed to be $1.96\% * 369 = 7.23$ hours of recovery during peak period. There are 260 hours in the peak period so the probability you will see savings during the peak period is $7.23 / 260 = 0.0278$

Algorithm

CALCULATION OF SAVINGS¹⁷⁵

ELECTRIC ENERGY SAVINGS

Note these savings are per showerhead fixture

$\Delta kWh =$

$$\%ElectricDHW * ((GPM_base * L_base - GPM_low * L_low) * NSPD * 365.25) * EPG_electric * ISR$$

Where:

%ElectricDHW = proportion of water heating supplied by electric resistance heating
 = 1 if electric DHW, 0 if fuel DHW, if unknown assume 16%¹⁷⁶

GPM_base = Flow rate of the baseline showerhead
 = 2.67 for Direct-install programs¹⁷⁷

GPM_low = As-used flow rate of the low-flow showerhead, which may, as a result of measurements of program evaluations deviate from rated flows, see table below:

Rated Flow
2.0 GPM
1.75 GPM
1.5 GPM
Custom or Actual ¹⁷⁸

L_base = Shower length in minutes with baseline showerhead
 = 8.20 min¹⁷⁹

L_low = Shower length in minutes with low-flow showerhead
 = 8.20 min¹⁸⁰

365.25 = Days per year, on average.

NSPD = Estimated number of showers taken per day for one showerhead

EPG_electric = Energy per gallon of hot water supplied by electric
 = $(8.33 * 1.0 * (ShowerTemp - SupplyTemp)) / (RE_electric * 3412)$
 = $(8.33 * 1.0 * (105 - 54.1)) / (0.98 * 3412)$
 = 0.127 kWh/gal

¹⁷⁵Based on excel spreadsheet 120911.xls ...on SharePoint

¹⁷⁶ Table HC8.9. Water Heating in U.S. Homes in Midwest Region, Divisions, and States, 2009 (RECS)

¹⁷⁷ Based on measured data from Ameren IL EM&V of Direct-Install program. Program targets showers that are rated 2.5 GPM or above.

¹⁷⁸ Note that actual values may be either a) program-specific minimum flow rate, or b) program-specific evaluation-based value of actual effective flow-rate due to increased duration or temperatures. The latter increases in likelihood as the rated flow drops and may become significant at or below rated flows of 1.5 GPM. The impact can be viewed as the inverse of the throttling described in the footnote for baseline flowrate.

¹⁷⁹ Representative value from sources 1, 2, 3, 4, 5, and 6 (See Source Table at end of measure section)

¹⁸⁰ Set equal to L_base.

- 8.33 = Specific weight of water (lbs/gallon)
- 1.0 = Heat Capacity of water (btu/lb-°F)
- ShowerTemp = Assumed temperature of water
= 105°F ¹⁸¹
- SupplyTemp = Assumed temperature of water entering house
= 54.1°F ¹⁸²
- RE_electric = Recovery efficiency of electric water heater
= 98% ¹⁸³
- 3412 = Converts Btu to kWh (btu/kWh)
- ISR = In service rate of showerhead
= Dependant on program delivery method as listed in table below

Selection	ISR ¹⁸⁴
Direct Install - Deemed	0.98

EXAMPLE

For example, a direct-installed 1.5 GPM showerhead in an office with electric DHW where the number of showers is estimated at 3 per day:

$$\begin{aligned} \Delta\text{kWh} &= 1 * ((2.67*8.20) - (1.5*8.20)) * 3*365.25 * 0.127 * 0.98 \\ &= 1308.4 \text{ kWh} \end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta\text{kW} = \Delta\text{kWh}/\text{Hours} * \text{CF}$$

Where:

- ΔkWh = calculated value above
- Hours = Annual electric DHW recovery hours for showerhead use
= ((GPM_base * L_base) * NSPD * 365.25) * 0.773 ¹⁸⁵ / GPH

Where:

- GPH = Gallons per hour recovery of electric water heater calculated for 65.9F temp rise (120-54.1), 98% recovery efficiency, and typical 4.5kW electric resistance storage tank.
= 27.51

¹⁸¹ Shower temperature cited from SBW Consulting, Evaluation for the Bonneville Power Authority, 1994, http://www.bpa.gov/energy/n/reports/evaluation/residential/faucet_aerator.cfm

¹⁸² US DOE Building America Program. Building America Analysis Spreadsheet. For Chicago, IL http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html.

¹⁸³ Electric water heaters have recovery efficiency of 98%: <http://www.ahrirectory.org/ahridirectory/pages/home.aspx>

¹⁸⁴ Deemed values are from ComEd Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: All Electric Single Family Home Energy Performance Tune-Up Program Table 3-8. Alternative ISRs may be developed for program delivery methods based on evaluation results.

¹⁸⁵ 77.3% is the proportion of hot 120F water mixed with 54.1°F supply water to give 105°F shower water

$$\begin{aligned} \text{CF} &= \text{Coincidence Factor for electric load reduction} \\ &= 0.0278^{186} \end{aligned}$$

EXAMPLE

For example, a direct-installed 1.5 GPM showerhead in an office with electric DHW where the number of showers is estimated at 3 per day:

$$\begin{aligned} \Delta \text{kW} &= (1308.4 / 674.1) * 0.0278 \\ &= 0.054 \text{ kW} \end{aligned}$$

FOSSIL FUEL IMPACT DESCRIPTIONS AND CALCULATION

$$\Delta \text{Therms} = \% \text{FossilDHW} * ((\text{GPM}_{\text{base}} * \text{L}_{\text{base}} - \text{GPM}_{\text{low}} * \text{L}_{\text{low}}) * \text{NSPD} * 365.25) * \text{EPG}_{\text{gas}} * \text{ISR}$$

Where:

$\% \text{FossilDHW}$ = proportion of water heating supplied by fossil fuel heating

DHW fuel	$\% \text{Fossil}_{\text{DHW}}$
Electric	0%
Fossil Fuel	100%
Unknown	84% ¹⁸⁷

$$\begin{aligned} \text{EPG}_{\text{gas}} &= \text{Energy per gallon of Hot water supplied by gas} \\ &= (8.33 * 1.0 * (\text{ShowerTemp} - \text{SupplyTemp})) / (\text{RE}_{\text{gas}} * 100,000) \\ &= 0.0063 \text{ Therm/gal} \end{aligned}$$

Where:

$$\begin{aligned} \text{RE}_{\text{gas}} &= \text{Recovery efficiency of gas water heater} \\ &= 67\%^{188} \end{aligned}$$

$$100,000 = \text{Converts Btus to Therms (btu/Therm)}$$

Other variables as defined above.

