Fuel Source	ΔkWh per Load	Therms per Load
Electric Hot Water, Electric Dryer	0.57	0
Gas Hot Water, Electric Dryer	0.25	0.02

$Load_{Year}$ = Number of loads per year
= 950[678]

For example, a commercial clothes washer is installed in a facility with electric water heating and electric drying:

$\Delta kWh = 0.57 \times 950$

$= 541.5\ kWh$

Summer Coincident Peak Demand Savings
No demand savings are claimed for this measure since there is insufficient peak coincident data.

Fossil Fuel Impact Descriptions and Calculation
Commercial clothes washers will only have fossil fuel impacts when either the washer, dryer, or both are powered by gas instead of electricity.

$\Delta MMBtu = \Delta MMBtu_{Load} \times Loads_{Year}$

Where:

$\Delta MMBtu_{Load}$ = The difference in gas consumption per load of laundry between baseline equipment and efficient equipment
= Dependent on energy source for washer and dryer – see Table 'Assumptions for Electricity and Gas Consumption for Commercial Clothes Washers' in the Reference Table Section

$Loads_{Year}$ = Number of loads per year
= 950

Water Impact Descriptions and Calculation
The annual water savings for a commercial clothes washer is assumed to be 15,854 gallons per year.[679]

Deemed O&M Cost Adjustment Calculation
n/a

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[677] ENERGY STAR calculator for Commercial Clothes Washers, values based on the difference between the average of all qualified models and the average of all unqualified models (July 2009).
[678] ENERGY STAR calculator for Commercial Clothes Washers, Multi-Family Laundry Association (2002)
[679] ENERGY STAR calculator for Commercial Clothes Washers, average water consumption based on all qualified models (July 2009)

Commercial Plug Load – Smart Strip Plug Outlets (Time of Use, Retrofit – New Equipment)

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

Description
A smart strip plug outlet is a multi-plug power strip with the ability to automatically disconnect specific loads that are plugged into it depending upon the power draw of a control load, also plugged into the strip. The energy savings are measured by estimating the number of hours that electronic devices at typical workstations are either in the "sleep" mode or shut off and the standby loads consumed by the devices at those times. The smart strip will eliminate these standby loads and result in measureable energy savings. A smart strip plug outlet is purchased through a retail outlet and installed in an office environment where standby loads are uncontrolled.

Definition of Efficient Equipment
The efficient condition assumes peripherals electronic office equipment is plugged into the controlled Smart Strip outlets resulting in a reduction in standby load. No savings are associated with the control load, or loads plugged into the uncontrolled outlets.

Definition of Baseline Equipment
The baseline assumes a mix of typical office equipment (computer and peripherals) each with uncontrolled standby load.

Deemed Savings for this Measure

Annual kWh Savings	= 23.6 kWh
Summer Coincident Peak kW Savings	= 0

Deemed Lifetime of Efficient Equipment
The estimated useful life for a smart strip plug outlet is 8 years[680]

Deemed Measure Cost
The estimated incremental cost for smart strip plug outlets is assumed to be $15.[681]

Deemed O&M Cost Adjustments
n/a

Coincidence Factor
0[682]

REFERENCE SECTION

Calculation of Savings

Energy Savings

$$\Delta kWh = (WORKDAYS \times \Delta Wh_{Workday} + (365 - WORKDAYS) * \Delta Wh_{Non\text{-}Workday}) / 1000$$

[680] BC Hydro report: Smart Strip electrical savings and usability, October 2008 (unit can only take one surge, then needs to be replaced)
681 Research Into Action, Inc. (2010) *Electronics and Energy Efficiency: A Plug Load Characterization Study*. Prepared for Southern California Edison.. Incremental cost over standard power strip with surge protection with average market price of $35 for controlled power strip and $20 for baseline plug strip with surge protection
[682] Based on the assumption that most office equipment will be operating during the peak coincident hour

Where:

WORKDAYS = Average number of workdays, or business days, in a year
= 240[683]

$\Delta Wh_{workday}$ = The energy savings of devices plugged into the strip on work days (Wh)
= 63.23[684]

$\Delta Wh_{Non-workday}$ = The energy savings of devices plugged into the strip on non-work days (Wh)
= 67.63

Summer Coincident Peak Demand Savings

$\Delta kW = 0$

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

Reference Tables

Standby Power Consumption for Devices Using Smart Strip Plug Outlets[685]

Plug Load	Watts in Standby	Hours in Standby	Watts when off	Hours Off, Workday	Hours Off, Non-Workday	% of strips[686]
LCD Monitor	1.38	4	1.13	12	24	69%
CRT Monitor	12.14	4	0.8	12	24	25%
Printer (avg. laser and ink)	NA	0	1.42	20	24	43%
Multifunction Printer (avg. laser and ink)	NA	0	4.19	20	24	12%
Speakers	1.79	4	1.79	12	24	1%
Scanner	NA	0	2.48	20	24	7%
Copier	NA	0	1.49	20	24	5%
Modem	3.85	16	3.84	0	24	8%
Charger	2.24	0	0.26	20	24	50%

$\Delta Wh_{Workday}$	63.23064
$\Delta Wh_{Non-Workday}$	67.6344

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[683] Assumes 2 weeks of vacation and 2 weeks of holidays for a total of 48 work weeks annually
[684] See Table 'Standby Power Consumption of Devices Using Smart Strip Plug Outlets'
[685] Standby and off loads sourced from Lawrence Berkeley National Laboratory http://standby.lbl.gov/summary-table.html. Hours of operation based on engineering estimates.
[686] Research Into Action, Inc. (2010) *Electronics and Energy Efficiency: A Plug Load Characterization Study*. Prepared for Southern California Edison.. Page k-2.

Plug Load Occupancy Sensor (Retrofit)

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

Description
Plug load occupancy sensors are devices that control low wattage office equipment using an occupancy sensor. They typically use an infrared sensor to monitor movement, and use a smart strip to turn off connected devices, or put them in standby mode, when no one is present.

Definition of Efficient Equipment
In order for this characterization to apply, the installed equipment must be a 'smart' power strip with both control and peripheral outlets, and an occupancy sensor.

Definition of Baseline Equipment
The baseline assumes a mix of typical document station office equipment (printers, scanners, fax machines, etc.) each with uncontrolled standby load.

Deemed Savings for this Measure

Annual kWh Savings	= 169 kWh/yr
Summer Coincident Peak kW Savings	= 0

Deemed Lifetime of Efficient Equipment
The estimated useful life for a smart strip plug outlet is 8 years[687]

Deemed Measure Cost
The incremental cost for this measure is assumed to be $70[688]

Deemed O&M Cost Adjustments
n/a

Coincidence Factor
0[689]

REFERENCE SECTION

Calculation of Savings

Energy Savings

$$\Delta kWh = (WORKDAYS \times \Delta W_{sleep}) / 1000$$

Where:

WORKDAYS = Average number of workdays, or business days, in a year
= 240[690]

ΔW_{sleep} = The energy savings of devices plugged into the strip when in 'sleep' mode (Wh)
= 704[691]

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687 BC Hydro report: Smart Strip electrical savings and usability, October 2008 (unit can only take one surge, then needs to be replaced)
688 *Plug Load Characterization Study for Southern California Edison*. Prepared by Research Into Action (2010)
689 Based on assumption that office equipment will be running during the peak period
690 Assumes 2 weeks of vacation and 2 weeks of holidays for a total of 48 work weeks annually
691 See Table 'Standby Power Consumption of Devices Using Smart Strip Plug Outlets'

Summer Coincident Peak Demand Savings

$$\Delta kW = 0$$

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

Reference Tables

Standby Power Consumption for Devices Using Smart Strip Plug Outlets[692] (All values in Watts)

Computer Peripherals	Connected Load when 'On'	Connected Load in 'Sleep'	Hours in Sleep Mode	Daily Savings
Laser Printer	131	2	4	516
Multi-function device, laser (scanner, fax)	50	3	4	188
			Total	704

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[692] Standby loads sourced from Lawrence Berkeley National Laboratory http://standby.lbl.gov/summary-table.html. Hours of operation based on engineering estimations.

Energy Efficient Furnace (Time of Sale, Retrofit – Early Replacement)

Official Measure Code (Measure Number: X-X-X-X (Efficient Products, HVAC End Use)

Description
This measure covers the installation of a high efficiency gas furnace in lieu of a standard efficiency gas furnace. High efficiency gas furnaces achieve savings through the utilization of a sealed, super insulated combustion chamber, more efficient burners, and multiple heat exchangers that remove a significant portion of the waste heat from the flue gasses. Because multiple heat exchangers are used to remove waste heat from the escaping flue gasses, most of the flue gasses condense and must be drained. Furnaces equipped with ECM fan motors can save additional electric energy.

Definition of Efficient Equipment
The efficient equipment is a natural gas-fired furnace with a minimum Annual Fuel Utilization Efficiency (AFUE) rating of 93%.

