### 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).

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###### 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 be[[1]](#footnote-1)

|  |  |  |
| --- | --- | --- |
| 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 |

###### Deemed Measure Cost

The incremental capital cost for this measure is provided below:[[2]](#footnote-2)

|  |  |  |
| --- | --- | --- |
| 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 types[[3]](#footnote-3):

|  |  |
| --- | --- |
| Location | CF  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**

###### 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.

Where:

ΔBuildingEnergy= Change in annual electric energy consumption of building water heater

= [(WaterUseBase \* RacksWashed \* Days) \* (∆Tin \*1.0 \* 8.2 ÷ EffHeater ÷ 3,413)] - [(WaterUseESTAR \* RacksWashed \* Days) \* (∆Tin \*1.0 \* 8.2 ÷ EffHeater ÷ 3,413)]

ΔBoosterEnergy= Annual electric energy consumption of booster water heater

= [(WaterUseBase \* RacksWashed \* Days) \* (∆Tin \*1.0 \* 8.2 ÷ EffHeater ÷ 3,413)] - [(WaterUseESTAR \* RacksWashed \* Days) \* (∆Tin \*1.0 \* 8.2 ÷ EffHeater ÷ 3,413)]

ΔIdleEnergy= Annual idle electric energy consumption of dishwasher

= [IdleDrawBase\* (Hours \*Days – Days \* RacksWashed \* WashTime ÷ 60)] –

[IdleDrawESTAR\* (Hours \*Days – Days \* RacksWashed \* WashTime ÷ 60)]

Where:

WaterUseBase = 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

WaterUseESTAR = 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 days per year

Tin = 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)

EffHeater = Efficiency of water heater

= Custom or if unknown, use 98% for electric building and booster water heaters

3,413 = kWh to Btu conversion factor

IdleDrawBase = Idle power draw (kW) of baseline dishwasher

= Custom or if unknown, use value from table below as determined by machine type and sanitation method

IdleDrawESTAR = 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:

ΔkWh = ΔBuildingEnergy + ΔBoosterEnergy + ΔIdleEnergy

Where:

ΔBuildingEnergy = [(1.09 \* 75 \* 365) \* (70 \*1.0 \* 8.2 ÷ 0.98÷ 3,413)] - [(0.86 \* 75 \* 365) \* (70 \*1.0 \* 8.2 ÷ 0.98÷ 3,413)]

= 1,082 kWh

ΔBoosterEnergy = [(1.09 \* 75 \* 365) \* (40 \*1.0 \* 8.2 ÷ 0.98÷ 3,413)] - [(0.86 \* 75 \* 365) \* (40 \*1.0 \* 8.2 ÷ 0.98÷ 3,413)]

= 618 kWh

ΔIdleEnergy = [0.76 \* (18 \*365 – 365 \* 75 \* 2.0 ÷ 60)] –

[0.50 \* (18 \*365 – 365 \* 75 \* 2.0 ÷ 60)]

= 1,471 Wh

ΔkWh = 1,082 + 618 + 1,471

= 3,171 kWh

Default values for WaterUse, RacksWashed, kWIdle, and WashTime are presented in the table below.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **RacksWashed** | **WashTime** | **WaterUse** | | **IdleDraw** | |
| **Low Temperature** | **All Dishwashers** | **All Dishwashers** | **Conventional** | **ENERGY STAR** | **Conventional** | **ENERGY STAR** |
| 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.

Electric building and electric booster water heating

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Dishwasher type** | | **kWhBase** | **kWhESTAR** | **ΔkWh** |
| **Low Temp** | Under Counter | 10,965 | 8,425 | 2,540 |
| Stationary Single Tank Door | 39,279 | 23,126 | 16,153 |
| Single Tank Conveyor | 42,201 | 28,574 | 13,626 |
| Multi Tank Conveyor | 50,077 | 31,266 | 18,811 |
| **High Temp** | Under Counter | 12,355 | 9,184 | 3,171 |
| Stationary Single Tank Door | 39,825 | 27,962 | 11,863 |
| Single Tank Conveyor | 45,561 | 36,350 | 9,212 |
| Multi Tank Conveyor | 72,473 | 45,065 | 27,408 |
| Pot, Pan, and Utensil | 21,065 | 17,754 | 3,311 |