¹⁸⁶ Calculated as follows: Assume 11% showers take place during peak hours (based on: <http://www.aquacraft.com/sites/default/files/pub/DeOreo-%282001%29-Disaggregated-Hot-Water-Use-in-Single-Family-Homes-Using-Flow-Trace-Analysis.pdf>). There are 65 days in the summer peak period, so the percentage of total annual aerator use in peak period is $0.11 * 65 / 365.25 = 1.96\%$. The number of hours of recovery during peak periods is therefore assumed to be $1.96\% * 369 = 7.23$ hours of recovery during peak period where 369 equals the average annual electric DHW recovery hours for showerhead use including SF and MF homes with Direct Install and Retrofit/TOS measures. There are 260 hours in the peak period so the probability you will see savings during the peak period is $7.23 / 260 = 0.0278$

¹⁸⁷ Default assumption for unknown fuel is based on EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of IL. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used

¹⁸⁸ Review of AHRI Directory suggests range of recovery efficiency ratings for new Gas DHW units of 70-87%. Average of existing units is estimated at 75%. Commercial properties are more similar to MF homes than SF homes. MF hot water is often provided by a larger commercial boiler. This suggests that the average recovery efficiency is somewhere between a typical central boiler efficiency of .59 and the .75 for single family home. An average is used for this analysis by default.

EXAMPLE

For example, a direct-installed 1.5 GPM showerhead in an office with gas DHW where the number of showers is estimated at 3 per day:

$$\begin{aligned} \Delta\text{Therms} &= 1.0 * ((2.67 * 8.2) - (1.5 * 8.2)) * 3 * 365.25 * 0.0063 * 0.98 \\ &= 64.9 \text{ therms} \end{aligned}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

$$\Delta\text{gallons} = ((\text{GPM}_{\text{base}} * L_{\text{base}} - \text{GPM}_{\text{low}} * L_{\text{low}}) * \text{NSPD} * 365.25 * \text{ISR})$$

Variables as defined above

EXAMPLE

For example, a direct-installed 1.5 GPM showerhead in an office with where the number of showers is estimated at 3 per day:

$$\begin{aligned} \Delta\text{gallons} &= ((2.67 * 8.20) - (1.5 * 8.20)) * 3 * 365.25 * 0.98 \\ &= 10,302 \text{ gallons} \end{aligned}$$

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

SOURCES

Source ID	Reference
1	2011, DeOreo, William. California Single Family Water Use Efficiency Study. April 20, 2011.
2	2000, Mayer, Peter, William DeOreo, and David Lewis. Seattle Home Water Conservation Study. December 2000.
3	1999, Mayer, Peter, William DeOreo. Residential End Uses of Water. Published by AWWA Research Foundation and American Water Works Association. 1999.
4	2003, Mayer, Peter, William DeOreo. Residential Indoor Water Conservation Study. Aquacraft, Inc. Water Engineering and Management. Prepared for East Bay Municipal Utility District and the US EPA. July 2003.
5	2011, DeOreo, William. Analysis of Water Use in New Single Family Homes. By Aquacraft. For Salt Lake City Corporation and US EPA. July 20, 2011.
6	2011, Aquacraft. Albuquerque Single Family Water Use Efficiency and Retrofit Study. For Albuquerque Bernalillo County Water Utility Authority. December 1, 2011.
7	2008, Schultdt, Marc, and Debra Tachibana. Energy related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes. 2008 ACEEE Summer Study on Energy Efficiency in Buildings.

MEASURE CODE: CI-HW_-LFSH-V03-150601

4.3.4 Commercial Pool Covers

DESCRIPTION

This measure refers to the installation of covers on commercial use pools that are heated with gas-fired equipment located either indoors or outdoors. By installing pool covers, the heating load on the pool boiler will be reduced by reducing the heat loss from the water to the environment and the amount of actual water lost due to evaporation (which then requires additional heated water to make up for it).

The main source of energy loss in pools is through evaporation. This is particularly true of outdoor pools where wind plays a larger role. The point of installing pool covers is threefold. First, it will reduce convective losses due to the wind by shielding the water surface. Second, it will insulate the water from the colder surrounding air. And third, it will reduce radiative losses to the night sky. In doing so, evaporative losses will also be minimized, and the boiler will not need to work as hard in replenishing the pool with hot water to keep the desired temperature.

This measure can be used for pools that (1) currently do not have pool covers, (2) have pool covers that are past the useful life of the existing cover, or (3) have pool covers that are past their warranty period and have failed.

DEFINITION OF EFFICIENT EQUIPMENT

For indoor pools, the efficient case is the installation of an indoor pool cover with a 5 year warranty on an indoor pool that operates all year.

For outdoor pools, the efficient case is the installation of an outdoor pool cover with a 5 year warranty on an outdoor pool that is open through the summer season.

DEFINITION OF BASELINE EQUIPMENT

For indoor pools, the base case is an uncovered indoor pool that operates all year.

For outdoor pools, the base case is an outdoor pool that is uncovered and is open through the summer season.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The useful life of this measure is assumed to be 6 years ¹⁸⁹

DEEMED MEASURE COST

The table below shows the costs for the various options and cover sizes. Since this measure covers a mix of various sizes, the average cost of these options is taken to be the incremental measure cost. ¹⁹⁰

¹⁸⁹ The effective useful life of a pool cover is typically one year longer than its warranty period. SolaPool Covers. Pool Covers Website, FAQ- "How long will my SolaPool cover blanket last?". Pool covers are typically offered with 3 and 5 year warranties with at least one company offering a 6 year warranty. Conversation with Trade Ally. Knorr Systems

¹⁹⁰ Pool Cover Costs: Lincoln Commercial Pool Equipment website. Accessed 8/26/11.