Definition of Baseline Equipment
The equivalent baseline equipment is a natural gas-fired furnace with an AFUE of 80%.

Deemed Calculation for this Measure

Annual kWh Savings	$= 5 \times CAP \times EFLH_h \times (\eta_{base}/\eta_{ee})$
Summer Coincident Peak kW Savings	= 0[693]
Annual MMBtu Savings	$= (CAP) * (EFLH_h) * ((1 - (\eta_{base}/\eta_{ee})) - MMBtu_{ECM}$

Deemed Lifetime of Efficient Equipment
20[694]

Deemed Measure Cost
Incremental cost estimated at $900[695]

Deemed O&M Cost Adjustments
$0[696]

Coincidence Factor
n/a

REFERENCE SECTION

Calculation of Savings

Energy Savings

693 For analysis purposes, it is assumed that the furnace fan does not operate during the summer season and therefore contributes no summer peak coincident savings.
694 Based on engineering modeling by Michael Blasnik (M. Blasnik & Associates) and KEMA in support of "Application of Columbia Gas of Ohio, Inc, to Establish Demand Side Management Programs for Residential and Commercial Consumers," Filed with the Ohio Public Utilities Commission, Case No. 08-0833-GA-UNC, July 1, 2008
695 Ibid.
696 Ibid.

If furnace equipped with ECM fan motors, the following algorithm can be used to calculate energy savings; otherwise, electric energy savings are zero:

$\Delta kWh = (5) \times (CAP) \times (EFLH_h) \times (\eta_{base}/\eta_{ee})$

Where:

5 = annual kWh savings per MMBtu of heating fuel consumption[697]

CAP = equipment heating capacity (MMBtu/hr)

$EFLH_h$ = equivalent full load heating hours
= 2,408[698]

η_{ee} = installed equipment efficiency; expressed as AFUE, Combustion Efficiency (E_c), or Thermal Efficiency (E_t).

η_{base} = Assume 80%[699].

Summer Coincident Peak Demand Savings

$\Delta kW = 0$

Fossil Fuel Impact Descriptions and Calculation

$\Delta MMBtu = (CAP) * (EFLH_h) * ((1 - (\eta_{base}/\eta_{ee})) - MMBtu_{ECM}$

Where:

$MMBtu_{ECM}$ = increased heating fuel consumption in MMBtu due to decreased fan motor waste heat (for furnaces with ECM fan ONLY)
$= (0.019) * (CAP) * (EFLH_h) * (\eta_{base}/\eta_{ee})$[700]

Deemed O&M Cost Adjustment Calculation

n/a

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[697] Adapted from "Electricity Use by New Furnaces: A Wisconsin Field Study," Energy Center of Wisconsin, 10/2003. Assumes ECM fan motor savings scale linearly with annual fuel consumption.

[698] From Guelph, Ontario – GuelphHydro Inc. Project LCC Analysis. Based on Climate data, average mean annual temperature and geographic location, Guelph is very similar to Akron, Ohio. While was judged internally to be an acceptable proxy value for Ohio, this factor is a candidate for future review and verification.

[699] International Energy Conservation Code (IECC 2006) 2006, Table 503.2.3(4), Warm Air Furnaces and Combination Warm Air Furnaces/Air-Conditioning Units, Warm Air Duct Furnaces and Unit Heaters, Minimum Efficiency Requirements. Dependent on equipment type and capacity, minimum efficiency levels range from 78% to 81% and are either expressed as AFUE, E_c, or E_t. For analysis purposes, assume 80%.

[700] Adapted from "Electricity Use by New Furnaces: A Wisconsin Field Study," Energy Center of Wisconsin, 10/2003.

High Efficiency Storage Tank Water Heater (Time of Sale, Retrofit – Early Replacement)

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

Description
Stand-alone, or tank-type heaters, run off natural gas. These water heaters consist of a storage tank with an attached heat source, in this case, a high-efficiency gas burner. They achieve energy savings through the use of efficient heating equipment and superior tank insulation.

Definition of Efficient Equipment
The efficient case is a natural gas-fired tank-type water heater exceeding the efficiency requirements as mandated by the International Energy Conservation Code (IECC) 2006, Table 504.2.

Definition of Baseline Equipment
The baseline condition is a gas-fired tank-type water heater meeting the efficiency requirements as mandated by the International Energy Conservation Code (IECC) 2006, Table 504.2.

Deemed Savings for this Measure

Annual kWh Savings = 0

Summer Coincident Peak kW Savings = 0

Annual MMBtu Savings $= [W \times 8.33 \times (T_{out} - T_{in}) \times ((1/\eta_{base}) - (1/\eta_{ee})) + (STBY_{base} - STBY_{ee}) \times 8760] / 1{,}000{,}000$

Deemed Lifetime of Efficient Equipment
12 years[701]

Deemed Measure Cost
$300[702]

Deemed O&M Cost Adjustments
n/a

Coincidence Factor
n/a

REFERENCE SECTION

Calculation of Savings

Energy Savings
There are no expected energy savings associated with this measure

Summer Coincident Peak Demand Savings
There is no expected peak demand reduction associated with this measure.

[701] Ibid.
[702] Ibid.

Fossil Fuel Impact Descriptions and Calculation

$$\Delta MMBtu = [W \times 8.33 \times (T_{out}-T_{in}) \times ((1/\eta_{base})-(1/\eta_{ee})) + (STBY_{base} - STBY_{ee}) \times 8760] / 1,000,000$$

Where:

W = Annual water use for equipment (in gallons)
= If actual water usage is unknown, assume 21,900[703].

8.33 = weight in lbs of 1 gallon of water, or the Btus required to raise 1 gallon of water 1 °F

T_{out} = water heater set point (°F)
= If unknown, assume 130 °F[704]

T_{in} = water inlet temperature (°F)
= If unknown, assume 50°F[705]

η_{base} = rated efficiency of baseline water heater expressed as Energy Factor (EF) or Thermal Efficiency (E_t); see table below for values:

Equipment Type	Size Category (Input)	Subcategory	Performance Required[706] (η_{base} and $STBY_{base}$)
Storage water heaters, Gas	<= 75,000 Btu/h	>= 20 gal	EF = 0.67 - 0.0019V
	> 75,000 Btu/h and <= 155,000 Btu/h	< 4,000 Btu/h/gal	E_t = 80%, $STBY_{base} = (Q / 800 + 110\sqrt{V})$
	> 155,000 Btu/h	< 4,000 Btu/h/gal	E_t = 80%, $STBY_{base} = (Q / 800 + 110\sqrt{V})$

V = rated tank volume in gallons
= Actual installed

Q = nameplate input rate in Btu/hr
= Actual installed

η_{ee} = rated efficiency of efficient water heater expressed as Energy Factor (EF) or Thermal Efficiency (E_t)
= Actual installed

$STBY_{base}$ = standby losses/hr of baseline water heater (Btu/hr); see table above for values.

$STBY_{ee}$ = standby losses/hr of efficient water heater (Btu/hr)
= Actual installed (for unit rated with Energy Factor (EF), $STBY_{base} = 0$)

8760 = hours per year

1,000,000 = conversion factor (Btu/MMBtu)

Water Impact Descriptions and Calculation

n/a

Deemed O&M Cost Adjustment Calculation

n/a

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[703] 60 gallons a day for 365 days per year

[704] NAHB Research Center, (2002). *Performance Comparison of Residential Hot Water Systems.* Prepared for: National Renewable Energy Laboratory, Golden, Colorado.

[705] NAHB Research Center, (2002). *Performance Comparison of Residential Hot Water Systems.* Prepared for: National Renewable Energy Laboratory, Golden, Colorado.

[706] International Energy Conservation Code (IECC 2006) 2006, Table 504.2, Minimum Performance of Water-Heating Equipment.

Tankless Water Heaters (Time of Sale, Retrofit – Early Replacement)

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

Description
This measure covers the installation of a natural gas-fired tankless or instantaneous water heater. Tankless water heaters essentially function like normal water heaters without the storage tank. When there is demand for hot water, the gas burner fires and heats water as it passes through the heater to the demand source. Because the water heater must heat water at the rate of flow through the device, tankless water heaters are not well suited to serve sources of significant demand. Tankless water heaters achieve savings by eliminating the standby losses that occur in stand-alone or tank-type water heaters.

Definition of Efficient Equipment
The efficient case is a tankless natural gas-fired water heater exceeding the efficiency requirements as mandated by the International Energy Conservation Code (IECC) 2006, Table 504.2.

Definition of Baseline Equipment
The baseline condition is a gas-fired tank-type water heater meeting the efficiency requirements as mandated by the International Energy Conservation Code (IECC) 2006, Table 504.2.