Electric building and natural gas booster water heating

| **Dishwasher type** | | **kWhBase** | **kWhESTAR** | **ΔkWh** |
| --- | --- | --- | --- | --- |
| **Low Temp** | Under Counter | 10,965 | 8,425 | 2,540 |
| Stationary Single Tank Door | 39,279 | 23,126 | 16,153 |
| Single Tank Conveyor | 42,201 | 28,574 | 13,626 |
| Multi Tank Conveyor | 50,077 | 31,266 | 18,811 |
| **High Temp** | Under Counter | 9,426 | 6,873 | 2,553 |
| Stationary Single Tank Door | 26,883 | 19,033 | 7,850 |
| Single Tank Conveyor | 33,092 | 26,317 | 6,775 |
| Multi Tank Conveyor | 51,619 | 33,456 | 18,163 |
| Pot, Pan, and Utensil | 14,042 | 11,935 | 2,107 |

Natural gas building and electric booster water heating

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Dishwasher type** | | **kWhBase** | **kWhESTAR** | **ΔkWh** |
| **Low Temp** | Under Counter | 2,829 | 2,829 | 0 |
| Stationary Single Tank Door | 2,409 | 2,409 | 0 |
| Single Tank Conveyor | 9,344 | 8,760 | 584 |
| Multi Tank Conveyor | 10,950 | 10,950 | 0 |
| **High Temp** | Under Counter | 7,229 | 5,140 | 2,089 |
| Stationary Single Tank Door | 17,176 | 12,336 | 4,840 |
| Single Tank Conveyor | 23,740 | 18,793 | 4,948 |
| Multi Tank Conveyor | 35,979 | 24,749 | 11,230 |
| Pot, Pan, and Utensil | 8,775 | 7,571 | 1,204 |

Natural gas building and natural gas booster water heating

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Dishwasher type** | | **kWhBase** | **kWhESTAR** | **ΔkWh** |
| **Low Temp** | Under Counter | 2,829 | 2,829 | 0 |
| Stationary Single Tank Door | 2,409 | 2,409 | 0 |
| Single Tank Conveyor | 9,344 | 8,760 | 584 |
| Multi Tank Conveyor | 10,950 | 10,950 | 0 |
| **High Temp** | Under Counter | 4,300 | 2,829 | 1,471 |
| Stationary Single Tank Door | 4,234 | 3,407 | 827 |
| Single Tank Conveyor | 11,271 | 8,760 | 2,511 |
| Multi Tank Conveyor | 15,126 | 13,140 | 1,986 |
| Pot, Pan, and Utensil | 1,752 | 1,752 | 0 |



















###### Summer Coincident Peak Demand Savings

ΔkW = ΔkWh/ AnnualHours

Where:

AnnualHours = Hours \* Days

= 18 \* 365.25

= 6575 annual hours

**Natural Gas Energy Savings**

Example:

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

ΔkW = ΔkWh/ AnnualHours

= 1213/6575

= 0.184 kW

Where:

ΔBuildingEnergy  = Change in annual natural gas consumption of building water heater

= [(WaterUseBase \* RacksWashed \* Days)\*(∆Tin \* 1.0 \* 8.2 ÷ EffHeater ÷ 100,000)] - [(WaterUseESTAR\* RacksWashed \* Days)\*(∆Tin \* 1.0\*8.2 ÷ EffHeater ÷ 100,000)]

ΔBoosterEnergy  = Change in annual natural gas consumption of booster water heater

= [(WaterUseBase \* RacksWashed \* Days)\*(∆Tin \* 1.0 \* 8.2 ÷ EffHeater ÷ 100,000)] - [(WaterUseESTAR\* RacksWashed \* Days)\*(∆Tin \* 1.0\*8.2 ÷ EffHeater ÷ 100,000)]

Where:

WaterUseBase = 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

WaterUseESTAR = 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

Tin = 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)

EffHeater = Efficiency of water heater

= Custom or 80% for gas building and booster water heaters

100,000 = Therms to Btu conversion factor

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:

ΔTherms = ΔBuildingEnergy + ΔBoosterEnergy

Where:

ΔBuildingEnergy = [(1.09\* 75 \* 365)\*(70\* 1.0 \* 8.2 ÷ 0.80 ÷ 100,000)] - [(0.86 \* 75 \* 365)\*(70\* 1.0 \* 8.2 ÷ 0.80 ÷ 100,000)]