<http://www.lincolnaquatics.com/shop/catalog/Pool+and+Spa+Covers+and+Accessories/product.html?ProductID=84-010>

Cover Size	Edge Style	
	Hemmed (indoor)	Weighted (outdoor)
1000-1,999 sq. ft.	\$2.19	\$2.24
2,000-2,999 sq. ft.	\$2.01	\$2.06
3,000+ sq. ft.	\$1.80	\$1.83
Average	\$2.00	\$2.04

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

NET TO GROSS RATIO

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS SAVINGS

The calculations are based on modeling runs using RSPEC! Energy Smart Pools Software that was created by the U.S. Department of Energy. ¹⁹¹

$$\Delta\text{Therms} = \text{SavingFactor} \times \text{Size of Pool}$$

Where

Savings factor = dependant on pool location and listed in table below¹⁹²

Location	Therm / sq-ft
Indoor	2.61
Outdoor	1.01

Size of Pool = custom input

WATER IMPACT DESCRIPTIONS AND CALCULATION

¹⁹¹ Full method and supporting information found in reference document: IL TRM - Business Pool Covers WorkPaper.docx. Note that the savings estimates are based upon Chicago weather data.

¹⁹² Business Pool Covers.xlsx

$$\Delta\text{Therms} = \text{WaterSavingFactor} \times \text{Size of Pool}$$

Where

WaterSavingFactor = Water savings for this measure dependant on pool location and listed in table below.¹⁹³.

Location	Annual Savings Gal / sq-ft
Indoor	15.28
Outdoor	8.94

Size of Pool = Custom input

DEEMED O&M COST ADJUSTMENT CALCULATION

There are no O&M cost adjustments for this measure.

MEASURE CODE: CI-HW_-PLCV-V01-130601

¹⁹³ Ibid.

4.3.5 Tankless Water Heater

DESCRIPTION

This measure covers the installation of on-demand or instantaneous tankless water heaters. Tankless water heaters function similar to standard hot water heaters except they do not have a storage tank. When there is a call for hot water, the water is heated instantaneously as it passes through the heating element and then proceeds to the user or appliance calling for hot water. Tankless water heaters achieve savings by eliminating the standby losses that occur in stand-alone or tank-type water heaters and by being more efficient than the baseline storage hot water heater.

This measure was developed to be applicable to the following program types: TOS, RF, ER.

If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

Electric	Gas
To qualify for this measure, the tankless water heater shall be a new electric powered tankless hot water heater with an energy factor greater than or equal to 0.98 with an output greater than or equal to 5 GPM output at 70° F temperature rise.	To qualify for this measure, the tankless water heater shall meet or exceed the efficiency requirements for tankless hot water heaters mandated by the International Energy Conservation Code (IECC) 2012/2015, Table C404.2.

DEFINITION OF BASELINE EQUIPMENT

Electric	Gas
The baseline condition is assumed to be an electric commercial-grade tanked water heater 50 or more gallon storage capacity with an energy factor less than or equal to 0.9 or the water heater is five or more years old.	The baseline condition is assumed to be a gas-fired tank-type water heater meeting the efficiency requirements mandated by the International Energy conservation Code (IECC) 2012/2015, Table C404.2

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

Electric	Gas
The expected measure life is assumed to be 5 years ¹⁹⁴ .	The expected measure life is assumed to be 20 years ¹⁹⁵

DEEMED MEASURE COST

The incremental capital cost for an electric tankless heater this measure is assumed to be¹⁹⁶

Output (gpm) at delta T 70	Incremental Cost
5	\$1050
10	\$1050
15	\$1950

The incremental capital cost for a gas fired tankless heater is as follows:

¹⁹⁴ Ohio Technical Reference Manual 8/2/2010 referencing CenterPoint Energy-Triennial CIP/DSM Plan 2010-2012 Report; Additional reference stating >20 years is at Energy Savers.Gov online at http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=12820

¹⁹⁵ Ibid.

¹⁹⁶ Act on Energy Technical Reference Manual, Table 9.6.2-3

Program	Capital Cost, \$ per unit
Retrofit	\$3,255 ¹⁹⁷
Time of Sale or New Construction	\$2,526 ¹⁹⁸

DEEMED O&M COST ADJUSTMENTS

\$100¹⁹⁹

LOADSHAPE

Loadshape C02 - Commercial Electric DHW

COINCIDENCE FACTOR

The measure has deemed kW savings therefor a coincidence factor is not applied

¹⁹⁷ Based on AOE historical average installation data of 42 tankless gas hot water heaters

¹⁹⁸ <http://www.mncee.org/getattachment/7b8982e9-4d95-4bc9-8e64-f89033617f37/>, Low contractor estimate used to reflect less labor required in new construction of venting.

¹⁹⁹ Water heaters (WH) require annual maintenance. There are different levels of effort for annual maintenance depending if the unit is gas or electric, tanked or tankless. Electric and gas tank water heater manufacturers recommend an annual tank drain to clear sediments. Also recommended are “periodic” inspections by qualified service professionals of operating controls, heating element and wiring for electric WHs and thermostat, burner, relief valve internal flue-way and venting systems for gas WHs. Tankless WH require annual maintenance by licensed professionals to clean control compartments, burners, venting system and heat exchangers. This information is from WH manufacturer product brochures including GE, Rinnai, Rheem, Takagi and Kenmore. References for incremental O&M costs were not found. Therefore the incremental cost of the additional annual maintenance for tankless WH is estimated at \$100.

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS²⁰⁰

The annual electric savings from an electric tankless heater is a deemed value and assumed to be:

Output (gpm) at delta T 70	Savings (kWh)
5.0	2,992
10.0	7,905
15.0	12,879

SUMMER COINCIDENT PEAK DEMAND SAVINGS²⁰¹

The annual kW savings from an electric tankless heater is a deemed value and assumed to be:

Output (gpm) at delta T 70	Savings (kW)
5.0	0.34
10.0	0.90
15.0	1.47

NATURAL GAS SAVINGS

$$\Delta \text{Therms} = \frac{[W_{\text{gal}} \times 8.33 \times 1 \times (T_{\text{out}} - T_{\text{in}}) \times [(1/\text{Eff}_{\text{base}}) - (1/\text{Eff}_{\text{ee}})]]}{100,000} + \frac{[(SL \times 8,766)/\text{Eff}_{\text{base}}]}{100,000} \text{ Btu/Therms}$$

Where:

- Wgal = Annual water use for equipment in gallons
= custom, otherwise assume 21,915 gallons²⁰²
- 8.33 lbm/gal = weight in pounds of one gallon of water
- 1 Btu/lbm°F = Specific heat of water: 1 Btu/lbm/°F
- 8,766 hr/yr = hours a year
- Tout = Unmixed Outlet Water Temperature
= custom, otherwise assume 130 °F²⁰³
- Tin = Inlet Water Temperature
= custom, otherwise assume 54.1 °F²⁰⁴

²⁰⁰ Act on Energy Technical Reference Manual, Table 9.6.2-3

²⁰¹ Ibid.