Deemed Calculation for this Measure

Annual kWh Savings = 0

Summer Coincident Peak kW Savings = 0

Annual MMBtu Savings $= W \times 8.33 \times (T_{out}-T_{in}) \times [(1/\eta_{base}) - (1/\eta_{ee})] \times (STBY_{base} \times 8760) / 1{,}000{,}000$

Deemed Lifetime of Efficient Equipment
20 years[707]

Deemed Measure Cost [708]
Full Installed Cost: $871.74
Incremental Material Cost: $433.72

Deemed O&M Cost Adjustments
$9.60[709]

Coincidence Factor
n/a

[707] CenterPoint Energy – Triennial CIP/DSM Plan 2010-2012 Report
[708] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Cost Values and Summary Documentation", California Public Utilities Commission, December 16, 2008
[709] CenterPoint Energy – Triennial CIP/DSM Plan 2010-2012 Report

REFERENCE SECTION

Calculation of Savings

Energy Savings
There are no expected energy savings associated with this measure

Summer Coincident Peak Demand Savings
There is no expected peak demand reduction associated with this measure.

Fossil Fuel Impact Descriptions and Calculation

$\Delta MMBtu = W \times 8.33 \times (T_{out} - T_{in}) \times [(1/\eta_{base}) - (1/\eta_{ee})] \times (STBY_{base} \times 8760) / 1{,}000{,}000$

Where:

W = Annual water use for equipment (in gallons)
= If actual water usage is unknown, assume 21,900[710].

8.33 = weight in lbs of 1 gallon of water, or the Btus required to raise 1 gallon of water 1 °F

T_{out} = water heater set point (°F) (demand temperature)
= If unknown, assume 130 °F[711]

T_{in} = water inlet temperature (°F)
= If unknown, assume 50°F[712]

η_{base} = rated efficiency of baseline water heater expressed as Energy Factor (EF) or Thermal Efficiency (E_t); see table below for values:

Equipment Type	Size Category (Input)	Subcategory	Performance Required[713] (η_{base} and $STBY_{base}$)
Storage water heaters, Gas	<= 75,000 Btu/h	>= 20 gal	EF = 0.67 - 0.0019V
	> 75,000 Btu/h and <= 155,000 Btu/h	< 4,000 Btu/h/gal	E_t = 80%, $STBY_{base} = (Q / 800 + 110\sqrt{V})$
	> 155,000 Btu/h	< 4,000 Btu/h/gal	E_t = 80%, $STBY_{base} = (Q / 800 + 110\sqrt{V})$

V = rated tank volume in gallons
= Actual installed

Q = nameplate input rate in Btu/hr
= Actual installed

η_{ee} = rated efficiency of efficient water heater expressed as Energy Factor (EF) or Thermal Efficiency (E_t)
= Actual installed

1,000,000 = conversion factor (Btu/MMBtu)

$STBY_{base}$ = standby losses/hr of baseline water heater (Btu/hr); see table above for values.

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

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[710] 60 gallons a day for 365 days per year
[711] NAHB Research Center, (2002). *Performance Comparison of Residential Hot Water Systems.* Prepared for: National Renewable Energy Laboratory, Golden, Colorado.
[712] NAHB Research Center, (2002). *Performance Comparison of Residential Hot Water Systems.* Prepared for: National Renewable Energy Laboratory, Golden, Colorado.
[713] International Energy Conservation Code (IECC 2006) 2006, Table 504.2, Minimum Performance of Water-Heating Equipment.

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Stack Damper (Retrofit – New Equipment)

Official Measure Code (Measure Number: X-X-X-X (Efficient Products, HVAC End Use)

Description
This measure covers the installation of a servo-controlled, exhaust vent stack damper on a boiler. The vent damper should be installed in the flue pipe, between the heating equipment and the chimney. A stack damper works like a flue damper on a fireplace by reducing draft, improving comfort, and minimizing heat loss. The vent damper can either be controlled by a heat sensor installed directly in the vent stack or by a mechanical switch connected to the thermostat, which is wired to work in unison with the ignition control switch on the boiler.

In combustion appliances that are directly vented to the atmosphere, there is a decrease in operating efficiency during standby, start-up and shut-down. During these times, warm room air is drawn through the stack via the draft hood or dilution air inlet at a rate proportional to the stack height, diameter and outdoor temperature. The most air is drawn through the vent immediately after the appliance shuts off and the flue is still hot.

A vent damper can prevent residual heat from being drawn up the warm vent stack by closing itself. Vent dampers can also reduce the amount of air that passes through the furnace or boiler heat exchanger by regulating start-up exhaust pressure, which can increase operating efficiency by reducing the time needed to achieve steady-state operating conditions. Lastly, by reducing air infiltration in the building, vent dampers can help to retain humidity, which can improve comfort during periods of high heating degree days.

Definition of Efficient Equipment
The efficient equipment is a vent stack with a damper installed.

Definition of Baseline Equipment
The baseline condition is a vent stack with no stack damper installed.

Deemed Calculation for this Measure

Annual kWh Savings = n/a

Summer Coincident Peak kW Savings = n/a

Annual MMBtu Savings = 100 MMBtu[714]

Deemed Lifetime of Efficient Equipment
12 yrs[715]

Deemed Measure Cost
$150[716]

Deemed O&M Cost Adjustments
n/a

Coincidence Factor
n/a

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[714] CenterPoint Energy – Triennial CIP/DSM Plan 2010-2012 Report. Based on information published by Natural Resources Canada and the Minneapolis Energy Office, savings estimates for stack dampers range from to 0 to 9.5% of total boiler gas consumption. This implies that the boiler capacity assumed to determine the deemed savings value is quite large and may overstate savings for smaller boilers. If significant participation for this measure is realized, it is suggested that the deemed savings estimate be abandoned in favor of a deemed calculated approach.
[715] CenterPoint Energy – Triennial CIP/DSM Plan 2010-2012 Report
[716] Manufacturer research suggests a range of $80-$200 materials cost, depending on size, safety controls and motor quality, as well as 1-2 hours average install time.

REFERENCE SECTION

Calculation of Savings

Energy Savings
There are no expected energy savings associated with this measure

Summer Coincident Peak Demand Savings
There is no expected peak demand reduction associated with this measure.

Baseline Adjustment
n/a

Fossil Fuel Impact Descriptions and Calculation

$$\Delta MMBtu = 100\ MMBtu$$

Deemed O&M Cost Adjustment Calculation
n/a

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Natural Gas-Fired Infrared Heater (Time of Sale)

Official Measure Code (Measure Number: X-X-X-X (Efficient Products, HVAC End Use)

Description
This measure covers the installation of a natural gas-fired infrared heater.

Definition of Efficient Equipment
An infrared heater heats primarily through radiation and conduction, as opposed to traditional forced-air space heaters which heat through convection. Infrared heaters are able to heat more efficiently because they directly heat the objects in the space, including the floor slab, which then radiate heat into the air space. With a forced hot air system, the heated air rises to the ceiling and stratifies, gradually working its way down to the floor level. The floor slab and equipment act as heat sinks causing the ceiling level to be much warmer than the floor area, which will cause the forced air system to work much harder to heat the same space. What is more, forced-air systems can experience drastic losses of heated air to ventilation air changes. There is also a negligible amount of electricity use (burner ignition and gas valve) compared to a forced-air system which requires large fans to move air around the conditioned space.

Definition of Baseline Equipment
The baseline equipment is a standard natural gas-fired convection space heater.

Deemed Calculation for this Measure

Annual kWh Savings	= n/a
Summer Coincident Peak kW Savings	= n/a
Annual MMBtu Savings	= 11.4 MMBtu/year[717]

Deemed Lifetime of Efficient Equipment
15 yrs[718]

Deemed Measure Cost
$920 (incremental cost)[719]

Deemed O&M Cost Adjustments
n/a

Coincidence Factor
n/a

[717] Based on engineering modeling by GSE in support of "Application of Columbia Gas of Ohio, Inc, to Establish Demand Side Management Programs for Residential and Commercial Consumers," Filed with the Ohio Public Utilities Commission, Case No. 08-0833-GA-UNC, July 1, 2008. A review of savings assumptions used in Massachusetts indicates that this estimate is very conservative. The proposed value is only 85% of what is assumed for Massachusetts and should be considered for future study if this measure receives significant participation.
[718] Ibid.
[719] Ibid.

REFERENCE SECTION

Calculation of Savings

Energy Savings
There are no expected energy savings associated with this measure

Summer Coincident Peak Demand Savings
There is no expected peak demand reduction associated with this measure.

Baseline Adjustment
n/a

Fossil Fuel Impact Descriptions and Calculation

$$\Delta MMBtu = 11.4\ MMBtu/year$$

Deemed O&M Cost Adjustment Calculation
n/a

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Energy Efficient Boiler (Time of Sale)

Official Measure Code (Measure Number: X-X-X-X (Efficient Products, HVAC End Use)

Description
This measure covers the replacement of an irreparable existing boiler with a high efficiency, gas-fired steam or hot water boiler. High efficiency boilers achieve gas savings through the utilization of a sealed combustion chamber and multiple heat exchangers that remove a significant portion of the waste heat from flue gasses. Because multiple heat exchangers are used to remove waste heat from the escaping flue gasses, some of the flue gasses condense and must be drained.

