4.4 HVAC End Use

Many of the commercial HVAC measures use equivalent full load hours (EFLH) to calculate heating and cooling savings. The tables with these values are included in this section and referenced in each measure.

Equivalent Full Load Hours is calculated using the annual energy use divided by the peak load. The team identified 15 building types to calculate EFLH. The method establish was to obtain energy models for typical building stock and then run the energy models to establish annual energy use and peak load to then calculate EFLH.

The goal was to find pre-developed energy models that could be run through eQuest software and output reports would provide the energy use and peak load. The team explored using California DEER models or ComEd models. It was determined that the ComEd models better represented IL building stock and equipment vintages than the California models[232].

A summary of the inputs to the building models is summarized in Building Descriptions.xls. After the buildings were run through eQuest, "Space Heating" value in MBtu/y found on the "Building Energy Performance Summary" was divided by "Maximum Heating Load" in kBtu/y found on the "Building HVAC Load Summary" to calculate hours.

The building characteristics are found in the tables below.

Table 4.4.1 – eQuest Modeling Inputs by Building Type (Part 1)

Building Type	Healthcare Clinic	Hospital	Lodging Hotel/Motel /Multifamily	Office – Low-rise	Office – Mid-rise	Office - High-rise	Religious Facility
Square Feet	67,500	200,000	56,000	7,500	50,000	537,600	30,000
Number of Floors Above Grade	3	4	2	1	5	20	1
Number of Floors Below Grade	0	1	0	0	0	1	1
Flr-to-Flr Height [ft]	13	14	10	13	13	13	Worship: 20'; other 13'
Flr-to-Ceiling Height [ft]	8	9	9	8	8	8	Worship: 20'; other 10'
Roof Constructio n	Flat, membrane, R-14 rigid insulation	Flat, membran e, R-14 rigid insulation	Flat, membrane, R-14 rigid insulation	Flat, membrane , R-14 rigid insulation	Flat, membrane , R-14 rigid insulation	Flat, membrane , R-14 rigid insulation	Sloped, attic, slate, no insulation
Above-ground Wall Constructio	2x4 steel frame, R-11 batt, brick	2x4 steel frame, R-11 batt, brick	2x4 steel frame, R-11 batt, brick	2x4 steel frame, R-11 batt, brick	2x4 steel frame, R-11 batt, brick	2x4 steel frame, R-11 batt, brick	12" masonry, no insulation

[232] A full description of the ComEd model development is found in "ComEd Portfolio Modeling Report. Energy Center of Wisconsin July 30, 2010"

Building Type	Healthcare Clinic	Hospital	Lodging Hotel/Motel /Multifamily	Office – Low-rise	Office – Mid-rise	Office - High-rise	Religious Facility
n							
Below-ground Wall Construction	N/A	12" concrete, no insulation	N/A	N/A	N/A	12" concrete, no insulation	12" concrete, no insulation
Window Type	2-pane, clear, alum frame w/o thm brk	2-pane, clear, alum frame w/o thm brk	2-pane, clear, alum frame w/o thm brk	2-pane, clear, alum frame w/o thm brk	2-pane, clear, alum frame w/o thm brk	2-pane, clear, alum frame w/o thm brk	Single-pane, clear, wood frame
Window U-value	0.48	0.48	0.48	0.48	0.48	0.48	1.04
Window SHGC	0.76	0.76	0.76	0.76	0.76	0.76	0.86
Window VT	0.81	0.81	0.81	0.81	0.81	0.81	0.9
Window-Wall Ratio	0.2	0.2	0.04 on ends, 0.15 on faces	0.2	0.33	0.4	0.2
Weekday	7am-7pm	24/7	24/7	8am-5pm	8am-5pm	8am-5pm	Office: 8am-5pm, other: closed
Saturday	9am-5pm	24/7	24/7	closed	20% 8am-noon	20% 8am-noon	closed
Sunday	closed	24/7	24/7	closed	closed	closed	8am-1pm
Holiday	closed	24/7	24/7	closed	closed	closed	closed
Lighting Power Density [W/sf]	2.52	Basement: 1, First Fl: 1.5, Second:1.5, Top 2	office: 1.4, laundry 1.1, Mtg room 2.3, exercise 1.5, employee lounge 1.8, guest room 2, corridor 0.95	1.9	1.7	1.6	worship: 3; other: 2
Plug Loads [W/sf]	2	Basement: .1, First Fl: 1.5, Second:1.5,	office: 1.5, laundry 2.2, mtg room 1.3, exercise 1.1, employee	0.8	0.8	0.8	Classroom .5, Kitchen 2, Office 1

Building Type	Healthcare Clinic	Hospital	Lodging Hotel/Motel /Multifamily	Office – Low-rise	Office – Mid-rise	Office - High-rise	Religious Facility
		Top 1.7	lounge 5.0, guest room 1.4				
Air System	Constant volume packaged rooftop unit	Constant volume indoor units	Packaged terminal heat pump	Constant volume packaged rooftop unit	Variable Air Volume (VAV)	Variable Air Volume (VAV)	none
Cooling Equip. Type	DX	Centrifugal water cooled chiller	Packaged terminal AC	DX	Centrifugal water cooled chiller	Centrifugal water cooled chiller	none
Cooling EER	10.8	9.6	11.1	10.8	9.6	9.6	11
Heating Equip. Type	Natural gas heater in RTU	Natural gas heater in RTU	Heat pump, supplemental electric	Natural gas heater in RTU	Boiler, hot water	Boiler, hot water	Boiler, steam
Heating Efficiency [%]	78%	78%	2.0 COP	78%	78%	78%	78%

Table 4.1.2 eQuest Modeling Inputs by Building Type (Part 2)

Building Type	Restaurant	Retail - Department Store	Retail - Strip Mall	Elementary School	High School	Convenience Store
Square Feet	7,500	45,000	3,000	75,000	225,000	6,000
Number of Floors Above Grade	1	1	1	2	2	1
Number of Floors Below Grade	0	0	0	0	0	0
Flr-to-Flr Height [ft]	13	20	15	13	13	15
Flr-to-Ceiling Height [ft]	9	20	10	9	9	10
Roof Construction	Flat, membrane, R-14 rigid insulation	Flat, membrane, R-14 rigid insulation	Flat, membrane, R-14 rigid insulation	Flat, membrane, R-14 rigid insulation	Flat, membrane, R-14 rigid insulation	Flat, membrane, R-14 rigid insulation
Above-ground Wall Construction	2x4 steel frame, R-11 batt, brick	2x4 steel frame, R-11 batt, brick	2x4 steel frame, R-11 batt, brick	2x4 steel frame, R-11 batt, brick	2x4 steel frame, R-11 batt, brick	2x4 steel frame, R-11 batt, brick
Below-ground Wall Construction	N/A	N/A	N/A	N/A	N/A	N/A

Building Type	Restaurant	Retail - Department Store	Retail - Strip Mall	Elementary School	High School	Convenience Store
Window Type	2-pane, clear, alum frame w/o thm brk	2-pane, clear, alum frame w/o thm brk	2-pane, clear, alum frame w/o thm brk	2-pane, clear, alum frame w/o thm brk	2-pane, clear, alum frame w/o thm brk	2-pane, clear, alum frame w/o thm brk
Window U-value	0.48	0.48	0.48	0.48	0.48	0.48
Window SHGC	0.76	0.76	0.76	0.76	0.76	0.76
Window VT	0.81	0.81	0.81	0.81	0.81	0.81
Window-Wall Ratio	Dining: 0.25; Kitchen: 0	Front: 0.25; Other 0	Front: 0.5; Other 0	0.35	0.35	Front: 0.5; Other 0
Weekday	7am-8pm	9am-9pm	9am-9pm	8am-4pm (20% in summer)	8am-4pm (20% in summer)	7am-10pm
Saturday	7am-8pm	9am-9pm	9am-9pm	closed	closed	9am-9pm
Sunday	7am-8pm	10am-5pm	10am-5pm	closed	closed	10am-5pm
Holiday	closed	10am-5pm	10am-5pm	closed	closed	10am-5pm
Lighting Power Density [W/sf]	kitchen: 1.6; dining: 2.0	sales floor: 3.0; back space: 1.3	sales floor: 3.0; back space: 1.3	classrooms: 2.15, corridors: 0.93, offices 2.0, gym 1.1, kitchen 1.7, cafeteria 1.4, library 1.6	classrooms: 2.15, corridors: 0.93, offices 2.0, gym 1.1, kitchen 1.7, cafeteria 1.4, library 1.6, aud. 1.2	office: 1.9, dry storage: 1.2,sales floor: 3.0
Plug Loads [W/sf]	kitchen .1, dining 0	point of sale 2.2, back space 0.8, rest 0.3	4.3	classrooms: 1.5, office 1, kitchen 19, cafeteria 2.5, library 1.5	classrooms: 1.5, office .75, kitchen .334, cafeteria 1.4, library .25	office: 0.8, deli & bakery 5.4, sales floor 0.5
Air System	Constant volume packaged rooftop unit	Constant volume packaged rooftop unit	Constant volume packaged rooftop unit	Constant volume unit ventilators	Constant volume unit ventilators	Constant volume packaged rooftop unit
Cooling Equip. Type	DX	DX	DX	Screw air cooled chiller	Screw air cooled chiller	DX
Cooling EER	10.8	11	10.8	9.6	11	11

Building Type	Restaurant	Retail - Department Store	Retail - Strip Mall	Elementary School	High School	Convenience Store
Heating Equip. Type	Natural gas heater in RTU	Natural gas heater in RTU	Natural gas heater in RTU	Boiler, hot water	Boiler, hot water	Natural gas heater in RTU
Heating Efficiency [%]	78%	78%	78%	78%	78%	78%

Heating Equivalent Full Load Hours ($EFLH_{heating}$)

Building Type	Heating EFLH				
	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville/	Zone 5 (Marion)
Office - High Rise	2,746	2,768	2,656	2,155	2,420
Office - Mid Rise	996	879	824	519	544
Office - Low Rise	797	666	647	343	329
Convenience Store	696	550	585	272	297
Healthcare Clinic	1,118	1,036	1,029	694	737
Manufacturing Facility	1,116	1,123	904	771	857
Lodging Hotel/Motel/Multifamily	2,098	2,050	1,780	1,365	1,666
High School	969	807	999	569	674
Hospital	2,031	1,929	1,863	1,497	1,800
Elementary School	970	840	927	524	637
Religious Facility	1,830	1,657	1,730	1,276	1,484
Restaurant	1,496	1,379	1,291	872	1,185
Retail - Strip Mall	1,266	1,147	1,151	732	863
Retail - Department Store	1,065	927	900	578	646
College/ University	373	404	376	187	187
Warehouse	416	443	427	226	232
Unknown	1,205	1,119	1,084	752	873

Equivalent Full Load Hours for Cooling ($EFLH_{cooling}$)

System Type[233]	EFLH by Zone[234]				
	1 (Rockford)	2 (Chicago)	3 (Springfield)	4 (Belleville)	5 (Marion)
CV reheat, no economizer	2,723	4,206	3,341	3,872	2,734
CV reheat, economizer	870	1,343	1,067	1,237	873
VAV reheat, economizer	803	1,241	985	1,142	806

[233] Cooling EFLHs have been modified from the "Technical Reference Manual (TRM) for Ohio and adjusted by CDD for IL locations. These appear reasonable, but are recommended for further study.
[234] Act on Energy Commercial Technical Reference Manual No. 2010-4

4.4.1 Air Conditioner Tune-up

DESCRIPTION

An air conditioning system that is operating as designed saves energy and provides adequate cooling and comfort to the conditioned space

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to be a unitary or split system air conditioner least 3 tons and preapproved by program. The measure requires that a certified technician performs the following items:

- Check refrigerant charge
- Identify and repair leaks if refrigerant charge is low
- Measure and record refrigerant pressures
- Measure and record temperature drop at indoor coil
- Clean condensate drain line
- Clean outdoor coil and straighten fins
- Clean and straighten indoor and outdoor fan blades
- Clean indoor coil with spray-on cleaner and straighten fins
- Repair damaged insulation – suction line
- Change air filter
- Measure and record blower amp draw
- Measure and record compressor integrity (MOhm)
- Measure and record condenser fan motor amp draw

A copy of contractor invoices that detail the work performed to identify tune-up items, as well as additional labor and parts to improve/repair air conditioner performance must be submitted to the program

DEFINITION OF BASELINE EQUIPMENT

In order for this characterization to apply, the baseline condition is assumed to be an AC system that that does not have a standing maintenance contract or a tune up within in the past 36 months.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 3 years.[235]

DEEMED MEASURE COST

The incremental capital cost for this measure is $35[236] per ton.

LOADSHAPE

Loadshape C03 - Commercial Cooling

[235] Ibid.
[236] Ibid.

COINCIDENCE FACTOR

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

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

The measure has a deemed savings which applies to all building types and air conditioning unit size and equals an average value of 878 kWh a year.[237]

SUMMER COINCIDENT PEAK DEMAND SAVINGS

The measure has a deemed savings which applies to all building types and air conditioning unit size and equals an average value 0.39 kW a year.[238]

NATURAL GAS ENERGY SAVINGS

WATER IMPACT DESCRIPTIONS AND CALCULATION

DEEMED O&M COST ADJUSTMENT CALCULATION

MEASURE CODE: CI-HVC-ACTU-V01-120601

[237] Ibid.

[238] Act on Energy Commercial Technical Reference Manual No. 2010-4. These deemed values should be compared to PY evaluation and revised as necessary.

4.4.2 Space Heating Boiler Tune-up [239]

DESCRIPTION

This measure is for a non-residential boiler that provides space heating. The tune-up will improve boiler efficiency by cleaning and/or inspecting burners, combustion chamber, and burner nozzles. Adjust air flow and reduce excessive stack temperatures, adjust burner and gas input. Check venting, safety controls, and adequacy of combustion air intake. Combustion efficiency should be measured before and after tune-up using an electronic flue gas analyzer.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the facility must, as applicable, complete the tune-up requirements[240] listed below, by approved technician:

- Measure combustion efficiency using an electronic flue gas analyzer
- Adjust airflow and reduce excessive stack temperatures
- Adjust burner and gas input, manual or motorized draft control
- Check for proper venting
- Complete visual inspection of system piping and insulation
- Check safety controls
- Check adequacy of combustion air intake
- Clean fireside surfaces.
- Inspect all refractory. Patch and wash coat as required.
- Inspect gaskets on front and rear doors and replace as necessary.
- Seal and close front and rear doors properly.
- Clean low and auxiliary low water cut-off controls, then re-install using new gaskets.
- Clean plugs in control piping.
- Remove all hand hole and man hole plates. Flush boiler with water to remove loose scale and sediment.
- Replace all hand hole and man hole plates with new gaskets.
- Open feedwater tank manway, inspect and clean as required. Replace manway plate with new gasket.
- Clean burner and burner pilot.
- Check pilot electrode and adjust or replace.
- Clean air damper and blower assembly.
- Clean motor starter contacts and check operation.
- Make necessary adjustments to burner for proper combustion.
- Perform all flame safeguard and safety trip checks.
- Check all hand hole plates and man hole plates for leaks at normal operating temperatures and pressures.
- Troubleshoot any boiler system problems as requested by on-site personnel

DEFINITION OF BASELINE EQUIPMENT

The baseline condition of this measure is a boiler that has not had a tune-up within the past 36 months

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The life of this measure is 3 years[241]

[239] High Impact Measure
[240] Act on Energy Commercial Technical Reference Manual No. 2010-4, 9.2.2 Gas Boiler Tune-up
[241] Act on Energy Commercial Technical Reference Manual No. 2010-4, 9.2.2 Gas Boiler Tune-up

DEEMED MEASURE COST

The cost of this measure is $0.83/MBtu/hr[242] per tune-up

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

$$\Delta therms = Ngi * SF * EFLH/(100))$$

Where:

Ngi = Boiler gas input size (kBtu/hr)

= custom

SF = Savings factor

Note: Savings factor is the percentage reduction in gas consumption as a result of the tune-up

= 1.6%[243] or custom

EFLH = Equivalent Full Load Hours for heating are provided in section 4.4 HVAC End Use

[242] Work Paper – Tune up for Boilers serving Space Heating and Process Load by Resource Solutions Group, January 2012

[243] Work Paper WPRRSGNGRO301 Resource Solutions Group "Boiler Tune-Up" which cites Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0, PA Consulting, KEMA, March 22, 2010

EXAMPLE

For example, a 1050 kBtu boiler in Chicago at a high rise office:

$$\Delta Therms = 1050 * 0.016 * 2768 / (100)$$
$$= 465 \text{ Therms}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-BLRT-V04-140601

4.4.3 Process Boiler Tune-up[244]

DESCRIPTION

This measure is for a non-residential boiler for process loads. For space heating, see measure 5.2.1. .The tune-up will improve boiler efficiency by cleaning and/or inspecting burners, combustion chamber, and burner nozzles. Adjust air flow and reduce excessive stack temperatures, adjust burner and gas input. Check venting, safety controls, and adequacy of combustion air intake. Combustion efficiency should be measured before and after tune-up using an electronic flue gas analyzer.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the facility must, as applicable, complete the tune-up requirements[245] by approved technician, as specified below:

- Measure combustion efficiency using an electronic flue gas analyzer
- Adjust airflow and reduce excessive stack temperatures
- Adjust burner and gas input, manual or motorized draft control
- Check for proper venting
- Complete visual inspection of system piping and insulation
- Check safety controls
- Check adequacy of combustion air intake
- Clean fireside surfaces
- Inspect all refractory. Patch and wash coat as required.
- Inspect gaskets on front and rear doors and replace as necessary.
- Seal and close front and rear doors properly.
- Clean low and auxiliary low water cut-off controls, then re-install using new gaskets.
- Clean plugs in control piping.
- Remove all hand hole and man hole plates. Flush boiler with water to remove loose scale and sediment.
- Replace all hand hole and man hole plates with new gaskets.
- Open feedwater tank manway, inspect and clean as required. Replace manway plate with new gasket.
- Clean burner and burner pilot.
- Check pilot electrode and adjust or replace.
- Clean air damper and blower assembly.
- Clean motor starter contacts and check operation.
- Make necessary adjustments to burner for proper combustion.
- Perform all flame safeguard and safety trip checks.
- Check all hand hole plates and man hole plates for leaks at normal operating temperatures and pressures.
- Troubleshoot any boiler system problems as reQuested by on-site personnel

DEFINITION OF BASELINE EQUIPMENT

The baseline condition of this measure is a boiler that has not had a tune-up within the past 36 months

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The life of this measure is 3 years[246]

[244] High Impact Measure
[245] Act on Energy Commercial Technical Reference Manual No. 2010-4, 9.2.2 Gas Boiler Tune-up
[246] Act on Energy Commercial Technical Reference Manual No. 2010-4, 9.2.2 Gas Boiler Tune-up

DEEMED MEASURE COST

The cost of this measure is $0.83/MBtu/hr[247] per tune-up

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

$$\Delta therms=((Ngi * 8766*UF)/100) * (1- (Eff_{pre}/Eff_{measured}))$$

Where:

Ngi = Boiler gas input size (kBtu/hr)

= custom

UF = Utilization Factor

= 41.9%[248] or custom

Eff_{pre} = Boiler Combustion Efficiency Before Tune-Up

= 80%[249] or custom

[247] Work Paper – Tune up for Boilers serving Space Heating and Process Load by Resource Solutions Group, January 2012

[248] Work Paper – Tune up for Boilers serving Space Heating and Process Load by Resource Solutions Group, January 2012

$Eff_{measured}$ = Boiler Combustion Efficiency After Tune-Up

= 81.3%[250] or custom

100 =converstion from kBtu to therms

8766 = hours a year

EXAMPLE

For example, a 1050 kBtuboiler:

Δtherms =((1050 * 8766*0.419)/100) * (1- (0.80/0.813))

= 617 therms

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-PBTU-V03-130601

[249] Work Paper – Tune up for Boilers serving Space Heating and Process Load by Resource Solutions Group, January 2012,which cites Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0, PA Consulting, KEMA, March 22, 2010

[250] Work Paper – Tune up for Boilers serving Space Heating and Process Load by Resource Solutions Group, January 2012,which cites Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0, PA Consulting, KEMA, March 22, 2010

4.4.4 Boiler Lockout/Reset Controls

DESCRIPTION

This measure relates to improving combustion efficiency by adding controls to non-residential building heating boilers to vary the boiler entering water temperature relative to heating load as a function of the outdoor air temperature to save energy. Energy is saved by increasing the temperature difference between the water temperature entering the boiler in the boiler's heat exchanger and the boiler's burner flame temperature. The flame temperature remains the same while the water temperature leaving the boiler decreases with the decrease in heating load due to an increase in outside air temperature. A lockout temperature is also set to prevent the boiler from turning on when it is above a certain temperature outdoors.