²⁰² 21,915 gallons is an estimate of 60 gal/day for 365.25 days/yr. If building type is known, reference 2007 ASHRAE Handbook HVAC Applications p. 49.14 Table 7 Hot Water Demands and Use for Various Types of Buildings to help estimate hot water consumption.

²⁰³ Based on 2010 Ohio Technical Reference Manual and NAHB Research Center, (2002) Performance Comparison of Residential hot Water Systems. Prepared for National Renewable Energy Laboratory, Golden, Colorado.

²⁰⁴ August 31, 2011 Memo of Savings for Hot Water Savings Measures to Nicor Gas from Navigant states that 54.1°F was

Eff base = Rated efficiency of baseline water heater expressed as Energy Factor (EF) or Thermal Efficiency (Et); see table below²⁰⁵

Input Btu/hr of existing, tanked water heater	Eff base	Units
Size: ≤ 75,000 Btu/hr	0.67 -0.0019* <i>Tank Volume</i>	Energy Factor
Size: >75,000 Btu/hr and ≤ 155,000 Btu/hr	80%	Thermal Efficiency
Size: >155,000 Btu/hr	80%	Thermal Efficiency

Where:

Tank Volume = custom input, if unknown assume 60 gallons for Size: ≤ 75,000 Btu/hr

Please note: Units in base case must match units in efficient case. If Energy Factor used in base case, Energy Factor to be used in efficient case. If Thermal Efficiency is used in base case, Thermal Efficiency must be used in efficient case.

Eff ee = Rated efficiency of efficient water heater expressed as Energy Factor (EF) or Thermal Efficiency (Eff t)

= custom input, if unknown assume 0.84²⁰⁶

SL = Stand-by Loss in Base Case Btu/hr

= custom input based on formula in table below, if unknown assume unit size in table below²⁰⁷

Input Btu/h of new, tankless water heater	Standby Loss (SL)
Size: ≤ 75,000 Btu/hr	0
Size: >75,000 Btu/hr	(Input rating/800)+(110* <i>vTank Volume</i>)

Where:

Tank Volume = custom input, if unknown assume, 60 gallons for <75,000 Btu/hr, 75 gallons for >75,000 Btu/hr and ≤ 155,000 Btu/hr and 150 for Size >155,000 Btu/hr

Input Rating = nameplate Btu/hr rating of water heater

calculated from the weighted average of monthly water mains temperatures reported in the 2010 Building America Benchmark Study for Chicago-Waukegan, Illinois.

²⁰⁵ International Energy Conservation Code (IECC) 2012/2015, Table C404.2, Minimum Performance of Water-Heating Equipment

²⁰⁶ Specifications of energy efficient tankless water heater. Reference Consortium for Energy Efficiency (CEE) which maintains a list of high efficiency tankless water heaters which currently have Energy Factors up to .96. Ameren currently requires minimum .82 energy factor.

²⁰⁷ Stand-by loss is provided in 2012/2015 IECC, Table C404.2, Minimum Performance of Water-Heating Equipment

EXAMPLE

For example, a 75,000 Btu/hr tankless unit using 21,915 gal/yr with outlet temperature at 130.0 and inlet temperature at 54.1, replacing a baseline unit with 0.8 thermal efficiency and standby losses of 1008.3 btu/hr:

$$\begin{aligned} \Delta\text{Therms} &= \left[\frac{21,915 \times 8.33 \times 1 \times (130 - 54.1) \times [(1/.8) - (1/.84)]}{100,000} \right] + \left[\frac{1008.3 \times 8,766}{.8} \right] / \\ &= 115 \text{ Therms} \end{aligned}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

The deemed O&M cost adjustment for a gas fired tankless heater is \$100

REFERENCE TABLES

Minimum Performance Water Heating Equipment²⁰⁸

²⁰⁸ International Energy Conservation Code (IECC)2012/2015

TABLE C404.2
MINIMUM PERFORMANCE OF WATER-HEATING EQUIPMENT

EQUIPMENT TYPE	SIZE CATEGORY (input)	SUBCATEGORY OR RATING CONDITION	PERFORMANCE REQUIRED ^{a, b}	TEST PROCEDURE
Water heaters, electric	≤ 12 kW	Resistance	0.97 - 0.00132 V, EF	DOE 10 CFR Part 430
	> 12 kW	Resistance	1.73 V - 155 SL, Btu/h	ANSI Z21.10.3
	≤ 24 amps and ≤ 260 volts	Heat pump	0.93 - 0.00132 V, EF	DOE 10 CFR Part 430
Storage water heaters, gas	≤ 75,000 Btu/h	≥ 20 gal	0.67 - 0.0019 V, EF	DOE 10 CFR Part 430
	> 75,000 Btu/h and ≤ 155,000 Btu/h	< 4,000 Btu/h/gal	80% E _r (Q/800 + 110/√V) SL, Btu/h	ANSI Z21.10.3
	> 155,000 Btu/h	< 4,000 Btu/h/gal	80% E _r (Q/800 + 110/√V) SL, Btu/h	
Instantaneous water heaters, gas	> 60,000 Btu/h and < 200,000 Btu/h ^c	≥ 4,000 (Btu/h)/gal and < 2 gal	0.62 - 0.0019 V, EF	DOE 10 CFR Part 430
	≥ 200,000 Btu/h	≥ 4,000 Btu/h/gal and < 10 gal	80% E _r	ANSI Z21.10.3
	≥ 200,000 Btu/h	≥ 4,000 Btu/h/gal and ≥ 10 gal	80% E _r (Q/800 + 110/√V) SL, Btu/h	
Storage water heaters, oil	≤ 105,000 Btu/h	≥ 20 gal	0.59 - 0.0019 V, EF	DOE 10 CFR Part 430
	≥ 105,000 Btu/h	< 4,000 Btu/h/gal	78% E _r (Q/800 + 110/√V) SL, Btu/h	ANSI Z21.10.3
Instantaneous water heaters, oil	≤ 210,000 Btu/h	≥ 4,000 Btu/h/gal and < 2 gal	0.59 - 0.0019 V, EF	DOE 10 CFR Part 430
	> 210,000 Btu/h	≥ 4,000 Btu/h/gal and < 10 gal	80% E _r	ANSI Z21.10.3
	> 210,000 Btu/h	≥ 4,000 Btu/h/gal and ≥ 10 gal	78% E _r (Q/800 + 110/√V) SL, Btu/h	
Hot water supply boilers, gas and oil	≥ 300,000 Btu/h and < 12,500,000 Btu/h	≥ 4,000 Btu/h/gal and < 10 gal	80% E _r	ANSI Z21.10.3
Hot water supply boilers, gas	≥ 300,000 Btu/h and < 12,500,000 Btu/h	≥ 4,000 Btu/h/gal and ≥ 10 gal	80% E _r (Q/800 + 110/√V) SL, Btu/h	
Hot water supply boilers, oil	> 300,000 Btu/h and < 12,500,000 Btu/h	> 4,000 Btu/h/gal and > 10 gal	78% E _r (Q/800 + 110/√V) SL, Btu/h	
Pool heaters, gas and oil	All	—	78% E _r	ASHRAE 146
Heat pump pool heaters	All	—	4.0 COP	AHRI 1160
Unfired storage tanks	All	—	Minimum insulation requirement R-12.5 (h · ft ² · °F)/Btu	(none)