Definition of Efficient Equipment
The efficient equipment is a natural gas-fired hot water or steam boiler exceeding the efficiency requirements as mandated by the International Energy Conservation Code (IECC) 2006, Table 503.2.3(5).

Definition of Baseline Equipment
The baseline equipment is a natural gas-fired boiler meeting the efficiency requirements as mandated by the International Energy Conservation Code (IECC) 2006, Table 503.2.3(5).

Deemed Calculation for this Measure

Annual kWh Savings = 0

Summer Coincident Peak kW Savings = 0

Annual MMBtu Savings = $(CAP) \times (EFLH_h) \times (1 - (\eta_{base}/\eta_{ee}))$

Deemed Lifetime of Efficient Equipment
20 years[720]

Deemed Measure Cost
Incremental cost is estimated at $5,000[721]

Deemed O&M Cost Adjustments
$0[722]

Coincidence Factor
n/a

REFERENCE SECTION

Calculation of Savings

Energy Savings
There are no expected energy savings associated with this measure

Summer Coincident Peak Demand Savings
There is no expected peak demand reduction associated with this measure.

[720] Based on engineering modeling by Michael Blasnik (M. Blasnik & Associates) in support of "Application of Columbia Gas of Ohio, Inc, to Establish Demand Side Management Programs for Residential and Commercial Consumers," Filed with the Ohio Public Utilities Commission, Case No. 08-0833-GA-UNC, July 1, 2008
[721] Ibid.
[722] Ibid.

Fossil Fuel Impact Descriptions and Calculation

ΔMMBtu = (CAP) x ($EFLH_h$) x (1 - (η_{base}/η_{ee}))

Where:

CAP = equipment heating capacity (MMBtu/hr)
= Actual installed

$EFLH_h$ = equivalent full load heating hours; determined with site-specific data. If actual value is unknown, assume 2,408[723].

η_{ee} = installed equipment efficiency; expressed as AFUE, Combustion Efficiency (E_c), or Thermal Efficiency (E_t).
= Actual installed

η_{base} = baseline equipment efficiency; expressed as AFUE, E_c, or E_t; see table below for values:

Equipment Type	Size Category (Input)	Subcategory Or Rating Condition	Minimum Efficiency[724]
Boilers, Gas fired	< 300,000 Btu/h	Hot water	80% AFUE
		Steam	75% AFUE
	>= 300,000 Btu/h and <= 2,500,000 Btu/h	Minimum capacity	75% E_t
	>2,500,000 Btu/h	Hot water	80% E_c
		Steam	80% E_c

Deemed O&M Cost Adjustment Calculation
n/a

Version Date & Revision History

Draft: Portfolio #
Effective date: Date TRM will become effective
End date: Date TRM will cease to be effective (or TBD)

[723] From Guelph, Ontario – GuelphHydro Inc. Project LCC Analysis. Based on Climate data, average mean annual temperature and geographic location, Guelph is very similar to Akron, Ohio. This was judged internally to be an acceptable proxy value for Ohio, although this surely warrants future review and verification.

[724] International Energy Conservation Code (IECC 2006) 2006, Table 503.2.3(5), Boilers, Gas- and Oil-Fired, Minimum Efficiency Requirements

IV. Protocols for Custom Commercial & Industrial Projects

C&I Equipment Replacement – Custom Measure Analysis Protocol

This protocol defines the requirements for analyzing and documenting commercial and industrial energy efficiency measures. It applies to custom measures filed under Utility Programs and those prepared for Mercantile Customers. This protocol addresses equipment replacement measures that are not covered by other analysis methodologies in the TRM. An equipment replacement project is defined as equipment replaced at the end of its rated service life, or when it is replaced due to failure, obsolescence or a need for increased capacity. If the project is replacing equipment prior to the end of its rated service life for the purpose of achieving energy savings, it is classified as Retrofit and the "C&I Retrofit – Custom Measure Analysis Protocol" should be used to guide analysis.

This protocol is intended to address the energy impacts of the incremental energy efficiency improvements over what would have been installed as per applicable federal/state/local codes or standard industry practice. Projects that include duplex, redundant and/or spare equipment shall calculate the energy savings based only on the operating equipment and systems.

This analysis protocol is supplemented by a glossary and an Analysis Template (Appendix B). Words used herein that are defined in the glossary are in italics. The Analysis Template is a tool that can guide applicants in preparing and presenting the documentation to support custom equipment replacement energy efficiency measure savings estimates.

The Analysis Protocol is divided into four sections:
Section 1: Project Information
Section 2: Project Savings
Section 3: Project Variables
Section 4: Documentation and Metering

Section 1: Project Information

Project Title
Provide a unique title for the project so that it is easily distinguishable from other projects prepared by the same customer and from projects with similar scope. Example: Company XYZ Building A - Compressed Air System Replacement.

Customer Name
Provide the name of the company undertaking the energy efficiency improvements.

Customer Contact
Provide the contact information including name, title, mailing address, phone, and email for the primary customer contact on this project.

Site (Location)
Provide the full address of the site at which the project is being implemented. If the customer has an additional business location that is involved with the project, include additional customer site information as needed.

Sector/Industry Description and NAICS Code
Describe the sector and industry in which the custom measure is being applied. Sectors include: Industrial, Commercial, Institutional, and Multi-family. Industry should specify the end use for commercial and institutional projects (e.g. office, restaurant, dormitory) and the specific industry for manufacturing projects[725].

[725] 2007 NAICS; North American Industry Classification System; http://www.census.gov/cgi-bin/sssd/naics/naicsrch?chart=2007

Utility(ies) Information
The name of the affected utility(ies) serving the customer. Provide all relevant account and meter information for electric and gas accounts and meters affected by the project.

Program
Identify the program under which this project will be submitted and why the project falls under the program. Projects submitted under existing utility programs should identify the program under which the project application will be filed and the utility-specific identifier for the project. Projects being submitted under the Mercantile Program should so indicate.

Project/Technology Description
Describe the energy using equipment and systems affected by the project in lay terms. Include specific information regarding industrial process technologies. For example: "Expand existing lab fume hoods by replacing two 10ft constant speed 10,000 CFM hoods with two 15ft modulating hoods controlled by smoke and temperature sensors."

Project Implementation Schedule
Define the implementation schedule for the project, including start and completion dates.

Measures Included in the Project
All energy efficiency measures included in the project shall be clearly identified and savings calculations and estimates shall be clearly documented for each measure in accordance with this protocol.

Affected Energy Sources (Electric, Gas, Other)
Identify all affected *energy sources* (electric, gas, propane, oil, solar, etc.) for the project, provide a brief description of how the source energy use is affected and quantify the impacts in the analysis.

Analysis Firm(s) and Contact(s)
Provide information regarding the firm performing the engineering analysis of the custom project. Provide the name(s) of the contacts for the firm(s) and contact information including company name, individual(s) name, address, phone, and email.

Section 2: Energy Consumption and Demand

This section defines the requirements for calculating baseline and efficient case energy consumption and demand as well as the method for calculating savings. Calculations shall address all project variables in accordance with the requirements of Section 3 and undertake the analysis in accordance with the documentation and metering requirements in Section 4.

The equations used in this protocol assume that the project has a single measure. If the project has multiple measures, these calculations shall be repeated for each measure in such a way as to capture interactive effects.

Efficient Case

Efficient Technology Description and Documentation
Describe the new technology, measure, and/or change in operations, and how it saves energy. Document any relevant efficiency codes or federal/state/local standards that apply to the proposed efficient equipment and the ratings of the measure equipment in comparison with applicable standards. If the efficient measure was the result of a process improvement that provides additional benefits, such as waste reduction, clearly describe all of the ways that the new process saves energy and resources. This can include reductions in areas such as waste heat, O&M costs, labor costs, water consumption, or process waste.

Efficient Case Annual Energy Use
Calculate the annual energy use for the proposed equipment using the methodologies outlined in this protocol and all referenced and applicable standards.

The total efficient energy use shall be calculated separately for each *energy source* (e.g. electric and gas) according to the following equations.

For loads calculated from a regression analysis (e.g. kW vs. Temperature as described in Section 4) the following equation shall be used:

$$ENERGY_{eff} = \sum_{j=1}^{m}(E\ LOAD_{j,eff} \times HOURS_{j,eff})$$

Where

$ENERGY_{eff}$ = Annual Efficient Energy Use - annual energy use with the efficiency improvement installed, calculated separately for each measure and each *energy source* (electric, gas).

$E\ LOAD_{j,eff}$ = Efficient Load (electric kW, gas therms) - efficient load for each system and subsystem with operating condition *j* (as defined below). For example, efficient load will need to be calculated differently for staged condenser fans that have different operating hours or multiple pumps that operate at varying speeds.

$HOURS_{j,eff}$ = Total Annual Operating – total annual operating hours for each system and subsystem with operating condition *j* (as defined below).