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

DEFINITION OF EFFICIENT EQUIPMENT

Natural gas customer adding boiler reset controls capable of resetting the boiler supply water temperature in an inverse linear fashion with outdoor air temperature. Boiler lockout temperatures should be set to 55 °F at this time as well, to turn the boiler off when the temperature goes above a certain setpoint.

DEFINITION OF BASELINE EQUIPMENT

Existing boiler without boiler reset controls, any size with constant hot water flow.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The life of this measure is 20 years[251]

DEEMED MEASURE COST

The cost of this measure is $612[252]

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

[251] CLEAResultreferences the Brooklyn Union Gas Company, High Efficiency Heating and Water and Controls, Gas Energy Efficiency Program Implementation Plan.
[252] Nexant. Questar DSM Market Characterization Report. August 9, 2006.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

Therm Savings = Binput * SF * EFLH /(100)

Where:

Binput = Boiler Input Capacity (kBtu/hr)

= custom

SF = Savings factor

= 8%[253] or custom

EFLH = Equivalent Full Load Hours for heating are provided in section 4.4 HVAC End Use

100 = conversion from kBtu to therms

EXAMPLE

For example, a 800 kBtu/hr boiler at a restaurant in Rockford, IL

ΔTherms = 800 * 0.08 * 1,496 / (100)
= 957 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

[253] Savings factor is the estimate of annual gas consumption that is saved due to adding boiler reset controls. The CLEAResultuses a boiler tuneup savings value derived from Xcel Energy "DSM Biennial Plan-Technical Assumptions," Colorado. Focus on Energy uses 8%, citing multiple sources. Vermont Energy Investment Corporation's boiler reset savings estimates for custom projects further indicate 8% savings estimate is better reflection of actual expected savings.

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-BLRC-V02-130601

4.4.5 Condensing Unit Heaters

DESCRIPTION

This measure applies to a gas fired condensing unit heater installed in a commercial application.

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

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to be a condensing unit heater up to 300 MBH with a Thermal Efficiency > 90% and the heater must be vented, and condensate drained per manufacturer specifications. The unit must be replacing existing natural gas equipment.

DEFINITION OF BASELINE EQUIPMENT

In order for this characterization to apply, the baseline condition is assumed to be a non-condensing natural gas unit heater at end of life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years[254]

DEEMED MEASURE COST

The incremental capital cost for a unit heater is $676[255]

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

[254] DEER 2008

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

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

The annual natural gas energy savings from this measure is a deemed value equaling 266 Therms.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-CUHT-V01-120601

4.4.6 Electric Chiller

DESCRIPTION

This measure relates to the installation of a new electric chiller meeting the efficiency standards presented below. This measure could relate to the replacement of an existing unit at the end of its useful life, or the installation of a new system in an existing building (i.e. time of sale). Only single-chiller applications should be assessed with this methodology. The characterization is not suited for multiple chillers projects or chillers equipped with variable speed drives (VSDs).

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

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to exceed the efficiency requirements of the 2009 International Energy Conservation Code, Table 503.2.3(7)

DEFINITION OF BASELINE EQUIPMENT

In order for this characterization to apply, the baseline equipment is assumed to meet the efficiency requirements of the2009 International Energy Conservation Code, Table 503.2.3(7).

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 20 years [256].

DEEMED MEASURE COST

The incremental capital cost for this measure is provided below.

Equipment Type	Size Category	Incremental Cost ($/ton)257
Air cooled, electrically operated	All capacities	$127/ton[258]
Water cooled, electrically operated, positive displacement (reciprocating)	All capacities	$22/ton

[256] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008 (http://deeresources.com/deer0911planning/downloads/EUL_Summary_10-1-08.xls)

[257] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Cost Values and Summary Documentation", California Public Utilities Commission, December 16, 2008 (http://deeresources.com/deer0911planning/downloads/DEER2008_Costs_ValuesAndDocumentation_080530Rev1.zip)

[258] Calculated as the simple average of screw and reciprocating air-cooled chiller incremental costs from DEER2008. This assumes that baseline shift from IECC 2009 to IECC 2012 carries the same incremental costs. Values should be verified during evaluation

Equipment Type	Size Category	Incremental Cost ($/ton)257
Water cooled, electrically operated, positive displacement (rotary screw and scroll)	< 150 tons	$128/ton
	>= 150 tons and < 300 tons	$70/ton
	>= 300 tons	$48/ton

LOADSHAPE

Loadshape C03 - Commercial Cooling

COINCIDENCE FACTOR

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market. Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

CF_{SSP} = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3% [259]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8% [260]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWH = TONS * ((IPLVbase) – (IPLVee)) * EFLH

Where:

TONS = chiller nominal cooling capacity in tons (note: 1 ton = 12,000 Btu/hr)

= Actual installed

[259] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

[260] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year

IPLVbase = efficiency of baseline equipment expressed as Integrated Part Load Value(kW/ton). Chiller units are dependent on chiller type. See Chiller Units, Convertion Values and Baseline Efficiency Values by Chiller Type and Capacity in the Reference Tables section.

IPLVee[261] = efficiency of high efficiency equipment expressed as Integrated Part Load Value (kW/ton)[262]

= Actual installed

EFLH = Equivalent Full Load Hours for cooling are provided in section 4.4 HVAC End Use:

For example, a 100 ton air-cooled electrically operated chiller in a high-rise office building with IPLV of 14 EER (0.86 kW/ton) and baseline EER of 12.5 (0.96 kW/ton) in Rockford would save:

ΔkWH = 100 * ((0.96) – (0.86)) * 899

= 9,247 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW_{SSP} = TONS * ((PEbase) – (PEee)) * CF_{SSP}

ΔkW_{PJM} = TONS * ((PEbase) – (PEee)) * CF_{PJM}

Where:

PEbase = Peak efficiency of baseline equipment expressed as Full Load (kW/ton)

PEee = Peak efficiency of high efficiency equipment expressed as Full Load (kW/ton)

= Actual installed

CF_{SSP} = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3%

CF_{PJM} = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8%

[261] Integrated Part Load Value is a seasonal average efficiency rating calculated in accordance with ARI Standard 550/590. It may be calculated using any measure of efficiency (EER, kW/ton, COP), but for consistency with IECC 2012, it is expressed in terms of IPLV here.

[262] Can determine IPLV from standard testing or looking at engineering specs for design conditions. Standard data is available from AHRnetI.org. http://www.ahrinet.org/

For example, a 100 ton air-cooled electrically operated chiller in a high-rise office building with a full load IPLV of 12 EER (0.86 kW/ton) with baseline full load IPLV 9.56 EER (1.3 kW/ton) in Rockford would save:

ΔkW_{SSP} = 100 * ((1.3) – (1.0)) * .913

=23 kW

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

REFERENCE TABLES

Chillers Ratings- Chillers are rated with different units depending on equipment type as shown below

Equipment Type	Unit
Air cooled, electrically operated	EER
Water cooled, electrically operated, positive displacement (reciprocating)	kW/ton
Water cooled, electrically operated, positive displacement (rotary screw and scroll)	kW/ton

In order to convert chiller equipment ratings to IPLV the following realtionships are provided

kW/ton = 12 / EER
kW/ton = 12 / (COP x 3.412)
COP = EER / 3.412
COP = 12 / (kW/ton) / 3.412
EER = 12 / kW/ton
EER = COP x 3.412

Baseline Efficiency Values by Chiller Type and Capacity[263]

[263] International Energy Conservation Code (IECC)2012

TABLE C403.2.3(7)
MINIMUM EFFICIENCY REQUIREMENTS:
WATER CHILLING PACKAGES[a]

EQUIPMENT TYPE	SIZE CATEGORY	UNITS	BEFORE 1/1/2010		AS OF 1/1/2010[b]				TEST PROCEDURE[c]
					PATH A		PATH B		
			FULL LOAD	IPLV	FULL LOAD	IPLV	FULL LOAD	IPLV	
Air-cooled chillers	< 150 tons	EER	≥ 9.562	≥ 10.416	≥ 9.562	≥ 12.500	NA	NA	AHRI 550/590
	≥ 150 tons	EER			≥ 9.562	≥ 12.750	NA	NA	
Air cooled without condenser, electrical operated	All capacities	EER	≥ 10.586	≥ 11.782	Air-cooled chillers without condensers shall be rated with matching condensers and comply with the air-cooled chiller efficiency requirements				
Water cooled, electrically operated, reciprocating	All capacities	kW/ton	≤ 0.837	≤ 0.696	Reciprocating units shall comply with water cooled positive displacement efficiency requirements				
Water cooled, electrically operated, positive displacement	< 75 tons	kW/ton	≤ 0.790	≤ 0.676	≤ 0.780	≤ 0.630	≤ 0.800	≤ 0.600	
	≥ 75 tons and < 150 tons	kW/ton			≤ 0.775	≤ 0.615	≤ 0.790	≤ 0.586	
	≥ 150 tons and < 300 tons	kW/ton	≤ 0.717	≤ 0.627	≤ 0.680	≤ 0.580	≤ 0.718	≤ 0.540	
	≥ 300 tons	kW/ton	≤ 0.639	≤ 0.571	≤ 0.620	≤ 0.540	≤ 0.639	≤ 0.490	
Water cooled, electrically operated, centrifugal	< 150 tons	kW/ton	≤ 0.703	≤ 0.669	≤ 0.634	≤ 0.596	≤ 0.639	≤ 0.450	
	≥ 150 tons and < 300 tons	kW/ton	≤ 0.634	≤ 0.596					
	≥ 300 tons and < 600 tons	kW/ton	≤ 0.576	≤ 0.549	≤ 0.576	≤ 0.549	≤ 0.600	≤ 0.400	
	≥ 600 tons	kW/ton	≤ 0.576	≤ 0.549	≤ 0.570	≤ 0.539	≤ 0.590	≤ 0.400	
Air cooled, absorption single effect	All capacities	COP	≥ 0.600	NR	≥ 0.600	NR	NA	NA	AHRI 560
Water cooled, absorption single effect	All capacities	COP	≥ 0.700	NR	≥ 0.700	NR	NA	NA	
Absorption double effect, indirect fired	All capacities	COP	≥ 1.000	≥ 1.050	≥ 1.000	≥ 1.050	NA	NA	
Absorption double effect, direct fired	All capacities	COP	≥ 1.000	≥ 1.000	≥ 1.000	≥ 1.000	NA	NA	

For SI: 1 ton = 3517 W, 1 British thermal unit per hour = 0.2931 W, °C = [(°F) - 32]/1.8.

NA = Not applicable, not to be used for compliance; NR = No requirement.

a. The centrifugal chiller equipment requirements, after adjustment in accordance with Section C403.2.3.1 or Section C403.2.3.2, do not apply to chillers used in low-temperature applications where the design leaving fluid temperature is less than 36°F. The requirements do not apply to positive displacement chillers with leaving fluid temperatures less than or equal to 32°F. The requirements do not apply to absorption chillers with design leaving fluid temperatures less than 40°F.

b. Compliance with this standard can be obtained by meeting the minimum requirements of Path A or B. However, both the full load and IPLV shall be met to fulfill the requirements of Path A or B.

c. Chapter 6 of the referenced standard contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

MEASURE CODE: CI-HVC-CHIL-V02-140601

4.4.7 ENERGY STAR and CEE Tier 1 Room Air Conditioner

DESCRIPTION

This measure relates to the purchase and installation of a room air conditioning unit that meets either the ENERGY STAR or CEE TIER 1 minimum qualifying efficiency specifications, in place of a baseline unit meeting minimum Federal Standard efficiency ratings presented below:[264]

Product Class (Btu/H)	Federal Standard EER, with louvered sides	Federal Standard EER, without louvered sides	ENERGY STAR EER, with louvered sides	ENERGY STAR EER, without louvered sides	CEE TIER 1 EER
< 8,000	9.7	9	10.7	9.9	11.2
8,000 to 13,999	9.8	8.5	10.8	9.4	11.3
14,000 to 19,999	9.7	8.5	10.7	9.4	11.2
>= 20,000	8.5	8.5	9.4	9.4	9.8

Casement	Federal Standard (EER)	ENERGY STAR (EER)
Casement-only	8.7	9.6
Casement-slider	9.5	10.5

[264] http://www.energystar.gov/index.cfm?c=roomac.pr_crit_room_ac and http://www.cee1.org/resid/seha/rm-ac/rm-ac_specs.pdf
Side louvers that extend from a room air conditioner model in order to position the unit in a window. A model without louvered sides is placed in a built-in wall sleeve and are commonly referred to as "through-the-wall" or "built-in" models.
Casement-only refers to a room air conditioner designed for mounting in a casement window of a specific size.
Casement-slider refers to a room air conditioner with an encased assembly designed for mounting in a sliding or casement window of a specific size.
Reverse cycle refers to the heating function found in certain room air conditioner models.
http://www.energystar.gov/ia/partners/product_specs/program_reqs/room_air_conditioners_prog_req.pdf

Reverse Cycle - Product Class (Btu/H)	Federal Standard EER, with louvered sides	Federal Standard EER, without louvered sides	ENERGY STAR EER, with louvered sides	ENERGY STAR EER, without louvered sides
< 14,000	N/A	8.5	N/A	9.4
>= 14,000	N/A	8	N/A	8.8
< 20,000	9	N/A	9.9	N/A
>= 20,000	8.5	N/A	9.4	N/A

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 new room air conditioning unit must meet the ENERGY STAR efficiency standards presented above.

DEFINITION OF BASELINE EQUIPMENT

The baseline assumption is a new room air conditioning unit that meets the current minimum federal efficiency standards presented above.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 9 years.[265]

DEEMED MEASURE COST

The incremental cost for this measure is assumed to be $40 for an ENERGY STAR unit and $80 for a CEE TIER 1 unit.[266]

LOADSHAPE

Loadshape C03 - Commercial Cooling

COINCIDENCE FACTOR

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid

[265] Energy Star Room Air Conditioner Savings Calculator,
http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=AC
http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf
[266] Based on field study conducted by Efficiency Vermont

into PJM's Forward Capacity Market. Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

CF_{SSP} = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3% [267]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8% [268]

Algorithm

CALCULATION OF SAVINGS

ENERGY SAVINGS

$$\Delta kWh = (FLH_{RoomAC} * Btu/H * (1/EERbase - 1/EERee))/1000$$

Where:

FLH_{RoomAC} = Full Load Hours of room air conditioning unit

= dependent on location:[269]

Zone	FLH_{RoomAC}
1 (Rockford)	253
2-(Chicago)	254
3 (Springfield)	310
4-(Belleville)	391
5-(Marion)	254

[267] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

[268] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year

[269] Full load hours for room AC is significantly lower than for central AC. The average ratio of FLH for Room AC (provided in RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008: http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf) to FLH for Central Cooling for the same location (provided by AHRI: http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls) is 31%. This ratio has been applied to the FLH from the unitary and split system air conditioning measure.

Btu/H = Size of unit

= Actual. If unknown assume 8500 Btu/hr [270]

EERbase = Efficiency of baseline unit

= As provided in tables above

EERee = Efficiency of ENERGY STAR or CEE Tier 1 unit

= Actual. If unknown assume minimum qualifying standard as provided in tables above

For example for an 8,500 Btu/H capacity ENERGY STAR unit, with louvered sides, in Rockford:

$\Delta kWH_{ENERGY\ STAR}$ = (253 * 8500 * (1/9.8 – 1/10.8)) / 1000

= 20.3 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = Btu/H * ((1/EERbase - 1/EERee))/1000) * CF

Where:

CF_{SSP} = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)
= 91.3% [271]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8%[272]

Other variable as defined above

For example for an 8,500 Btu/H capacity ENERGY STAR unit, with louvered sides, in Rockford during system peak

$\Delta kW_{ENERGY\ STAR}$ = (8500 * (1/9.8 – 1/10.8)) / 1000 * 0.913

= 0.073 kW

[270] Based on maximum capacity average from the RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008

[271] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

[272] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year

FOSSIL FUEL SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-ESRA-V01-120601

4.4.8 Guest Room Energy Management (PTAC & PTHP)

DESCRIPTION

This measure applied to the installation of a temperature setback and lighting control system for individual guest rooms. The savings are achieved based on Guest Room Energy Management's (GREM's) ability to automatically adjust the guest room's set temperatures and control the HVAC unit for various occupancy modes.

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

DEFINITION OF EFFICIENT EQUIPMENT

Guest room temperature set point must be controlled by automatic occupancy detectors or keycard that indicates the occupancy status of the room. During unoccupied periods the default setting for controlled units differs by at least 5 degrees from the operating set point. Theoretically, the control system may also be tied into other electric loads, such as lighting and plug loads to shut them off when occupancy is not sensed. This measure bases savings on improved HVAC controls. If system is connected to lighting and plug loads, additional savings would be realized. The incentive is per guestroom controlled, rather than per sensor, for multi-room suites. Replacement or upgrades of existing occupancy-based controls are not eligible for an incentive.

DEFINITION OF BASELINE EQUIPMENT

Guest room energy management thermostats replace manual heating/cooling temperature set-point and fan On/Off/Auto thermostat controls. Two possible baselines exist based on whether housekeeping staff are directed to set-back (or turn off) thermostats when rooms are not rented.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life for GREM is 15 years [273].

DEEMED MEASURE COST

$260/unit

The IMC documented for this measure is $260 per room HVAC controller, which is the cost difference between a non-programmable thermostat and a GREM[274].

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C03 - Commercial Cooling

[273] DEER 2008 value for energy management systems
[274] This value was extracted from Smart Ideas projects in PY1 and PY2.

COINCIDENCE FACTOR

A coincidence factor is not used in the determination of coincident peak kW savings.