For SI: °C = [(°F) - 32]/1.8, 1 British thermal unit per hour = 0.2931 W, 1 gallon = 3.785 L, 1 British thermal unit per hour per gallon = 0.078 W/L.

a. Energy factor (EF) and thermal efficiency (E_r) are minimum requirements. In the EF equation, V is the rated volume in gallons.

b. Standby loss (SL) is the maximum Btu/h based on a nominal 70°F temperature difference between stored water and ambient requirements. In the SL equation, Q is the nameplate input rate in Btu/h. In the SL equation for electric water heaters, V is the rated volume in gallons. In the SL equation for oil and gas water heaters and boilers, V is the rated volume in gallons.

c. Instantaneous water heaters with input rates below 200,000 Btu/h must comply with these requirements if the water heater is designed to heat water to temperatures 180°F or higher.

MEASURE CODE: CI-HW_-TKWH-V03-160601

4.3.6 Ozone Laundry

DESCRIPTION

A new ozone laundry system(s) is added-on to new or existing commercial washing machine(s) using hot water heated with natural gas. The system generates ozone (O₃), a naturally occurring molecule, which helps clean fabrics by chemically reacting with soils in cold water. Adding an ozone laundry system(s) will reduce the amount of chemicals, detergents, and hot water needed to wash linens. Using ozone also reduces the total amount of water consumed, saving even more in energy.

Natural gas energy savings will be achieved at the hot water heater/boiler as they will be required to produce less hot water to wash each load of laundry. The decrease in hot water usage will increase cold water usage, but overall water usage at the facility will decrease.

Electric savings can be realized through reduced washer cycle length and reduced pumping load at the boiler feeding the commercial washers. The increased usage associated with operating the ozone system should also be accounted for when determining total kWh impact. Data reviewed for this measure characterization indicated that pumping savings should be accounted for, but washer savings and ozone generator consumption are comparatively so small that they can be ignored.

The reduced washer cycle length may decrease the dampness of the clothes when they move to the dryer. This can result in shorter runtimes which result in gas and electrical savings. However, at this time, there is inconclusive evidence that energy savings are achieved from reduced dryer runtimes so the resulting dryer effects are not included in this analysis. Additionally, there would be challenges verifying that dryer savings will be achieved throughout the life of the equipment.

This incentive only applies to the following facilities with on-premise laundry operations:

- Hotels/motels
- Fitness and recreational sports centers.
- Healthcare (excluding hospitals)
- Assisted living facilities

Ozone laundry system(s) could create significant energy savings opportunities at other larger facility types with on-premise laundry operations (such as correctional facilities, universities, and staff laundries), however, the results included in this analysis are based heavily on past project data for the applicable facility types listed above and may not apply to facilities outside of this list due to variances in number of loads and average pound (lbs.)-capacity per project site. Projects at these facilities should continue to be evaluated through custom programs and the applicable facility types and the resulting analysis should be updated based on new information.

This measure was developed to be applicable to the following program types: TOS, RF.

If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

A new ozone laundry system(s) is added-on to new or existing commercial washing machine(s) using hot water heated with natural gas. The ozone laundry system(s) must transfer ozone into the water through:

- Venturi Injection
- Bubble Diffusion
- Additional applications may be considered upon program review and approval on a case by case basis

DEFINITION OF BASELINE EQUIPMENT

The base case equipment is a conventional washing machine system with no ozone generator installed. The washing machines are provided hot water from a gas-fired boiler.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure equipment effective useful life (EUL) is estimated at 10 years based on typical lifetime of the ozone generator’s corona discharge unit.²⁰⁹

DEEMED MEASURE COST

The actual measure costs should be used if available. If not a deemed value of \$79.84 / lbs capacity should be used²¹⁰.

LOADSHAPE

Loadshape C53 – Flat

COINCIDENCE FACTOR

Past project documentation and data collection is not sufficient to determine a coincidence factor for this measure. Value should continue to be studied and monitored through additional studies due to limited data points used for this determination

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

Electric savings can be realized through reduced washer cycle length and reduced pumping load at the boiler feeding the commercial washers. There is also an increased usage associated with operating the ozone system. Data reviewed for this measure characterization indicated that while pumping savings is significant and should be accounted for, washer savings and ozone generator consumption are negligible, counter each other out and are well within the margin of error so these are not included to simplify the characterization²¹¹.

$$\Delta kWh_{PUMP} = HP * HP_{CONVERSION} * Hours * \%water_savings$$

²⁰⁹ Aligned with other national energy efficiency programs and confirmed with national vendors

²¹⁰ Average costs per unit of capacity were generated using data collected from existing ozone laundry projects that received incentives under the Non-Residential Retrofit Demand Reduction program (NRR-DR), as well as from the Nicor Custom Incentive Program, and the Nicor Emerging Technology Program (ETP). See referenced document Table 2 and RSM Means Mechanical Cost Data, 31st Annual Edition (2008)

²¹¹ Washer savings were reviewed but were considered negligible and not included in the algorithm (0.00082 kWh / lbs-capacity, determined through site analysis through Nicor Emerging Technology Program (ETP) and confirmed with national vendors). Note that washer savings from Nicor’s site analysis are smaller than those reported in a WI Focus on Energy case study (0.23kWh/100lbs, Hampton Inn Brookfield, November 2010). Electric impact of operating ozone generator (0.0021 kWh / lbs-capacity same source as washer savings) was also considered negligible and not included in calculations. Values should continue to be studied and monitored through additional studies due to limited data points used for this determination.