For loads calculated based on metering of full load or on equipment specifications:

$$ENERGY_{eff} = \sum_{j=1}^{m}(FULL\ LOAD_{j,eff} \times LF_{j,eff} \times HOURS_{j,eff})$$

where

$ENERGY_{eff}$ = Annual Efficient Energy Use - annual energy use with the efficiency improvement installed, calculated separately for each measure and each *energy source* (electric, gas).

$FULL\ LOAD_{j,eff}$ = Efficient Full Load - the maximum operating load of each efficient system and subsystem with operating condition *j* (as defined below).

$LF_{j,eff}$ = Load Factor - fraction of Full Load for each efficient system and subsystem with operating condition *j* (as defined below). Typically less than 1.00 unless the equipment was sized to run at 100% of rated capacity.

If needed, LF could be calculated from a regression curve kW and FULL LOAD for distinct operating conditions. This may arise when comparing efficient data with non-metered baseline LF ranges which are not based on a regression curve.

$HOURS_{j,eff}$ = Total Annual Operating Hours – Total Annual Operating Hours for each system and subsystem with operating condition *j* (as defined below).

$j \equiv$ System Condition - refers to each distinct combination of system mode, number of hours, full load demand, and load factor for each system or subsystem. Refer to example below.

m = Number of Terms – total Number of Terms needed to cover all conditions of affected systems and subsystems.

Efficient Case Coincident Electric Demand (kW)
Document the efficient case coincident electric demand for each measure according to one of the following equations:

For variable loads:
$$C\ LOAD_{eff} = AVG\ PH\ LOAD_{eff}$$

Where

$AVG\ PH\ LOAD_{eff}$ = Average Efficient Load of all affected equipment during the *Performance Hours* of 3-6 pm, weekday, non-holidays from June 1 – August 31 for a total of 195 hours. Includes non-operating time during the *Performance Hours* and is equal to total energy use during the *Performance Hours* divided by the total *Performance Hours*.

For constant loads or loads without metered data:

$$C\ LOAD_{eff} = \sum_{k=1}^{n} (FULL\ LOAD_{k,eff} \times LF_{k,eff} \times CF_{k,eff})$$

where

$C\ LOAD_{eff}$ = Average Coincident Efficient Load – Average Coincident Load of all affected efficient equipment during the *Performance Hours* of 3-6 pm, weekday, non-holidays from June 1 – August 31 for a total of 195 hours. Includes non-operating time during the *Performance Hours*.

$FULL\ LOAD_{k,eff}$ = Efficient Full Load - the maximum operating load of each efficient system and subsystem during the *Performance Hours* with operating condition *k* (as defined below), exclusive of non operating time.

$LF_{k,eff}$ = Load Factor - fraction of Full Load for each efficient system and subsystem with operating condition *k* (as defined below). Typically less than 1.00 unless the equipment was sized to run at 100% of rated capacity.

$CF_{k,eff}$ = *Coincidence Factor* - the Coincidence Factor is the fraction of time that each efficient system and subsystem is operating during the *Performance Hours* for operating condition *k* (as defined below). The three typical conditions for CF are as follows: CF is unity if the equipment is continuously on during the *Performance Hours;* CF is zero for each system or subsystem that is not operating during the *Performance Hours*; otherwise, CF is the ratio of the 'on' time to the total number of performance hours.

k = System Condition - refers to each distinct combination of the system mode, Full Load demand, and Load Factor for each system or subsystem operating during the *Performance Hours*. Refer to example below.

n = Number of Terms – total Number of Terms needed to cover all operating modes of affected systems and subsystems during *Performance Hours*.

The analysis shall include documentation of how the load varies during the *Performance Hours*. For constant load equipment, the analysis shall be based on the equipment load and operating schedule during the performance hours. For variable load equipment, the analysis shall address variations in equipment load and operating schedule during the performance hours.

Additional analysis will typically be prepared to address the impact of the energy efficiency measure on customer peak demand. Such analysis is critical to calculating customer cost savings but should not be confused with the required calculation of the coincident demand during the performance hours.

Baseline Case

Baseline Technology Methodology and Description

Baseline for Equipment Replacement projects is the equipment meeting the level of efficiency required by State Code[726], applicable Federal product efficiency standard[727] or standard practices, whichever is most stringent, in place at the time of installation. If there is no applicable State code or Federal Standard then the methodology for establishing standard practice shall be documented in the M&V plan as described in PJM Manual 18B[728] Section 8. The baseline description shall detail information regarding the baseline technology(ies) including make, model number, nameplate data and rated capacity of the equipment, operating schedule, and controls and how the baseline was determined.

Baseline Case Annual Energy Use

Calculate the annual energy use for the baseline equipment and systems using the methodologies outlined in this protocol and all referenced and applicable standards.

The total baseline energy use shall be calculated separately for each *energy source* (e.g. electric and gas) according to the following equations.

For loads calculated from a regression analysis (e.g. kW vs. Temperature as described in Section 4) the following equation shall be used:

$$ENERGY_{base} = \sum_{j=1}^{m} (E\ LOAD_{j,base} \times HOURS_{j,base})$$

Where

$ENERGY_{base}$ =	Annual Baseline Energy Use - Annual Energy Use for baseline equipment calculated separately for each measure and each energy source (electric, gas).
$E\ LOAD_{j,base}$ =	Baseline Load (electric kW, gas therms) - Baseline Load for each system and subsystem with operating condition *j* (as defined below). For example, Baseline Load will need to be calculated differently for staged condenser fans that have different operating hours or multiple pumps that operate at varying speeds.
$HOURS_{j,base}$ =	Total Annual Operating Hours – Total Annual Operating Hours for each system and subsystem with operating condition *j* (as defined below).

For loads calculated based on equipment specifications and metering of baseline operating conditions including load factor and operating hours:

[726] International Code Council, 2007 Ohio Building Code; http://publicecodes.citation.com/st/oh/st/b2v07/index.htm?bu2=undefined

[727] ANSI/ASHRAE/IESNA Standard 90.1-2004, ISSN 1041-2336; www.ashrae.org

[728] PJM Manual 18B: Energy Efficiency Measurement and Verification, Rev. 0, Effective date: April 23, 2009; PJM M&V Manual approved 4_09.pdf

$$ENERGY_{base} = \sum_{j=1}^{m}(FULL\ LOAD_{j,base} \times LF_{j,base} \times HOURS_{j,base})$$

where

$ENERGY_{base}$ ≡ Annual Baseline Energy Use - Annual Energy Use for baseline equipment calculated separately for each measure and each *energy source* (electric, gas).

$FULL\ LOAD_{j,base}$ ≡ Baseline Full Load - the maximum operating load of each baseline system and subsystem with operating condition *j* (as defined below).

$LF_{j,base}$ ≡ Load Factor - fraction of Full Load for each baseline system and subsystem with operating condition *j* (as defined below). Typically less than 1.00 unless the equipment was sized to run at 100% of rated capacity.

$HOURS_{j,base}$ ≡ Total Annual Operating Hours – Total Annual Operating Hours for each system and subsystem with operating condition *j* (as defined below).

j ≡ System Condition - refers to each distinct combination of system mode, number of hours, Full Load demand, and Load Factor for each system or subsystem. Refer to example below.

m ≡ Number of Terms – total Number of Terms needed to cover all conditions of affected systems and subsystems.

Baseline Case Full Load Demand
Document the baseline case coincident electric demand for each measure according to one of the following equations:

For variable loads:
$C\ LOAD_{base} = AVG\ PH\ LOAD_{base}$

Where

$AVG\ PH\ LOAD_{base}$ ≡ Average Baseline Load of all affected equipment during the *Performance Hours* of 3-6 pm, weekday, non-holidays from June 1 – August 31 for a total of 195 hours. Includes non-operating time during the *Performance Hours* and is equal to total energy use during the *Performance Hours* divided by the total *Performance Hours*.

For constant loads:

$$C\ LOAD_{base} = \sum_{h=1}^{n}(FULL\ LOAD_{h,base} \times LF_{h,base} \times CF_{h,base})$$

where

$C\ LOAD_{base}$ ≡ Average Coincident Baseline Load – average coincident load of all affected baseline equipment during the *Performance Hours* of 3-6 pm, weekday, non-holidays from June 1 – August 31 for a total of 195 hours. Includes non-operating time during the *Performance Hours*.

$FULL\ LOAD_{k,base} \equiv$ Baseline Full Load - the maximum operating load of each baseline system and subsystem during the *Performance Hours* with operating condition *k* (as defined below), exclusive of non operating time.

$LF_{k,base} \equiv$ Load Factor - fraction of Full Load for each baseline system and subsystem with operating condition *k* (as defined below). Typically less than 1.00 unless the equipment was sized to run at 100% of rated capacity.