Algorithm

CALCULATION OF SAVINGS

Below are the annual kWh savings per installed EMS for different sizes and types of HVAC units. The savings are achieved based on GREM's ability to automatically adjust the guest room's set temperatures and control the HVAC unit to maintain set temperatures for various occupancy modes. Note that care should be taken in selecting a value consistent with actual baseline conditions (e.g. whether housekeeping staff are directed to set-back/turn-off the thermostats when rooms are unrented). Different values are provided for Motels and Hotels since significant differences in shell performance, number of external walls per room and typical heating and cooling efficiencies result in significantly different savings estimates. Energy savings estimates are derived using a prototypical EnergyPlus simulation of a motel[275]. Model outputs are normalized to the installed capacity and reported here as kWh/Ton, coincident peak kW/Ton and Therms/Ton.

ELECTRIC ENERGY SAVINGS

Motel Electric Energy Savings			
Climate Zone (City based upon)	Heating Source	Baseline	Electric Savings (kWh/Ton)
1 (Rockford)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	744
		No Housekeeping Setback	1,786
	PTAC w/ Gas Heating	Housekeeping Setback	63
		No Housekeeping Setback	155
	PTHP	Housekeeping Setback	385
		No Housekeeping Setback	986
2 (Chicago)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	506
		No Housekeeping Setback	1,582
	PTAC w/ Gas Heating	Housekeeping Setback	51
		No Housekeeping Setback	163
	PTHP	Housekeeping Setback	211
		No Housekeeping Setback	798
3 (Springfield)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	462
		No Housekeeping Setback	1,382
	PTAC w/ Gas Heating	Housekeeping Setback	65
		No Housekeeping Setback	198
	PTHP	Housekeeping Setback	202
		No Housekeeping Setback	736
4 (Belleville)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	559

[275] See S. Keates, ADM Associates Workpaper: "Suggested Revisions to Guest Room Energy Management (PTAC & PTHP)", 11/14/2013 and spreadsheet summarizing the results: 'GREM Savings Summary_IL TRM_1_22_14.xlsx'.

Motel Electric Energy Savings			
Climate Zone (City based upon)	Heating Source	Baseline	Electric Savings (kWh/Ton)
		No Housekeeping Setback	1,877
	PTAC w/ Gas Heating	Housekeeping Setback	85
		No Housekeeping Setback	287
	PTHP	Housekeeping Setback	260
		No Housekeeping Setback	1,023
5 (Marion-Williamson)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	388
		No Housekeeping Setback	1,339
	PTAC w/ Gas Heating	Housekeeping Setback	81
		No Housekeeping Setback	274
	PTHP	Housekeeping Setback	174
		No Housekeeping Setback	682

Hotel Electric Energy Savings			
Climate Zone (City based upon)	Heating Source	Baseline	Electric Savings (kWh/Ton)
1 (Rockford)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	298
		No Housekeeping Setback	716
	PTAC w/ Gas Heating	Housekeeping Setback	242
		No Housekeeping Setback	594
	PTHP	Housekeeping Setback	263
		No Housekeeping Setback	673
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	228
		No Housekeeping Setback	546
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	171
		No Housekeeping Setback	421
2 (Chicago)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	323
		No Housekeeping Setback	1,010
	PTAC w/ Gas Heating	Housekeeping Setback	249
		No Housekeeping Setback	793
	PTHP	Housekeeping Setback	276
		No Housekeeping Setback	1,046
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	251
		No Housekeeping Setback	785
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	176
		No Housekeeping Setback	563
3 (Springfield)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	288

Hotel Electric Energy Savings			
Climate Zone (City based upon)	**Heating Source**	**Baseline**	**Electric Savings (kWh/Ton)**
		No Housekeeping Setback	863
	PTAC w/ Gas Heating	Housekeeping Setback	259
		No Housekeeping Setback	785
	PTHP	Housekeeping Setback	270
		No Housekeeping Setback	983
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	211
		No Housekeeping Setback	632
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	182
		No Housekeeping Setback	551
4 (Belleville)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	322
		No Housekeeping Setback	1,083
	PTAC w/ Gas Heating	Housekeeping Setback	259
		No Housekeeping Setback	876
	PTHP	Housekeeping Setback	283
		No Housekeeping Setback	1,113
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	245
		No Housekeeping Setback	822
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	182
		No Housekeeping Setback	615
5 (Marion-Williamson)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	321
		No Housekeeping Setback	1,109
	PTAC w/ Gas Heating	Housekeeping Setback	260
		No Housekeeping Setback	885
	PTHP	Housekeeping Setback	283
		No Housekeeping Setback	1,110
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	244
		No Housekeeping Setback	842
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	183
		No Housekeeping Setback	622

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Motel Coincident Peak Demand Savings			
Climate Zone (City based upon)	Heating Source	Baseline	Coincident Peak Demand Savings (kW/Ton)
1 (Rockford)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	0.08
		No Housekeeping Setback	0.17
	PTAC w/ Gas Heating	Housekeeping Setback	0.08
		No Housekeeping Setback	0.17
	PTHP	Housekeeping Setback	0.08
		No Housekeeping Setback	0.17
2 (Chicago)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	0.06
		No Housekeeping Setback	0.17
	PTAC w/ Gas Heating	Housekeeping Setback	0.06
		No Housekeeping Setback	0.17
	PTHP	Housekeeping Setback	0.06
		No Housekeeping Setback	0.17
3 (Springfield)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	0.07
		No Housekeeping Setback	0.17
	PTAC w/ Gas Heating	Housekeeping Setback	0.07
		No Housekeeping Setback	0.17
	PTHP	Housekeeping Setback	0.07
		No Housekeeping Setback	0.17
4 (Belleville)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	0.10
		No Housekeeping Setback	0.28
	PTAC w/ Gas Heating	Housekeeping Setback	0.10
		No Housekeeping Setback	0.28
	PTHP	Housekeeping Setback	0.10
		No Housekeeping Setback	0.28
5 (Marion-Williamson)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	0.08
		No Housekeeping Setback	0.21
	PTAC w/ Gas Heating	Housekeeping Setback	0.08
		No Housekeeping Setback	0.21
	PTHP	Housekeeping Setback	0.08
		No Housekeeping Setback	0.21

Hotel Coincident Peak Demand Savings			
Climate Zone (City based upon)	**Heating Source**	**Baseline**	**Coincident Peak Demand Savings (kW/Ton)**
1 (Rockford)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	0.03
		No Housekeeping Setback	0.07
	PTAC w/ Gas Heating	Housekeeping Setback	0.03
		No Housekeeping Setback	0.06
	PTHP	Housekeeping Setback	0.03
		No Housekeeping Setback	0.06
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	0.03
		No Housekeeping Setback	0.06
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	0.02
		No Housekeeping Setback	0.04
2 (Chicago)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	0.04
		No Housekeeping Setback	0.10
	PTAC w/ Gas Heating	Housekeeping Setback	0.03
		No Housekeeping Setback	0.08
	PTHP	Housekeeping Setback	0.03
		No Housekeeping Setback	0.09
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	0.03
		No Housekeeping Setback	0.08
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	0.02
		No Housekeeping Setback	0.06
3 (Springfield)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	0.03
		No Housekeeping Setback	0.08
	PTAC w/ Gas Heating	Housekeeping Setback	0.03
		No Housekeeping Setback	0.07
	PTHP	Housekeeping Setback	0.03
		No Housekeeping Setback	0.07
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	0.02
		No Housekeeping Setback	0.06
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	0.02
		No Housekeeping Setback	0.05
4 (Belleville)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	0.04
		No Housekeeping Setback	0.10
	PTAC w/ Gas Heating	Housekeeping Setback	0.03
		No Housekeeping Setback	0.08
	PTHP	Housekeeping Setback	0.03
		No Housekeeping Setback	0.09

Hotel Coincident Peak Demand Savings			
Climate Zone (City based upon)	Heating Source	Baseline	Coincident Peak Demand Savings (kW/Ton)
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	0.03
		No Housekeeping Setback	0.08
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	0.02
		No Housekeeping Setback	0.06
5 (Marion-Williamson)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	0.04
		No Housekeeping Setback	0.10
	PTAC w/ Gas Heating	Housekeeping Setback	0.03
		No Housekeeping Setback	0.08
	PTHP	Housekeeping Setback	0.03
		No Housekeeping Setback	0.08
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	0.03
		No Housekeeping Setback	0.07
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	0.02
		No Housekeeping Setback	0.05

NATURAL GAS ENERGY SAVINGS

For PTACs with gas heating:

Motel Natural Gas Energy Savings		
Climate Zone (City based upon)	Baseline	Gas Savings (Therms/Ton)
1 (Rockford)	Housekeeping Setback	30
	No Housekeeping Setback	71
2 (Chicago)	Housekeeping Setback	20
	No Housekeeping Setback	62
3 (Springfield)	Housekeeping Setback	17
	No Housekeeping Setback	52
4 (Belleville)	Housekeeping Setback	21
	No Housekeeping Setback	70
5 (Marion-Williamson)	Housekeeping Setback	13
	No Housekeeping Setback	47

Hotel Natural Gas Energy Savings			
Climate Zone (City based upon)	Heating Source	Baseline	Gas Savings (Therms/Ton)
1 (Rockford)	PTAC w/ Gas Heating	Housekeeping Setback	2.5
		No Housekeeping Setback	5.9
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	2.4
		No Housekeeping Setback	5.7
2 (Chicago)	PTAC w/ Gas Heating	Housekeeping Setback	3.3
		No Housekeeping Setback	10.2
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	3.2
		No Housekeeping Setback	9.9
3 (Springfield)	PTAC w/ Gas Heating	Housekeeping Setback	1.3
		No Housekeeping Setback	3.9
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	1.3
		No Housekeeping Setback	3.8
4 (Belleville)	PTAC w/ Gas Heating	Housekeeping Setback	2.8
		No Housekeeping Setback	9.3
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	2.7
		No Housekeeping Setback	9.0
5 (Marion-Williamson)	PTAC w/ Gas Heating	Housekeeping Setback	2.7
		No Housekeeping Setback	9.3
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	2.6
		No Housekeeping Setback	9.0

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-GREM-V02-140601

4.4.9 Heat Pump Systems

DESCRIPTION

This measure applies to the installation of high-efficiency air cooled, water source, ground water source, and ground source heat pump systems. This measure could apply to replacing an existing unit at the end of its useful life, or installation of a new unit in a new or existing building

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

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to be a high-efficiency air cooled, water source, ground water source, or ground source heat pump system that exceeds the energy efficiency requirements of the International Energy Conservation Code (IECC) 2012,.

DEFINITION OF BASELINE EQUIPMENT

In order for this characterization to apply, the baseline equipment is assumed to be a standard-efficiency air cooled, water source, ground water source, or ground source heat pump system that meets the energy efficiency requirements of the International Energy Conservation Code (IECC) 2012,. The rating conditions for the baseline and efficient equipment efficiencies must be equivalent

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 15 years.[276]

DEEMED MEASURE COST

For analysis purposes, the incremental capital cost for this measure is assumed as $100 per ton for air-cooled units.[277] The incremental cost for all other equipment types should be determined on a site-specific basis

LOADSHAPE

Loadshape C05 - Commercial Electric Heating and Cooling

[276] Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, Inc., June 2007.

[277] Based on a review of TRM incremental cost assumptions from Vermont, Wisconsin, and California.

COINCIDENCE FACTOR

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market. Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

CF_{SSP} = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3% [278]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8% [279]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

For units with cooling capacities less than 65 kBtu/hr:

ΔkWh = Annual kWh $Savings_{cool}$ + Annual kWh $Savings_{heat}$

Annual kWh $Savings_{cool}$ = $(kBtu/hr_{cool})$ * [(1/SEERbase) – (1/SEERee)] * $EFLH_{cool}$

Annual kWh $Savings_{heat}$ = $(kBtu/hr_{cool})$ * [(1/HSPFbase) – (1/HSPFee)] * $EFLH_{heat}$

For units with cooling capacities equal to or greater than 65 kBtu/hr:

ΔkWh = Annual kWh $Savings_{cool}$ + Annual kWh $Savings_{heat}$

Annual kWh $Savings_{cool}$ = $(kBtu/hr_{cool})$ * [(1/EERbase) – (1/EERee)] * $EFLH_{cool}$

Annual kWh $Savings_{heat}$ = $(kBtu/hr_{heat})$/3.412 * [(1/COPbase) – (1/COPee)] * $EFLH_{heat}$

Where:

$kBtu/hr_{cool}$ = capacity of the cooling equipment in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/hr).

= Actual installed

SEERbase =Seasonal Energy Efficiency Ratio of the baseline equipment; see table below for values. [280]

[278] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

[279] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year

[280] International Energy Conservation Code (IECC) 2012

TABLE C403.2.3(2)
MINIMUM EFFICIENCY REQUIREMENTS:
ELECTRICALLY OPERATED UNITARY AND APPLIED HEAT PUMPS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Air cooled (cooling mode)	< 65,000 Btu/h[b]	All	Split System	13.0 SEER	AHRI 210/240
			Single Packaged	13.0 SEER	
Through-the-wall, air cooled	≤ 30,000 Btu/h[b]	All	Split System	13.0 SEER	
			Single Packaged	13.0 SEER	
Single-duct high-velocity air cooled	< 65,000 Btu/h[b]	All	Split System	10.0 SEER	
Air cooled (cooling mode)	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.2 IEER	AHRI 340/360
		All other	Split System and Single Package	10.8 EER 11.0 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.6 EER 10.7 IEER	
		All other	Split System and Single Package	10.4 EER 10.5 IEER	
	≥ 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.5 EER 9.6 IEER	
		All other	Split System and Single Package	9.3 EER 9.4 IEER	
Water source (cooling mode)	< 17,000 Btu/h	All	86°F entering water	11.2 EER	ISO 13256-1
	≥ 17,000 Btu/h and < 65,000 Btu/h	All	86°F entering water	12.0 EER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	All	86°F entering water	12.0 EER	
Ground water source (cooling mode)	< 135,000 Btu/h	All	59°F entering water	16.2 EER	
		All	77°F entering water	13.4 EER	
Water-source water to water (cooling mode)	< 135,000 Btu/h	All	86°F entering water	10.6 EER	ISO 13256-2
			59°F entering water	16.3 EER	
Ground water source Brine to water (cooling mode)	< 135,000 Btu/h	All	77°F entering fluid	12.1 EER	
Air cooled (heating mode)	< 65,000 Btu/h[b]	—	Split System	7.7 HSPF	AHRI 210/240
		—	Single Package	7.7 HSPF	
Through-the-wall, (air cooled, heating mode)	≤ 30,000 Btu/h[b] (cooling capacity)	—	Split System	7.4 HSPF	
		—	Single Package	7.4 HSPF	
Small-duct high velocity (air cooled, heating mode)	< 65,000 Btu/h[b]	—	Split System	6.8 HSPF	

(continued)

TABLE C403.2.3(2)—continued
MINIMUM EFFICIENCY REQUIREMENTS:
ELECTRICALLY OPERATED UNITARY AND APPLIED HEAT PUMPS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUB-CATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Air cooled (heating mode)	≥ 65,000 Btu/h and < 135,000 Btu/h (cooling capacity)	—	47°F db/43°F wb Outdoor Air	3.3 COP	AHRI 340/360
			17°F db/15°F wb Outdoor Air	2.25 COP	
	≥ 135,000 Btu/h (cooling capacity)	—	47°F db/43°F wb Outdoor Air	3.2 COP	
			17°F db/15°F wb Outdoor Air	2.05 COP	
Water source (heating mode)	< 135,000 Btu/h (cooling capacity)	—	68°F entering water	4.2 COP	ISO 13256-1
Ground water source (heating mode)	< 135,000 Btu/h (cooling capacity)	—	50°F entering water	3.6 COP	
Ground source (heating mode)	< 135,000 Btu/h (cooling capacity)	—	32°F entering fluid	3.1 COP	
Water-source water to water (heating mode)	< 135,000 Btu/h (cooling capacity)	—	68°F entering water	3.7 COP	ISO 13256-2
		—	50°F entering water	3.1 COP	
Ground source brine to water (heating mode)	< 135,000 Btu/h (cooling capacity)	—	32°F entering fluid	2.5 COP	

For SI: 1 British thermal unit per hour = 0.2931 W, °C = [(°F) - 32]/1.8.

a. Chapter 6 of the referenced standard contains a complete specification of the referenced test procedure, including the reference year version of the test procedure.

b. Single-phase, air-cooled air conditioners less than 65,000 Btu/h are regulated by NAECA. SEER values are those set by NAECA.

SEERee = Seasonal Energy Efficiency Ratio of the energy efficient equipment.

= Actual installed

$EFLH_{cool}$ = Equivalent Full Load Hours for cooling are provided in section 4.4 HVAC End Use:

HSPFbase = Heating Seasonal Performance Factor of the baseline equipment; see table above for values.

HSPFee = Heating Seasonal Performance Factor of the energy efficient equipment.

= Actual installed

$EFLH_{heat}$ = heating mode equivalent full load hours; see table above for default values.

EERbase = Energy Efficiency Ratio of the baseline equipment; see the table above for values. Since IECC 2006 does not provide EER requirements for air-cooled heat pumps < 65 kBtu/hr, assume the following conversion from SEER to EER: EER≈SEER/1.1.

EERee = Energy Efficiency Ratio of the energy efficient equipment. For air-cooled air conditioners < 65 kBtu/hr, if the actual EERee is unknown, assume the following conversion from SEER to EER: EER≈SEER/1.1.

= Actual installed

$kBtu/hr_{heat}$ = capacity of the heating equipment in kBtu per hour.

= Actual installed

3.412 = Btu per Wh.

COPbase = coefficient of performance of the baseline equipment; see table above for values.

COPee = coefficient of performance of the energy efficient equipment.

= Actual installed

Annual kWh $Savings_{cool}$ = $(kBtu/hr_{cool})$ * [(1/SEERbase) – (1/SEERee)] * $EFLH_{cool}$

Annual kWh $Savings_{heat}$ = $(kBtu/hr_{heat})$ * [(1/HSPFbase) – (1/HSPFee)] * $EFLH_{heat}$

For example a 5 ton cooling unit with 60 kbtu heating with an efficient EER of 14 and an efficient HSPF of 9 saves

= [(60) * [(1/13) – (1/14)] * 816] + [(60) * [(1/7.7) – (1/9)] * 1153]

= 1567 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = $(kBtu/hr_{cool})$ * [(1/EERbase) – (1/EERee)] *CF

Where CF value is chosen between:

CF_{SSP} = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3% [281]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8% [282]

For example a 5 ton cooling unit with 60 kbtu heating with an efficient EER of 14 and an efficient HSPF of 9 saves

ΔkW = [(60) * [(1/13) – (1/14)] *.913

= 0.3

[281] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

[282] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-HPSY-V02-140601

4.4.10 High Efficiency Boiler[283]

DESCRIPTION

To qualify for this measure the installed equipment must be replacement of an existing boiler at the end of its service life, in a commercial or multifamily space 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.

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

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a boiler used 80% or more for space heating, not process, and boiler AFUE, TE (thermal efficiency), or Ec (combustion efficiency) rating must be rated greater than or equal to 85% for hot water boilers and 81% for steam boilers.

DEFINITION OF BASELINE EQUIPMENT

Dependent on when the unit is installed and whether the unit is hot water or steam. The baseline efficiency source is the Energy Independence and Security Act of 2007 with technical amendments from Federal Register, volume 73, Number 145, Monday, July 28, 2008 for boilers <300,000 Btu/hr and is Final Rule, Federal Register, volume 74, Number 139, Wednesday, July 22, 2009 for boiler ≥300,000 Btu/hr.