Where:

- ΔkWh_{PUMP} = Electric savings from reduced pumping load
- HP = Brake horsepower of boiler feed water pump;
= Actual or use 5 HP if unknown²¹²
- $HP_{CONVERSION}$ = Conversion from Horsepower to Kilowatt
= 0.746
- Hours = Actual associated boiler feed water pump hours
= 800 hours if unknown²¹³
- %water_savings = water reduction factor: how much more efficient an ozone injection washing machine is compared to a typical conventional washing machine as a rate of hot and cold water reduction.
= 25%²¹⁴

Using defaults above:

$$\begin{aligned} \Delta kWh_{PUMP} &= 5 * 0.746 * 800 * 0.25 \\ &= 746 \text{ kWh} \end{aligned}$$

Default per lb capacity: = $\Delta kWh_{PUMP} / \text{lb capacity}$

Where:

$$\begin{aligned} \text{Lbs-Capacity} &= \text{Average Capacity in lbs of washer} \\ &= 254.38^{215} \\ \Delta kWh_{PUMP} / \text{lb capacity} &= 746/254.38 \\ &= 2.93 \text{ kWh/lb-capacity} \end{aligned}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Past project documentation and data collection is not sufficient to determine summer coincident peak demand savings for this measure. Value should continue to be studied and monitored through additional studies due to limited data points used for this determination. In absence of site-specific data, the summer coincident peak demand savings should be assumed to be zero.

$$\Delta kW = 0$$

²¹² Assumed average horsepower for boilers connected to applicable washer

²¹³ Engineered estimate provided by CLEAResult review of Nicor custom projects. Machines spent approximately 7 minutes per hour filling with water and were in operation approximately 20 hours per day. Total pump time therefore estimated as $7/60 * 20 * 365 = 852$ hours, and rounded down conservatively to 800 hours.

²¹⁴ Average water reduction factors were generated using data collected from existing ozone laundry projects that received incentives under the Non-Residential Retrofit Demand Reduction program (NRR-DR). Table 6 summarizes data gathered from several NRR-DR projects, Nicor Custom projects, and Nicor ETP projects. Nicor Savings Numbers are associated with ACEE_AWE_Ozone Laundry / From Gas Savings Calculations

²¹⁵ Average lbs-capacity per project site was generated using data collected from existing ozone laundry projects that received incentives under the Non-Residential Retrofit Demand Reduction program (NRR-DR), as well as from the Nicor Custom Incentive Program, and the Nicor Emerging Technology Program (ETP). See referenced document Table 2

NATURAL GAS SAVINGS

$$\Delta\text{Therm} = \text{Therm}_{\text{Baseline}} * \% \text{hot_water_savings}$$

Where:

ΔTherm = Gas savings resulting from a reduction in hot water use, in therm.

$\text{Therm}_{\text{Baseline}}$ = Annual Baseline Gas Consumption
 = $\text{WHE} * \text{WUtiliz} * \text{WUsage_hot}$

Where:

WHE = water heating energy: energy required to heat the hot water used
 = 0.00885 therm/gallon²¹⁶

WUtiliz = washer utilization factor: the annual pounds of clothes washed per year
 = actual, if unknown use 916,150 lbs laundry²¹⁷, approximately equivalent to 13 cycles/day

WUsage_hot = hot water usage factor: how much hot water a typical conventional washing machine utilizes, normalized per pounds of clothes washed
 = 1.19 gallons/lbs laundry²¹⁸

Using defaults above:

$$\begin{aligned} \text{Therm}_{\text{Baseline}} &= 0.00885 * 916,150 * 1.19 \\ &= 9,648 \text{ therms} \end{aligned}$$

Default per lb capacity:

$$\begin{aligned} \text{Therm}_{\text{Baseline}} / \text{lb capacity} &= 9,648 / 254.38 \\ &= 37.9 \text{ therms / lb-capacity} \end{aligned}$$

$\% \text{hot_water_savings}$ = hot water reduction factor: how much more efficient an ozone injection washing machine is, compared to a typical conventional washing machine, as a rate of hot water reduction
 = 81%²¹⁹

Savings using defaults above:

$$\Delta\text{Therm} = \text{Therm}_{\text{Baseline}} * \% \text{hot_water_savings}$$

²¹⁶ Assuming boiler efficiency is the regulated minimum efficiency (80%), per Title 20 Appliance Standard of the California Energy Regulations (October 2007). The incoming municipal water temperature is assumed to be 55 °F with an average hot water supply temperature of 140°F, based on default test procedures on clothes washers set by the Department of Energy’s Office of Energy Efficiency and Renewable Energy (Federal Register, Vol. 52, No. 166). Enthalpies for these temperatures (107 btu/lbs at 140F, 23.07 btu/lbs at 55F) were obtained from ASHRAE Fundamentals

²¹⁷ Average utilization factors were generated using data collected from existing ozone laundry projects that received incentives under the NRR-DR program. Table 3 summarizes data gathered from several NRR-DR projects, Nicor Custom projects, and Nicor ETP projects

²¹⁸ Average hot water usage factors were generated using data collected from existing ozone laundry projects that received incentives under the NRR-DR program. summarizes data gathered from several NRR-DR projects:

²¹⁹ Average hot water reduction factors were generated using data collected from existing ozone laundry projects that received incentives under the Non-Residential Retrofit Demand Reduction program (NRR-DR). Table 5 summarizes data gathered from several NRR-DR projects, Nicor Custom projects, and Nicor ETP projects. Nicor Savings Numbers are associated with ACEE_AWE_Ozone Laundry / From Gas Savings Calculations

$$= 9648 * 0.81$$

$$= 7,815 \text{ therms}$$

Default per lb capacity:

$$\Delta \text{Therm} / \text{lb-capacity} = 7815 / 254.38$$

$$= 30.7 \text{ therms} / \text{lb-capacity}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