$CF_{k,base} \equiv$ *Coincidence Factor* - the Coincidence Factor is the fraction of time that each baseline system and subsystem is operating during the *Performance Hours* for operating condition *k* (as defined below). The three typical conditions for CF are as follows: CF is unity if the equipment is continuously on during the *Performance Hours;* CF is zero for each system or subsystem that is not operating during the *Performance Hours*; otherwise, CF is the ratio of the 'on' time to the total number of performance hours.

$k \equiv$ System Condition - refers to each distinct combination of the system mode, Full Load demand, and Load Factor for each system or subsystem operating during *Performance Hours*. Refer to example below.

$n \equiv$ Number of Terms – total Number of Terms needed to cover all operating modes of affected systems and subsystems during *Performance Hours*.

The analysis shall include documentation of how the load varies during the *Performance Hours*. For constant load equipment, the analysis shall be based on the equipment load and operating schedule during the *Performance Hours*. For variable load equipment, the analysis shall address variations in equipment load and operating schedule during the *Performance Hours*.

Additional analysis will typically be prepared to address the impact of the baseline equipment on customer peak demand. Such analysis is critical to calculating customer cost savings but should not be confused with the required calculation of the coincident demand during the *Performance Hours*.

Savings

Savings shall be calculated from the efficient case and baseline case energy and demand calculations from above. Address project variables as described in Section 3 and aggregate so that interactive effects are accurately accounted for in the analysis.

Annual Energy Savings (kWh for electrical, therms for gas)

$$ENERGY_{saved} = ENERGY_{base} - ENERGY_{eff}$$

where

$ENERGY_{base}$ and $ENERGY_{eff}$ are defined above.

Coincident Electrical Demand Reduction (kW) =

$$C\ LOAD_{saved} = C\ LOAD_{base} - C\ LOAD_{eff}$$

where

$CLOAD_{base}$ and $CLOAD_{eff}$ are defined above.

Section 3: Project Variables

Accurately capturing and documenting the variables that affect annual energy use and savings as well as those affecting peak period demand coincidence are critical elements in developing meaningful and reliable energy savings estimates. The savings analysis shall consider and address the variables over the life of the measure for both the baseline and efficient case. Uncertainty in variables shall be quantified and the savings analysis shall clearly demonstrate transparency and reasonableness in definition and application of variables affecting energy savings[729].

The variables below are common to many custom energy analyses. Document the variables that affect the energy use of the project for both the baseline and efficient scenarios and delineate the methods used for data collection (i.e. meter data, trend logs, manufacturer data, customer interviews, production logs, etc.) and any uncertainty associated with the values used in the analysis. ALL savings calculations must be *normalized* to reflect consistent application of the assumed variables for the project under both baseline and post installation conditions over the full range of operating conditions for the affected systems.

Load Characterization
Accurate characterization of the baseline and efficient energy use involves a comprehensive analysis of all variables that affect the loads over the analysis period. Concepts that are commonly used in performing energy analysis are discussed below. In all cases it is the intent of this document to require that the variations in load due to all factors (weather, production, schedule, etc) are accounted for in the analysis.

Load Shape
The load shape reflects variations in load over the course of a year, with specific attention paid to the peak periods defined by the affected utility and/or regional transmission organization. The load shape should capture the expected period at which the load will operate at full load (full load hours) as well as all part load and non-operating or standby-modes. For highly variable loads, development of an 8760 load shape will increase the accuracy of the analysis and the reliability of claimed demand reductions during peak periods[730].

Load Factor
Load factor is the ratio of maximum energy demand to the average electric demand for the affected end use. Analysis of loads across a representative sample of operating conditions can generate a single load factor for constant load applications. For variable load applications, a series of load factors must be developed to accurately represent the variations in energy use under the variety of loading conditions that occur over the range of operating cycles in a typical calendar year. Variable load analysis shall address the variations in load factor over a one year period for all dependent variables.

Peak Load Factor
Peak Load Factor describes the variation between the maximum connected load of the equipment and the highest actual load of the equipment. In some cases the peak load factor is unity. For oversized equipment it is frequently less than one. In some rare instances where equipment is operated above its rated load, the peak load factor may be greater than one.

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[729] Anne Arquit Niederberger, PhD, A+B International (2005), Baseline Methodologies for Industrial End-Use Efficiency Presentation. Presented at World Bank; Anne_Arquit_Niederberger_Industry_EE_CDM_Dec_05.xls
[730] Patil, Yogesh, et. al. (Aug, 2009) "Taking Engineering Savings to the Next Level, presented at IEPEC 2009 http://www.ers-inc.com/images/articles/Papers/takingsavingstonextlevel.pdf

Coincidence Factor

Coincidence Factor is the coincidence of the demand savings during the *Peak Performance Hours*. For custom Equipment Replacement measures, the average coincident demand, including non-operational hours, is typically determined by metering the post-installation condition and deriving the Coincidence Factor for the pre-installation condition from the metered data. However, in some cases, the use of a known or predetermined published Coincidence Factor, such as measure specific coincidence factors identified in other sections of the TRM is acceptable.

An example of Coincidence Factor derivation from metered data would be a stepped demand device such as a high efficiency compressor. Based on post-installation metering, a Coincidence Factor can be calculated and applied to the baseline equipment when the baseline operating schedule is the same as the efficient operating schedule. In this case, the Coincidence Factor is defined as the ratio of average metered demand for the *Peak Performance Hours* and max 'equipment on' demand when operating. If the equipment is operating continuously for the full peak performance hours, then the coincidence factor is 1.00.

Operating Conditions

Characterize all variable operating conditions that affect the load over the analysis period. Typical operating variables are outlined below. Additional factors may be required to accurately characterize variability in equipment operations and the energy savings resulting from energy efficiency measures over the full range of operating conditions.

Operating Hours

Establish the baseline and post-installation operating hours for all affected equipment using logging, metering, and/or DDC trending for a representative period of not less than one week. Where pre- and post-installation operating schedules are the same, use of pre- or post-logging of operating hours to prepare the analysis is adequate. Address all variations in operating schedule over an annual operating cycle including, but not limited to weekends, holidays, and shift or occupancy changes that are a result in cyclical changes in operations over the course of a year. (For example retail applications may have longer operating hours in November and December). Project analysis shall clearly identify all operating, non-operating, and standby hours, the related loads, the periods for which those conditions apply and the basis for the assumptions in the analysis. Special attention should be paid that the hours of *Coincident Peak* (3:00 – 6:00 weekdays from June 1 through August 31) are detailed.

Weather

For weather-dependent projects, the analysis shall address the impact of annual weather, including temperature, humidity, and solar incidence (where applicable) on energy consumption. All savings (energy and demand) should be normalized to the TMY3 (Typical Meteorological Year) that corresponds to the nearest TMY3 weather site using modeling and/or regression analysis. TMY3 data should be obtained from National Renewable Energy Laboratory (NREL[731]) and used as the 8760 weather file to model and/or normalize annual energy use for weather dependent measures. Modeling tools, such as eQuest[732], currently use TMY2 data. TMY3 data is based on more-recent and more accurate data and is available for many more locations; TMY3 data is available for over 1,000 locations, where TMY2 data is available for fewer than 300 locations.

Projects with hourly correlation of metered or utility billed usage to local weather conditions should be done using National Oceanic and Atmospheric Administration (NOAA[733]) or NREL data. NOAA weather data is available for a small fee downloadable from the Internet and is typically the most accurate and complete historical local weather data set. NREL data is free but typically has some gaps in the data and is emailed in response to specific requests. Caution should be exercised when using non-government generated weather data as it may not meet accepted standards for quality and accuracy.

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731 Typical Meteorological Data (TMY3) - http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/
732 DOE2 eQuest simulation software - http://www.doe2.com/equest/
733 NOAA local weather data - http://cdo.ncdc.noaa.gov/qclcd/QCLCD?prior=N

Production
Project analysis shall reflect variations in production over the cycles within the analysis period. Variations can include such things as the number of shifts or changes in quantity or type of product manufactured.

For industrial process measures, production documentation shall normalize energy use based on the energy intensity of the process (i.e. energy use per unit of output) over the lifetime of the measure for both the baseline and efficient cases. Measurement of output should be based on physical measures of output (i.e. ton of steel or paper) and capture variations in both production levels and manufactured product types over the analysis period for both the calculated baseline and the metered efficient case[734]. Post-installation metering shall include documentation of production output during metering periods; work with plant personnel to ensure logged production data accurately reflects changes in production over the metering period.

Assumptions regarding economic climate, changes in production levels, and shifts all affect calculated energy savings over the life of the measures. Develop reasonable assumptions regarding these variables and ensure the application of these variables is clearly identified in both the analysis and project documentation. Identify the uncertainty introduced into the energy savings estimates as a result of these assumptions.

Controls
Control settings and level of control shall be accounted for in the analysis. Clearly document the control points that affect energy use, the control setpoints, sequence of operation and accuracy of controls that would have been used in the baseline case. Clearly document the changes in these conditions for the efficient case. Include relevant information such as commissioning of control points, potential manual overrides of control sequences and anticipated control point calibration over the life of the measure.