= 45 therms

ΔBoosterEnergy = [(1.09\* 75 \* 365)\*(40\* 1.0 \* 8.2 ÷ 0.80 ÷ 100,000)] - [(0.86 \* 75 \* 365)\*(40\* 1.0 \* 8.2 ÷ 0.80 ÷ 100,000)]

= 26 therms

ΔTherms = 45 + 26

= 71 therms

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

Electric building and natural gas booster water heating

| **Dishwasher type** | | **ThermsBase** | **ThermsESTAR** | **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 | 122 | 97 | 26 |
| Stationary Single Tank Door | 541 | 373 | 168 |
| Single Tank Conveyor | 521 | 419 | 102 |
| Stationary Single Tank Door | 872 | 485 | 386 |
| Pot, Pan, and Utensil | 294 | 243 | 50 |

Natural gas building and natural gas booster water heating

| **Dishwasher type** | | **ThermsBase** | **ThermsESTAR** | **ΔTherms** |
| --- | --- | --- | --- | --- |
| **Low Temp** | Under Counter | 340 | 234 | 106 |
| Stationary Single Tank Door | 1,542 | 866 | 675 |
| Single Tank Conveyor | 1,374 | 828 | 545 |
| Multi Tank Conveyor | 1,636 | 849 | 786 |
| **High Temp** | Under Counter | 337 | 266 | 71 |
| Stationary Single Tank Door | 1,488 | 1,027 | 461 |
| Single Tank Conveyor | 1,434 | 1,154 | 280 |
| Multi Tank Conveyor | 2,398 | 1,335 | 1,063 |
| Pot, Pan, and Utensil | 807 | 669 | 138 |

Natural gas building and electric booster water heating

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Dishwasher type** | | **ThermsBase** | **ThermsESTAR** | **ΔTherms** |
| **Low Temp** | Under Counter | 340 | 234 | 106 |
| Stationary Single Tank Door | 1,542 | 866 | 675 |
| Single Tank Conveyor | 1,374 | 828 | 545 |
| Multi Tank Conveyor | 1,636 | 849 | 786 |
| **High Temp** | Under Counter | 214 | 169 | 45 |
| Stationary Single Tank Door | 947 | 653 | 294 |
| Single Tank Conveyor | 912 | 734 | 178 |
| Multi Tank Conveyor | 1,526 | 849 | 676 |
| Pot, Pan, and Utensil | 514 | 426 | 88 |

**Water Impact Descriptions and Calculation**

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Where:

WaterUseBase = 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

WaterUseESTAR = 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:

∆Water = (WaterUseBase \* RacksWashed \* Days) - (WaterUseESTAR \* RacksWashed \* Days)

ΔWater = (1.73\* 75 \* 365) - (1.19\* 75 \* 365)

= 14,783 gallons

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

|  | **Annual Water Consumption (gallons)** | | |
| --- | --- | --- | --- |
| **Baseline** | **ENERGY STAR** | **Savings** |
| **Low Temperature** | | | |
| Under Counter | 47,359 | 32,576 | 14,783 |
| Stationary Single Tank Door | 214,620 | 120,596 | 94,024 |
| Single Tank Conveyor | 191,260 | 115,340 | 75,920 |
| Multi Tank Conveyor | 227,760 | 118,260 | 109,500 |
| **High Temperature** | | | |
| Under Counter | 29,839 | 23,543 | 6,296 |
| Stationary Single Tank Door | 131,838 | 90,958 | 40,880 |
| Single Tank Conveyor | 127,020 | 102,200 | 24,820 |
| Multi Tank Conveyor | 212,430 | 118,260 | 94,170 |
| Pot, Pan, and Utensil | 71,540 | 59,276 | 12,264 |

###### Deemed O&M Cost Adjustment Calculation

N/A

###### Measure Code: CI-FSE-ESDW-V02-160601

1. Lifetime from ENERGY STAR Commerical 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 [↑](#footnote-ref-1)
2. Measure cost from ENERGY STAR Commercial Kitchen Equipment Savings Calculator which cites reference as “EPA research on available models using AutoQuotes, 2012” [↑](#footnote-ref-2)
3. 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 [↑](#footnote-ref-3)