The water savings calculations listed here account for the combination of hot and cold water used. Savings calculations for this measure were based on the reduction in total water use from implementing an ozone washing system to the base case. There are three main components in obtaining this value:

$$\Delta \text{gallons} = \text{WUsage} * \text{WUtiliz} * \% \text{water_savings}$$

Where:

- $\Delta \text{gallons}$ = reduction in total water use from implementing an ozone washing system to the base case
- WUsage = water usage factor: how efficiently a typical conventional washing machine utilized hot and cold water normalized per unit of clothes washed
= 2.03 gallons/lbs laundry²²⁰
- WUtiliz = washer utilization factor: the annual pounds of clothes washed per year
= actual, if unknown use 916,150 lbs laundry²²¹, approximately equivalent to 13 cycles/day
- $\% \text{water_savings}$ = water reduction factor: how much more efficient an ozone injection washing machine is compared to a typical conventional washing machine as a rate of hot and cold water reduction.
= 25%²²²

Savings using defaults above:

$$\Delta \text{Gallons} = \text{WUsage} * \text{WUtiliz} * \% \text{water_savings}$$

$$= 2.03 * 916,150 * 0.25$$

$$= 464,946 \text{ gallons}$$

Default per lb capacity:

$$\Delta \text{ Gallons} / \text{lb-capacity} = 464,946 / 254.38$$

$$= 1,828 \text{ gallons} / \text{lb-capacity}$$

²²⁰ Average water usage factors were generated using data collected from existing ozone laundry projects that received incentives under the NRR-DR program. summarizes data gathered from several NRR-DR projects

²²¹ Average utilization factors were generated using data collected from existing ozone laundry projects that received incentives under the NRR-DR program. Table 3 summarizes data gathered from several NRR-DR projects, Nicor Custom projects, and Nicor ETP projects

²²² Average water reduction factors were generated using data collected from existing ozone laundry projects that received incentives under the Non-Residential Retrofit Demand Reduction program (NRR-DR). Table 6 summarizes data gathered from several NRR-DR projects, Nicor Custom projects, and Nicor ETP projects. Nicor Savings Numbers are associated with ACEE_AWE_Ozone Laundry / From Gas Savings Calculations

DEEMED O&M COST ADJUSTMENT CALCULATION

Maintenance is required for the following components annually:²²³

- Ozone Generator: filter replacement, check valve replacement, fuse replacement, reaction chamber inspection/cleaning, reaction chamber o-ring replacement
- Air Preparation – Heat Regenerative: replacement of two medias
- Air Preparation – Oxygen Concentrators: filter replacement, pressure relief valve replacement, compressor rebuild
- Venturi Injector: check valve replacement

Maintenance is expected to cost \$0.79 / lbs capacity.

REFERENCES

- 1 "Lodging Report", December 2008, California Travel & Tourism Commission, http://tourism.visitcalifornia.com/media/uploads/files/editor/Research/CaliforniaTourism_200812.pdf
- 2 "Health, United States, 2008" Table 120, U.S. Department of Health & Human Services, Centers for Disease Control & Prevention, National Center for Health Statistics, <http://www.cdc.gov/nchs/data/hus/08.pdf#120>
- 3 Fourth Quarter 2008 Facts and Figures, California Department of Corrections & Rehabilitation (CDCR), http://www.cdcr.ca.gov/Divisions_Boards/Adult_Operations/docs/Fourth_Quarter_2008_Facts_and_Figures.pdf
- 4 Jail Profile Survey (2008), California Department of Corrections & Rehabilitation (CDCR), http://www.cdcr.ca.gov/Divisions_Boards/CSA/FSO/Docs/2008_4th_Qtr_JPS_full_report.pdf
- 5 DEER2011_NTGR_2012-05-16.xls from DEER Database for Energy-Efficient Resources; Version 2011 4.01 found at http://www.deeresources.com/index.php?option=com_content&view=article&id=68&Itemid=60
Under: DEER2011 Update Documentation linked at: DEER2011 Update Net-To-Gross table Cells: T56 and U56
- 6 The Benefits of Ozone in Hospitality On-Premise Laundry Operations, PG&E Emerging Technologies Program, Application Assessment Report #0802, April 2009.
- 7 Federal Register, Vol. 52, No. 166
- 8 2009 ASHRAE Handbook – Fundamentals, Thermodynamic Properties of Water at Saturation, Section 1.1 (Table 3), 2009
- 9 Table 2 through 6: Excel file summarizing data collected from existing ozone laundry projects that received incentives under the NRR-DR program

MEASURE CODE CI-HW-OZLD-VO1-140601

²²³ Confirmed through communications with national vendors and available references E.g. <http://ozonelaundry.wordpress.com/2010/11/17/the-importance-of-maintenance/>

4.3.7 Multifamily Central Domestic Hot Water Plants

DESCRIPTION

This measure covers multifamily central domestic hot water (DHW) plants with thermal efficiencies greater than or equal to 88%. This measure is applicable to any combination of boilers and storage tanks provided the thermal efficiency of the boilers is greater than 88%. Plants providing other than solely DHW are not applicable to this measure.

This measure was developed to be applicable to the following program types: TOS, NC, ER.

If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify the boiler(s) must have a Thermal Efficiency of 88% or greater and supply domestic hot water to multi-family buildings.

DEFINITION OF BASELINE EQUIPMENT

For TOS the baseline boiler is assumed to have a Thermal Efficiency of 80%.²²⁴

For Early Replacement the savings are calculated between existing unit and efficient unit consumption during the remaining life of the existing unit, and between new baseline unit as above and efficient unit consumption for the remainder of the measure life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life for the domestic hot water boilers is 15 years.²²⁵

DEEMED MEASURE COST

TOS: The actual install cost should be used for the efficient case, minus the baseline cost assumption provided below:

Capacity Range	Baseline Installed Cost per kBtu ²²⁶
<300kBtuh	\$65 per kBtUh
300 – 2500 kBtuh	\$38 per kBtUh
>2500 kBtuh	\$32 per kBtUh

LOADSHAPE

N/A

²²⁴ International Energy Conservation Code (IECC) 2012/2015, Table C404.2, Minimum Performance of Water-Heating Equipment

²²⁵ Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011.