Hot water boiler baseline:

Year	Efficiency
Hot Water <300,000 Btu/hr < June 1, 2013[284]	80% AFUE
Hot Water <300,000 Btu/hr ≥ June 1, 2013	82% AFUE
Hot Water ≥300,000 & ≤2,500,000 Btu/hr	80% TE
Hot Water >2,500,000 Btu/hr	82% Ec

[283] High Impact Measure

[284] The Federal baseline for boilers <300,000 btu/hr changes from 80% to 82% in September 2012. To prevent a change in baseline mid-program, the increase in efficiency is delayed until June 2013 when a new program year starts.

Steam boiler baseline:

Year	Efficiency
Steam <300,000 Btu/hr < June 1, 2013[285]	75% AFUE
Steam <300,000 Btu/hr ≥June 1, 2013	80% AFUE
Steam - all except natural draft ≥300,000 & ≤2,500,000 Btu/hr	79% TE
Steam - natural draft ≥300,000 & ≤2,500,000 Btu/hr	77% TE
Steam - all except natural draft >2,500,000 Btu/hr	79% TE
Steam - natural draft >2,500,000 Btu/hr	77% TE

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 20 years[286]

DEEMED MEASURE COST

The incremental capital cost for this measure depends on efficiency as listed below[287]

Measure Tier	Incr. Cost, per unit
ENERGY STAR® Minimum	$1,470
AFUE 90%	$2,400
AFUE 95%	$3,370
AFUE ≥ 96%	$4,340

[285] Ibid.

[286] The Technical support documents for federal residential appliance standards: http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/fb_fr_tsd/appendix_e.pdf Note that this value is below the 20 years used by CA's DEER and the range of 20-40 year estimate made by the Consortium for Energy Efficiency in 2010

[287] Average of low and high incremental cost based on Nicor Gas program data for non-condensing and condensing boilers. Nicor Gas Energy Efficiency Plan 2011 - 2014, May 27, 2011 $1,470 for ≤ 300,000 Btu/hr for non-condensing hydronic boilers >85% AFUE & $3,365 for condensing boilers > 90% AFUE. The exception is $4,340 for AFUE ≥ 96% AFUE which was obtained from extrapolation above the size range that Nicor Gas Energy Efficiency Plan provided for incremental cost.

Measure Tier	Incr. Cost, per unit
Boilers > 300,000 Btu/hr with TE (thermal efficiency) rating	Custom

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

ΔTherms = EFLH * Capacity * ((EfficiencyRating(actual) - EfficiencyRating(base)/ EfficiencyRating(base)) / 100,000

Where:

EFH = Equivalent Full Load Hours for heating are provided in section 4.4 HVAC End Use

Capacity = Nominal Heating Input Capacity Boiler Size (Btu/hr) for efficient unit not existing unit

= custom Boiler input capacity in Btu/hr

EfficiencyRating(base) = Baseline Boiler Efficiency Rating, dependant on year and boiler type. Baseline efficiency values by boiler type and capacity are found in the Definition of Baseline Equipment Section

EfficiencyRating(actual) = Efficent Boiler Efficiency Rating use actual value

Measure Type	Actual AFUE
ENERGY STAR® Minimum	85%
AFUE 90%	90%
AFUE 95%	95%
AFUE ≥ 96%	≥ 96%
Custom	Value to one significant digit i.e. 95.7%

EXAMPLE

For example, a 150,000 btu/hr water boiler meeting AFUE 90% in Rockford at a high rise office building , in the year 2012

ΔTherms = 2,746* 150,000 * (0.90-0.80)/0.80) / 100,000 Btu/Therm
= 515 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-BOIL-V04-130601

4.4.11 High Efficiency Furnace[288]

DESCRIPTION

This measure covers the installation of a high efficiency gas furnace in lieu of a standard efficiency gas furnace in a commercial or industrial space. 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

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

Time of sale:

a. The installation of a new high efficiency, gas-fired condensing furnace in a commercial location. This could relate to the replacement of an existing unit at the end of its useful life, or the installation of a new system.

Early replacement:

a. The early removal of an existing functioning AFUE 75% or less furnace from service, prior to its natural end of life, and replacement with a new high efficiency unit. Savings are calculated between existing unit and efficient unit consumption during the remaining life of the existing unit, and between new baseline unit and efficient unit consumption for the remainder of the measure life. At time of writing, the DOE had rescinded the next Federal Standard change for furnaces, however it is likely that a new standard will be in effect after the assumed remaining useful life of the existing unit. For the purposes of this measure- the new baseline is assumed to be 90%.
b. The assumption of the existing unit efficiency in the Early Replacement section of this TRM is based upon the average efficiency of units that were classified in Ameren's PY3-PY4 as functioning and AFUE <=75%. Therefore it is only appropriate to use these Early Replacement assumptions where those conditions are met. The TAC defined "functioning" as the unit is fully operational – providing sufficient space conditioning (i.e. heat exchanger, compressors, pumps work effectively) and/or the cost of repair is under 20% of the new baseline replacement cost. Therefore in order to apply early replacement assumptions the programs should apply the following eligibility criteria: AFUE <=75% and cost of any repairs <$528.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a furnace with input energy less than 225,000 Btu/hr rated natural gas fired furnace with an Annual Fuel Utilization Efficiency (AFUE) rating and fan electrical efficiency exceeding the program requirements:

DEFINITION OF BASELINE EQUIPMENT

Time of Sale: Although the current Federal Standard for gas furnaces is an AFUE rating of 78%, based upon review of available product in the AHRI database, the baseline efficiency for this characterization is assumed to be 80%.

[288] High Impact Measure

The baseline will be adjusted when the Federal Standard is updated.

Early replacement: The baseline for this measure is the efficiency of the existing equipment for the assumed remaining useful life of the unit and a new baseline unit for the remainder of the measure life. As discussed above we estimate that the new baseline unit that could be purchased in the year the existing unit would have needed replacing is 90%

DEFINITION OF MEASURE LIFE

The expected measure life is assumed to be 16.5 years[289]

Remaining life of existing equipment is assumed to be 5.5 years[290].

DEEMED MEASURE COST

Time of Sale: The incremental capital cost for this measure depends on efficiency as listed below[291]:

AFUE	Installation Cost	Incremental Install Cost
80%	$2011	n/a
90%	$2641	$630
91%	$2727	$716
92%	$2813	$802
93%	$3049	$1,038
94%	$3286	$1,275
95%	$3522	$1,511
96%	$3758	$1,747

Early Replacement: The full installation cost is provided in the table above. The assumed deferred cost (after 5.5 years) of replacing existing equipment with a new baseline unit is assumed to be $2641. This cost should be discounted to present value using the utilities discount rate.

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

[289] Average of 15-18 year lifetime estimate made by the Consortium for Energy Efficiency in 2010.
[290] Assumed to be one third of effective useful life
[291] Based on data from Appendix E of the Appliance Standards Technical Support Documents including equipment cost and installation labor (http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/fb_fr_tsd/appendix_e.pdf). Where efficiency ratings are not provided, the values are interpolated from those that are.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = Heating Savings + Cooling Savings + Shoulder Season Savings

Where:

Heating Savings = Brushless DC motor or Electronically commutated motor (ECM)
= 418 kWh[292]

Cooling Savings = Brushless DC motor or electronically commutated motor (ECM) savings during cooling season

If air conditioning = 263 kWh

If no air conditioning = 175 kWh

If unknown (weighted average)= 241 kWh[293]

Shoulder Season Savings = Brushless DC motor or electronically commutated motor (ECM) savings during shoulder seasons

= 51 kWh

EXAMPLE

For example, a blower motor in an office building where air conditioning presence is unknown:

ΔkWh = Heating Savings + Cooling Savings + Shoulder Season Savings
= 418 +251 + 51
= 721 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

For units that have evaporator coils and condensing units and are cooling in the summer in addition to heating in the winter the summer coincident peak demand savings should be calculated. If the unit is not equipment with coils or condensing units, the summer peak demand savings will not apply.

ΔkW = (ΔkWh/HOURSyear) * CF

[292] To estimate heating, cooling and shoulder season savings for Illinois, VEIC adapted results from a 2009 Focus on Energy study of BPM blower motor savings in Wisconsin. This study included effects of behavior change based on the efficiency of new motor greatly increasing the amount of people that run the fan continuously. The savings from the Wisconsin study were adjusted to account for different run hour assumptions (average values used) for Illinois. See: FOE to IL Blower Savings.xlsx.

[293] The weighted average value is based on assumption that 75% of buildings installing BPM furnace blower motors have Central AC.

Where:

HOURSyear = Actual hours per year if known, otherwise use hours from Table below for building type.

Building Type	Pumps and fans (h/yr)
College/University	4216
Grocery	5840
Heavy Industry	3585
Hotel/Motel	6872
Light Industry	2465
Medical	6871
Office	1766
Restaurant	4654
Retail/Service	3438
School(K-12)	2203
Warehouse	3222
Average=Miscellaneous	4103

CF =Summer Peak Coincidence Factor for measure is provided below for different building types[294]:

Location	CF
Restaurant	0.80
Office	0.66
School (K-12)	0.22
College/University	0.56
Medical	0.75

EXAMPLE

For example, a blower motor in an office building where air conditioning presence is unknown:

ΔkW = (721 kWh/1766) * 0.66 = 0.27 kW

NATURAL GAS ENERGY SAVINGS

Time of Sale:

ΔTherms = EFLH * Capacity * ((AFUE(eff) – AFUE(base)/AFUE(base))/ 100,000 Btu/Therm

Early replacement[295]:

[294] Based on DEER 2008 values

ΔTherms for remaining life of existing unit (1st 5.5 years):

ΔTherms = EFLH * Capacity * (AFUE(eff) – AFUE(exist)/ AFUE(exist)) / 100,000 Btu/Therm

ΔTherms for remaining measure life (next 11 years):

ΔTherms = EFLH * Capacity * (AFUE(eff) - AFUE(base)/AFUE(base)) / 100,000 Btu/Therm

Where:

EFLH Equivalent Full Load Hours for heating are provided in section 4.4 HVAC End Use

Capacity = Nominal Heating Input Capacity Furnace Size (Btu/hr) for efficient unit not existing unit

= custom Furnace input capacity in Btu/hr

AFUE(exist)= Existing Furnace Annual Fuel Utilization Efficiency Rating

= Use actual AFUE rating where it is possible to measure or reasonably estimate.

If unknown, assume 64.4 AFUE% [296].

AFUE(base) = Baseline Furnace Annual Fuel Utilization Efficiency Rating, dependant on year as listed below:

Dependent on program type as listed below[297]:

Program Year	AFUE(base)
Time of Sale	80%
Early Replacement	90%

AFUE(eff) = Efficent Furnace Annual Fuel Utilization Efficiency Rating.

= Actual. If Unknown, assume 95%[298]

[295] The two equations are provided to show how savings are determined during the initial phase of the measure (existing to efficient) and the remaining phase (new baseline to efficient). In practice, the screening tools used may either require a First Year savings (using the first equation) and then a “number of years to adjustment” and “savings adjustment” input which would be the (new base to efficient savings)/(existing to efficient savings).
[296] Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.
[297] Though the Federal Minimum AFUE is 78%, there were only 50 models listed in the AHRI database at that level. At AFUE 79% the total rises to 308. There are 3,548 active furnace models listed with AFUE ratings between 78 and 80.
[298]Minimum ENERGY STAR efficiency after 2.1.2012.

EXAMPLE

For example, a 150,000 btu/hr 92% efficient furnace at a low rise office building in Rockford, in the year 2012

ΔTherms = 797 * 150,000 * ((0.92-0.80)/0.80)/ 100,000 Btu/Therm
= 179 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-FRNC-V03-130601

4.4.12 Infrared Heaters (all sizes), Low Intensity

DESCRIPTION

This measure applies to natural gas fired low-intensity infrared heaters with an electric ignition that use non-conditioned air for combustion

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

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a natural gas heater with an electric ignition that uses non-conditioned air for combustion

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is a standard natural gas fired heater warm air heater.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years[299]

DEEMED MEASURE COST

The incremental capital cost for this measure is $1716[300]

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

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

[300]Ibid.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

The annual natural gas energy savings from this measure is a deemed value equaling 451 Therms[301]

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-IRHT-V01-120601

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

4.4.13 Package Terminal Air Conditioner (PTAC) and Package Terminal Heat Pump (PTHP)

DESCRIPTION

A PTAC is a packaged terminal air conditioner that cools and sometimes provides heat through an electric resistance heater (heat strip). A PTHP is a packaged terminal heat pump. A PTHP uses its compressor year round to heat or cool. In warm weather, it efficiently captures heat from inside your building and pumps it outside for cooling. In cool weather, it captures heat from outdoor air and pumps it into your home, adding heat from electric heat strips as necessary to provide heat.

This measure characterizes:

a) Time of Sale: the purchase and installation of a new efficient PTAC or PTHP.
b) Early Replacement: the early removal of an existing PTAC or PTHP from service, prior to its natural end of life, and replacement with a new efficient PTAC or PTHP unit. Savings are calculated between existing unit and efficient unit consumption during the remaining life of the existing unit, and between new baseline unit and efficient unit consumption for the remainder of the measure life. The measure is only valid for non-fuel switching installations – for example replacing a cooling only PTAC with a PTHP can currently not use the TRM.

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

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to be PTACs or PTHPs that exceed baseline efficiencies.

DEFINITION OF BASELINE EQUIPMENT

Time of Sale: the baseline conditions is provided in the Federal Baseline reference table provided below.

Early Replacement: the baseline is the existing PTAC or PTHP for the assumed remaining useful life of the unit and the new baseline as defined above for the remainder of the measure life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 15 years. [302]

Remaining life of existing equipment is assumed to be 5 years[303]

DEEMED MEASURE COST

Time of Sale: The incremental capital cost for this equipment is estimated to be $84/ton.[304]

[302] Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, Inc., June 2007
[303] Standard assumption of one third of effective useful life.
[304] DEER 2008. This assumes that baseline shift from IECC 2006 to IECC 2012 carries the same incremental costs.

Early Replacement: The measure cost is the full cost of removing the existing unit and installing a new one. The actual program cost should be used. *Default and deferred baseline cost TBD*

LOADSHAPE

Loadshape C03 - Commercial Cooling

COINCIDENCE FACTOR

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market. Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

CF_{SSP} = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3% [305]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8% [306]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Electric savings for PTACs and PTHPs should be calculated using the following algorithms

ENERGY SAVINGS

Time of Sale:

PTAC ΔkWh[307] = Annual kWh $Savings_{cool}$

PTHP ΔkWh = Annual kWh $Savings_{cool}$ + Annual kWh $Savings_{heat}$

Values should be verified during evaluation

[305] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

[306] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year

[307] There are no heating efficiency improvements for PTACs since although some do provide heating, it is always through electric resistance and therefore the COPbase and COPee would be 1.0.

Annual kWh $Savings_{cool}$ = $(kBtu/hr_{cool})$ * [(1/EERbase) – (1/EERee)] * $EFLH_{cool}$

Annual kWh $Savings_{heat}$ = $(kBtu/hr_{heat})$/3.412 * [(1/COPbase) – (1/COPee)] * $EFLH_{heat}$

Early Replacement:

ΔkWh for remaining life of existing unit (1st 5years) = Annual kWh $Savings_{cool}$ + Annual kWh $Savings_{heat}$

Annual kWh $Savings_{cool}$ = $(kBtu/hr_{cool})$ * [(1/EERexist) – (1/EERee)] * $EFLH_{cool}$

Annual kWh $Savings_{heat}$ = $(kBtu/hr_{heat})$/3.412 * [(1/COPexist) – (1/COPee)] * $EFLH_{heat}$

ΔkWh for remaining measure life (next 10 years) = Annual kWh $Savings_{cool}$ + Annual kWh $Savings_{heat}$

Annual kWh $Savings_{cool}$ = $(kBtu/hr_{cool})$ * [(1/EERbase) – (1/EERee)] * $EFLH_{cool}$

Annual kWh $Savings_{heat}$ = $(kBtu/hr_{heat})$/3.412 * [(1/COPbase) – (1/COPee)] * $EFLH_{heat}$

Where:

$kBtu/hr_{cool}$ = capacity of the cooling equipment in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/hr).

= Actual installed

$EFLH_{cool}$ = Equivalent Full Load Hours for cooling are provided in section 4.4 HVAC End Use:

$EFLH_{heat}$ = Equivalent Full Load Hours for heating are provided in section 4.4 HVAC End Use

EERexist = Energy Efficiency Ratio of the existing equipment

= Actual. If unknown assume 8.1 EER[308]

EERbase = Energy Efficiency Ratio of the baseline equipment; see the table below for values.

[308] Estimated using the IECC building energy code up until year 2003 (p107; https://law.resource.org/pub/us/code/ibr/icc.iecc.2000.pdf) and assuming a 1 ton unit; EER = 10 – (0.16 * 12,000/1,000) = 8.1.

Copy of Table C403.2.3(3), IECC 2012:
Minimum Efficiency Reguirements: Electrically operated packaged terminal air conditioners, packaged terminal heat pumps

Equipment Type	Minimum Efficiency as of 10/08/2012
PTAC (Cooling mode) New Construction	13.8 – (0.300 x Cap/1000) EER
PTAC (Cooling mode) Replacements	10.9 – (0.213 x Cap/1000) EER
PTHP (Cooling mode) New Construction	14.0 – (0.300 x Cap/1000) EER
PTHP (Cooling mode) Replacements	10.8 – (0.213 x Cap/1000) EER
PTHP (Heating mode) New Construction	3.2 – (0.026 x Cap/1000) COP
PTHP (Heating mode) Replacements	2.9 – (0.026 x Cap/1000) COP

"Cap" = The rated cooling capacity of the project in Btu/hr. If the units capacity is less than 7000 Btu/hr, use 7,000 Btu/hr in the calculation. If the unit's capacity is greater than 15,000 Btu/hr, use 15,000 Btu/hr in the calculations.

Replacement unit shall be factory labeled as follows "MANUFACTURED FOR REPLACEMENT APPLICATIONS ONLY; NOT TO BE INSTALLED IN NEW CONSTRUCTION PROJECTS", Replacement efficiencies apply only to units with existing sleeves less than 16 inches (406mm) in height and less than 42 inches (1067 mm) in width.

EEReе = Energy Efficiency Ratio of the energy efficient equipment. For air-cooled air conditioners < 65 kBtu/hr, if the actual EEReе is unknown, assume the following conversion from SEER to EER: EER≈SEER/1.1.

= Actual installed

$kBtu/hr_{heat}$ = capacity of the heating equipment in kBtu per hour.

= Actual installed

3.412 = Btu per Wh.

COPexist = coefficient of performance of the existing equipment

= Actual. If unknown assume 1.0 COP for PTAC units and 2.6 COP[309] for PTHPs.

COPbase = coefficient of performance of the baseline equipment; see table above for values.

COPee = coefficient of performance of the energy efficient equipment.

= Actual installed

[309]Estimated using the IECC building energy code up until year 2003 (p107; https://law.resource.org/pub/us/code/ibr/icc.iecc.2000.pdf) and assuming a 1 ton unit; COP = 2.9 – (0.026 * 12,000/1,000) = 2.6

Time of Sale (assuming new construction baseline):

For example a 1 ton PTAC with an efficient EER of 12 in Rockford saves:

= [(12) * [(1/10.2) – (1/12)] * 816

= 144 kWh

Early Replacement (assuming replacement baseline for deferred replacement in 5 years):

For example a 1 ton PTHP with an efficient EER of 12, COP of 3.0 in Rockford replaces a PTAC unit (with electric resistance heat) with unknown efficiency.