Occupancy
Where occupancy affects energy use and varies over time, capture the variations in occupancy and their effects over the analysis period. At a minimum there is typically an 'occupied' and an 'unoccupied' mode for most facilities.

Assumptions regarding economic climate and shifts in hours of occupancy affect calculated energy savings over the life of the measures. Develop reasonable assumptions regarding these variables and ensure the application of these variables is clearly identified in both the analysis and project documentation. Identify the uncertainty introduced into the energy savings estimates as a result of these assumptions

Interactive Effects
Analysis shall explicitly account for interactive effects between measures. For projects that include both prescriptive and custom measures, account for the energy use reduction from the prescriptive measure in the custom measure analysis. As prescriptive measures include interactive effects themselves, document the methodology that is used to ensure that savings from the interactive effects are only accounted for once in the claimed savings.

One common set of interactive effects is the impact of electrical energy efficiency measures within a facility on that facility's heating and/or cooling load. These shall be addressed as follows:

Waste Heat
For efficiency upgrades that reduce the rejection of waste heat into air conditioned spaces (i.e. evaporator fans in a refrigerated enclosure), quantify the reduction in heat rejection[735] and the associated cooling reduction.

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[734] Ruth, Michael, Lawrence Berkeley National Laboratory, et. al. (2001) A Process-Step Benchmarking Approach to Energy Use at Industrial Facilities: Examples from the Iron and Steel and Cement Industries; Process_Step_Benchmarking_ACEEE_LBNL-50444.doc
[735] 2009 ASHRAE Handbook, Fundamentals, Chapter 18, page 18.3.

Heating Increase
For efficiency upgrades that reduce the rejection of waste heat into heated spaces, quantify the additional heating fuel required to offset the change and maintain temperature within the space[14]. The analysis shall address heating system efficiency and include basis for assumptions regarding fossil fuel increases.

For projects with multiple measures, the procedure for interactive effects is to calculate savings for the longest lived measure first, then consider that measure's impact on the next longest-lived measure, and so on. This is because a short-lived measure can affect savings from a long-lived measure, but only for part of its life. Since tracking system limitations require that annual measure savings remain constant for all years, this is the only way to ensure proper lifetime savings and total resource benefits are captured.

Measure Life
Document both the life of the baseline and efficient case equipment. The efficient case analysis is typically performed over the lifetime of the efficiency measures. Where the analysis period and the efficiency measure life are not the same, describe the rationale for the analysis period and assumptions regarding replacement equipment for measures with lives that are shorter than the analysis period.

Persistence
Persistence factors may be used to reduce lifetime measure savings in recognition that initial engineering estimates of annual savings may not persist long term[736]. The persistence factor accounts for uncertainties and for normal operations over the life of the measure. For instance if energy efficient motors are installed as part of a process and the customer's standard procedure is to have motors rewound upon failure, the energy efficiency associated with the efficient motor would only persist until the expected time when the motor is rewound. Persistence is also affected by measures being removed or failing prior to the end of its normal engineering lifetime, improper maintained over the life of the measure, control overrides or loss of calibration (controls only), etc.

Related Variables:
Related variables are those which are not included in the energy and demand calculations, but may be required for project cost-effectiveness screening by the utility(ies). Document the following variables for the project:

Operation &Maintenance (O&M) Impacts
Where O&M practices would have resulted in changes to the baseline during the analysis period, account for such practices in the establishment of baseline and efficiency case energy use.

Water Consumption Impacts
Quantify any changes in water consumption attributable to the project.

Cost
Document the cost of each measure. Include invoices, bids and other documentation to substantiate project cost data. Identify portions of the cost which are for equipment being purchased for redundancy or backup and will not generate savings in the project. Related costs such as the costs for audits, design, engineering, permits, fees or M&V should be reported separately from the costs associated with the design and installation of energy efficiency improvements.

Other Variables
As needed - clearly document all variables affecting the energy use of the project that have not been covered in this document.

Section 4: Documentation and Metering

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

Documentation and metering of custom projects are essential to developing reliable energy savings and Coincident Electrical Demand reduction claims.[737] The following guidelines support the accurate estimation of energy and demand savings.

Data and Metering

Document how the data will be collected and utilized in the savings analysis in a Measurement and Verification (M&V) Plan. The Custom Analysis Template (Appendix B) can be used as a tool to document the M&V plan and analysis[738]. Metering for Equipment Replacement projects is typically conducted post-installation to establish the Coincidence Factor, operating hours and Load Factor. Where measures include a control component, metering of these factors in the baseline condition is necessary to accurately establish the baseline.

Interval and Utility Data

Utility interval data is typically not useful in analyzing equipment replacement projects because the baseline condition is not represented in the utility billing data.

For completed mercantile projects in existing facilities, project documentation shall include two - three years of utility billing information from years PRIOR to measure installation and up to three years of utility data post installation in accordance with PUCO requirements.

Meter Data

Accuracy of all metering and measurement equipment shall be documented in the M&V Plan.

Document the metering methods including equipment type, location of metering equipment, and equipment set up process, as well as metering duration and timeframe for which data was collected. Capture all variables that affect energy use of the measures during the metering period as outlined in Section 3. Describe how the metered data, including timeframe and operational factors at the time of metering, relate to the operational conditions that occur over the course of a year. Provide photographs of meter installation and clear documentation of meter numbers and the associated equipment names of the equipment being metered in the project documentation. Meter data files should clearly identify the equipment to which the meter data applies.

For variable loads, three-phase power data loggers shall be used to collect electrical power data for systems and subsystems of the custom measure739. For constant loads, accurate spot reading of the load coupled with runtime logging is an acceptable metering methodology. Temperature and time of use loggers can be used to meter proxy variables, equipment status, and runtimes. Ensure that proxy variable metering yields calculated kW values in compliance with PJM740 Section 11 requirements.

Three-phase power data loggers shall record: amperage, voltage, power factor, and kW on all phases as well as the totals for each variable. All electrical power metering shall adequately account for harmonics[741]. Logging shall capture equipment load under representative operating conditions. The time period of logging shall be adequate to represent variations in load that will occur over the analysis period. Where feasible, use metering or data logging to capture variables affecting load during the metering period. Where variables cannot be captured using meters or data loggers, institute and clearly document a method for accurately capturing variables, validating non-metered data, and aligning it with metered data. Metering periods shall be a minimum of one week, including a weekend, for constant load equipment and

[737] Parlin, Kathryn, et. al. (August, 2009 IEPEC) "Demand Reduction in the Forward Capacity Market, Verifying the Efficiency Power Plant"

[738] IPMVP, Volume III, Part I, January 2006, Chapter 3, page 7 through 10, and PJM Manual 18B, April 2009, section 2, page 10 through 14

[739] PJM Manual 18B: Energy Efficiency Measurement and Verification, Rev. 0, Section 11, Effective date: April 23, 2009; PJM M&V Manual approved 4_09.pdf

[740] PJM Manual 18B: Energy Efficiency Measurement and Verification, Rev. 0, Section 11, Effective date: April 23, 2009; PJM M&V Manual approved 4_09.pdf

[741] PJM Manual 18B: Energy Efficiency Measurement and Verification, Rev. 0, Section 11, Effective date: April 23, 2009; PJM M&V Manual approved 4_09.pdf

at least two weeks, including weekends, for variable load equipment, but as noted above, must be long enough to capture representative variations in load expected over the entire analysis period.

Integrating/averaging three-phase power meters are desirable. Power metering accuracy requirements are outlined in PJM Manual 18B[742] and RLW Analytics Review of ISO New England Measurement and Verification Equipment Requirements[743]. Metering intervals shall be the smallest time interval that will permit acquisition of data over the minimum required metering period. For short-cycling or modulating systems, 30-second or 1-minute data intervals are preferred, with a maximum recommended interval of 5 minutes. For constant load systems, the metering interval can be longer. No metering interval should exceed 15 minutes. Clearly document how meter intervals and meter periods capture the expected load variations for the project.

Meters and data loggers shall be synchronized to the NIST time clock, and differences between the time at the facility and the NIST time setting should be noted when the meters are installed.

DDC/PLC Monitor Data
Use of DDC and PLC monitoring software trends in the analysis is acceptable provided that the sensors are calibrated on site using calibrated test instruments and the results documented by the energy analyst before the metering period commences. Review and submission of annual equipment calibration records for DDC sensors and metering equipment is a less desirable, but acceptable alternative to calibration of DDC equipment as part of the project. Timestamps for trends should be set up to coincide with those of any concurrently deployed data loggers to enable accurate data analysis.

Load Profiles
For measures with well established and reliable load profiles, the load profile can be a useful tool for determining savings. Load profiles are most reliable when used for common measures in typical applications, such as office lighting projects. Typically, load profiles should not be relied on where project peak demand savings exceed 20 kW.

General Procedures for Data Analysis

Data Cleaning

It is usually necessary to 'clean' the raw data before proceeding with the analysis. The following data cleaning tasks are typically required.