²²⁶ Baseline install costs are based on data from the W017 Itron California Measure Cost Study, accessed via <http://www.energydataweb.com/cpuc/search.aspx>. The data is provided in a file named “MCS Results Matrix – Volume I”.

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

There are no anticipated electrical savings from this measure.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS SAVINGS

Time of Sale:

$$\begin{aligned} \Delta\text{Therms} &= \text{Hot Water Savings} + \text{Standby Loss Savings} \\ &= \left[\frac{(\text{MFHH} * \#\text{Units} * \text{GPD} * \text{Days/yr} * \nu\text{Water} * (\text{Tout} - \text{Tin}) * (1/\text{Eff_base} - 1/\text{Eff_ee}))}{100,000} \right] + \left[\frac{(\text{SL} * \text{Hours/yr} * (1/\text{Eff_base} - 1/\text{Eff_ee}))}{100,000} \right] \end{aligned}$$

Early Replacment²²⁷:

$$\begin{aligned} \Delta\text{Therms for remaining life of existing unit (1st 5 years):} \\ &= \left[\frac{(\text{MFHH} * \#\text{Units} * \text{GPD} * \text{Days/yr} * \nu\text{Water} * (\text{Tout} - \text{Tin}) * (1/\text{Eff_exist} - 1/\text{Eff_ee}))}{100,000} \right] + \left[\frac{(\text{SL} * \text{Hours/yr} * (1/\text{Eff_exist} - 1/\text{Eff_ee}))}{100,000} \right] \end{aligned}$$

$$\begin{aligned} \Delta\text{Therms for remaining measure life (next 10 years):} \\ &= \left[\frac{(\text{MFHH} * \#\text{Units} * \text{GPD} * \text{Days/yr} * \nu\text{Water} * (\text{Tout} - \text{Tin}) * (1/\text{Eff_base} - 1/\text{Eff_ee}))}{100,000} \right] + \left[\frac{(\text{SL} * \text{Hours/yr} * (1/\text{Eff_base} - 1/\text{Eff_ee}))}{100,000} \right] \end{aligned}$$

Where:

MFHH = number of people in Multi-Family House Hold
 = Actual. If unknown assume 2.1 persons/unit²²⁸

²²⁷ The two equations are provided to show how savings are determined during the initial phase of the measure (existing to efficient) and the remaining phase (new baseline to efficient). In practice, the screening tools used may either require a First Year savings (using the first equation) and then a “number of years to adjustment” and “savings adjustment” input which would be the (new base to efficient savings)/(existing to efficient savings).

²²⁸ Navigant, ComEd PY3 Multi-Family Home Energy Savings Program Evaluation Report Final, May 16, 2012.

#Units	= Number of units served by hot water boiler
	= Actual
GPD	= Gallons of hot water used per person per day
	= Actual. If unknown assume 17.6 gallons per person per day ²²⁹
Days/yr	= 365.25
ν Water	= Specific Weight of Water
	= 8.33 gal/lb
Tout	= tank temperature of hot water
	= 125°F or custom
Tin	= Incoming water temperature from well or municipal system
	= 54°F ²³⁰
Eff_base	= thermal efficiency of base unit
	= 80% ²³¹
Eff_ee	= thermal efficiency of efficient unit complying with this measure
	= Actual. If unknown assume 88%
Eff_exist	= thermal efficiency of existing unit
	= Actual. If unknown assume 73% ²³²
SL	= Standby Loss ²³³
	= (Input rating / 800) + (110 * ν Tank Volume)
	Input rating = Name plate input capacity in Btuh
	Tank Volume = Rated volume of the tank in gallons
Hours / yr	= 8766 hours

²²⁹ Deoreo, B., and P. Mayer. Residential End Uses of Water Study Update. Forthcoming. ©2015 Water Research Foundation. Reprinted With Permission.

²³⁰ US DOE Building America Program. Building America Analysis Spreadsheet. For Chicago, IL http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html

²³¹ IECC 2012/2015, Table C404.2, Minimum Performance of Water-Heating Equipment

²³² Based upon DCEO data provided 10/2014; average age adjusted efficiency of existing units replaced through the program. Efficiency age adjustment of 0.5% per year based upon NREL “Building America Performance Analysis Procedures for Existing Homes”.

²³³ Stand-by loss is provided in IECC 2012/2015, Table C404.2, Minimum Performance of Water-Heating Equipment

100,000 = btu/therm

EXAMPLES

Time of Sale:

For example, an 88% 1000 gallon boiler with 150,000 Btuh input rating installed serving 50 units.

$$\begin{aligned} \Delta\text{Therms} &= \text{Hot Water Savings} + \text{Standby Loss Savings} \\ &= \left[\frac{(\text{MFHH} * \text{\#Units} * \text{GPD} * \text{Days/yr} * \nu\text{Water} * (\text{Tout} - \text{Tin}) * (1/\text{Eff_base} - 1/\text{Eff_ee}))}{100,000} \right] + \left[\frac{(\text{SL} * \text{Hours/yr} * (1/\text{Eff_base} - 1/\text{Eff_ee}))}{100,000} \right] \\ &= \left[\frac{(2.1 * 50 * 17.6 * 8.33 * 365.25 * 1.0 * (125-54) * (1/0.8 - 1/0.88))}{100000} \right] + \left[\frac{((150000/800 + (110 * \nu 1000)) * 8766 * (1/0.8 - 1/0.88))}{100000} \right] \\ &= 454 + 37 \\ &= 490 \text{ therms} \end{aligned}$$

Early Replacement:

For example, an 88% 1000 gallon boiler with 150,000 Btuh input rating installed serving 50 units replaces a working unit with unknown efficiency.

$$\begin{aligned} \Delta\text{Therms for remaining life of existing unit (1st 5 years):} \\ &= \left[\frac{(2.1 * 50 * 17.6 * 8.33 * 365.25 * 1.0 * (125-54) * (1/0.73 - 1/0.88))}{100000} \right] + \left[\frac{((150000/800 + (110 * \nu 1000)) * 8766 * (1/0.73 - 1/0.88))}{100000} \right] \\ &= 932 + 75 \\ &= 1007 \text{ therms} \\ \Delta\text{Therms for remaining measure life (next 10 years):} \\ &= 454 + 37 \text{ (as above)} \\ &= 490 \text{ therms} \end{aligned}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HW_-MDHW-V02-160601