ΔkWh for remaining life of existing unit (1st 5years)

= (12 * (1/8.1 – 1/12) * 816) + (12/3.412 * (1/1.0 – 1/3.0) * 1153)

= 393 + 2,703

= 3,096 kWh

ΔkWh for remaining measure life (next 10 years)

= (12 * (1/8.3 – 1/12) * 816) + (12/3.412 * (1/1.0 – 1/3.0) * 1153)

= 364 + 2,703

= 3,067 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Time of Sale:

$\Delta kW = (kBtu/hr_{cool}) * [(1/EERbase) – (1/EERee)] *CF$

Early Replacement:

ΔkW for remaining life of existing unit (1st 5years) $= (kBtu/hr_{cool}) * [(1/EERexist) – (1/EERee)] *CF$

ΔkWh for remaining measure life (next 10 years) $= (kBtu/hr_{cool}) * [(1/EERbase) – (1/EERee)] *CF$

Where:

CF_{SSP} = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3% [310]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8% [311]

[310] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

Time of Sale:

For example a 1 ton replacement cooling unit with no heating with an efficient EER of 12 in Rockford saves

ΔkW_{SSP} = (12 * (1/10.2 – 1/12) *0.913

= 0.16 kW

For example a 1 ton PTHP with an efficient EER of 12, COP of 3.0 in Rockford replaces a PTAC unit with unknown efficiency.

ΔkW for remaining life of existing unit (1st 5years):

ΔkW_{SSP} = 12 * (1/8.1 – 1/12) * 0.913

= 0.44 kW

ΔkW for remaining measure life (next 10 years):

ΔkW_{SSP} = 12 * (1/10.2 – 1/12) * 0.913

= 0.16 kW

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-PTAC-V04-140601

[311] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year

4.4.14 Pipe Insulation

DESCRIPTION

This measure provides rebates for installation of ≥1" or ≥2" fiberglass, foam, calcium silicate or other types of insulation with similar insulating properties to existing bare pipe on straight piping as well as other pipe components such as elbows, tees, valves, and flanges for all non-residential installations.

Default per linear foot savings estimates are provided for the both exposed indoor or above ground outdoor piping distributing fluid in the following system types (natural gas fired systems only):

- Hydronic heating systems (with or without outdoor reset controls), including:
  - boiler systems that do not circulate water around a central loop and operate upon demand from a thermostat ("non-recirculation")
  - systems that recirculate during heating season only ("Recirculation – heating season only")
  - systems recirculating year round ("Recirculation – year round")
- Domestic hot water
- Low and high-pressure steam systems
  - non-recirculation
  - recirculation - heating season only
  - recirculation - year round

Process piping can also use the algorithms provided but requires custom entry of hours.

Minimum qualifying nominal pipe diameter is 1." Indoor piping must have at least 1" of insulation and outdoor piping must have at least 2" of insulation and include an all-weather protective jacket. New advanced insulating materials may be thinner and savings can be calculated with 3E Plus.

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

DEFINITION OF EFFICIENT EQUIPMENT

The efficient case is installing pipe wrap insulation to a length of pipe. Indoor piping must have at least 1" of insulation (or equivalent R-value) and outdoor piping must have at least 2" of insulation (or equivalent R-value) and include an all-weather protective jacket. Minimum qualifying pipe diameter is 1." Insulation must be continuous and contiguous over fittings that directly connect to straight pipe, including elbows and tees.[312]

DEFINITION OF BASELINE EQUIPMENT

The base case for savings estimates is a bare pipe. Pipes are required by new construction code to be insulated but are still commonly found uninsulated in older commercial buildings.

[312] *ASHRAE Handbook—Fundamentals*, 23.14; Hart, G., "Saving energy by insulating pipe components on steam and hot water distribution systems", *ASHRAE Journal*, October 2011

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 15 years.[313]

DEEMED MEASURE COST

Actual costs should be used if known. Otherwise the deemed measure costs below based on RS Means[314] pricing reference materials may be used.[315] The following table summarizes the estimated costs for this measure per foot of insulation added and include installation costs:

	INSULATION THICKNESS	
	1 INCH (INDOOR)	2 INCHES (OUTDOOR)
Pipe- RS Means #	220719.10.5170	220719.10.5530
Jacket- RS Means #	220719.10.0156	220719.10.0320
Jacket Type	PVC	Aluminum
Insulation Cost per foot	$9.40	$13.90
Jacket Cost per foot	$4.57	$7.30
Total Cost per foot	**$13.97**	**$21.20**

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

[313] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf
[314] RS Means 2008. Mechanical Cost Data, pages 106 to 119
[315] RS Means 2010: "for fittings, add 3 linear feet for each fitting plus 4 linear feet for each flange of the fitting"

NATURAL GAS SAVINGS

Δtherms per foot[316] = $((Q_{base} – Q_{eff}) * TRF * HOURS) / (100,000 * \eta Boiler)$

Δtherms = $(L_{sp} + L_{oc,i})$ * Δtherms per foot

Where:

HOURS = annual operating time, in hours

= Actual or defaults by piping use and building type below:

Piping Use	Building Type	EFLH				
		Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville/	Zone 5 (Marion)
Space Heating - Non-recirculating[317]	Office - High Rise	2,746	2,768	2,656	2,155	2,420
	Office - Mid Rise	996	879	824	519	544
	Office - Low Rise	797	666	647	343	329
	Convenience	696	550	585	272	297
	Healthcare Clinic	1,118	1,036	1,029	694	737
	Manufacturing Facility	1,116	1,123	904	771	857
	Lodging Hotel/ Motel/Multifamily	2,098	2,050	1,780	1,365	1,666
	High School	969	807	999	569	674
	Hospital	2,031	1,929	1,863	1,497	1,800
	Elementary	970	840	927	524	637
	Religious Facility	1,830	1,657	1,730	1,276	1,484
	Restaurant	1,496	1,379	1,291	872	1,185
	Retail - Strip Mall	1,266	1,147	1,151	732	863
	Retail - Department Store	1,065	927	900	578	646

[316] This value comes from the reference table "Savings Summary by Building Type and System Type." The formula and the input tables in this section document assumptions used in calculation spreadsheet "Pipe Insulation Savings 2013-11-12.xlsx"

[317] Equivalent full load hours for heating were developed using eQuest models for various building types averaged across each climate zones for Illinois for the following building types: office, healthcare/clinic, manufacturing, lodging, high school, hospital, elementary school, religious/assembly, restaurant, retail, college and warehouse. eQuest models were those developed for IL lighting interactive effects.

	College/University	373	404	376	187	187
	Warehouse	416	443	427	226	232
	Unknown	1,205	1,119	1,084	752	873
Space Heating – recirculation heating season only [318]	All buildings (Hours below 55F)	5,039	4,963	4,495	4,021	4,150
Space Heating – recirculation year round [319]	All buildings (All hours)	8,760	8,760	8,760	8,760	8,760
Domestic Hot Water	Recirculation loop	8,760	8,760	8,760	8,760	8,760
Process	Custom	Custom				

Q_{base} = Heat Loss from Bare Pipe (Btu/hr/ft)

= See table below

Q_{eff} = Heat Loss from Insulated Pipe (Btu/hr/ft)

= See table below

100,000 = conversion factor (1 therm = 100,000 Btu)

ηBoiler = Efficiency of the boiler being used to generate the hot water or steam in the pipe

= 81.9% for water boilers[320]

= 80.7% for steam boilers[321]

= 64.8% for multifamily low-pressure steam boilers[322]

TRF = Thermal Regain Factor for space type, applied only to space heating energy[323]

[318] These hours of use represent the number of hours in each climate zone that the outside temperature is below 55 degrees F. This is a consistent assumption of heating set point for commercial buildings. Hourly temperature data is obtained from the National Climactic Data Center (NCDC).

[319] For example reheat systems such as VAV and constant volume systems.

[320] Average efficiencies of units from the California Energy Commission (CEC).

[321] Ibid.

[322] Katrakis, J. and T.S. Zawacki. "Field-Measured Seasonal Efficiency of Intermediate-sized Low-Pressure Steam Boilers". ASHRAE V99, pt. 2, 1993.

[323] Thermal regain for *residential* pipe insulation measures is discussed in Home Energy Services Impact Evaluation, prepared for the Massachusetts Residential Retrofit and Low Income Program Area Evaluation, Cadmus Group, Inc., August 2012 and Andrews, John, Better Duct Systems for Home Heating and Cooling, U.S. Department of Energy, 2001. Recognizing the differences between residential and commercial heating systems, the factors have been adjusted based on professional judgment. This factor would benefit from additional study and evaluation.

Pipe Location	Assumed Regain	TRF, Thermal Regain Factor
Outdoor	0%	1.0
Indoor, conditioned space	85%	0.15
Indoor, semi-conditioned, (unconditioned space, with heat transfer to conditioned space. E.g.: boiler room, ceiling plenum, basement, crawlspace, wall)	30%	0.70
Indoor, unconditioned, (no heat transfer to conditioned space)	0%	1.0
Location not specified	85%	0.15
Custom	Custom	1 – assumed regain

L_{sp} = Length of straight pipe to be insulated (linear foot)

= actual installed ((linear foot)

$L_{oc,I}$ = Total equivalent length of the other components (valves and tees) of pipe to be insulated

= Actual installed (linear foot). See table "Equivalent Length of Other Components – Elbows and Tees" for equivalent lengths.

The heat loss estimates (Q_{base} and Q_{eff}) were developed using the 3E Plus v4.0 software program.[324] The energy savings analysis is based on adding 1-inch (indoor) or 2-inch (outdoor) thick insulation around bare pipe. The thermal conductivity of pipe insulation varies by material and temperature rating; to obtain a typical value, a range of materials allowed for this measure were averaged. For insulation materials not in the table below, use 3E Plusv4.0 software to calculate Q_{base} and $Q_{eff.}$

Insulation Type	Conductivity (Btu.in / hr.ft^2.ºF @ 75F)	Max temp (ºF)
Polyethylene foam	0.25	200
Flexible polyurethane-based foam	0.27	200
Fiberglass	0.31	250
Melamine foam	0.26	350
Flexible silicon foam	0.40	392
Calcium silicate	0.40	1200
Cellular glass	0.31	400
Average conductivity of all these materials (Btu.in / hr.ft^2.ºF @ 75ºF)	0.31	

The pipe fluid temperature assumption used depends upon both the system type and whether there is outdoor reset controls:

[324] 3E Plus is a heat loss calculation software provided by the NAIMA (North American Insulation Manufacturer Association).

System Type	Fluid temperature assumption (°F)
Hot Water space heating with outdoor reset - Non recirculation	145
Hot Water space heating without outdoor reset - Non recirculation	170
Hot Water space heating with outdoor reset – Recirculation heating season only	145
Hot Water space heating without outdoor reset – Recirculation heating season only	170
Hot Water space heating with outdoor reset – Recirculation year round	130
Hot Water space heating without outdoor reset – Recirculation year round	170
Domestic Hot Water	125
Low Pressure Steam	225
High Pressure Steam	312

	Indoor Insulation, Hot Water	Indoor Insulation, Low Pressure Steam	Indoor Insulation, High Pressure Steam	Domestic Hot Water	Outdoor Insulation, Hot Water	Outdoor Insulation, Low Pressure Steam	Outdoor Insulation, High Pressure Steam
Insulation thickness (inch)	1	1	1	1	2	2	2
Temperature, Fluid in Pipe (ºF)	170 (w/o reset) 145 (w/ reset heat) 130 (w/reset year)	225	312	125	170 (w/o reset) 145 (w/ reset heat) 130 (w/reset year)	225	312
Av. steam pressure (psig)	n/a	10.9	82.8	n/a	n/a	10.9	82.8
Operating Time (hrs/yr)	2,746 (non-recirc) 5,039 (recirc heating season) 8,760 (recirc year round)						
Ambient Temperature (ºF)[325]	75	75	75	75	48.6	48.6	48.6
Wind speed (mph)[326]	0	0	0	0	9.4	9.4	9.4
Pipe parameters							
Pipe material	Copper	Steel	Steel	Copper	Copper	Steel	Steel
Pipe size for Heat Loss Calc	2”	2”	2”	2”	2”	2”	2”
Outer Diameter, Pipe, actual	2.38”	2.38”	2.38”	2.38”	2.38”	2.38”	2.38”
Heat Loss, Bare Pipe (from 3EPlus) (Btu/hr.ft)	114 (w/o reset) 78 (w/ reset heat) 58 (w/reset year)	232	432	52	460 (w/o reset) 363 (w/ reset heat) 306 (w/reset year)	710	1101
Insulation parameters							
Outer diameter, insulation	4.38”	4.38”	4.38”	4.38”	4.38”	4.38”	4.38”
Average Heat Loss, Insulation (from 3EPlus) (Btu/hr.ft)	24 (w/o reset) 17 (w/ reset heat) 13 (w/reset year)	40	70	13.25	21 (w/o reset) 16 (w/ reset heat) 13 (w/reset year)	32	52
Annual Energy Savings							
Boiler / Water Heater efficiency	81.9%	80.7%	80.7%	67%	81.9%	80.7%	80.7%
Annual Gas Use, Base Case (therms/yr/ft)	3.8 (w/o reset) 4.8 (w/ reset heat) 6.2 (w/reset year)	7.9 (non recirc) 14.5 (recirc heat) 25.2 (recirc year)	14.7 (non recirc) 27.0 (recirc heat) 46.9 (recirc year)	6.76	15.4 (w/o reset) 22.5 (w/ reset heat) 32.7 (w/reset year)	24.1 (non recirc) 44.3 (recirc heat) 77.0 (recirc year)	37.5 (non recirc) 68.7 (recirc heat) 119.5 (recirc year)
Annual Gas Use, Measure case (therms/yr/ft)	0.8 (w/o reset) 1.1 (w/ reset heat) 1.4 (w/reset year)	1.4 (non recirc) 2.5 (recirc heat) 4.4 (recirc year)	2.4 (non recirc) 4.4 (recirc heat) 7.6 (recirc year)	1.73	0.7 (w/o reset) 1.0 (w/ reset heat) 1.4 (w/reset year)	1.1 (non recirc) 2.0 (recirc heat) 3.4 (recirc year)	1.8 (non recirc) 3.2 (recirc heat) 5.6 (recirc year)
Annual Gas Savings (therms/yr/ft)	3.0 (w/o reset) 3.7 (w/ reset heat) 4.8 (w/reset year)	6.5 (non recirc) 12.0 (recirc heat) 20.8 (recirc year)	12.3 (non recirc) 22.6 (recirc heat) 39.3 (recirc year)	5.0	14.7 (w/o reset) 21.4 (w/ reset heat) 31.3 (w/reset year)	23.1 (non recirc) 42.3 (recirc heat) 73.6 (recirc year)	35.7 (non recirc) 65.5 (recirc heat) 113.9 (recirc year)

Heat = heating season only, year = year round

[325] DOE Weather Data.
http://apps1.eere.energy.gov/buildings/energyplus/weatherdata/4_north_and_central_america_wmo_region_4/1_usa/USA_IL_Aurora.Muni.AP.744655_TMY3.stat Ibid.
[326] Ibid.

All variables were the same except for hours of operation in the calculation of the default savings per foot for the various building types and applications as presented in the table below:

Savings Summary for Indoor pipe insulation by System Type and Building Type (Δtherms per foot) (continues for 3 pages)

			Annual therm Savings per linear foot (therm /ft) (2" pipe / 1" insulation for hot water, 2" insulation for steam)				
Location	System Type	Building Type	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
Indoor	Hot Water Space Heating with outdoor reset – non-recirculation	Office - High Rise	2.04	2.05	1.97	1.60	1.79
		Office - Mid Rise	0.74	0.65	0.61	0.38	0.40
		Office - Low Rise	0.59	0.49	0.48	0.25	0.24
		Convenience	0.52	0.41	0.43	0.20	0.22
		Healthcare Clinic	0.83	0.77	0.76	0.51	0.55
		Manufacturing Facility	0.83	0.83	0.67	0.57	0.64
		Lodging Hotel/ Motel/MF	1.55	1.52	1.32	1.01	1.23
		High School	0.72	0.60	0.74	0.42	0.50
		Hospital	1.51	1.43	1.38	1.11	1.33
		Elementary	0.72	0.62	0.69	0.39	0.47
		Religious Facility	1.36	1.23	1.28	0.95	1.10
		Restaurant	1.11	1.02	0.96	0.65	0.88
		Retail - Strip Mall	0.94	0.85	0.85	0.54	0.64
		Retail - Department Store	0.79	0.69	0.67	0.43	0.48
		College/University	0.28	0.30	0.28	0.14	0.14
		Warehouse	0.31	0.33	0.32	0.17	0.17
		Unknown	0.93	0.86	0.84	0.58	0.67
	Hot Water Space Heating without outdoor reset – non-recirculation	Office - High Rise	3.00	3.03	2.91	2.36	2.65
		Office - Mid Rise	1.09	0.96	0.90	0.57	0.60
		Office - Low Rise	0.87	0.73	0.71	0.38	0.36
		Convenience	0.76	0.60	0.64	0.30	0.32
		Healthcare Clinic	1.22	1.13	1.13	0.76	0.81
		Manufacturing Facility	1.22	1.23	0.99	0.84	0.94
		Lodging Hotel/ Motel/MF	2.30	2.24	1.95	1.49	1.82
		High School	1.06	0.88	1.09	0.62	0.74
		Hospital	2.22	2.11	2.04	1.64	1.97
		Elementary	1.06	0.92	1.01	0.57	0.70
		Religious Facility	2.00	1.81	1.89	1.40	1.62
		Restaurant	1.64	1.51	1.41	0.95	1.30
		Retail - Strip Mall	1.39	1.25	1.26	0.80	0.94
		Retail - Department Store	1.17	1.01	0.98	0.63	0.71
		College/University	0.41	0.44	0.41	0.20	0.20
		Warehouse	0.46	0.48	0.47	0.25	0.25
		Unknown	1.37	1.27	1.24	0.86	1.00
	Hot Water with outdoor reset - Recirculation heating season only	All buildings (Hours below 55F)	3.73	3.68	3.33	2.98	3.08

			Annual therm Savings per linear foot (therm /ft) (2" pipe / 1" insulation for hot water, 2" insulation for steam)				
Location	System Type	Building Type	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
	Hot Water without outdoor reset-Recirculation heating season only	All buildings (Hours below 55F)	5.51	5.43	4.92	4.40	4.54
	Hot Water with outdoor reset-Recirculation year round	All buildings (All hours)	4.79	4.79	4.79	4.79	4.79
	Hot Water without outdoor reset-Recirculation year round	All buildings (All hours)	9.58	9.58	9.58	9.58	9.58
	Domestic Hot Water	DHW circulation loop	5.02	5.02	5.02	5.02	5.02
	LP Steam – non-recirculation	Office - High Rise	6.53	6.59	6.32	5.13	5.76
		Office - Mid Rise	2.37	2.09	1.96	1.23	1.29
		Office - Low Rise	1.90	1.58	1.54	0.82	0.78
		Convenience	1.66	1.31	1.39	0.65	0.71
		Healthcare Clinic	2.66	2.47	2.45	1.65	1.75
		Manufacturing Facility	2.66	2.67	2.15	1.83	2.04
		Lodging Hotel/ Motel/MF	4.99	4.88	4.24	3.25	3.96
		High School	2.31	1.92	2.38	1.35	1.60
		Hospital	4.83	4.59	4.43	3.56	4.28
		Elementary	2.31	2.00	2.21	1.25	1.52
		Religious Facility	4.35	3.94	4.12	3.04	3.53
		Restaurant	3.56	3.28	3.07	2.07	2.82
		Retail - Strip Mall	3.01	2.73	2.74	1.74	2.05
		Retail - Department Store	2.53	2.21	2.14	1.38	1.54
		College/University	0.89	0.96	0.89	0.44	0.44
		Warehouse	0.99	1.05	1.02	0.54	0.55
		Unknown	2.97	2.77	2.69	1.87	2.17
	LP Steam-Recirculation heating season only	All buildings (Hours below 55F)	11.99	11.81	10.70	9.57	9.88
	LP Steam-Recirculation year round	All buildings (All hours)	20.84	20.84	20.84	20.84	20.84
	HP Steam – non-recirculation	Office - High Rise	12.33	12.42	11.92	9.67	10.86
		Office - Mid Rise	4.47	3.95	3.70	2.33	2.44
		Office - Low Rise	3.58	2.99	2.90	1.54	1.48
		Convenience	3.12	2.47	2.63	1.22	1.33
		Healthcare Clinic	5.02	4.65	4.62	3.12	3.31
		Manufacturing Facility	5.01	5.04	4.06	3.46	3.85
		Lodging Hotel/ Motel/MF	9.42	9.20	7.99	6.13	7.48

			Annual therm Savings per linear foot (therm /ft) (2" pipe / 1" insulation for hot water, 2" insulation for steam)				
Location	System Type	Building Type	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
		High School	4.35	3.62	4.48	2.55	3.03
		Hospital	9.12	8.66	8.36	6.72	8.08
		Elementary	4.35	3.77	4.16	2.35	2.86
		Religious Facility	8.21	7.44	7.77	5.73	6.66
		Restaurant	6.71	6.19	5.79	3.91	5.32
		Retail - Strip Mall	5.68	5.15	5.17	3.29	3.87
		Retail - Department Store	4.78	4.16	4.04	2.59	2.90
		College/University	1.67	1.81	1.69	0.84	0.84
		Warehouse	1.87	1.99	1.92	1.01	1.04
		Unknown	5.61	5.22	5.07	3.53	4.08
	HP Steam-Recirculation heating season only	All buildings (Hours below 55F)	22.62	22.28	20.18	18.05	18.63
	HP Steam-Recirculation year round	All buildings (All hours)	39.32	39.32	39.32	39.32	39.32

Savings Summary for Outdoor pipe insulation by System Type and Building Type (Δtherms per foot) (continues for 3 pages)

			Annual therm Savings per linear foot (therm /ft) (2" pipe / 1" insulation for hot water, 2" insulation for steam)				
Location	System Type	Building Type	Zone 1 (Rockford)	Location	System Type	Building Type	Zone 1 (Rockford)
Outdoor	Hot Water Space Heating with outdoor reset – non-recirculation	Office - High Rise	11.65	11.74	11.27	9.14	10.27
		Office - Mid Rise	4.23	3.73	3.50	2.20	2.31
		Office - Low Rise	3.38	2.83	2.74	1.46	1.40
		Convenience	2.95	2.33	2.48	1.15	1.26
		Healthcare Clinic	4.74	4.40	4.37	2.94	3.13
		Manufacturing Facility	4.73	4.76	3.84	3.27	3.64
		Lodging Hotel/ Motel/MF	8.90	8.70	7.55	5.79	7.07
		High School	4.11	3.42	4.24	2.41	2.86
		Hospital	8.62	8.18	7.90	6.35	7.64
		Elementary	4.12	3.56	3.93	2.22	2.70
		Religious Facility	7.76	7.03	7.34	5.41	6.30
		Restaurant	6.35	5.85	5.48	3.70	5.03
		Retail - Strip Mall	5.37	4.87	4.88	3.11	3.66
		Retail - Department Store	4.52	3.93	3.82	2.45	2.74
		College/University	1.58	1.71	1.60	0.79	0.79
		Warehouse	1.76	1.88	1.81	0.96	0.98
		Unknown	5.30	4.93	4.79	3.33	3.86
	Hot Water Space Heating without outdoor reset – non-recirculation	Office - High Rise	14.74	14.86	14.26	11.57	12.99
		Office - Mid Rise	5.35	4.72	4.42	2.79	2.92
		Office - Low Rise	4.28	3.57	3.47	1.84	1.77
		Convenience	3.74	2.95	3.14	1.46	1.59
		Healthcare Clinic	6.00	5.56	5.52	3.73	3.96

			Annual therm Savings per linear foot (therm /ft) (2" pipe / 1" insulation for hot water, 2" insulation for steam)				
Location	System Type	Building Type	Zone 1 (Rockford)	Location	System Type	Building Type	Zone 1 (Rockford)
		Manufacturing Facility	5.99	6.03	4.85	4.14	4.60
		Lodging Hotel/ Motel/MF	11.26	11.00	9.55	7.33	8.94
		High School	5.20	4.33	5.36	3.05	3.62
		Hospital	10.90	10.35	10.00	8.04	9.66
		Elementary	5.21	4.51	4.98	2.81	3.42
		Religious Facility	9.82	8.89	9.29	6.85	7.97
		Restaurant	8.03	7.40	6.93	4.68	6.36
		Retail - Strip Mall	6.80	6.16	6.18	3.93	4.63
		Retail - Department Store	5.72	4.98	4.83	3.10	3.47
		College/University	2.00	2.17	2.02	1.00	1.00
		Warehouse	2.23	2.38	2.29	1.21	1.25
		Unknown	6.70	6.24	6.07	4.22	4.88
	Hot Water with outdoor reset - Recirculation heating season only	All buildings (Hours below 55F)	21.38	21.06	19.07	17.06	17.61
	Hot Water without outdoor reset- Recirculation heating season only	All buildings (Hours below 55F)	27.05	26.64	24.13	21.58	22.28
	Hot Water with outdoor reset- Recirculation year round	All buildings (All hours)	37.16	37.16	37.16	37.16	37.16
	Hot Water without outdoor reset- Recirculation year round	All buildings (All hours)	47.02	47.02	47.02	47.02	47.02
	LP Steam – non-recirculation	Office - High Rise	23.07	23.25	22.31	18.10	20.33
		Office - Mid Rise	8.37	7.38	6.92	4.36	4.57
		Office - Low Rise	6.70	5.59	5.44	2.88	2.76
		Convenience	5.85	4.62	4.91	2.29	2.50
		Healthcare Clinic	9.39	8.70	8.64	5.83	6.19
		Manufacturing Facility	9.38	9.43	7.59	6.48	7.20
		Lodging Hotel/ Motel	17.63	17.22	14.95	11.47	14.00
		Multifamily	21.95	21.45	18.62	14.28	17.43
		High School	8.14	6.78	8.39	4.78	5.66
		Hospital	17.06	16.21	15.65	12.58	15.12
		Elementary	8.15	7.06	7.79	4.40	5.35
		Religious Facility	15.37	13.92	14.53	10.72	12.47
		Restaurant	12.57	11.58	10.85	7.33	9.96
		Retail - Strip Mall	10.64	9.64	9.67	6.15	7.25
		Retail - Department Store	8.95	7.79	7.56	4.86	5.43
		College/University	3.13	3.39	3.16	1.57	1.57
		Warehouse	3.49	3.72	3.59	1.90	1.95
		Unknown	10.49	9.77	9.49	6.60	7.64
	LP Steam- Recirculation heating season only	All buildings (Hours below 55F)	42.33	41.69	37.76	33.78	34.86

			Annual therm Savings per linear foot (therm /ft) (2" pipe / 1" insulation for hot water, 2" insulation for steam)				
Location	System Type	Building Type	Zone 1 (Rockford)	Location	System Type	Building Type	Zone 1 (Rockford)
	LP Steam-Recirculation year round	All buildings (All hours)	73.59	73.59	73.59	73.59	73.59
	HP Steam – non-recirculation	Office - High Rise	35.71	36.00	34.54	28.02	31.47
		Office - Mid Rise	12.95	11.43	10.72	6.75	7.07
		Office - Low Rise	10.36	8.66	8.41	4.46	4.28
		Convenience	9.05	7.15	7.61	3.54	3.86
		Healthcare Clinic	14.54	13.47	13.38	9.03	9.58
		Manufacturing Facility	14.51	14.60	11.76	10.03	11.14
		Lodging Hotel/ Motel Multifamily	27.28	26.66	23.15	17.75	21.67
		High School	12.60	10.49	12.99	7.40	8.76
		Hospital	26.41	25.09	24.23	19.47	23.41
		Elementary	12.61	10.92	12.06	6.81	8.28
		Religious Facility	23.80	21.55	22.50	16.59	19.30
		Restaurant	19.45	17.93	16.79	11.34	15.41
		Retail - Strip Mall	16.46	14.92	14.97	9.52	11.22
		Retail - Department Store	13.85	12.06	11.70	7.52	8.40
		College/University	4.85	5.25	4.89	2.43	2.43
		Warehouse	5.41	5.76	5.55	2.94	3.02
		Unknown	16.24	15.12	14.69	10.22	11.83
	HP Steam-Recirculation heating season only	All buildings (Hours below 55F)	65.53	64.54	58.45	52.29	53.97
	HP Steam-Recirculation year round	All buildings (All hours)	113.92	113.92	113.92	113.92	113.92

For insulation covering elbows and tees that connect straight pipe, a calculated surface area will be assumed based on the dimensions for fittings given by ANSI/ASME B36.19. The surface area is then converted to an equivalent length of pipe that must be added to the total length of straight pipe in order to calculate total savings. Equivalent pipe lengths are given in 1” increments in pipe diameter for simplicity. In the case of pipe diameters in between full inch diameters, the closest equivalent length should be used. The larger pipe sizes mostly apply to steam header piping, which has the most heat loss per foot.

Calculated Surface Areas of Elbows and Tees

Nominal Pipe Diameter	Calculated Surface Area (ft)	
	90 Degree Elbow[327]	Straight Tee[328]
1”	0.10	0.13
2”	0.41	0.39
3”	0.93	0.77
4”	1.64	1.21
5”	2.57	1.77
6”	3.70	2.44
8”	6.58	3.95
10”	10.28	5.98
12”	14.80	8.34

Equivalent Length of Other Components – Elbows and Tees (L_{oc})

Nominal Pipe Diameter	Equivalent Length of Other Components (ft)	
	90 Degree Elbow	Straight Tee
1”	0.30	0.38
2”	0.66	0.63
3”	1.01	0.84
4”	1.40	1.03
5”	1.76	1.22
6”	2.13	1.41
8”	2.91	1.75
10”	3.65	2.13
12”	4.44	2.50

For insulation around valves or flanges, a surface area from ASTM standard C1129-12 will be assumed for 2” pipes. For 1” pipes, which weren’t included in the standard, a linear-trended value will be used. The surface area is then converted to an equivalent length of either 1” or 2” straight pipe that must be added to the total length of straight pipe in order to calculate total savings.

[327] Based on the dimensions for diameter, long radius, and short radius given by ANSI/ASME 36.19
[328] Based on the center to face and diameter dimensions given by ANSI/ASME B36.19

Calculated Surface Areas of Flanges and Valves

Valves				
Class (psi)	150	300	600	900
NPS (in)	ft^2	ft^2	ft^2	ft^2
1	0.69	1.8	1.8	2.4
2	2.21	2.94	2.94	5.2
2.5	2.97	3.51	3.91	6.6
3	3.37	4.39	4.69	6.5
4	4.68	6.06	7.64	9.37
6	7.03	9.71	13.03	15.8
8	10.3	13.5	18.4	23.8
10	13.8	18	26.5	32.1
12	16.1	24.1	31.9	41.9

Flanges				
Class (psi)	150	300	600	900
NPS (in)	ft^2	ft^2	ft^2	ft^2
1	0.36	0.36	0.4	1.23
2	0.71	0.84	0.88	1.54
3	1.06	1.32	1.36	1.85
4	1.44	1.83	2.23	2.64
6	2.04	2.72	3.6	4.37
8	2.92	3.74	4.89	6.4
10	3.68	4.8	6.93	8.47
12	5.01	6.34	7.97	10.43

Equivalent Length of Other Components - Flanges and Valves (L_{oc})

ANSI Class (psi)	Equivalent Length of Other Components (ft)			
	1" Valve	1" Flange	2" Valve	2" Flange
150	3.56	1.05	3.56	1.14
300	4.73	1.05	4.73	1.35
600	4.73	1.16	4.73	1.42
900	8.37	3.57	8.37	2.48

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-PINS-V02-140601

4.4.15 Single-Package and Split System Unitary Air Conditioners

DESCRIPTION

This measure promotes the installation of high-efficiency unitary air-, water-, and evaporatively cooled air conditioning equipment, both single-package and split systems. Air conditioning (AC) systems are a major consumer of electricity and systems that exceed baseline efficiencies can save considerable amounts of energy. This measure could apply to the replacing of an existing unit at the end of its useful life or the installation of a new unit in a new or existing building.

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

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the efficient equipment is assumed to be a high-efficiency air-, water-, or evaporatively cooled air conditioner that exceeds the energy efficiency requirements of the International Energy Conservation Code (IECC) 2012

DEFINITION OF BASELINE EQUIPMENT

In order for this characterization to apply, the baseline equipment is assumed to be a standard-efficiency air-, water, or evaporatively cooled air conditioner that meets the energy efficiency requirements of the International Energy Conservation Code (IECC) 2012,. The rating conditions for the baseline and efficient equipment efficiencies must be equivalent.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 15 years.[329]

DEEMED MEASURE COST

The incremental capital cost for this measure is assumed to be $100 per ton.[330]

LOADSHAPE

Loadshape C03 - Commercial Cooling

COINCIDENCE FACTOR

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid

[329] Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, Inc., June 2007.

[330] Based on a review of TRM incremental cost assumptions from Vermont, Wisconsin, and California. This assumes that baseline shift from IECC 2009 to IECC 2012 carries the same incremental costs. Values should be verified during evaluation

into PJM's Forward Capacity Market. Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

CF_{SSP} = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3% [331]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8% [332]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

For units with cooling capacities less than 65 kBtu/hr:

ΔkWH = (kBtu/hr) * [(1/SEERbase) – (1/SEERee)] * EFLH

For units with cooling capacities equal to or greater than 65 kBtu/hr:

ΔkWH = (kBtu/hr) * [(1/EERbase) – (1/EERee)] * EFLH

Where:

kBtu/hr = capacity of the cooling equipment actually installed in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/hr).

SEERbase = Seasonal Energy Efficiency Ratio of the baseline equipment; see table below for default values[333]::

[331] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

[332] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year

[333] International Energy Conservation Code (IECC) 2012

TABLE C403.2.3(1)
MINIMUM EFFICIENCY REQUIREMENTS:
ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY		TEST PROCEDURE[a]
				Before 6/1/2011	As of 6/1/2011	
Air conditioners, air cooled	< 65,000 Btu/h[b]	All	Split System	13.0 SEER	13.0 SEER	AHRI 210/240
			Single Package	13.0 SEER	13.0 SEER	
Through-the-wall (air cooled)	≤ 30,000 Btu/h[b]	All	Split system	12.0 SEER	12.0 SEER	
			Single Package	12.0 SEER	12.0 SEER	
Small-duct high-velocity (air cooled)	< 65,000 Btu/h[b]	All	Split System	10.0 SEER	10.0 SEER	
Air conditioners, air cooled	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.2 EER 11.4 IEER	11.2 EER 11.4 IEER	AHRI 340/360
		All other	Split System and Single Package	11.0 EER 11.2 IEER	11.0 EER 11.2 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.2 IEER	11.0 EER 11.2 IEER	
		All other	Split System and Single Package	10.8 EER 11.0 IEER	10.8 EER 11.0 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.0 EER 10.1 IEER	10.0 EER 10.1 IEER	
		All other	Split System and Single Package	9.8 EER 9.9 IEER	9.8 EER 9.9 IEER	
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.7 EER 9.8 IEER	9.7 EER 9.8 IEER	
		All other	Split System and Single Package	9.5 EER 9.6 IEER	9.5 EER 9.6 IEER	
Air conditioners, water cooled	< 65,000 Btu/h[b]	All	Split System and Single Package	12.1 EER 12.3 IEER	12.1 EER 12.3 IEER	AHRI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.5 EER 11.7 IEER	12.1 EER 12.3 IEER	AHRI 340/360
		All other	Split System and Single Package	11.3 EER 11.5 IEER	11.9 EER 12.1 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.2 IEER	12.5 EER 12.7 IEER	
		All other	Split System and Single Package	10.8 EER 11.0 IEER	12.3 EER 12.5 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.1 IEER	12.4 EER 12.6 IEER	
		All other	Split System and Single Package	10.8 EER 10.9 IEER	12.2 EER 12.4 IEER	
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.1 IEER	12.0 EER 12.4 IEER	
		All other	Split System and Single Package	10.8 EER 10.9 IEER	12.0 EER 12.2 IEER	

(continued)

TABLE C403.2.3(1)—continued
MINIMUM EFFICIENCY REQUIREMENTS:
ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUB-CATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY		TEST PROCEDURE[a]
				Before 6/1/2011	As of 6/1/2011	
Air conditioners, evaporatively cooled	< 65,000 Btu/h[b]	All	Split System and Single Package	12.1 EER 12.3 IEER	12.1 EER 12.3 IEER	AHRI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.5 EER 11.7 IEER	12.1 EER 12.3 IEER	AHRI 340/360
		All other	Split System and Single Package	11.3 EER 11.5 IEER	11.9 EER 12.1 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.2 IEER	12.0 EER 12.2 IEER	
		All other	Split System and Single Package	10.8 EER 11.0 IEER	11.8 EER 12.0 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.1 IEER	11.9 EER 12.1 IEER	
		All other	Split System and Single Package	10.8 EER 10.9 IEER	12.2 EER 11.9 IEER	
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.0 EER 11.1 IEER	11.7 EER 11.9 IEER	
		All other	Split System and Single Package	10.8 EER 10.9 IEER	11.5 EER 11.7 IEER	
Condensing units, air cooled	≥ 135,000 Btu/h			10.1 EER 11.4 IEER	10.5 EER 14.0 IEER	AHRI 365
Condensing units, water cooled	≥ 135,000 Btu/h			13.1 EER 13.6 IEER	13.5 EER 14.0 IEER	
Condensing units, evaporatively cooled	≥ 135,000 Btu/h			13.1 EER 13.6 IEER	13.5 EER 14.0 IEER	

For SI: 1 British thermal unit per hour = 0.2931 W.

a. Chapter 6 of the referenced standard contains a complete specification of the referenced test procedure, including the reference year version of the test procedure.

b. Single-phase, air-cooled air conditioners less than 65,000 Btu/h are regulated by NAECA. SEER values are those set by NAECA.

SEERee = Seasonal Energy Efficiency Ratio of the energy efficient equipment (actually installed).

EERbase = Energy Efficiency Ratio of the baseline equipment; see table above for default values. Since IECC 2006 does not provide EER requirements for air-cooled air conditioners < 65 kBtu/hr, assume the following conversion from SEER to EER: EER≈SEER/1.1

EERee = Energy Efficiency Ratio of the energy efficient equipment. For air-cooled air conditioners < 65 kBtu/hr, if the actual EERee is unknown, assume the following conversion from SEER to EER: EER≈SEER/1.1.

= Actual installed

EFLH = Equivalent Full Load Hours for cooling are provided in section 4.4 HVAC End Use:

For example a 5 ton air cooled split system with a SEER of 15 in Rockford would save

$$\Delta kWH = (60) * [(1/13) - (1/15)] * 816$$

$$= 502 \text{ kWh}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW_{SSP} = (kBtu/hr * (1/EERbase - 1/EERee)) * CF_{SSP}

ΔkW_{PJM} = (kBtu/hr * (1/EERbase - 1/EERee)) * CF_{PJM}

Where:

CF_{SSP} = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3% [334]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8% [335]

For example a 5 ton air cooled split system with a SEER of 15 in Rockford would save

ΔkW_{SSP} = (60) * [(1/13) – (1/15)] * .913

= 0.562

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

MEASURE CODE: CI-HVC-SPUA-V02-140601

[334] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

[335] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year

4.4.16 Steam Trap Replacement or Repair [336]

DESCRIPTION

The measure is for the repair or replacement of faulty steam traps that are allowing excess steam to escape and thereby increasing steam generation. The measure is applicable to commercial applications, commercial HVAC (low pressure steam) including multifamily buildings, low pressure industrial applications, medium pressure industrial applications, applications and high pressure industrial applications. Maximum pressure for this measure is 300 psig.

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

DEFINITION OF EFFICIENT EQUIPMENT

Customers must have leaking traps to qualify for rebates. However, if a commercial customer opts to replace all traps without inspection, rebates and the savings are discounted to take into consideration the fact that some traps are being replaced that have not yet failed.

DEFINITION OF BASELINE EQUIPMENT

The baseline criterion is a faulty steam trap in need of replacing. No minimum leak rate is required. Any leaking or blow through trap can be repaired or replaced. If a commercial customer chooses to repair or replace all the steam traps at the facility without verification, the savings are adjusted. Savings for commercial full replacement projects are reduced by the percentage of traps found to be leaking on average from the studies listed. If an audit is performed on a commercial site, then the leaking and blowdown can be adjusted.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The life of this measure is 6 years[337]

[336] High Impact Measure

[337] Source paper is the CLEAResult"Steam Traps Revision #1" dated August 2011. Primary studies used to prepare the source paper include Enbridge Steam Trap Survey, KW Engineering Steam Trap Survey, Enbridge Steam Saver Program 2005, Armstrong Steam Trap Survey, DOE Federal Energy Management Program Steam Trap Performance Assessment, Oak Ridge National Laboratory Steam System Survey Guide, KEMA Evaluation of PG&E's Steam Trap Program, Sept. 2007. Communication with vendors suggested a inverted bucket steam trap life typically in the range of 5 - 7 years, float and thermostatic traps 4- 6 years, float and thermodynamic disc traps of 1 - 3 years. Cost does not include installation.

DEEMED MEASURE COST

Steam System	Cost per trap[338] ($)
Commercial Dry Cleaners	77
Commercial Heating (including Multifamily), low pressure steam	77
Industrial Medium Pressure >15 psig psig < 30 psig	180
Steam Trap, Industrial Medium Pressure ≥30 <75 psig	223
Steam Trap, Industrial High Pressure ≥75 <125 psig	276
Steam Trap, Industrial High Pressure ≥125 <175 psig	322
Steam Trap, Industrial High Pressure ≥175 <250 psig	370
Steam Trap, Industrial High Pressure ≥250 psig	418
Steam Trap, Industrial Medium Pressure ≥30 <75 psig	223
Steam Trap, Industrial High Pressure ≥75 <125 psig	276
Steam Trap, Industrial High Pressure ≥125 <175 psig	322
Steam Trap, Industrial High Pressure ≥175 <250 psig	370
Steam Trap, Industrial High Pressure ≥250 psig	418

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ENERGY SAVINGS

$$\Delta therm = S * (Hv/B) * Hours * A * L / 100{,}000$$

Where:

[338] Ibid.

S = Maximum theoretical steam loss per trap

Steam System	Avg Steam Loss[339] (lb/hr/trap)
Commercial Dry Cleaners	38.1
Commercial Heating (including Multifamily)LPS	13.8
Industrial Low Pressure, <15 psig	13.8
Industrial Medium Pressure >15 psig < 30 psig	12.7
Steam Trap, Industrial Medium Pressure ≥30 <75 psig	19.0
Steam Trap, Industrial High Pressure ≥75 <125 psig	67.9
Steam Trap, Industrial High Pressure ≥125 <175 psig	105.8
Steam Trap, Industrial High Pressure ≥175 <250 psig	143.7
Steam Trap, Industrial High Pressure ≥250 psig	200.5

Hv = Heat of vaporization of steam

Steam System	Heat of Vaporization[340] (Btu/lb)
Commercial Dry Cleaners	890
Commercial Heating (including Multifamily) LPS	951
Industrial Low Pressure ≤15 psig	951
Industrial Medium Pressure >15 psig < 30 psig	945
Steam Trap, Industrial Medium Pressure ≥30 <75 psig	928
Steam Trap, Industrial High Pressure ≥75 <125 psig	894
Steam Trap, Industrial High Pressure ≥125 <175 psig	868
Steam Trap, Industrial High Pressure ≥175 <250 psig	846
Steam Trap, Industrial High Pressure ≥250 psig	820

[339] CLEAResult"Steam Traps Revision #1" dated August 2011.

[340] Heat of vaporization of steam at the inlet pressure to the steam trap. Implicit assumption that the average boiler nominal pressure where the vaporization occurs, is essentially that same pressure. Reference CLEAResult"Steam Traps Revision #1" dated August 2011.

B = Boiler efficiency

= custom, if unknown 0.8[341]

Hours = Annual operating hours of steam plant

Steam System	Hours/Yr[342]	Zone
Commercial Dry Cleaners	2,425	
Industrial Low Pressure ≤15 psig	7,752	
Industrial Medium Pressure >15 psig < 30 psig	7,752	
Steam Trap, Industrial Medium Pressure ≥30 <75 psig	7,752	
Steam Trap, Industrial High Pressure ≥75 <125 psig	7,752	
Steam Trap, Industrial High Pressure ≥125 <175 psig	7,752	
Steam Trap, Industrial High Pressure ≥175 <250 psig	7,752	
Steam Trap, Industrial High Pressure ≥250 psig	7,752	
Industrial Medium Pressure >15 psig < 30 psig	7,752	
Steam Trap, Industrial Medium Pressure ≥30 <75 psig	7,752	
Commercial Heating (including Multifamily)LPS[343]	4,272	1 (Rockford)
	4,029	2 (Chicago O'Hare)
	3,406	3 (Springfield)
	2,515	4 (Belleville)
	2,546	5 (Marion)

A = Adjustment factor

= 50%[344]

This factor is to account for reducing the maximum theortical steam flow (S) to the average steam flow (the Enbridge factor).

L = Leaking & blow-thru

L is 1.0 when applied to the replacment of an individual leaking trap. If a number of

[341] California Energy Commission Efficiency Data for Steam Boilers as sited in CLEAResult"Steam Traps Revision #1" dated August 2011.
[342] CLEAResult"Steam Traps Revision #1" dated August 2011, which references Enbridge service territory data and kW Engineering study.
[343] Since commercial LPS reflect heating systems, Hours/yr are equivalent to HDD55 zone table
[344] Enbridge adjustment factor used as referenced in CLEAResult"Steam Traps Revision #1" dated August 2011 and DOE Federal Energy Management Program Steam Trap Performance Assessment.

steam traps are replaced and the system has not been audited, the leaking and blow-thru is applied to reflect the assumed percentage of steam traps that were actually leaking and need to be replaced. A custom value can be utilized if a supported by an evaluation.

Steam System	%[345]
Custom	Custom
Commercial Dry Cleaners	27%
Industrial Low Pressure ≤15 psig	16%
Industrial Medium and High Pressure >15 psig	16%
Commercial Heating (including Multifamily) LPS	27%

EXAMPLE

For example, a commercial dry cleaning facility with the default hours of operation and boiler efficiency;

ΔTherms = S * (Hv/B) * Hours * A * L

= 38.1 lbs/hr/trap * (890 Btu/lb / 80%)/100,000 * 2,425 * 50% * 27% =

138.8 therms per trap

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-STRE-V03-140601

[345] Dry cleaners survey data as referenced in CLEAResult"Steam Traps Revision #1" dated August 2011.

4.4.17 Variable Speed Drives for HVAC

DESCRIPTION

This measure is applied to variable speed drives (VSD) which are installed on the following HVAC system applications: chilled water pump, hot water pumps, supply fans, return fans. All other VSD applications require custom analysis by the program administrator. The VSD will modulate the speed of the motor when it does not need to run at full load. Since the power of the motor is proportional to the cube of the speed for these types of applications, significant energy savings will result.

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

DEFINITION OF EFFICIENT EQUIPMENT

The VSD is applied to a motor which does not have a VSD. The application must have a variable load and installation is to include the necessary controls. Savings are based on application of VSDs to a range of baseline load conditions including no control, inlet guide vanes, outlet guide vanes and throttling valves.

DEFINITION OF BASELINE EQUIPMENT

The time of sale baseline is a new motor installed without a VSD or other methods of control. Retrofit baseline is an existing motor operating as is. Retrofit baselines may or may not include guide vanes, throttling valves or other methods of control. This information shall be collected from the customer.

Installations of new equipment with VSDs which are required by IECC 2009 as adopted by the State of Illinois are not eligible for incentives.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life for HVAC application is 15 years;[346] measure life for process is 10 years.[347]

DEEMED MEASURE COST

Customer provided costs will be used when available. Default measure costs[348] are noted below for up to 20 hp motors. Custom costs must be gathered from the customer for motor sizes not listed below.

HP	Cost
1 -5 HP	$ 1,330
7.5 HP	$ 1,622
10 HP	$ 1,898

[346] Efficiency Vermont TRM 10/26/11 for HVAC VSD motors
[347] DEER 2008
[348] Ohio TRM 8/6/2010 varies by motor/fan size based on equipment costs from Granger 2008 Catalog pp 286-289, average across available voltages and models. Labor costs from RS Means Data 2008 Ohio average cost adjustment applied.

HP	Cost
15 HP	$ 2,518
20 HP	$ 3,059

LOADSHAPE

Loadshape C39 - VFD - Supply fans <10 HP
Loadshape C40 - VFD - Return fans <10 HP
Loadshape C41 - VFD - Exhaust fans <10 HP
Loadshape C42 - VFD - Boiler feedwater pumps <10 HP
Loadshape C43 - VFD - Chilled water pumps <10 HP
Loadshape C44 - VFD Boiler circulation pumps <10 HP
Loadshape C48 - VFD Boiler draft fans <10 HP
Loadshape C49 - VFD Cooling Tower Fans <10 HP

COINCIDENCE FACTOR

The demand savings factor (DSF) is already based upon coincident savings, and thus there is no additional coincidence factor for this characterization.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$\Delta kWh = kW_{connected} * Hours * ESF$

Where:

$kW_{Connected}$ = kW of equipment is calculated using motor efficiency.

(HP * .746 kw/hp* load factor)/motor efficiency

Motors are assumed to have a load factor of 80% for calculating KW if actual values cannot be determined[349]. Custom load factor may be applied if known. Actual motor efficiency shall be used to calculate KW. If not known a default value of 93% shall be used.[350]

HP	BHP	Load Factor	kW Connected[351]
5 HP	5	80%	3.23

[349] Com Ed TRM June 1, 2010
[350] Ohio TRM 8/6/2010 pp207-209, Com Ed Trm June 1, 2010.
[351] Field data from Illinois evaluations, Navigant, 2011.

HP	BHP	Load Factor	kW Connected[351]
7.5 HP	7.5	80%	4.84
10 HP	10	80%	6.45
15 HP	15	80%	9.68
20 HP	20	80%	12.90

Hours = Default hours are provided for HVAC applications which vary by HVAC application and building type[352]. When available, actual hours should be used.

Building Type		Pumps and fans
College/University		4216
Grocery		5840
Heavy Industry		3585
Hotel/Motel		6872
Light Industry		2465
Medical		6871
Office		1766
Restaurant		4654
Retail/Service		3438
School(K-12)		2203
Warehouse		3222
Average=Miscellaneous		4103

ESF = Energy savings factor varies by VFD application.

[352] Com Ed Trm June 1, 2010 page 139.

Application	ESF[353]
Hot Water Pump	0.482
Chilled Water Pump	0.432
Constant Volume Fan	0.535
Air Foil/inlet Guide Vanes	0.227
Forward Curved Fan, with discharge dampers	0.179
Forward Curved Inlet Guide Vanes	0.092

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = kW_{connected} * DSF$

Where:

DSF = Demand Savings Factor varies by VFD application.[354] Values listed below are based on typical peak load for the listed application. When possible the actual Demand Savings Factor should be calculated.

Application	DSF
Hot Water Pump	0
Chilled Water Pump	0.299
Constant Volume Fan	0.348
Air Foil/inlet Guide Vanes	0.13
Forward Curved Fan, with discharge dampers	0.136
Forward Curved Inlet Guide Vanes	0.03
Custom Process	custom

[353] CL&P and UI Program Savings Documentation for 2008 Program Year. http://www.ctsavesenergy.com/files/Final%202008%20Program%20Savings%20Document.pdf.
[354] Ibid

FOSSIL FUEL IMPACT DESCRIPTIONS AND CALCULATION

There are no expected fossil fuel impacts for this measure.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-VSDH-V01-120601

4.4.18 Small Commercial Programmable Thermostats

DESCRIPTION

This measure characterizes the energy savings from the installation of a new Programmable Thermostat for reduced heating energy consumption through temperature set-back during unoccupied or reduced demand times. This measure is limited to small businesses, as they have smaller HVAC systems that are similar to residential HVAC systems and may be controlled by a simple manual adjustment thermostat. Mid to large sized businesses will typically have a building automation system or some other form of automated HVAC controls. Therefore, it is limited to select building types, including small office, retail – strip mall, restaurants (characterized as 1, 2 or 3 meal), small manufacturing, religious facilities, and convenience stores. This measure is only appropriate for single zone heating systems. Custom calculations are required for savings for programmable thermostats installed in multi-zone systems.

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

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

DEFINITION OF EFFICIENT EQUIPMENT

The criteria for this measure are established by replacement of a manual-only temperature control, with one that has the capability to adjust temperature setpoints according to a schedule without manual intervention.

DEFINITION OF BASELINE EQUIPMENT

For new thermostats the baseline is a non-programmable thermostat requiring manual intervention to change temperature setpoint.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life of a programmable thermostat is assumed to be 8 years[355] based upon equipment life only[356]. For the purposes of claiming savings for a new programmable thermostat, this is reduced by a 50% persistence factor to give a final measure life of 4 years.

DEEMED MEASURE COST

Actual material and labor costs should be used if the implementation method allows. If unknown the capital cost for this measure is assumed to be $181[357], as summarized in the table below.

LOADSHAPE

N/A

[355] Table 1, HVAC Controls, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

[356] Future evaluation is strongly encouraged to inform the persistence of savings to further refine measure life assumption. As this characterization depends heavily upon a large scale but only 2-year study of the energy impacts of programmable thermostats, the longer term impacts should be assessed.

[357] Nicor Rider 30 Business EER Program Database, Paid Rebates with Programmable Thermostat Installation Costs, Program to Date as of January 11, 2013.

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh[358] = ($\Delta Therms * F_e * 29.3$)

Where:

ΔTherms	= Therm savings if Natural Gas heating system
	= See calculation in Natural Gas section below
F_e	= Furnace Fan energy consumption as a percentage of annual fuel consumption
	= 3.14%[359]
29.3	= kWh per therm
100,000	=conversion from Btu to therms

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

ΔTherms = (EFLH * Capacity * Degree of Setback * Savings Factor) / 100000

Where:

EFLH	= Equivalent Full Load Hours for heating are provided as a reference in section 4.4 HVAC End Use
Capacity	= Nominal Input Heating Capacity Furnace Size (Btu/hr.)
	= Actual

[358] Relates to furnace fan savings

[359] . F_e is not one of the AHRI certified ratings provided for residential furnaces, but can be reasonably estimated from a calculation based on the certified values for fuel energy (Ef in MMBtu/yr) and Eae (kWh/yr). An average of a 300 record sample (non-random) out of 1495 was 3.14%. This is, appropriately, ~50% greater than the Energy Star version 3 criteria for 2% F_e. See "Programmable Thermostats Furnace Fan Analysis.xlsx" for reference.

Degree of Setback = The degrees in Farenheit the temperature is setback from the space temperature setpoint (°F). Baseline manual setback should be determined and only the incremental setback due to the programmable thermostat be applied.

= Actual

Savings Factor = The percent heating savings per incremental °F setback.

= Dependent on location and building type[360]:

Savings Factor (Percent Saved/°F)					
Building Type	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
College/University	1.45%	1.47%	1.48%	1.72%	1.50%
Convenience	0.93%	0.86%	0.84%	1.00%	0.97%
Elementary	2.03%	2.10%	2.10%	2.23%	2.00%
Healthcare Clinic	1.50%	1.56%	1.54%	1.70%	1.35%
High School	2.13%	2.18%	2.20%	2.41%	2.14%
Lodging - Guest Room	1.34%	1.31%	1.24%	1.20%	1.56%
Lodging - Common Area	1.11%	1.04%	1.02%	1.21%	1.20%
Manufacturing Facility - 1 Shift	2.62%	2.67%	2.71%	2.79%	2.56%
Manufacturing Facility - 2 Shift	1.57%	1.53%	1.53%	1.71%	1.52%
Manufacturing Facility - 3 Shift	0.37%	0.35%	0.35%	0.41%	0.37%
Multifamily Common Area	1.80%	1.71%	1.76%	2.10%	1.80%
Office - Low Rise	1.99%	1.98%	2.00%	2.21%	1.89%
Office - Mid Rise	1.99%	1.98%	2.00%	2.21%	1.89%
Religious Facility	2.01%	2.03%	2.07%	2.34%	2.11%
Restaurant - 1 Meal	1.92%	1.93%	2.01%	2.28%	2.15%
Restaurant - 2 Meal	1.52%	1.45%	1.51%	1.88%	1.80%
Restaurant - 3 Meal	0.99%	0.96%	0.94%	1.14%	1.02%
Retail Department Store	1.74%	1.70%	1.75%	2.09%	1.78%
Retail Strip Mall	1.74%	1.70%	1.75%	2.09%	1.78%
Warehouse	0.95%	0.88%	0.86%	1.01%	0.98%

[360] Savings factors were developed by RSG and used TMY3 weather data and ASHRAE 62.1 design standards to estimate the heating loads through 8760 hours. The model was run with no setback and setback temperatures of 1°F, 3°F, 5°F, 7°F, and 10°F. The percent savings as a function of setback temperature was found in the slope of the line using degrees of setback at the independent variables and the percent savings as the dependent variables. See workpaper entitled "New Measure_Nicor_CLEAResult_CI_PRGTSTAT_01-23-14.docx" for further details on the methodology and assumptions used. It is strongly recommended that future evaluation efforts are conducted to assess how reasonable these estimates are in predicting actual savings from installation of these measures.

For example, a programmable thermostat with 5°F of setback installed in Rockford on a 75,000 btu/hr furnace at a low rise office and installed by a contractor

$$\Delta Therms = 797 * 75{,}000 * 5 * 1.99\% / 100{,}000 \text{ Btu/Therm}$$
$$= 59 \text{ therms}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-PROG-V01-140601

4.4.19 Demand Controlled Ventilation

DESCRIPTION

Demand control ventilation (DCV) adjusts outside ventilation air based on the number of occupants and the ventilation demands that those occupants create. DCV is part of a building's ventilation system control strategy. It may include hardware, software, and controls as an integral part of a building's ventilation design. Active control of the ventilation system provides the opportunity to reduce heating and cooling energy use.

The primary component is a control sensor to communicate either directly with the economizer or with a central computer. The component is most typically a carbon dioxide (CO_2) sensor, occupancy sensor, or turnstile counter. This measure is applicable to multiple building types, and savings are classified by the specific building types defined in the Illinois TRM. . This measure is modeled to assume night time set backs are in operation and minimum outside air is being used when the building is unoccupied. Systems that have static louvers or that are open at night will likely have greater savings by using the custom program.

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

DEFINITION OF EFFICIENT EQUIPMENT

The efficient equipment condition is defined by new CO_2 sensors installed on return air systems where no other sensors were previously installed. For heating savings, this measure does not apply to any system with terminal reheat (constant volume or variable air volume). For terminal reheat system a custom savings calculation should be used.**DEFINITION OF BASELINE EQUIPMENT**

The base case for this measure is a space with no demand control capability. The current code minimum for outside air (OA) is 17 CFM per occupant (ASHRAE 62.1) which is the value assumed in this measure.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The deemed measure life is 10 years and based on CO2 sensor estimated life. [361]

DEEMED MEASURE COST

The deemed measure cost is assumed to be the full cost of installation of a DCV retrofit including sensor cost ($500) and installation ($1000 labor) for a total of $1500[362].

LOADSHAPE

Commercial ventilation C23

COINCIDENCE FACTOR

[361] During the course of conversations with vendors and Building Automation System (BAS) contractors, it was determined that sensors have to be functional for up to 10 years. It is recommended that they are part of a normal preventive maintenance program in which calibration is an important part of extending useful life. Although they are not subject to mechanical failure, they do fall out of tolerance over time.

[362] Discussion with vendors

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = Condition Space/1000 * Savings_Factor

Where:

Conditioned Space = actual square footage of conditioned space controlled by sensor

Elec_Savings_Factor= value in table below based on building type and weather zone[363]

Building Type	Elect_Savings Factor (kWh/1000 sq ft)				
	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
Office - Low-rise	518	520	539	541	516
Office - Mid-rise	472	473	485	484	469
Office- High-rise	505	507	524	525	503
Religious Building	1039	1036	1235	1335	1036
Restaurant	773	791	899	949	791
Retail - Department Store	639	655	663	662	656
Retail - Strip Mall	252	246	188	435	435
Convenience Store	650	652	672	680	652
Elementary School	592	582	672	718	588
High School	579	570	660	706	576
College/University	604	639	725	736	648
Healthcare Clinic	521	521	586	618	521
Lodging	640	641	667	678	641
Manufacturing	525	524	535	535	519
Special Assembly Auditorium	759	780	928	987	784
De-fault	605	609	665	706	622

[363] The electric energy savings was calculated using TMY3 weather data and methodology consistent with ASHRAE standards. Savings are calculated on an annual basis for each given temperature zone in Illinois. Energy savings for DCV were developed utilizing standards, inputs and approaches as set forth by ASHRAE 62.1[363] and 90.1[363], respectively. Building input parameters like square footage, equipment efficiencies and occupancy match those used in the EFLH calculations. Reference calculation found in Demand Control Ventilation 12-30-13.xls.

For example: 7,500 SqFt of office space in Chicago.

ΔkWh= 7,500 SqFt /1000 SqFt *520 kWh
= 3,900 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

TBD[364]

NATURAL GAS SAVINGS

Δtherms = Condition Space/1000 * Therm_Savings_Factor

Where:

Conditioned Space = actual square footage of conditioned space controlled by sensor

Therm _Savings_Factor= value in table below based on building type and weather zone[365]

Building Type	Therm_Savings Factor (kWh/1000 sq ft)				
	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
Office - Low-rise	30	26	14	22	55
Office - Mid-rise	20	17	10	15	37
Office- High-rise	27	23	13	20	49
Religious Building	191	169	147	143	354
Restaurant	135	122	74	104	251
Retail - Department Store	47	42	30	36	84
Retail - Strip Mall	31	27	25	24	57
Convenience Store	23	21	13	17	42
Elementary School	83	73	56	60	155
High School	81	71	54	59	152
College/University	161	141	72	120	292
Healthcare Clinic	57	50	43	42	106
Lodging	26	23	17	20	49
Manufacturing	21	19	12	15	40

[364] Need to discuss peak savings with tool developer before draft is finalized

[365] The natural gas energy savings was calculated using TMY3 weather data and methodology consistent with ASHRAE standards. Savings are calculated on an annual basis for each given temperature zone in Illinois. Energy savings for DCV were developed utilizing standards, inputs and approaches as set forth by ASHRAE 62.1[365] and 90.1[365], respectively. Building input parameters like square footage, equipment efficiencies and occupancy match those used in the EFLH calculations. Reference calculation found in Demand Control Ventilation 12-30-13.xls.

Building Type	Therm_Savings Factor (kWh/1000 sq ft)				
	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
Special Assembly Auditorium	225	198	187	175	399
De-fault	77	68	51	58	141

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-DCV-V01-14060

4.4.20 High Turndown Burner for Space Heating Boilers

DESCRIPTION

This measure is for a non-residential boilers equipped with linkageless controls providing space heating with burners having a turndown less than 6:1.[366] Turndown is the ratio of the high firing rate to the low firing rate. When boilers are subjected to loads below the low firing rate, the boiler must cycle on/off to meet the load requirements. A higher turndown ratio reduces burner startups, provides better load control, saves wear-and-tear on the burner, and reduces purge-air requirements, all of these benefits result in better overall efficiency.

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

DEFINITION OF EFFICIENT EQUIPMENT

To qualify the boiler linkageless burner must operate with a turndown greater than or equal to 10:1 and be subjected to loads less than or equal to 30%[367] of the full fire input MBH for greater than 60%[368] of the operating hours.

DEFINITION OF BASELINE EQUIPMENT

The baseline boiler utilizes a linkageless burner with a turndown ration of 6:1 or less and is used primarily for space heating. Redundant boilers do not qualify.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 21 years.[369]

DEEMED MEASURE COST

The deemed installed measure cost including labor is approximately $2.53/MBtu/hr.[370]

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

N/A

[366] The standard turndown ratio for boilers is 6:1. Understanding Fuel Savings in the Boiler Room, ASHRAE Journal, David Eoff, December, 2008 p 38
[367] Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0, March 22, 2010. This factor implies that boilers are 30% oversized on average.
[368] FES Analysis of bin hours based upon a 30% oversizing factor.
[369] "Burner," Obtained from a nation-wide survey conducted by ASHRAE TC 1.8 (Akalin 1978). Data changed by TC 1.8 in 1986.
[370] FES review of PY2/PY3 costs for custom People's and North Shore high turndown burner projects. See High Turndown Costs.xlsx for details.

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS SAVINGS

Δtherms= Ngi * SF * EFLH / 100

Where:

Ngi = Boiler gas input size (kBtu/hr) = custom

SF = Savings Factor = Percentage of energy loss per hour

= (∑ ((EL_base – EL_eff) * H_cycling)) / H)*100

Where:

EL_base = Base Boiler Percentage of energy loss due to cycling at % of Base Boiler Load where BL_base ≤ TDR_base

= 0.003 * $(Cycles_base)^2$ – 0.001 * Cycles_base [371]

Where:

Cycles_base = Number of Cycles/hour of base boiler

= TDR_base / BL

Where:

BL = % of full boiler load at bin hours being evaluated. This is assumed to be a straight line based on 0% load at the building balance point (assumed to be 55F), and full load corrected for the oversizing (OSF) at the lowest temperature bin of -10 to -5F.

[371] Release 3.0 Operations & Maintenance Best Practices A Guide to Achieving Operational Efficiency, August 2010, Federal Energy Management Program, US Department of Energy. The equation was determined by plotting the values in Table 9.2.1 – Boiler Cycling Energy Loss.

OSF = Oversizing Factor = 1.3[372] or custom

TDR_base = Turndown ratio = 0.33[373] or custom

EL_eff = Efficient Boiler Percentage of energy loss due to cycling at % of Efficient Boiler Load

= 0.003 * (Cycles_eff)^2 – 0.001 * Cycles_eff

Where:

Cycles_eff = Number of Cycles/hour

= TDR_eff / BL

Where:

TDR_eff = Turndown ratio = 0.10[374] or custom

H_cycling = Hours base boiler is cycling at % of base boiler load

= see table below or custom

H = Total Number of Hours in Heating Season

= 4,946 or custom

100 = convert to a percentage

SF = 69.1 / 4946 *100 = 1.4% or custom (see table below for summary of values)

Temperature	H_cycling	BL	EL_base	EL_eff	(EL_base-EL_eff)* Hours
50 to 55	601	6.0%	8.5%	0.7%	47.2
45 to 50	603	12.0%	2.0%	0.0%	12.0
40 to 45	455	18.0%	0.8%	0.0%	3.8
35 to 40	925	24.0%	0.4%	0.0%	4.0
30 to 35	814	30.0%	0.3%	0.0%	2.1
Total					69.1

EFLH = Equivalent Full Load Hours for heating are provided in section 4.4 HVAC End Use.

100 = convert kBtu to therms

[372] PA Consulting, KEMA, Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0, March 22, 2010, Page 4-12.
[373] Ibid.
[374] 10:1 ratio used to qualify for efficient equipment.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVAC-HTBC-V04-140601

4.4.21 Linkageless Boiler Controls for Space Heating

DESCRIPTION

This measure is for a non-residential boiler providing space heating and currently having single point positioning combustion control. In single-point positioning control, the fuel valve is linked to the combustion air damper via a jackshaft mechanism to maintain correspondence between fuel and combustion air input. Most boilers with single point positioning control do not maintain low excess air levels over their entire firing range. Generally these boilers are calibrated at high fire, but due to the non-linearity required for efficient combustion, excess air levels tend to dramatically increase as the firing rate decreases. Boiler efficiency drops as the excess air levels are increased.

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

DEFINITION OF EFFICIENT EQUIPMENT

To qualify the boiler burner must have a linkageless control system allowing the combustion air damper position to be adjusted and set for optimal efficiency at several firing rates throughout the burner's firing range. This requires the fuel valve and combustion air damper to each be powered by a separate actuator. An alternative to the combustion air damper is a Variable Speed Drive on the combustion air fan.

DEFINITION OF BASELINE EQUIPMENT

The baseline boiler utilizes single point positioning for the burner combustion control.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 16 years.[375]

DEEMED MEASURE COST

The deemed measure cost is estimated at $2.50/MBtu/hr burner input.[376]

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

N/A

[375] Total number of hours for heating with a base temperature of 55°F for Chicago, IL as noted by National Climate Data Center
[377] Available and Emerging Technologies for Reducing Greenhouse Gas Emissions from Industrial, Commercial, and Institutional Boilers, Prepared by the Sector Policies and Programs Division Office of Air Quality Planning and Standards U.S. Environmental Protection Agency Research Triangle Park, North Carolina 27711, October 2010, Table 1. ICI Boilers – Summary of Greenhouse Gas Emission Reduction Measures, pg. 8

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

When a Variable Speed Drive is incorporated, electrical savings are calculated according to the Variable Speed Drive measure.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS SAVINGS

Δtherms= Ngi * SF * EFLH / 100

Where:

Ngi = Boiler gas input size (kBtu/hr) = custom

SF = Savings factor

Note: Savings factor is the percentage increase in efficiency as a result of the addition of linkageless burner controls. At an average boiler load of 35%, single point controls are assumed to have excess air of 91%, while linkageless controls are assumed to have 34% excess air.[377] The difference between controls types is 57% at this average operating condition. A 15% reduction in excess air is approximately a 1% increase in efficiency.[378] Therefore the nominal combustion efficiency increase is 57 / 15 * 1% = 3.8%.

= 3.8%

EFLH = Equivalent Full Load Hours for heating are provided in section 4.4 HVAC End Use

100 = convert kBtu to therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

[377] Available and Emerging Technologies for Reducing Greenhouse Gas Emissions from Industrial, Commercial, and Institutional Boilers, Prepared by the Sector Policies and Programs Division Office of Air Quality Planning and Standards U.S. Environmental Protection Agency Research Triangle Park, North Carolina 27711, October 2010, Table 1. ICI Boilers – Summary of Greenhouse Gas Emission Reduction Measures, pg. 8

[378] Department of Energy (DOE). January 2012, Steam Tip Sheet #4, Improve Your Boiler's Combustion Efficiency. Advanced Manufacturing Office. Washington, DC: U.S. Department of Energy. This value was determined as an appropriate average over the stack temperatures and excess air levels indicated.

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-LBC-V04-140601

4.4.22 Oxygen Trim Controls for Space Heating Boilers

DESCRIPTION

This measure is for a non-residential boiler providing space heating without oxygen trim combustion controls. Oxygen trim controls limit the amount of excess oxygen provided to the burner for combustion. This oxygen level is dependent upon the amount of air provided. Oxygen trim control converts parallel positioning, linkageless controls, into a closed-loop control configuration with the addition of an exhaust gas analyzer and PID controller. Boilers with oxygen trim controls can maintain a predetermined excess air rate (generally 15% to 30% excess air) over the entire burner firing rate. Boilers without these controls typically have excess air rates around 30% over the entire firing rate. Boiler efficiency drops as the excess air levels are increased.

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

DEFINITION OF EFFICIENT EQUIPMENT

To qualify the boiler burner must have an oxygen control system allowing the combustion air to be adjusted to maintain a predetermined excess oxygen level in the flue exhaust at all firing rates throughout the burner's firing range. This requires an oxygen sensor in the flue exhaust and linkageless fuel valve and combustion air controls.

DEFINITION OF BASELINE EQUIPMENT

The baseline boiler utilizes single point positioning for the burner combustion control.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life for the O2 Trim controls is 18 years.[379]

DEEMED MEASURE COST

The deemed measure cost is approximately $23,250.[380]

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

[379] State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study Final Report: August 25, 2009, Table 1-2. Recommended Measure Life by WISeerts Group Description, pg. 1-4.
[380] CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE) PROCESS BOILERS, 2013 California Building Energy Efficiency Standards, California Utilities Statewide Codes and Standards Team, October 2011, pg. 22

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

Δtherms = Ngi * SF * EFLH / 100

Where:

Ngi = Boiler gas input size (kBtu/hr)

= Custom

SF = Savings factor

Note: Savings factor is the percentage reduction in gas consumption as a result of the addition of O2 trim controls. Linkageless controls have an excess air rate of 28% over the entire firing range.[381] O2 trim controls have an excess air rate of 15%.[382] The average difference is 13%. A 15% reduction in excess air is approximately a 1% increase in efficiency.[383] Therefore the nominal combustion efficiency increase is 13 / 15 * 1% = 0.87%.

= 0.87%

EFLH = Default Equivalent Full Load Hours for heating are provided in section 4.4 HVAC End Use. When available, actual hours should be used.

100 = convert kBtu to therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

[381] Department of Energy (DOE). 2009. Energy Matters newsletter. Fall 2009- Vol. 1, Iss. 1. Washington, DC: U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Industrial Technologies Program.
[382] Ibid.
[384] Department of Energy (DOE). January 2012, Steam Tip Sheet #4, Improving Your Boiler's Combustion Efficiency. Advanced Manufacturing Office. Washington, DC: U.S. Department of Energy. This value was determined as an appropriate average over the stack temperatures and excess air levels indicated.

DEEMED O&M COST ADJUSTMENT CALCULATION

The deemed annual Operations and Maintenance cost is $800.[384]

MEASURE CODE: CI-HVC-O2TC-V01-140601

[384] Department of Energy (DOE). January 2012, Steam Tip Sheet #4, Improving Your Boiler's Combustion Efficiency. Advanced Manufacturing Office. Washington, DC: U.S. Department of Energy. This value was determined as an appropriate average over the stack temperatures and excess air levels indicated.

4.4.23 Shut Off Damper for Space Heating Boilers or Furnaces

DESCRIPTION

This measure is for non-residential atmospheric boilers or furnaces providing space heating without a shut off damper. When appliances are on standby mode 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. More air is drawn through the vent immediately after the appliance shuts off and the flue is still hot. Installation of a new shut off damper can prevent heat from being drawn up the warm vent and reducing the amount of air that passes through the furnace or boiler heat exchanger. This reduction in air can slightly increase overall operating efficiency by reducing the time needed to achieve steady-state operating conditions.

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

DEFINITION OF EFFICIENT EQUIPMENT

To qualify the space heating boiler or furnace must have a new electrically or thermally activated shut off damper installed on either the exhaust flue or combustion air intake. Barometric dampers do not qualify. The damper actuation shall be interlocked with the firing controls.

DEFINITION OF BASELINE EQUIPMENT

The baseline boiler or furnace incorporates no shut off damper on the combustion air intake or flue exhaust.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life for the shut off damper is 15 years.[385]

DEEMED MEASURE COST

The deemed measure cost for this approximately $1,500.[386]

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

[385] State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Measure Life Study Final Report: August 25, 2009, Table 1-2. Recommended Measure Life by WISeerts Group Description, pg. 1-4.
[386] CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE) PROCESS BOILERS, 2013 California Building Energy Efficiency Standards, California Utilities Statewide Codes and Standards Team, October 2011, pg. 22

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

Δtherms = Ngi * SF * EFLH / 100

Where:

Ngi = Boiler gas input size (kBtu/hr)

= Custom

SF = Savings factor

= 1%[387]

Note: The savings factor assumes the boiler or furnace is located in an unconditioned space. The savings factor can be higher for those units located within conditioned space.

EFLH = Default Equivalent Full Load Hours for heating are provided in section 4.4 HVAC End Use. When available, actual hours should be used.

100 = convert kBtu to therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

The deemed annual Operations and Maintenance cost is $112.[388]

[387] Based on internet review of savings potential;
"Up to 4%": Use of Automatic Vent Dampers for New and Existing Boilers and Furnaces, Energy Innovators Initiative Technical Fact Sheet, Office of Energy Efficiency, Canada, 2002
"Up to 1%": Page 9, The Carbon Trust, "Steam and high temperature hot water boilers" http://www.carbontrust.com/media/13332/ctv052_steam_and_high_temperature_hot_water_boilers.pdf,
"1 - 2%": Page 2, Sustainable Energy Authority of Ireland "Steam Systems Technical Guide", http://www.seai.ie/Your_Business/Technology/Buildings/Steam_Systems_Technical_Guide.pdf.

[388] CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE) PROCESS BOILERS, 2013 California Building Energy

MEASURE CODE: CI-HVC-SODP-V01-140601

Efficiency Standards, California Utilities Statewide Codes and Standards Team, October 2011, pg. 22