Ensure that the timestamps match between datasets (e.g. for concurrent kW and temperature datasets), and that any gaps in the data which are not representative of typical operation have been addressed by interpolation or other means. Interpolated or derived data shall be flagged, and the method used to fill in data gaps shall be described.

Note that in preparing the data for use in the 8760 analysis, there will likely be blocks of time during the metering period that will be analyzed differently. For example, during regular business hours a load may be temperature dependent and the data will be analyzed using a regression analysis of kW vs. outdoor air temperature; whereas the same piece of equipment on the weekend may have a constant standby load and is thus schedule driven and non-temperature dependent on the weekends. Different blocks of the 8760 hours in a year will be populated from the separate analyses of the distinct blocks of meter data.

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[742] PJM Manual 18B: Energy Efficiency Measurement and Verification, Rev. 0, Effective date: April 23, 2009; PJM M&V Manual approved 4_09.pdf
[743] RLW Analytics, Review of ISO New England Measurement and Verification Equipment Requirements, Final Report, April 24, 2008 Prepared for: Northeast Energy Efficiency Partnerships' Evaluation and State Program Working Group; RLW Metering Report.pdf

Annualization and Analysis Approach

The recommended approach to annualization of meter data and savings calculations is an 8760 analysis744. This approach inherently captures seasonality and peak period variability on an hourly basis and is therefore more accurate than other traditional methods such as binned analysis.

Typical approaches to analyzing custom measures include:

- Demand vs. temperature analysis for temperature dependent measures.
- Daily operating profiles for schedule-driven measures
- Cyclical production profiles for production-related measures

These methods should address part load performance, and may employ different metrics such as:

- Demand vs. percent capacity
- Demand/Ton vs. percent capacity
- Demand vs. hours
- Demand per ton, pound, cubic foot or quantity

Calculations

Clearly document all calculations. Indicate how the meter data is used in the analysis and why this is appropriate for the measure. Meter data used in the analysis shall be clearly distinguished from data not used in the analysis.

Computer simulation of energy efficiency measures based on meter data using 8760 hourly simulation models such as eQuest, or customized spreadsheet analysis or other energy analysis tools can be employed to calculate energy savings. The algorithms of the modeling software must be designed to address the custom measure. Minimum documentation requirements include model output reports stating unmet load hours for the baseline and efficient case, hourly energy use and demand, and electronic copies of the model or spreadsheet analysis files.

Annual kWh and therms for baseline and efficient cases shall be the annualized and normalized per the equations in Section 2 using the methods described above. Coincident Electric Demand for baseline and efficient cases shall be calculated from post-installation meter data as the average demand over the *Performance Hours* as indicated in Section 2. Calculation documentation shall include definitions and reference sources for all variables and assumed factors in Section 3.

Documentation

Analysis shall be documented with comprehensive, well labeled supporting information including, but not limited to:

Manufacturer literature documenting connected load for both the baseline and the installed equipment or manufacturer data documenting the information necessary to calculate peak demand (such as horsepower, voltage, efficiency, etc.) shall be included in the project documentation. Manufacturer data shall be clearly marked to indicate the specific equipment model number and data that is applicable to the project and used in the calculations.

Where citing nameplate ratings in the analysis, provide documentation of the ratings.

[744] Patil, Yogesh, et. al. (Aug, 2009) "Taking Engineering Savings to the Next Level, presented at IEPEC 2009: http://www.ers-inc.com/images/articles/Papers/takingsavingstonextlevel.pdf

Manufacturer data shall be adjusted to reflect actual site operating conditions. Document calculation of the adjusted connected load reflecting metered on site conditions.

Reporting

The following metrics and details shall be reported:

- All information required in this protocol
- M&V Plan/Analysis Template
- Regression R^2 values for fits of demand vs. proxy variables.
- Cleaned meter data (raw data shall be included as an appendix) clearly indicating which data was used in the savings analysis
- Discussion of approach to anomalies, outliers, interpolations and extrapolations in the analysis
- Assessment of the level of uncertainty associated with the energy and demand calculated savings.
- Project commissioning can reduce energy use and is recommended. If the project was commissioned, submit a copy of the commissioning report.

C&I Retrofit – Custom Measure Analysis Protocol

This protocol defines the requirements for analyzing and documenting commercial and industrial energy efficiency measures. It applies to custom measures filed under Utility Programs and those prepared for Mercantile Customers. This protocol addresses retrofit measures that are not covered by other analysis methodologies in the TRM. A retrofit project is defined as equipment replacement prior to the end of its rated service life in order to achieve energy savings. Where equipment is replaced due to failure or for other reasons (such as obsolescence or a need for increased capacity), the project is classified as Equipment Replacement and the "C&I Equipment Replacement – Custom Measure Analysis Protocol" should be used to guide analysis.

This protocol is intended to address the energy impacts of the operating energy efficiency improvements. Projects that include duplex, redundant and/or spare equipment shall calculate the energy savings based only on the operating equipment and systems.

This analysis protocol is supplemented by a glossary and an Analysis Template (Appendix B). Words used herein that are defined in the glossary are in italics. The Analysis Template is a tool that can guide applicants in preparing and presenting the documentation to support custom retrofit energy efficiency measure savings estimates.

The Analysis Protocol and Analysis Template are divided into four sections:
Section 1: Project Information
Section 2: Project Savings
Section 3: Project Variables
Section 4: Documentation and Metering

Section 1: Project Information

Project Title
Provide a unique title for the project so that it is easily distinguishable from other projects prepared by the same customer and from projects with similar scope. Example: Company XYZ Building A - Compressed Air System Improvements.

Customer Name
Provide the name of the company undertaking the energy efficiency improvements.

Customer Contact
Provide the contact information including name, title, mailing address, phone, and email for the primary customer contact on this project.

Site (Location)
Provide the full address of the site at which the project is being implemented. If the customer has an additional business location that is involved with the project, include additional customer site information as needed.

Sector/Industry Description and NAICS Code
Describe the sector and industry in which the custom measure is being applied. Sectors include: Industrial, Commercial, Institutional, and Multi-family. Industry should specify the end use for commercial and institutional projects (e.g. office, restaurant, dormitory) and the specific industry for manufacturing projects[745].

Utility(ies) Information
The name of the affected utility(ies) serving the customer. Provide all relevant account and meter information for electric and gas accounts and meters affected by the project.

Program

[745] 2007 NAICS; North American Industry Classification System; http://www.census.gov/cgi-bin/sssd/naics/naicsrch?chart=2007

Identify the program under which this project will be submitted and why the project falls under the program. Projects submitted under existing utility programs should identify the program under which the project application will be filed and the utility-specific identifier for the project. Projects being submitted under the Mercantile Program should so indicate.

Project/Technology Description
Describe the energy using equipment and systems affected by the project in lay terms. Include specific information regarding industrial process technologies. For example: "Replace two 10ft constant speed 10,000 CFM fume hoods with modulating fume hoods controlled by smoke and temperature sensors."

Project Implementation Schedule
Define the implementation schedule for the project, including start and completion dates.

Measures Included in the Project
All energy efficiency measures included in the project shall be clearly identified and savings calculations and estimates shall be clearly documented for each measure in accordance with this protocol.

Affected Energy Sources (Electric, Gas, Other)
Identify all affected *energy sources* (electric, gas, propane, oil, solar, etc.) for the project, provide a brief description of how the source energy use is affected and quantify the impacts in the analysis.

Analysis Firm(s) and Contact(s)
Provide information regarding the firm performing the engineering analysis of the custom project. Provide the name(s) of the contacts for the firm(s) and contact information including company name, individual(s) name, address, phone, and email.

Section 2: Energy Consumption and Demand

This section defines the requirements for calculating baseline and efficient case energy consumption and demand as well as the method for calculating savings. Calculations shall address all project variables in accordance with the requirements of Section 3 and undertake the analysis in accordance with the documentation and metering requirements in Section 4.

The equations used in this protocol assume that the project has a single measure. If the project has multiple measures, these calculations shall be repeated for each measure in such a way as to capture interactive effects.

Efficient Case

Efficient Technology Description and Documentation
Describe the new technology, measure, and/or change in operations, and how it saves energy. Document any relevant efficiency codes or federal/state/local standards that apply to the proposed efficient equipment and the ratings of the measure equipment in comparison with applicable standards. If the efficient measure was the result of a process improvement that provides additional benefits, such as waste reduction, clearly describe all of the ways that the new process saves energy and resources. This can include reductions in areas such as waste heat, O&M costs, labor costs, water consumption, or process waste.

Efficient Case Annual Energy Use
Calculate the annual energy use for the proposed equipment using the methodologies outlined in this protocol and all referenced and applicable standards.

The total efficient energy use shall be calculated separately for each *energy source* (e.g. electric and gas) according to the following equations.

For loads calculated from a regression analysis (e.g. kW vs. Temperature as described in Section 4) the following equation shall be used: