

## 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.

To calculate the updated EFLHs by building type and climate zone provided below, a TAC Subcommittee utilized building energy models originally developed for ComEd<sup>259</sup>, applying some adjustments and additions for new building type models and mechanical systems. Based on comparisons with available field data from Navigant, the EFLH calculation was finalized by the Subcommittee to be the annual total (heating or cooling) output (in Btu) divided by the 95th percentile hourly peak output (heating or cooling) demand (in Btu/hr). This calculation keeps EFLH independent of modeled systems efficiency (which is utilized in the TRM savings calculation) and buffers EFLH value from hourly variances in the modeling that are not representative of actual buildings. See “EFLH Description 2015-02-11.doc” for further explanation.

The building characteristics can be found in the reference table named “EFLH Building Descriptions Updated 2014-11-21.xlsx”.

Building Type	Heating EFLH				
	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
Assembly	1,787	1,831	1,635	1,089	1,669
Assisted Living	1,683	1,646	1,446	1,063	1,277
College	1,530	1,430	1,276	709	849
Convenience Store	1,481	1,368	1,214	871	973
Elementary School	1,781	1,736	1,531	1,057	1,283
Garage	985	969	852	680	752
Grocery	1,608	1,602	1,404	876	1,047
Healthcare Clinic	1,579	1,620	1,414	963	1,019
High School	1,845	1,857	1,666	1,187	1,388
Hospital - CAV no econ <sup>260</sup>	1,764	1,818	1,549	1,332	1,512
Hospital - CAV econ <sup>261</sup>	1,788	1,853	1,580	1,369	1,555
Hospital - VAV econ <sup>262</sup>	731	695	522	314	340
Hospital - FCU	1,325	1,512	1,232	1,448	1,946
Hotel/Motel	1,761	1,712	1,544	1,056	1,290

<sup>259</sup> A full description of the ComEd model development is found in “ComEd Portfolio Modeling Report. Energy Center of Wisconsin July 30, 2010”

<sup>260</sup> Based on model with single duct reheat system with a fixed outdoor air volume.

<sup>261</sup> Based on model with single duct reheat system with airside economizer controls, with constant volume zone reheat boxes and single speed fan motors.

<sup>262</sup> Based on model with single duct reheat system with airside economizer controls, zone VAV reheat boxes and VFD fan motors.

Building Type	Heating EFLH				
	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
Hotel/Motel - Common	1,601	1,626	1,548	1,260	1,323
Hotel/Motel - Guest	1,758	1,702	1,521	1,018	1,252
Manufacturing Facility	1,048	1,013	939	567	634
MF - High Rise	1,526	1,506	1,373	1,169	1,172
MF - High Rise - Common	1,815	1,762	1,580	1,089	1,406
MF - High Rise - Residential	1,475	1,464	1,330	1,152	1,123
MF - Mid Rise	1,666	1,685	1,450	1,067	1,216
Movie Theater	1,916	1,905	1,718	1,288	1,538
Office - High Rise - CAV no econ	2,020	2,050	1,869	1,252	1,363
Office - High Rise - CAV econ	2,089	2,132	1,960	1,351	1,487
Office - High Rise - VAV econ	1,528	1,558	1,284	759	846
Office - High Rise - FCU	1,118	1,102	952	505	530
Office - Low Rise	1,428	1,425	1,132	692	793
Office - Mid Rise	1,585	1,587	1,342	855	950
Religious Building	1,603	1,504	1,440	1,054	1,205
Restaurant	1,350	1,354	1,216	920	1,091
Retail - Department Store	1,392	1,278	1,200	781	891
Retail - Strip Mall	1,332	1,233	1,090	751	810
Warehouse	1,456	1,357	1,400	875	1,078
Unknown	1,553	1,539	1,369	982	1,139

Equivalent Full Load Hours for Cooling (EFLH<sub>cooling</sub>) :

Building Type	Cooling EFLH				
	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
Assembly	725	796	937	1,183	932
Assisted Living	1,475	1,457	1,773	2,110	1,811
College	475	481	662	746	806
Convenience Store	1,088	1,067	1,368	1,541	1,371
Elementary School	725	764	905	1,142	956
Garage	934	974	1,226	1,582	1,383
Grocery	1,033	1,000	1,236	1,499	1,286
Healthcare Clinic	1,282	1,305	1,519	1,767	1,571
High School	675	721	840	1,060	920
Hospital - CAV no econ	4,166	4,275	4,319	4,692	4,445
Hospital - CAV econ	1,751	1,814	2,120	2,411	2,112
Hospital - VAV econ	1,531	1,592	1,853	2,163	1,876
Hospital - FCU	3,245	3,291	3,451	4,128	3,806
Hotel/Motel	1,233	1,186	1,436	1,274	1,616
Hotel/Motel - Common	2,186	2,103	2,344	1,391	2,651
Hotel/Motel - Guest	1,042	1,019	1,269	1,216	1,418
Manufacturing Facility	1,010	1,055	1,209	1,453	1,273
MF - High Rise	921	845	1,048	1,779	1,099
MF - High Rise - Common	914	839	1,055	2,893	1,132
MF - High Rise - Residential	899	831	1,011	1,569	1,055
MF - Mid Rise	809	767	992	1,119	993
Movie Theater	876	745	1,036	1,178	1,010
Office - High Rise - CAV no econ	1,688	1,708	1,811	1,865	1,725
Office - High Rise - CAV econ	1,454	1,452	1,551	1,568	1,416
Office - High Rise - VAV econ	875	919	1,057	1,275	1,077
Office - High Rise - FCU	1,117	1,170	1,277	1,642	1,412
Office - Low Rise	949	1,010	1,182	1,452	1,281
Office - Mid Rise	883	938	1,072	1,286	1,083
Religious Building	861	817	967	1,159	1,067
Restaurant	1,074	1,134	1,279	1,627	1,325

Building Type	Cooling EFLH				
	Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
Retail - Department Store	949	889	1,124	1,367	1,157
Retail - Strip Mall	950	919	1,149	1,351	1,215
Warehouse	357	338	422	647	533
Unknown	1,215	1,221	1,408	1,670	1,480

#### 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 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

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.<sup>263</sup>

##### **DEEMED MEASURE COST**

The incremental capital cost for this measure is \$35<sup>264</sup> per ton.

##### **LOADSHAPE**

Loadshape C03 - Commercial Cooling

##### **COINCIDENCE FACTOR**

$$\begin{aligned} CF_{SSP} &= \text{Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)} \\ &= 91.3\% \end{aligned} \quad ^{265}$$

---

<sup>263</sup>Ibid.

<sup>264</sup>Ibid.

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

$$= 47.8\%^{266}$$

---

**Algorithm**

---

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

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

$$\Delta kWh = (\text{kBtu/hr}) * [(1/SEER_{\text{before}}) - (1/SEER_{\text{after}})] * EFLH$$

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

$$\Delta kWh = (\text{kBtu/hr}) * [(1/EER_{\text{before}}) - (1/EER_{\text{after}})] * EFLH$$

Where:

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

=Actual

SEER<sub>before</sub> = Seasonal Energy Efficiency Ratio of the equipment prior to tune-up

=Actual

SEER<sub>after</sub> = Seasonal Energy Efficiency Ratio of the equipment after to tune-up

=Actual

EER<sub>before</sub> = Energy Efficiency Ratio of the baseline equipment prior to tune-up

=Actual

EER<sub>after</sub> = Energy Efficiency Ratio of the baseline equipment after to tune-up

=Actual

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

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

$$\Delta kW_{SSP} = (\text{kBtu/hr} * (1/EER_{\text{before}} - 1/EER_{\text{after}})) * CF_{SSP}$$

$$\Delta kW_{PJM} = (\text{kBtu/hr} * (1/EER_{\text{before}} - 1/EER_{\text{after}})) * CF_{PJM}$$

Where:

CF<sub>SSP</sub> = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

$$= 91.3\%^{267}$$

---

<sup>265</sup> 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.

<sup>266</sup> 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

<sup>267</sup> 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.

$$\begin{aligned} CF_{PJM} &= \text{PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)} \\ &= 47.8\%^{268} \end{aligned}$$

**NATURAL GAS ENERGY SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HVC-ACTU-V02-150601**

---

<sup>268</sup>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

## 4.4.2 Space Heating Boiler Tune-up

### 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<sup>269</sup> 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

---

<sup>269</sup> Act on Energy Commercial Technical Reference Manual No. 2010-4, 9.2.2 Gas Boiler Tune-up

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The life of this measure is 3 years<sup>270</sup>

**DEEMED MEASURE COST**

The cost of this measure is \$0.83/MBtu/hr<sup>271</sup> 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**

$$\Delta \text{therms} = (\text{Capacity} * \text{EFLH} * (((\text{Effbefore} + \text{Ei}) / \text{Effbefore}) - 1)) / 100,000$$

Where:

Capacity = Boiler gas input size (Btu/hr)

= custom

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

Effbefore = Efficiency of the boiler before the tune-up

Ei = Efficiency Improvement of the boiler tune-up measure

---

<sup>270</sup> Act on Energy Commercial Technical Reference Manual No. 2010-4, 9.2.2 Gas Boiler Tune-up

<sup>271</sup> Work Paper – Tune up for Boilers serving Space Heating and Process Load by Resource Solutions Group, January 2012

100,000 = Converts Btu to therms

**EXAMPLE**

For example, a 1050 kBtu boiler in a Chicago high rise office records an efficiency prior to tune up of 82% AFUE and a 1.8% improvement in efficiency are tune up:

$$\begin{aligned}\Delta\text{therms} &= (1,050,000 * 2050 * ((0.82 + 0.018) / 0.82 - 1)) / 100,000 \\ &= 473 \text{ Therms}\end{aligned}$$

**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-V05-150601**

### 4.4.3 Process Boiler Tune-up

#### DESCRIPTION

This measure is for a non-residential boiler for process loads. For space heating, see measure 4.4.2. 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<sup>272</sup> 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

---

<sup>272</sup> Act on Energy Commercial Technical Reference Manual No. 2010-4, 9.2.2 Gas Boiler Tune-up

**DEEMED LIFETIME OF EFFICIENT EQUIPMENT**

The life of this measure is 3 years<sup>273</sup>

**DEEMED MEASURE COST**

The cost of this measure is \$0.83/MBtu/hr<sup>274</sup> 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**

$$\Delta\text{therms} = ((N_{gi} * 8766 * UF) / 100) * (1 - (\text{Eff}_{pre} / \text{Eff}_{measured}))$$

Where:

$N_{gi}$  = Boiler gas input size (kBtu/hr)

= custom

UF = Utilization Factor

= 41.9%<sup>275</sup> or custom

---

<sup>273</sup> Act on Energy Commercial Technical Reference Manual No. 2010-4, 9.2.2 Gas Boiler Tune-up

<sup>274</sup> Work Paper – Tune up for Boilers serving Space Heating and Process Load by Resource Solutions Group, January 2012

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

= Actual

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

= Actual

100 =conversion from kBtu to therms

8766 = hours a year

**EXAMPLE**

For example, a 80% 1050 kBtu boiler is tuned-up resulting in final efficiency of 81.3%:

$$\begin{aligned}\Delta\text{therms} &= ((1050 * 8766 * 0.419) / 100) * (1 - (0.80 / 0.813)) \\ &= 617 \text{ therms}\end{aligned}$$

**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-V04-150601**

---

<sup>275</sup> Work Paper – Tune up for Boilers serving Space Heating and Process Load by Resource Solutions Group, January 2012

#### 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<sup>276</sup>

##### DEEMED MEASURE COST

The cost of this measure is \$612<sup>277</sup>

##### LOADSHAPE

N/A

##### COINCIDENCE FACTOR

N/A

---

---

#### Algorithm

---

---

##### CALCULATION OF SAVINGS

##### ELECTRIC ENERGY SAVINGS

N/A

---

<sup>276</sup> CLEAR result references the Brooklyn Union Gas Company, High Efficiency Heating and Water and Controls, Gas Energy Efficiency Program Implementation Plan.

<sup>277</sup> Nexant. Questar DSM Market Characterization Report. August 9, 2006.

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**NATURAL GAS ENERGY SAVINGS**

$$\text{Therm Savings} = \text{Binput} * \text{SF} * \text{EFLH} / (100)$$

Where:

Binput = Boiler Input Capacity (kBtu/hr)  
= custom

SF = Savings factor  
= 8%<sup>278</sup> 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

$$\begin{aligned} \Delta \text{Therms} &= 800 * 0.08 * 1,350 / (100) \\ &= 864 \text{ Therms} \end{aligned}$$

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HVC-BLRC-V03-150601**

---

<sup>278</sup> Savings factor is the estimate of annual gas consumption that is saved due to adding boiler reset controls. The CLEAResult uses 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.

#### 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<sup>279</sup>

##### **DEEMED MEASURE COST**

The incremental capital cost for a unit heater is \$676<sup>280</sup>

##### **LOADSHAPE**

N/A

##### **COINCIDENCE FACTOR**

N/A

---

#### **Algorithm**

---

##### **CALCULATION OF SAVINGS**

##### **ELECTRIC ENERGY SAVINGS**

N/A

##### **SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

---

<sup>279</sup>DEER 2008

<sup>280</sup>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

**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 the 2009 International Energy Conservation Code, Table 503.2.3(7).

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 20 years<sup>281</sup>.

### DEEMED MEASURE COST

The incremental capital cost for this measure is provided below.

Equipment Type	Size Category	Incremental Cost (\$/ton) <sup>282</sup>
Air cooled, electrically operated	All capacities	\$127/ton <sup>283</sup>
Water cooled, electrically operated, positive displacement (reciprocating)	All capacities	\$22/ton
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

<sup>281</sup> 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](http://deeresources.com/deer0911planning/downloads/EUL_Summary_10-1-08.xls))

<sup>282</sup> 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](http://deeresources.com/deer0911planning/downloads/DEER2008_Costs_ValuesAndDocumentation_080530Rev1.zip))

<sup>283</sup> 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

**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.

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

$$= 91.3\%^{284}$$

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

$$= 47.8\%^{285}$$

---

**Algorithm**

---

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

$$\Delta kWh = \text{TONS} * ((IPLV_{base}) - (IPLV_{ee})) * EFLH$$

Where:

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

$$= \text{Actual installed}$$

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

$$IPLV_{ee}^{286} = \text{efficiency of high efficiency equipment expressed as Integrated Part Load Value (kW/ton)}^{287}$$

$$= \text{Actual installed}$$

$$EFLH = \text{Equivalent Full Load Hours for cooling are provided in section 4.4 HVAC End Use.}$$

---

<sup>284</sup> 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.

<sup>285</sup> 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

<sup>286</sup> 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.

<sup>287</sup> Can determine IPLV from standard testing or looking at engineering specs for design conditions. Standard data is available from AHRnet.org. <http://www.ahrinet.org/>

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:

$$\begin{aligned} \Delta \text{kWh} &= 100 * ((0.96) - (0.86)) * 923 \\ &= 9,230 \text{ kWh} \end{aligned}$$

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

$$\Delta \text{kW}_{\text{SSP}} = \text{TONS} * ((\text{PE}_{\text{base}}) - (\text{PE}_{\text{ee}})) * \text{CF}_{\text{SSP}}$$

$$\Delta \text{kW}_{\text{PJM}} = \text{TONS} * ((\text{PE}_{\text{base}}) - (\text{PE}_{\text{ee}})) * \text{CF}_{\text{PJM}}$$

Where:

PE<sub>base</sub> = Peak efficiency of baseline equipment expressed as Full Load (kW/ton)

PE<sub>ee</sub> = Peak efficiency of high efficiency equipment expressed as Full Load (kW/ton)  
 = Actual installed

CF<sub>SSP</sub> = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)  
 = 91.3%

CF<sub>PJM</sub> = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)  
 = 47.8%

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:

$$\begin{aligned} \Delta \text{kW}_{\text{SSP}} &= 100 * ((1.3) - (1.0)) * .913 \\ &= 23 \text{ kW} \end{aligned}$$

**NATURAL GAS ENERGY SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**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

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

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

$$\text{kW/ton} = 12 / \text{EER}$$

$$\text{kW/ton} = 12 / (\text{COP} \times 3.412)$$

$$\text{COP} = \text{EER} / 3.412$$

$$\text{COP} = 12 / (\text{kW/ton}) / 3.412$$

$$\text{EER} = 12 / \text{kW/ton}$$

$$\text{EER} = \text{COP} \times 3.412$$

Baseline Efficiency Values by Chiller Type and Capacity<sup>288</sup>

**TABLE C403.2.3(7)  
MINIMUM EFFICIENCY REQUIREMENTS:  
WATER CHILLING PACKAGES\***

EQUIPMENT TYPE	SIZE CATEGORY	UNITS	BEFORE 1/1/2010		AS OF 1/1/2010 <sup>b</sup>				TEST PROCEDURE <sup>c</sup>
			FULL LOAD	IPLV	PATH A		PATH B		
					FULL LOAD	IPLV	FULL LOAD	IPLV	
Air-cooled chillers	< 150 tons	EER	≥ 9.562	≥ 10.4	≥ 9.562	≥ 12.500	NA	NA	AHRI 550/590
	≥ 150 tons	EER		16	≥ 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-V03-150601**

<sup>288</sup> International Energy Conservation Code (IECC)2012

#### 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:<sup>289</sup>

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

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

<sup>289</sup> [http://www.energystar.gov/index.cfm?c=roomac.pr\\_crit\\_room\\_ac](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](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](http://www.energystar.gov/ia/partners/product_specs/program_reqs/room_air_conditioners_prog_req.pdf)

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.<sup>290</sup>

#### **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.<sup>291</sup>

#### **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%<sup>292</sup>

$CF_{PJM}$  = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)  
= 47.8%<sup>293</sup>

---

<sup>290</sup> Energy Star Room Air Conditioner Savings Calculator,  
[http://www.energystar.gov/index.cfm?fuseaction=find\\_a\\_product.showProductGroup&pgw\\_code=AC](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](http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf)

<sup>291</sup> Based on field study conducted by Efficiency Vermont

<sup>292</sup> 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.

<sup>293</sup> 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

**Algorithm**

**CALCULATION OF SAVINGS**

**ENERGY SAVINGS**

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

Where:

FLH<sub>RoomAC</sub> = Full Load Hours of room air conditioning unit  
 = dependent on location:<sup>294</sup>

Zone	FLH <sub>RoomAC</sub>
1 (Rockford)	253
2-(Chicago)	254
3 (Springfield)	310
4-(Belleville)	391
5-(Marion)	254

Btu/H = Size of unit  
 = Actual. If unknown assume 8500 Btu/hr<sup>295</sup>

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:

$$\begin{aligned} \Delta kWh_{ENERGY STAR} &= (253 * 8500 * (1/9.8 - 1/10.8)) / 1000 \\ &= 20.3 kWh \end{aligned}$$

<sup>294</sup> 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](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](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.

<sup>295</sup> Based on maximum capacity average from the RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008

### SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \text{Btu/H} * ((1/\text{EER}_{\text{base}} - 1/\text{EER}_{\text{ee}}))/1000 * \text{CF}$$

Where:

$$\begin{aligned} \text{CF}_{\text{SSP}} &= \text{Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)} \\ &= 91.3\%^{296} \end{aligned}$$

$$\begin{aligned} \text{CF}_{\text{PJM}} &= \text{PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)} \\ &= 47.8\%^{297} \end{aligned}$$

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

$$\begin{aligned} \Delta kW_{\text{ENERGY STAR}} &= (8500 * (1/9.8 - 1/10.8)) / 1000 * 0.913 \\ &= 0.073 \text{ kW} \end{aligned}$$

### 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**

---

<sup>296</sup> 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.

<sup>297</sup> 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

## 4.4.8 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<sup>298</sup>.

### 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<sup>299</sup>.

### DEEMED O&M COST ADJUSTMENTS

N/A

### LOADSHAPE

Loadshape C03 - Commercial Cooling

### COINCIDENCE FACTOR

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

---

<sup>298</sup> DEER 2008 value for energy management systems

<sup>299</sup> This value was extracted from Smart Ideas projects in PY1 and PY2.

**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 and a hotel<sup>300</sup>. 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

<sup>300</sup> For motels, 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’. In 2014 the hotel models were also run to compile results, rather than by applying adjustment factors to the motel results as had been done in V3.0 of the TRM. The updated values can be found in ‘GREM Savings Summary (Hotel)\_IL TRM\_10\_16\_14.xls’.

Motel Electric Energy Savings			
Climate Zone (City based upon)	Heating Source	Baseline	Electric Savings (kWh/Ton)
	PTHP	Housekeeping Setback	202
		No Housekeeping Setback	736
4 (Belleville)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	559
		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	204
		No Housekeeping Setback	345
	PTAC w/ Gas Heating	Housekeeping Setback	121
		No Housekeeping Setback	197
	PTHP	Housekeeping Setback	152
		No Housekeeping Setback	253
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	177
		No Housekeeping Setback	296
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	94
		No Housekeeping Setback	148
2 (Chicago)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	188

Hotel Electric Energy Savings				
Climate Zone (City based upon)	Heating Source	Baseline	Electric Savings (kWh/Ton)	
	PTAC w/ Gas Heating	No Housekeeping Setback	342	
		Housekeeping Setback	119	
	PTHP	No Housekeeping Setback	195	
		Housekeeping Setback	145	
	Central Hot Water Fan Coil w/ Electric Resistance Heating	No Housekeeping Setback	250	
		Housekeeping Setback	161	
	Central Hot Water Fan Coil w/ Gas Heating	No Housekeeping Setback	294	
		Housekeeping Setback	92	
	3 (Springfield)	PTAC w/ Electric Resistance Heating	No Housekeeping Setback	147
			Housekeeping Setback	182
		PTAC w/ Gas Heating	No Housekeeping Setback	291
			Housekeeping Setback	123
PTHP		No Housekeeping Setback	197	
		Housekeeping Setback	145	
Central Hot Water Fan Coil w/ Electric Resistance Heating		No Housekeeping Setback	233	
		Housekeeping Setback	153	
Central Hot Water Fan Coil w/ Gas Heating		No Housekeeping Setback	240	
		Housekeeping Setback	94	
4 (Belleville)		PTAC w/ Electric Resistance Heating	No Housekeeping Setback	146
			Housekeeping Setback	182
	PTAC w/ Gas Heating	No Housekeeping Setback	308	
		Housekeeping Setback	125	
	PTHP	No Housekeeping Setback	199	
		Housekeeping Setback	146	
	Central Hot Water Fan Coil w/ Electric Resistance Heating	No Housekeeping Setback	240	
		Housekeeping Setback	152	
	Central Hot Water Fan Coil w/ Gas Heating	No Housekeeping Setback	255	
		Housekeeping Setback	95	
			No Housekeeping Setback	147

Hotel Electric Energy Savings			
Climate Zone (City based upon)	Heating Source	Baseline	Electric Savings (kWh/Ton)
5 (Marion-Williamson)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	171
		No Housekeeping Setback	295
	PTAC w/ Gas Heating	Housekeeping Setback	122
		No Housekeeping Setback	199
	PTHP	Housekeeping Setback	140
		No Housekeeping Setback	235
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	141
		No Housekeeping Setback	243
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	92
		No Housekeeping Setback	146

**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

Motel Coincident Peak Demand Savings			
Climate Zone (City based upon)	Heating Source	Baseline	Coincident Peak Demand Savings (kW/Ton)
		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	0.08	
		No Housekeeping Setback	0.11	
	PTAC w/ Gas Heating	Housekeeping Setback	0.08	
		No Housekeeping Setback	0.11	
	PTHP	Housekeeping Setback	0.08	
		No Housekeeping Setback	0.11	
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	0.05	
		No Housekeeping Setback	0.08	
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	0.05	
		No Housekeeping Setback	0.08	
	2 (Chicago)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	0.07
			No Housekeeping Setback	0.11
		PTAC w/ Gas Heating	Housekeeping Setback	0.07
			No Housekeeping Setback	0.11
PTHP		Housekeeping Setback	0.07	
		No Housekeeping Setback	0.11	
Central Hot Water Fan Coil w/ Electric Resistance Heating		Housekeeping Setback	0.05	
		No Housekeeping Setback	0.07	
Central Hot Water Fan Coil w/ Gas Heating		Housekeeping Setback	0.05	
		No Housekeeping Setback	0.07	
3 (Springfield)		PTAC w/ Electric Resistance Heating	Housekeeping Setback	0.08
			No Housekeeping Setback	0.11
	PTAC w/ Gas Heating	Housekeeping Setback	0.08	

Hotel Coincident Peak Demand Savings				
Climate Zone (City based upon)	Heating Source	Baseline	Coincident Peak Demand Savings (kW/Ton)	
	PTHP	No Housekeeping Setback	0.11	
		Housekeeping Setback	0.08	
	Central Hot Water Fan Coil w/ Electric Resistance Heating	No Housekeeping Setback	0.11	
		Housekeeping Setback	0.05	
	Central Hot Water Fan Coil w/ Gas Heating	No Housekeeping Setback	0.07	
		Housekeeping Setback	0.05	
	4 (Belleville)	PTAC w/ Electric Resistance Heating	Housekeeping Setback	0.08
			No Housekeeping Setback	0.11
PTAC w/ Gas Heating		Housekeeping Setback	0.08	
		No Housekeeping Setback	0.11	
PTHP		Housekeeping Setback	0.08	
		No Housekeeping Setback	0.11	
Central Hot Water Fan Coil w/ Electric Resistance Heating		Housekeeping Setback	0.05	
		No Housekeeping Setback	0.08	
Central Hot Water Fan Coil w/ Gas Heating		Housekeeping Setback	0.05	
		No Housekeeping Setback	0.08	
5 (Marion-Williamson)		PTAC w/ Electric Resistance Heating	Housekeeping Setback	0.08
			No Housekeeping Setback	0.11
	PTAC w/ Gas Heating	Housekeeping Setback	0.08	
		No Housekeeping Setback	0.11	
	PTHP	Housekeeping Setback	0.08	
		No Housekeeping Setback	0.11	
	Central Hot Water Fan Coil w/ Electric Resistance Heating	Housekeeping Setback	0.05	
		No Housekeeping Setback	0.08	
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	0.05	
		No Housekeeping Setback	0.08	

**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	3.6
		No Housekeeping Setback	6.4
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	3.6
		No Housekeeping Setback	6.4
2 (Chicago)	PTAC w/ Gas Heating	Housekeeping Setback	3.0
		No Housekeeping Setback	6.5
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	3.0
		No Housekeeping Setback	6.5
3 (Springfield)	PTAC w/ Gas Heating	Housekeeping Setback	2.6
		No Housekeeping Setback	4.1
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	2.6
		No Housekeeping Setback	4.1
4 (Belleville)	PTAC w/ Gas Heating	Housekeeping Setback	2.5
		No Housekeeping Setback	4.8

Hotel Natural Gas Energy Savings			
Climate Zone (City based upon)	Heating Source	Baseline	Gas Savings (Therms/Ton)
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	2.5
		No Housekeeping Setback	4.8
5 (Marion-Williamson)	PTAC w/ Gas Heating	Housekeeping Setback	2.1
		No Housekeeping Setback	4.2
	Central Hot Water Fan Coil w/ Gas Heating	Housekeeping Setback	2.1
		No Housekeeping Setback	4.2

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HVC-GREM-V05-150601**

## 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.<sup>301</sup>

### DEEMED MEASURE COST

For analysis purposes, the incremental capital cost for this measure is assumed as \$100 per ton for air-cooled units.<sup>302</sup> The incremental cost for all other equipment types should be determined on a site-specific basis

### LOADSHAPE

Loadshape C05 - Commercial Electric Heating and 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%<sup>303</sup>

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

---

<sup>301</sup> Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, Inc., June 2007.

<sup>302</sup> Based on a review of TRM incremental cost assumptions from Vermont, Wisconsin, and California.

<sup>303</sup> 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.

$$= 47.8\%^{304}$$

---



---

**Algorithm**

---



---

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

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

$$\Delta \text{kWh} = \text{Annual kWh Savings}_{\text{cool}} + \text{Annual kWh Savings}_{\text{heat}}$$

$$\text{Annual kWh Savings}_{\text{cool}} = (\text{kBtu/hr}_{\text{cool}}) * [(1/\text{SEERbase}) - (1/\text{SEERee})] * \text{EFLH}_{\text{cool}}$$

$$\text{Annual kWh Savings}_{\text{heat}} = (\text{kBtu/hr}_{\text{cool}}) * [(1/\text{HSPFbase}) - (1/\text{HSPFee})] * \text{EFLH}_{\text{heat}}$$

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

$$\Delta \text{kWh} = \text{Annual kWh Savings}_{\text{cool}} + \text{Annual kWh Savings}_{\text{heat}}$$

$$\text{Annual kWh Savings}_{\text{cool}} = (\text{kBtu/hr}_{\text{cool}}) * [(1/\text{EERbase}) - (1/\text{EERee})] * \text{EFLH}_{\text{cool}}$$

$$\text{Annual kWh Savings}_{\text{heat}} = (\text{kBtu/hr}_{\text{heat}})/3.412 * [(1/\text{COPbase}) - (1/\text{COPee})] * \text{EFLH}_{\text{heat}}$$

Where:

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

= Actual installed

$\text{SEERbase}$  = Seasonal Energy Efficiency Ratio of the baseline equipment; see table below for values.  
305

---

<sup>304</sup> 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

<sup>305</sup> 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*
Air cooled (cooling mode)	< 65,000 Btu/h <sup>3</sup>	All	Split System	13.0 SEER	AHRI 210/240
			Single Packaged	13.0 SEER	
Through-the-wall, air cooled	≤ 30,000 Btu/h <sup>3</sup>	All	Split System	13.0 SEER	
			Single Packaged	13.0 SEER	
Single-duct high-velocity air cooled	< 65,000 Btu/h <sup>3</sup>	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	
		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 <sup>3</sup>	—	Split System	7.7 HSPF	AHRI 210/240
		—	Single Package	7.7 HSPF	
Through-the-wall, (air cooled, heating mode)	≤ 30,000 Btu/h <sup>3</sup> (cooling capacity)	—	Split System	7.4 HSPF	
		—	Single Package	7.4 HSPF	
Small-duct high velocity (air cooled, heating mode)	< 65,000 Btu/h <sup>3</sup>	—	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*
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.

SEER<sub>ee</sub> = Seasonal Energy Efficiency Ratio of the energy efficient equipment.  
 = Actual installed

EFLH<sub>cool</sub> = Equivalent Full Load Hours for cooling are provided in section 4.4 HVAC End Use.

HSPF<sub>base</sub> = Heating Seasonal Performance Factor of the baseline equipment; see table above for values.

HSPF<sub>ee</sub> = Heating Seasonal Performance Factor of the energy efficient equipment.  
 = Actual installed

EFLH<sub>heat</sub> = heating mode equivalent full load hours are provided in section 4.4 HVAC End Use.

EER<sub>base</sub> = Energy Efficiency Ratio of the baseline equipment; see the table above for values. Since IECC 2012 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.

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

kBtu/hr<sub>heat</sub> = capacity of the heating equipment in kBtu per hour.  
 = Actual installed

3.412 = Btu per Wh.

COP<sub>base</sub> = coefficient of performance of the baseline equipment; see table above for values.

COP<sub>ee</sub> = coefficient of performance of the energy efficient equipment.

= Actual installed

$$\text{Annual kWh Savings}_{\text{cool}} = (\text{kBtu/hr}_{\text{cool}}) * [(1/\text{SEER}_{\text{base}}) - (1/\text{SEER}_{\text{ee}})] * \text{EFLH}_{\text{cool}}$$

$$\text{Annual kWh Savings}_{\text{heat}} = (\text{kBtu/hr}_{\text{heat}}) * [(1/\text{HSPF}_{\text{base}}) - (1/\text{HSPF}_{\text{ee}})] * \text{EFLH}_{\text{heat}}$$

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

$$= [(60) * [(1/13) - (1/14)] * 1134] + [(60) * [(1/7.7) - (1/9)] * 1354]$$

$$= 1650 \text{ kWh}$$

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

$$\Delta \text{kW} = (\text{kBtu/hr}_{\text{cool}}) * [(1/\text{EER}_{\text{base}}) - (1/\text{EER}_{\text{ee}})] * \text{CF}$$

Where CF value is chosen between:

$$\text{CF}_{\text{SSP}} = \text{Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)}$$

$$= 91.3\%^{306}$$

$$\text{CF}_{\text{PJM}} = \text{PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)}$$

$$= 47.8\%^{307}$$

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

$$\Delta \text{kW} = [(60) * [(1/13) - (1/14)] * .913]$$

$$= 0.3$$

**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-V03-150601**

<sup>306</sup> 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.

<sup>307</sup> 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

#### 4.4.10 High Efficiency Boiler

##### 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 <sup>308</sup>	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

---

<sup>308</sup> 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 <sup>309</sup>	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<sup>310</sup>

**DEEMED MEASURE COST**

The incremental capital cost for this measure depends on efficiency as listed below<sup>311</sup>

Measure Tier	Incr. Cost, per unit
ENERGY STAR® Minimum	\$1,470
AFUE 90%	\$2,400
AFUE 95%	\$3,370
AFUE ≥ 96%	\$4,340
Boilers > 300,000 Btu/hr with TE (thermal efficiency) rating	Custom

**LOADSHAPE**

N/A

**COINCIDENCE FACTOR**

N/A

<sup>309</sup> Ibid.

<sup>310</sup> 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](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

<sup>311</sup> 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.

**Algorithm**

**CALCULATION OF ENERGY SAVINGS**

**ELECTRIC ENERGY SAVINGS**

N/A

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**NATURAL GAS ENERGY SAVINGS**

$$\Delta\text{Therms} = \text{EFLH} * \text{Capacity} * ((\text{EfficiencyRating}(\text{actual}) - \text{EfficiencyRating}(\text{base})) / \text{EfficiencyRating}(\text{base})) / 100,000$$

Where:

- EFLH = 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) = Efficient 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

$$\begin{aligned} \Delta\text{Therms} &= 2,089 * 150,000 * (0.90-0.80)/0.80 / 100,000 \text{ Btu/Therm} \\ &= 392 \text{ Therms} \end{aligned}$$

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HVC-BOIL-V05-150601**

#### 4.4.11 High Efficiency Furnace

##### 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  $\leq 75\%$ . 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  $\leq 75\%$  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%. 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<sup>312</sup>

Remaining life of existing equipment is assumed to be 5.5 years<sup>313</sup>.

**DEEMED MEASURE COST**

Time of Sale: The incremental capital cost for this measure depends on efficiency as listed below<sup>314</sup>:

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

---



---

**Algorithm**


---

**CALCULATION OF SAVINGS****ELECTRIC ENERGY SAVINGS**

$$\Delta \text{kWh} = \text{Heating Savings} + \text{Cooling Savings} + \text{Shoulder Season Savings}$$

Where:

---

<sup>312</sup> Average of 15-18 year lifetime estimate made by the Consortium for Energy Efficiency in 2010.

<sup>313</sup> Assumed to be one third of effective useful life

<sup>314</sup> 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](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.

- Heating Savings = Brushless DC motor or Electronically commutated motor (ECM)  
= 418 kWh<sup>315</sup>
- 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<sup>316</sup>
- 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:

$$\begin{aligned} \Delta kWh &= \text{Heating Savings} + \text{Cooling Savings} + \text{Shoulder Season Savings} \\ &= 418 + 263 + 51 \\ &= 732 \text{ kWh} \end{aligned}$$

**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.

$$\Delta kW = (\Delta kWh/HOURSyear) * CF$$

Where:

HOURSyear = Actual hours per year if known, otherwise use hours from Table below for building type<sup>317</sup>.

Building Type	Pumps and fans (h/yr)
College/University	4216
Grocery	5840
Heavy Industry	3585
Hotel/Motel	6872

<sup>315</sup> 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.

<sup>316</sup> The weighted average value is based on assumption that 75% of buildings installing BPM furnace blower motors have Central AC.

<sup>317</sup> ComEd Trm June 1, 2010 page 139. The Office hours is based upon occupancy from the eQuest model developed for EFLH, since it was agreed the ComEd value was too low.

Building Type	Pumps and fans (h/yr)
Light Industry	2465
Medical	6871
Office	2301
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<sup>318</sup>:

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:

$$\begin{aligned} \Delta kW &= (732 / 2301) * 0.66 \\ &= 0.21 \text{ kW} \end{aligned}$$

**NATURAL GAS ENERGY SAVINGS**

Time of Sale:

$$\Delta \text{Therms} = \text{EFLH} * \text{Capacity} * ((\text{AFUE}(\text{eff}) - \text{AFUE}(\text{base}))/\text{AFUE}(\text{base}))/ 100,000 \text{ Btu/Therm}$$

Early replacement<sup>319</sup>:

$\Delta$ Therms for remaining life of existing unit (1st 5.5 years):

<sup>318</sup> Based on DEER 2008 values

<sup>319</sup> 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).

$$\Delta\text{Therms} = \text{EFLH} * \text{Capacity} * (\text{AFUE}(\text{eff}) - \text{AFUE}(\text{exist}) / \text{AFUE}(\text{exist})) / 100,000 \text{ Btu/Therm}$$

$\Delta\text{Therms}$  for remaining measure life (next 11 years):

$$\Delta\text{Therms} = \text{EFLH} * \text{Capacity} * (\text{AFUE}(\text{eff}) - \text{AFUE}(\text{base}) / \text{AFUE}(\text{base})) / 100,000 \text{ Btu/Therm}$$

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%<sup>320</sup>.

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

Dependent on program type as listed below<sup>321</sup>:

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

AFUE(eff) = Efficient Furnace Annual Fuel Utilization Efficiency Rating.  
 = Actual. If Unknown, assume 95%<sup>322</sup>

**EXAMPLE**

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

$$\begin{aligned} \Delta\text{Therms} &= 1428 * 150,000 * ((0.92-0.80)/0.80) / 100,000 \\ &= 321 \text{ Therms} \end{aligned}$$

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

<sup>320</sup> Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.

<sup>321</sup> 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.

<sup>322</sup> Minimum ENERGY STAR efficiency after 2.1.2012.

**MEASURE CODE: CI-HVC-FRNC-V04-150601**

#### 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<sup>323</sup>

##### **DEEMED MEASURE COST**

The incremental capital cost for this measure is \$1716<sup>324</sup>

##### **LOADSHAPE**

N/A

##### **COINCIDENCE FACTOR**

N/A

---

---

#### **Algorithm**

---

---

##### **CALCULATION OF SAVINGS**

##### **ELECTRIC ENERGY SAVINGS**

N/A

##### **SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

---

<sup>323</sup>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

<sup>324</sup>ibid.

**NATURAL GAS ENERGY SAVINGS**

The annual natural gas energy savings from this measure is a deemed value equaling 451 Therms<sup>325</sup>

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

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

---

<sup>325</sup>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.<sup>326</sup>

Remaining life of existing equipment is assumed to be 5 years<sup>327</sup>

##### DEEMED MEASURE COST

Time of Sale: The incremental capital cost for this equipment is estimated to be \$84/ton.<sup>328</sup>

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. If unknown assume \$1,047 per ton<sup>329</sup>.

The assumed deferred cost (after 5 years) of replacing existing equipment with new baseline unit is assumed to be

---

<sup>326</sup> Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, Inc., June 2007

<sup>327</sup> Standard assumption of one third of effective useful life.

<sup>328</sup> DEER 2008. This assumes that baseline shift from IECC 2006 to IECC 2012 carries the same incremental costs. Values should be verified during evaluation

<sup>329</sup> Based on DCEO – IL PHA Efficient Living Program data.

\$963 per ton<sup>330</sup>. This cost should be discounted to present value using the utilities' discount rate.

**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.

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

$$= 91.3\%^{331}$$

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

$$= 47.8\%^{332}$$

---



---

**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:

$$PTAC \Delta kWh^{333} = \text{Annual kWh Savings}_{cool}$$

$$PTHP \Delta kWh = \text{Annual kWh Savings}_{cool} + \text{Annual kWh Savings}_{heat}$$

$$\text{Annual kWh Savings}_{cool} = (kBtu/hr_{cool}) * [(1/EERbase) - (1/EERee)] * EFLH_{cool}$$

$$\text{Annual kWh Savings}_{heat} = (kBtu/hr_{heat})/3.412 * [(1/COPbase) - (1/COPEe)] * EFLH_{heat}$$

Early Replacement:

$$\Delta kWh \text{ for remaining life of existing unit (1}^{st} \text{ 5years)} = \text{Annual kWh Savings}_{cool} + \text{Annual kWh Savings}_{heat}$$

---

<sup>330</sup> Based on subtracting TOS incremental cost from the DCEO data.

<sup>331</sup> 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.

<sup>332</sup> 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

<sup>333</sup> 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.

$$\begin{aligned} \text{Annual kWh Savings}_{\text{cool}} &= (\text{kBtu/hr}_{\text{cool}}) * [(1/\text{EER}_{\text{exist}}) - (1/\text{EER}_{\text{ee}})] * \text{EFLH}_{\text{cool}} \\ \text{Annual kWh Savings}_{\text{heat}} &= (\text{kBtu/hr}_{\text{heat}})/3.412 * [(1/\text{COP}_{\text{exist}}) - (1/\text{COP}_{\text{ee}})] * \text{EFLH}_{\text{heat}} \\ \Delta\text{kWh for remaining measure life (next 10 years)} &= \text{Annual kWh Savings}_{\text{cool}} + \text{Annual kWh Savings}_{\text{heat}} \\ \text{Annual kWh Savings}_{\text{cool}} &= (\text{kBtu/hr}_{\text{cool}}) * [(1/\text{EER}_{\text{base}}) - (1/\text{EER}_{\text{ee}})] * \text{EFLH}_{\text{cool}} \\ \text{Annual kWh Savings}_{\text{heat}} &= (\text{kBtu/hr}_{\text{heat}})/3.412 * [(1/\text{COP}_{\text{base}}) - (1/\text{COP}_{\text{ee}})] * \text{EFLH}_{\text{heat}} \end{aligned}$$

Where:

- $\text{kBtu/hr}_{\text{cool}}$  = capacity of the cooling equipment in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/hr).  
= Actual installed
- $\text{EFLH}_{\text{cool}}$  = Equivalent Full Load Hours for cooling are provided in section 4.4 HVAC End Use:
- $\text{EFLH}_{\text{heat}}$  = Equivalent Full Load Hours for heating are provided in section 4.4 HVAC End Use
- $\text{EER}_{\text{exist}}$  = Energy Efficiency Ratio of the existing equipment  
= Actual. If unknown assume 8.1 EER<sup>334</sup>
- $\text{EER}_{\text{base}}$  = Energy Efficiency Ratio of the baseline equipment; see the table below for values.

Copy of Table C403.2.3(3), IECC 2012: Minimum Efficiency Requirements: 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

<sup>334</sup> 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;  $\text{EER} = 10 - (0.16 * 12,000/1,000) = 8.1$ .

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.

- EER<sub>ee</sub> = Energy Efficiency Ratio of the energy efficient equipment. For air-cooled air conditioners < 65 kBtu/hr, if the actual EER<sub>ee</sub> is unknown, assume the following conversion from SEER to EER: EER≈SEER/1.1.  
 = Actual installed
- kBtu/hr<sub>heat</sub> = capacity of the heating equipment in kBtu per hour.  
 = Actual installed
- 3.412 = Btu per Wh.
- COP<sub>exist</sub> = coefficient of performance of the existing equipment  
 = Actual. If unknown assume 1.0 COP for PTAC units and 2.6 COP<sup>335</sup> for PTHPs.
- COP<sub>base</sub> = coefficient of performance of the baseline equipment; see table above for values.
- COP<sub>ee</sub> = coefficient of performance of the energy efficient equipment.  
 = Actual installed

Time of Sale (assuming new construction baseline):

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

$$= [(12) * [(1/10.2) - (1/12)] * 1,042$$

$$= 184 \text{ kWh}$$

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 (1<sup>st</sup> 5years)

$$= (12 * (1/8.1 - 1/12) * 1,042) + (12/3.412 * (1/1.0 - 1/3.0) * 1,758)$$

$$= 502 + 4,122$$

$$= 4,624 \text{ kWh}$$

ΔkWh for remaining measure life (next 10 years)

$$= (12 * (1/8.3 - 1/12) * 1,042) + (12/3.412 * (1/1.0 - 1/3.0) * 1,758)$$

$$= 465 + 4,122$$

$$= 34,587 \text{ kWh}$$

<sup>335</sup>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

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

Time of Sale:

$$\Delta kW = (\text{kBtu/hr}_{\text{cool}}) * [(1/\text{EER}_{\text{base}}) - (1/\text{EER}_{\text{ee}})] * \text{CF}$$

Early Replacement:

$$\Delta kW \text{ for remaining life of existing unit (1}^{\text{st}} \text{ 5years)} = (\text{kBtu/hr}_{\text{cool}}) * [(1/\text{EER}_{\text{exist}}) - (1/\text{EER}_{\text{ee}})] * \text{CF}$$

$$\Delta kWh \text{ for remaining measure life (next 10 years)} = (\text{kBtu/hr}_{\text{cool}}) * [(1/\text{EER}_{\text{base}}) - (1/\text{EER}_{\text{ee}})] * \text{CF}$$

Where:

$$\begin{aligned} \text{CF}_{\text{SSP}} &= \text{Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)} \\ &= 91.3\%^{336} \end{aligned}$$

$$\begin{aligned} \text{CF}_{\text{PJM}} &= \text{PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)} \\ &= 47.8\%^{337} \end{aligned}$$

Time of Sale:

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

$$\begin{aligned} \Delta kW_{\text{SSP}} &= (12 * (1/10.2 - 1/12)) * 0.913 \\ &= 0.16 \text{ kW} \end{aligned}$$

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.

$\Delta kW$  for remaining life of existing unit (1<sup>st</sup> 5years):

$$\begin{aligned} \Delta kW_{\text{SSP}} &= 12 * (1/8.1 - 1/12) * 0.913 \\ &= 0.44 \text{ kW} \end{aligned}$$

$\Delta kW$  for remaining measure life (next 10 years):

$$\begin{aligned} \Delta kW_{\text{SSP}} &= 12 * (1/8.3 - 1/12) * 0.913 \\ &= 0.41 \text{ kW} \end{aligned}$$

**NATURAL GAS ENERGY SAVINGS**

N/A

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

---

<sup>336</sup> 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.

<sup>337</sup> 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

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HVC-PTAC-V05-150601**

## 4.4.14 Pipe Insulation

### DESCRIPTION

This measure provides rebates for installation of  $\geq 1''$  or  $\geq 2''$  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.<sup>338</sup>

### 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.

### DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 15 years.<sup>339</sup>

---

<sup>338</sup> ASHRAE Handbook—Fundamentals, 23.14; Hart, G., “Saving energy by insulating pipe components on steam and hot water distribution systems”, *ASHRAE Journal*, October 2011

<sup>339</sup> 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](http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf)

**DEEMED MEASURE COST**

Actual costs should be used if known. Otherwise the deemed measure costs below based on RS Means<sup>340</sup> pricing reference materials may be used.<sup>341</sup> 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
<b>Total Cost per foot</b>	<b>\$13.97</b>	<b>\$21.20</b>

**LOADSHAPE**

N/A

**COINCIDENCE FACTOR**

N/A

---

**Algorithm**

---

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

N/A

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**NATURAL GAS SAVINGS**

$$\begin{aligned} \Delta \text{therms per foot}^{342} &= [(Q_{\text{base}} - Q_{\text{eff}}) * \text{EFLH}] / (100,000 * \eta_{\text{Boiler}}) * \text{TRF} \\ &= [\text{Provided by tables below}] * \text{TRF} \end{aligned}$$

---

<sup>340</sup> RS Means 2008. Mechanical Cost Data, pages 106 to 119

<sup>341</sup> RS Means 2010: “for fittings, add 3 linear feet for each fitting plus 4 linear feet for each flange of the fitting”

<sup>342</sup> 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”

$$\Delta\text{therms} = (L_{sp} + L_{oc,i}) * \Delta\text{therms per foot}$$

Where:

EFLH = Equivalent Full Load Hours for Heating  
 = Actual or defaults by building type provided in Section 4.4, HVAC end use

For year round recirculation or domestic hot water:  
 = 8,766

For heating season recirculation, hours with the outside air temperature below 55°F:

Zone	Hours
Zone 1 (Rockford)	5,039
Zone 2 (Chicago)	4,963
Zone 3 (Springfield)	4,495
Zone 4 (Belleville/	4,021
Zone 5 (Marion)	4,150
Zone 1 (Rockford)	5,039

$Q_{base}$  = 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)

$\eta_{Boiler}$  = Efficiency of the boiler being used to generate the hot water or steam in the pipe  
 = 81.9% for water boilers<sup>343</sup>  
 = 80.7% for steam boilers, except multifamily low-pressure<sup>344</sup>  
 = 64.8% for multifamily low-pressure steam boilers<sup>345</sup>

TRF = Thermal Regain Factor for space type, applied only to space heating energy and is applied to values resulting from  $\Delta\text{therms/ft}$  tables below<sup>346</sup>  
 = See table below for base TRF values by pipe location

---

<sup>343</sup> Average efficiencies of units from the California Energy Commission (CEC).

<sup>344</sup> Ibid.

<sup>345</sup> Katrakis, J. and T.S. Zawacki. "Field-Measured Seasonal Efficiency of Intermediate-sized Low-Pressure Steam Boilers". ASHRAE V99, pt. 2, 1993.

<sup>346</sup> 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.

May vary seasonally such as:  $TRF[\text{summer}] * \text{summer hours} + TRF[\text{winter}] * \text{winter hours}$  where TRF values reflecting summer and winter conditions are apportioned by the hours for those conditions. TRF may also be adjusted by building specific balance temperature and operating hours above and below that balance temperature.<sup>347</sup>

Pipe Location	Assumed Regain	TRF, Thermal Regain Factor
Outdoor	0%	1.0
Indoor, heated space	85%	0.15
Indoor, semi- heated, (unconditioned space, with heat transfer to conditioned space. E.g.: boiler room, ceiling plenum, basement, crawlspace, wall)	30%	0.70
Indoor, unheated, (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)

$L_{oc,l}$  = 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.<sup>348</sup> 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  $Q_{eff}$ .

<sup>347</sup> Thermal Regain Factor\_4-30-14.docx

<sup>348</sup> 3E Plus is a heat loss calculation software provided by the NAIMA (North American Insulation Manufacturer Association).

Insulation Type	Conductivity (Btu.in / hr.ft <sup>2</sup> .°F @ 75F)	Max temp (°F)
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 <sup>2</sup> .°F @ 75°F)	0.31	

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

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 (°F)	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 (°F) <sup>349</sup>	75	75	75	75	48.6	48.6	48.6
Wind speed (mph) <sup>350</sup>	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)	40	70	13.25	21 (w/o reset) 16 (w/ reset heat)	32	52

<sup>349</sup> 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](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.

<sup>350</sup> Ibid.

	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
	13 (w/reset year)				13 (w/reset year)		
<b>Annual Energy Savings</b>							
Boiler / Water Heater efficiency	81.9%	80.7% (64.8% for MF)	80.7%	67%	81.9%	80.7% (64.8% for MF)	80.7%
Annual Gas Use, Base Case (therms/yr/ft)	3.8 (w/o reset)	7.9 (non recirc)	14.7 (non recirc)	6.76	15.4 (w/o reset)	24.1 (non recirc)	37.5 (non recirc)
	4.8 (w/ reset heat)	14.5 (recirc heat)	27.0 (recirc heat)		22.5 (w/ reset heat)	44.3 (recirc heat)	68.7 (recirc heat)
	6.2 (w/reset year)	25.2 (recirc year)	46.9 (recirc year)		32.7 (w/reset year)	77.0 (recirc year)	119.5 (recirc year)
Annual Gas Use, Measure case (therms/yr/ft)	0.8 (w/o reset)	1.4 (non recirc)	2.4 (non recirc)	1.73	0.7 (w/o reset)	1.1 (non recirc)	1.8 (non recirc)
	1.1 (w/ reset heat)	2.5 (recirc heat)	4.4 (recirc heat)		1.0 (w/ reset heat)	2.0 (recirc heat)	3.2 (recirc heat)
	1.4 (w/reset year)	4.4 (recirc year)	7.6 (recirc year)		1.4 (w/reset year)	3.4 (recirc year)	5.6 (recirc year)
Annual Gas Savings (therms/yr/ft)	3.0 (w/o reset)	6.5 (non recirc)	12.3 (non recirc)	5.0	14.7 (w/o reset)	23.1 (non recirc)	35.7 (non recirc)
	3.7 (w/ reset heat)	12.0 (recirc heat)	22.6 (recirc heat)		21.4 (w/ reset heat)	42.3 (recirc heat)	65.5 (recirc heat)
	4.8 (w/reset year)	20.8 (recirc year)	39.3 (recirc year)		31.3 (w/reset year)	73.6 (recirc year)	113.9 (recirc year)

Heat = heating season only, year = year round

Values below must be multiplied by the appropriate Thermal Regain Factor (TRF). 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 ( $\Delta$ therms per foot)  
(continues for 3.5 pages)**

Location	System Type	Building Type	Annual therm Savings per linear foot (therm /ft) (2" pipe / 1" insulation for hot water, 2" insulation for steam)				
			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	Assembly	1.32	1.36	1.21	0.81	1.24
		Assisted Living	1.25	1.22	1.07	0.79	0.95
		College	1.13	1.06	0.95	0.53	0.63
		Convenience Store	1.10	1.01	0.90	0.65	0.72
		Elementary School	1.32	1.29	1.13	0.78	0.95
		Garage	0.73	0.72	0.63	0.50	0.56
		Grocery	1.19	1.19	1.04	0.65	0.78
		Healthcare Clinic	1.17	1.20	1.05	0.71	0.75
		High School	1.37	1.38	1.23	0.88	1.03
		Hospital - CAV no econ	1.31	1.35	1.15	0.99	1.12
		Hospital - CAV econ	1.33	1.37	1.17	1.01	1.15
		Hospital - VAV econ	0.54	0.51	0.39	0.23	0.25
		Hospital - FCU	0.98	1.12	0.91	1.07	1.44
		Hotel/Motel	1.31	1.27	1.14	0.78	0.96
		Hotel/Motel - Common	1.19	1.21	1.15	0.93	0.98
		Hotel/Motel - Guest	1.30	1.26	1.13	0.75	0.93
		Manufacturing Facility	0.78	0.75	0.70	0.42	0.47
		MF - High Rise	1.13	1.12	1.02	0.87	0.87
		MF - High Rise - Common	1.35	1.31	1.17	0.81	1.04
		MF - High Rise - Residential	1.09	1.08	0.99	0.85	0.83
		MF - Mid Rise	1.23	1.25	1.07	0.79	0.90
		Movie Theater	1.35	1.33	1.24	0.94	1.12
		Office - High Rise - CAV no econ	1.50	1.52	1.38	0.93	1.01
		Office - High Rise - CAV econ	1.55	1.58	1.45	1.00	1.10
Office - High Rise - VAV econ	1.13	1.15	0.95	0.56	0.63		

Location	System Type	Building Type	Annual therm Savings per linear foot (therm /ft) (2" pipe / 1" insulation for hot water, 2" insulation for steam)				
			Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
		Office - High Rise - FCU	0.83	0.82	0.71	0.37	0.39
		Office - Low Rise	1.06	1.06	0.84	0.51	0.59
		Office - Mid Rise	1.17	1.18	0.99	0.63	0.70
		Religious Building	1.19	1.11	1.07	0.78	0.89
		Restaurant	1.00	1.00	0.90	0.68	0.81
		Retail - Department Store	1.03	0.95	0.89	0.58	0.66
		Retail - Strip Mall	0.99	0.91	0.81	0.56	0.60
		Warehouse	1.08	1.01	1.04	0.65	0.80
		Unknown	1.15	1.14	1.01	0.73	0.84
	Hot Water Space Heating without outdoor reset – non-recirculation	Assembly	1.96	2.00	1.79	1.19	1.83
		Assisted Living	1.84	1.80	1.58	1.16	1.40
		College	1.67	1.56	1.40	0.78	0.93
		Convenience Store	1.62	1.50	1.33	0.95	1.06
		Elementary School	1.95	1.90	1.68	1.16	1.40
		Garage	1.08	1.06	0.93	0.74	0.82
		Grocery	1.76	1.75	1.54	0.96	1.15
		Healthcare Clinic	1.73	1.77	1.55	1.05	1.11
		High School	2.02	2.03	1.82	1.30	1.52
		Hospital - CAV no econ	1.93	1.99	1.69	1.46	1.65
		Hospital - CAV econ	1.96	2.03	1.73	1.50	1.70
		Hospital - VAV econ	0.80	0.76	0.57	0.34	0.37
		Hospital - FCU	1.45	1.65	1.35	1.58	2.13
		Hotel/Motel	1.93	1.87	1.69	1.16	1.41
		Hotel/Motel - Common	1.75	1.78	1.69	1.38	1.45
		Hotel/Motel - Guest	1.92	1.86	1.66	1.11	1.37
		Manufacturing Facility	1.15	1.11	1.03	0.62	0.69
		MF - High Rise	1.67	1.65	1.50	1.28	1.28
		MF - High Rise - Common	1.99	1.93	1.73	1.19	1.54
		MF - High Rise - Residential	1.61	1.60	1.46	1.26	1.23

Location	System Type	Building Type	Annual therm Savings per linear foot (therm /ft) (2" pipe / 1" insulation for hot water, 2" insulation for steam)				
			Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
		MF - Mid Rise	1.82	1.84	1.59	1.17	1.33
		Movie Theater	1.99	1.96	1.83	1.39	1.66
		Office - High Rise - CAV no econ	2.21	2.24	2.04	1.37	1.49
		Office - High Rise - CAV econ	2.29	2.33	2.14	1.48	1.63
		Office - High Rise - VAV econ	1.67	1.70	1.40	0.83	0.93
		Office - High Rise - FCU	1.22	1.21	1.04	0.55	0.58
		Office - Low Rise	1.56	1.56	1.24	0.76	0.87
		Office - Mid Rise	1.73	1.74	1.47	0.94	1.04
		Religious Building	1.75	1.65	1.58	1.15	1.32
		Restaurant	1.48	1.48	1.33	1.01	1.19
		Retail - Department Store	1.52	1.40	1.31	0.85	0.97
		Retail - Strip Mall	1.46	1.35	1.19	0.82	0.89
		Warehouse	1.59	1.49	1.53	0.96	1.18
		Unknown	1.70	1.68	1.50	1.07	1.25
	Hot Water with outdoor reset	All buildings, Recirculation heating season only (Hours below 55F)	3.73	3.68	3.33	2.98	3.08
	Hot Water w/o outdoor reset	All buildings, Recirculation heating season only (Hours below 55F)	5.51	5.43	4.92	4.40	4.54
	Hot Water with outdoor reset	All buildings, Recirculation year round (All hours)	4.79	4.79	4.79	4.79	4.79
	Hot Water w/o outdoor reset	All buildings, Recirculation year round (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	Assembly	4.25	4.36	3.89	2.59	3.97
		Assisted Living	4.01	3.92	3.44	2.53	3.04
		College	3.64	3.40	3.04	1.69	2.02
		Convenience Store	3.52	3.26	2.89	2.07	2.32
		Elementary School	4.24	4.13	3.64	2.52	3.05
		Garage	2.34	2.31	2.03	1.62	1.79
		Grocery	3.83	3.81	3.34	2.08	2.49
		Healthcare Clinic	3.76	3.85	3.36	2.29	2.42

Location	System Type	Building Type	Annual therm Savings per linear foot (therm /ft) (2" pipe / 1" insulation for hot water, 2" insulation for steam)				
			Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
		High School	4.39	4.42	3.96	2.82	3.30
		Hospital - CAV no econ	4.20	4.33	3.69	3.17	3.60
		Hospital - CAV econ	4.25	4.41	3.76	3.26	3.70
		Hospital - VAV econ	1.74	1.65	1.24	0.75	0.81
		Hospital - FCU	3.15	3.60	2.93	3.44	4.63
		Hotel/Motel	4.19	4.07	3.67	2.51	3.07
		Hotel/Motel - Common	3.81	3.87	3.68	3.00	3.15
		Hotel/Motel - Guest	4.18	4.05	3.62	2.42	2.98
		Manufacturing Facility	2.49	2.41	2.23	1.35	1.51
		MF - High Rise	4.52	4.46	4.07	3.46	3.47
		MF - High Rise - Common	5.38	5.22	4.68	3.23	4.17
		MF - High Rise - Residential	4.37	4.34	3.94	3.41	3.33
		MF - Mid Rise	4.94	4.99	4.30	3.16	3.60
		Movie Theater	4.33	4.26	3.98	3.03	3.61
		Office - High Rise - CAV no econ	4.81	4.88	4.45	2.98	3.24
		Office - High Rise - CAV econ	4.97	5.07	4.66	3.21	3.54
		Office - High Rise - VAV econ	3.64	3.71	3.06	1.81	2.01
		Office - High Rise - FCU	2.66	2.62	2.27	1.20	1.26
		Office - Low Rise	3.40	3.39	2.69	1.65	1.89
		Office - Mid Rise	3.77	3.78	3.19	2.03	2.26
		Religious Building	3.82	3.58	3.43	2.51	2.87
		Restaurant	3.21	3.22	2.89	2.19	2.60
		Retail - Department Store	3.31	3.04	2.86	1.86	2.12
		Retail - Strip Mall	3.17	2.94	2.59	1.79	1.93
		Warehouse	3.46	3.23	3.33	2.08	2.56
		Unknown	3.70	3.66	3.26	2.34	2.71
	LP Steam	All buildings, Recirculation heating season only (Hours below 55F)	11.99	11.81	10.70	9.57	9.88
	LP Steam	All buildings, Recirculation year round (All hours)	20.84	20.84	20.84	20.84	20.84

Location	System Type	Building Type	Annual therm Savings per linear foot (therm /ft) (2" pipe / 1" insulation for hot water, 2" insulation for steam)				
			Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
	HP Steam – non-recirculation	Assembly	8.02	8.22	7.34	4.89	7.49
		Assisted Living	7.56	7.39	6.49	4.77	5.73
		College	6.87	6.42	5.73	3.18	3.81
		Convenience Store	6.65	6.14	5.45	3.91	4.37
		Elementary School	8.00	7.79	6.87	4.75	5.76
		Garage	4.42	4.35	3.82	3.05	3.38
		Grocery	7.22	7.19	6.30	3.93	4.70
		Healthcare Clinic	7.09	7.27	6.35	4.32	4.57
		High School	8.28	8.34	7.48	5.33	6.23
		Hospital - CAV no econ	7.92	8.16	6.95	5.98	6.79
		Hospital - CAV econ	8.03	8.32	7.09	6.14	6.98
		Hospital - VAV econ	3.28	3.12	2.35	1.41	1.53
		Hospital - FCU	5.95	6.79	5.53	6.50	8.73
		Hotel/Motel	7.91	7.69	6.93	4.74	5.79
		Hotel/Motel - Common	7.18	7.30	6.95	5.65	5.94
		Hotel/Motel - Guest	7.89	7.64	6.83	4.57	5.62
		Manufacturing Facility	4.70	4.55	4.22	2.55	2.84
		MF - High Rise	6.85	6.76	6.16	5.25	5.26
		MF - High Rise - Common	8.15	7.91	7.09	4.89	6.31
		MF - High Rise - Residential	6.62	6.57	5.97	5.17	5.04
		MF - Mid Rise	7.48	7.57	6.51	4.79	5.46
		Movie Theater	8.16	8.04	7.52	5.71	6.80
		Office - High Rise - CAV no econ	9.07	9.20	8.39	5.62	6.12
		Office - High Rise - CAV econ	9.38	9.57	8.80	6.06	6.67
		Office - High Rise - VAV econ	6.86	6.99	5.76	3.41	3.80
		Office - High Rise - FCU	5.02	4.95	4.27	2.27	2.38
		Office - Low Rise	6.41	6.40	5.08	3.11	3.56
		Office - Mid Rise	7.12	7.12	6.03	3.84	4.27
	Religious Building	7.20	6.75	6.46	4.73	5.41	

			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)
		Restaurant	6.06	6.08	5.46	4.13	4.90
		Retail - Department Store	6.25	5.74	5.39	3.51	4.00
		Retail - Strip Mall	5.98	5.54	4.89	3.37	3.63
		Warehouse	6.53	6.09	6.29	3.93	4.84
		Unknown	6.97	6.91	6.14	4.41	5.11
	HP Steam	All buildings, Recirculation heating season only (Hours below 55F)	22.62	22.28	20.18	18.05	18.63
	HP Steam	All buildings, Recirculation year round (All hours)	39.32	39.32	39.32	39.32	39.32

**Savings Summary for Outdoor pipe insulation by System Type and Building Type ( $\Delta$ therms per foot)  
(continues for 3.5 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)
Outdoor	Hot Water Space Heating with outdoor reset – non-recirculation	Assembly	7.58	7.77	6.94	4.62	7.08
		Assisted Living	7.14	6.98	6.13	4.51	5.42
		College	6.49	6.07	5.41	3.01	3.60
		Convenience Store	6.28	5.80	5.15	3.70	4.13
		Elementary School	7.56	7.36	6.50	4.49	5.44
		Garage	4.18	4.11	3.61	2.88	3.19
		Grocery	6.82	6.80	5.96	3.72	4.44
		Healthcare Clinic	6.70	6.87	6.00	4.09	4.32
		High School	7.83	7.88	7.07	5.03	5.89
		Hospital - CAV no econ	7.49	7.71	6.57	5.65	6.41
		Hospital - CAV econ	7.59	7.86	6.70	5.81	6.60
		Hospital - VAV econ	3.10	2.95	2.22	1.33	1.44
		Hospital - FCU	5.62	6.42	5.23	6.14	8.26
		Hotel/Motel	7.47	7.26	6.55	4.48	5.47

Location	System Type	Building Type	Annual therm Savings per linear foot (therm /ft) (2" pipe / 1" insulation for hot water, 2" insulation for steam)				
			Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
		Hotel/Motel - Common	6.79	6.90	6.57	5.34	5.61
		Hotel/Motel - Guest	7.46	7.22	6.45	4.32	5.31
		Manufacturing Facility	4.45	4.30	3.98	2.41	2.69
		MF - High Rise	6.48	6.39	5.83	4.96	4.97
		MF - High Rise - Common	7.70	7.48	6.70	4.62	5.96
		MF - High Rise - Residential	6.26	6.21	5.64	4.89	4.77
		MF - Mid Rise	7.07	7.15	6.15	4.53	5.16
		Movie Theater	7.71	7.60	7.10	5.40	6.43
		Office - High Rise - CAV no econ	8.57	8.70	7.93	5.31	5.78
		Office - High Rise - CAV econ	8.86	9.04	8.32	5.73	6.31
		Office - High Rise - VAV econ	6.48	6.61	5.45	3.22	3.59
		Office - High Rise - FCU	4.75	4.67	4.04	2.14	2.25
		Office - Low Rise	6.06	6.05	4.80	2.94	3.36
		Office - Mid Rise	6.73	6.73	5.70	3.63	4.03
		Religious Building	6.80	6.38	6.11	4.47	5.11
		Restaurant	5.73	5.75	5.16	3.90	4.63
		Retail - Department Store	5.91	5.42	5.09	3.31	3.78
		Retail - Strip Mall	5.65	5.23	4.62	3.19	3.44
		Warehouse	6.18	5.76	5.94	3.71	4.57
		Unknown	6.59	6.53	5.81	4.17	4.83
Hot Water Space Heating without outdoor reset – non-recirculation	Assembly	9.59	9.83	8.77	5.85	8.96	
	Assisted Living	9.04	8.83	7.76	5.70	6.86	
	College	8.21	7.68	6.85	3.80	4.56	
	Convenience Store	7.95	7.34	6.52	4.68	5.22	
	Elementary School	9.56	9.32	8.22	5.68	6.89	
	Garage	5.28	5.20	4.57	3.65	4.04	
	Grocery	8.63	8.60	7.54	4.70	5.62	
	Healthcare Clinic	8.47	8.70	7.59	5.17	5.47	
	High School	9.90	9.97	8.94	6.37	7.45	
	Hospital - CAV no econ	9.47	9.76	8.31	7.15	8.11	

Location	System Type	Building Type	Annual therm Savings per linear foot (therm /ft) (2" pipe / 1" insulation for hot water, 2" insulation for steam)				
			Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
		Hospital - CAV econ	9.60	9.95	8.48	7.35	8.34
		Hospital - VAV econ	3.93	3.73	2.80	1.68	1.82
		Hospital - FCU	7.11	8.12	6.61	7.77	10.45
		Hotel/Motel	9.45	9.19	8.29	5.67	6.92
		Hotel/Motel - Common	8.59	8.73	8.31	6.76	7.10
		Hotel/Motel - Guest	9.44	9.13	8.16	5.47	6.72
		Manufacturing Facility	5.63	5.44	5.04	3.05	3.40
		MF - High Rise	8.19	8.08	7.37	6.27	6.29
		MF - High Rise - Common	9.74	9.46	8.48	5.85	7.54
		MF - High Rise - Residential	7.92	7.86	7.14	6.18	6.03
		MF - Mid Rise	8.94	9.05	7.78	5.73	6.53
		Movie Theater	9.76	9.61	8.99	6.83	8.14
		Office - High Rise - CAV no econ	10.84	11.01	10.03	6.72	7.32
		Office - High Rise - CAV econ	11.21	11.44	10.52	7.25	7.98
		Office - High Rise - VAV econ	8.20	8.36	6.89	4.07	4.54
		Office - High Rise - FCU	6.00	5.91	5.11	2.71	2.84
		Office - Low Rise	7.67	7.65	6.08	3.72	4.25
		Office - Mid Rise	8.51	8.52	7.21	4.59	5.10
		Religious Building	8.61	8.07	7.73	5.66	6.47
		Restaurant	7.25	7.27	6.53	4.94	5.85
		Retail - Department Store	7.47	6.86	6.44	4.19	4.78
		Retail - Strip Mall	7.15	6.62	5.85	4.03	4.35
		Warehouse	7.81	7.29	7.52	4.69	5.78
		Unknown	8.34	8.26	7.35	5.27	6.11
	Hot Water with outdoor reset	All buildings, Recirculation heating season only (Hours below 55F)	21.38	21.06	19.07	17.06	17.61
	Hot Water without outdoor reset	All buildings, Recirculation heating season only (Hours below 55F)	27.05	26.64	24.13	21.58	22.28
	Hot Water with outdoor reset	All buildings, Recirculation year round (All hours)	31.30	31.30	31.30	31.30	31.30
	Hot Water without outdoor reset	All buildings, Recirculation year round (All hours)	47.02	47.02	47.02	47.02	47.02

Location	System Type	Building Type	Annual therm Savings per linear foot (therm /ft) (2" pipe / 1" insulation for hot water, 2" insulation for steam)				
			Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
	LP Steam – non-recirculation	Assembly	15.01	15.38	13.73	9.15	14.02
		Assisted Living	14.14	13.82	12.15	8.93	10.73
		College	12.85	12.01	10.72	5.95	7.13
		Convenience Store	12.44	11.49	10.20	7.32	8.17
		Elementary School	14.96	14.58	12.86	8.88	10.78
		Garage	8.27	8.14	7.15	5.71	6.32
		Grocery	13.51	13.46	11.80	7.36	8.79
		Healthcare Clinic	13.26	13.61	11.88	8.09	8.56
		High School	15.50	15.60	13.99	9.97	11.66
		Hospital - CAV no econ	14.82	15.27	13.01	11.19	12.70
		Hospital - CAV econ	15.02	15.57	13.27	11.50	13.06
		Hospital - VAV econ	6.14	5.84	4.39	2.64	2.85
		Hospital - FCU	11.13	12.71	10.35	12.16	16.35
		Hotel/Motel	14.80	14.38	12.97	8.87	10.84
		Hotel/Motel - Common	13.45	13.66	13.00	10.58	11.12
		Hotel/Motel - Guest	14.77	14.29	12.78	8.56	10.52
		Manufacturing Facility	8.80	8.51	7.89	4.77	5.32
		MF - High Rise	15.97	15.76	14.37	12.23	12.26
		MF - High Rise - Common	18.99	18.44	16.53	11.39	14.71
		MF - High Rise - Residential	15.43	15.31	13.92	12.05	11.75
		MF - Mid Rise	17.43	17.63	15.17	11.16	12.72
		Movie Theater	15.27	15.05	14.07	10.69	12.73
		Office - High Rise - CAV no econ	16.97	17.22	15.70	10.51	11.45
		Office - High Rise - CAV econ	17.55	17.91	16.47	11.35	12.49
		Office - High Rise - VAV econ	12.83	13.09	10.79	6.37	7.11
		Office - High Rise - FCU	9.40	9.26	8.00	4.25	4.45
		Office - Low Rise	12.00	11.97	9.51	5.82	6.66
		Office - Mid Rise	13.32	13.33	11.28	7.18	7.98
		Religious Building	13.47	12.64	12.10	8.86	10.13
		Restaurant	11.34	11.38	10.21	7.73	9.16

Location	System Type	Building Type	Annual therm Savings per linear foot (therm /ft) (2" pipe / 1" insulation for hot water, 2" insulation for steam)				
			Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
		Retail - Department Store	11.69	10.74	10.08	6.56	7.48
		Retail - Strip Mall	11.19	10.36	9.15	6.31	6.80
		Warehouse	12.23	11.40	11.77	7.35	9.05
		Unknown	13.05	12.93	11.50	8.25	9.57
	LP Steam	All buildings, Recirculation heating season only (Hours below 55F)	42.33	41.69	37.76	33.78	34.86
	LP Steam	All buildings, Recirculation year round (All hours)	73.59	73.59	73.59	73.59	73.59
	HP Steam – non-recirculation	Assembly	23.24	23.81	21.26	14.16	21.70
		Assisted Living	21.89	21.40	18.80	13.82	16.61
		College	19.90	18.60	16.60	9.22	11.04
		Convenience Store	19.26	17.79	15.79	11.33	12.65
		Elementary School	23.16	22.57	19.91	13.75	16.69
		Garage	12.80	12.60	11.08	8.84	9.78
		Grocery	20.91	20.83	18.26	11.39	13.61
		Healthcare Clinic	20.53	21.07	18.39	12.53	13.25
		High School	23.99	24.15	21.66	15.43	18.05
		Hospital - CAV no econ	22.94	23.64	20.14	17.32	19.66
		Hospital - CAV econ	23.25	24.10	20.54	17.80	20.22
		Hospital - VAV econ	9.51	9.03	6.79	4.08	4.42
		Hospital - FCU	17.24	19.67	16.02	18.82	25.31
		Hotel/Motel	22.90	22.27	20.08	13.74	16.77
		Hotel/Motel - Common	20.81	21.15	20.13	16.38	17.21
		Hotel/Motel - Guest	22.87	22.13	19.78	13.24	16.28
		Manufacturing Facility	13.63	13.18	12.21	7.38	8.24
		MF - High Rise	19.85	19.59	17.86	15.20	15.24
		MF - High Rise - Common	23.60	22.92	20.55	14.16	18.28
MF - High Rise - Residential		19.18	19.03	17.30	14.98	14.61	
MF - Mid Rise	21.67	21.92	18.86	13.87	15.81		
Movie Theater	23.64	23.29	21.78	16.55	19.71		
Office - High Rise - CAV no econ	26.27	26.66	24.30	16.28	17.73		

Location	System Type	Building Type	Annual therm Savings per linear foot (therm /ft) (2" pipe / 1" insulation for hot water, 2" insulation for steam)				
			Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville)	Zone 5 (Marion)
		Office - High Rise - CAV econ	27.16	27.72	25.49	17.57	19.33
		Office - High Rise - VAV econ	19.87	20.26	16.70	9.87	11.00
		Office - High Rise - FCU	14.54	14.33	12.38	6.57	6.89
		Office - Low Rise	18.58	18.53	14.72	9.00	10.31
		Office - Mid Rise	20.61	20.64	17.46	11.12	12.36
		Religious Building	20.85	19.56	18.72	13.71	15.67
		Restaurant	17.55	17.61	15.81	11.96	14.18
		Retail - Department Store	18.10	16.63	15.61	10.16	11.58
		Retail - Strip Mall	17.32	16.04	14.17	9.77	10.53
		Warehouse	18.93	17.65	18.21	11.37	14.02
		Unknown	20.20	20.01	17.80	12.77	14.81
	HP Steam	All buildings, Recirculation heating season only (Hours below 55F)	65.53	64.54	58.45	52.29	53.97
	HP Steam	All buildings, Recirculation year round (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 <sup>351</sup>	Straight Tee <sup>352</sup>
1"	0.10	0.13
2"	0.41	0.39
3"	0.93	0.77
4"	1.64	1.21

<sup>351</sup> Based on the dimensions for diameter, long radius, and short radius given by ANSI/ASME 36.19

<sup>352</sup> Based on the center to face and diameter dimensions given by ANSI/ASME B36.19

Nominal Pipe Diameter	Calculated Surface Area (ft)	
	90 Degree Elbow <sup>351</sup>	Straight Tee <sup>352</sup>
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<sub>oc</sub>)**

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.

**Calculated Surface Areas of Flanges and Valves**

Valves					Flanges				
Class (psi)	150	300	600	900	Class (psi)	150	300	600	900
NPS (in)	ft <sup>2</sup>	ft <sup>2</sup>	ft <sup>2</sup>	ft <sup>2</sup>	NPS (in)	ft <sup>2</sup>	ft <sup>2</sup>	ft <sup>2</sup>	ft <sup>2</sup>
1	0.69	1.8	1.8	2.4	1	0.36	0.36	0.4	1.23
2	2.21	2.94	2.94	5.2	2	0.71	0.84	0.88	1.54
2.5	2.97	3.51	3.91	6.6					
3	3.37	4.39	4.69	6.5	3	1.06	1.32	1.36	1.85
4	4.68	6.06	7.64	9.37	4	1.44	1.83	2.23	2.64
6	7.03	9.71	13.03	15.8	6	2.04	2.72	3.6	4.37

Valves				
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				
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<sub>oc</sub>)**

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-V03-150601**

#### 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.<sup>353</sup>

##### DEEMED MEASURE COST

The incremental capital cost for this measure is assumed to be \$100 per ton.<sup>354</sup>

##### 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.

$$\begin{aligned} CF_{SSP} &= \text{Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)} \\ &= 91.3\% \end{aligned} \quad ^{355}$$

---

<sup>353</sup> Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, Inc., June 2007.

<sup>354</sup> 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

---

$$\begin{aligned} CF_{PJM} &= \text{PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)} \\ &= 47.8\%^{356} \end{aligned}$$

---

---

**Algorithm**

---

---

**CALCULATION OF SAVINGS**

**ELECTRIC ENERGY SAVINGS**

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

$$\Delta kWH = (\text{kBtu/hr}) * [(1/SEER_{base}) - (1/SEER_{ee})] * EFLH$$

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

$$\Delta kWH = (\text{kBtu/hr}) * [(1/EER_{base}) - (1/EER_{ee})] * EFLH$$

Where:

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

SEER<sub>base</sub> = Seasonal Energy Efficiency Ratio of the baseline equipment; see table below for default values<sup>357</sup>:

---

<sup>355</sup> 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.

<sup>356</sup> 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

<sup>357</sup> 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 <sup>a</sup>
				Before 6/1/2011	As of 6/1/2011	
Air conditioners, air cooled	< 65,000 Btu/h <sup>b</sup>	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 <sup>b</sup>	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 <sup>b</sup>	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 <sup>b</sup>	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 <sup>a</sup>
				Before 6/1/2011	As of 6/1/2011	
Air conditioners, evaporatively cooled	< 65,000 Btu/h <sup>b</sup>	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	
		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.

- SEER<sub>ee</sub> = Seasonal Energy Efficiency Ratio of the energy efficient equipment (actually installed).
- EER<sub>base</sub> = Energy Efficiency Ratio of the baseline equipment; see table above for default values. Since IECC 2012 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
- EER<sub>ee</sub> = Energy Efficiency Ratio of the energy efficient equipment. For air-cooled air conditioners < 65 kBtu/hr, if the actual EER<sub>ee</sub> 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 at a retail strip mall in Rockford would save

$$\begin{aligned} \Delta \text{kWh} &= (60) * [(1/13) - (1/15)] * 950 \\ &= 585 \text{ kWh} \end{aligned}$$

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

$$\Delta \text{kW}_{SSP} = (\text{kBtu/hr} * (1/\text{EER}_{base} - 1/\text{EER}_{ee})) * \text{CF}_{SSP}$$

$$\Delta \text{kW}_{PJM} = (\text{kBtu/hr} * (1/\text{EER}_{base} - 1/\text{EER}_{ee})) * \text{CF}_{PJM}$$

Where:

$CF_{SSP}$  = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)  
= 91.3%<sup>358</sup>

$CF_{PJM}$  = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)  
= 47.8%<sup>359</sup>

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

$$\begin{aligned}\Delta kW_{SSP} &= (60) * [(1/13) - (1/15)] * .913 \\ &= 0.562\end{aligned}$$

#### **NATURAL GAS ENERGY SAVINGS**

N/A

#### **WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**MEASURE CODE: CI-HVC-SPUA-V03-150601**

---

<sup>358</sup> 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.

<sup>359</sup> 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

### 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<sup>360</sup>

### DEEMED MEASURE COST

Steam System	Cost per trap <sup>361</sup> (\$)
Commercial Dry Cleaners	77
Commercial Heating (including Multifamily), low pressure steam	77
Industrial Medium Pressure >15 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

<sup>360</sup>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 an 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.

<sup>361</sup>Ibid.

Steam System	Cost per trap <sup>361</sup> (\$)
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**

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

Where:

S = Maximum theoretical steam loss per trap

Steam System	Avg Steam Loss <sup>362</sup> (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

---

<sup>362</sup> CLEAResult "Steam Traps Revision #1" dated August 2011.

Hv = Heat of vaporization of steam

Steam System	Heat of Vaporization <sup>363</sup> (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

B = Boiler efficiency

= custom, if unknown:

= 80.7% for steam boilers, except multifamily low-pressure<sup>364</sup>

= 64.8% for multifamily low-pressure steam boilers<sup>365</sup>

Hours = Annual operating hours of steam plant

Steam System	Zone (where applicable)	Hours/Yr <sup>366</sup>
Commercial Dry Cleaners	n/a	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

<sup>363</sup> 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 CLEARResult"Steam Traps Revision #1" dated August 2011.

<sup>364</sup> Ibid.

<sup>365</sup> Katrakis, J. and T.S. Zawacki. "Field-Measured Seasonal Efficiency of Intermediate-sized Low-Pressure Steam Boilers". ASHRAE V99, pt. 2, 1993.

<sup>366</sup> CLEARResult"Steam Traps Revision #1" dated August 2011, which references Enbridge service territory data and kW Engineering study.

Steam System	Zone (where applicable)	Hours/Yr <sup>366</sup>
Steam Trap, Industrial High Pressure $\geq 250$ psig		7,752
Industrial Medium Pressure $>15$ psig $< 30$ psig		7,752
Steam Trap, Industrial Medium Pressure $\geq 30 < 75$ psig		7,752
Commercial Heating (including Multifamily)LPS <sup>367</sup>	1 (Rockford)	4,272
	2 (Chicago O'Hare)	4,029
	3 (Springfield)	3,406
	4 (Belleville)	2,515
	5 (Marion)	2,546

A = Adjustment factor  
 = 50%<sup>368</sup>

This factor is to account for reducing the maximum theoretical 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 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	% <sup>369</sup>
Custom	Custom
Commercial Dry Cleaners	27%
Industrial Low Pressure $\leq 15$ psig	16%
Industrial Medium and High Pressure $>15$ psig	16%
Commercial Heating (including Multifamily) LPS	27%

<sup>367</sup> Since commercial LPS reflect heating systems, Hours/yr are equivalent to HDD55 zone table

<sup>368</sup> 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.

<sup>369</sup> Dry cleaners survey data as referenced in CLEAResult "Steam Traps Revision #1" dated August 2011.

**EXAMPLE**

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

$$\Delta\text{Therms} = S * (\text{Hv}/\text{B}) * \text{Hours} * A * L$$

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

$$138.8 \text{ therms per trap}$$

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

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

#### 4.4.17 Variable Speed Drives for HVAC Pumps and Cooling Tower Fans

##### 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. There is a separate measure for HVAC supply and 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 2012 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;<sup>370</sup> measure life for process is 10 years.<sup>371</sup>

##### DEEMED MEASURE COST

Customer provided costs will be used when available. Default measure costs<sup>372</sup> 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
15 HP	\$ 2,518
20 HP	\$ 3,059

---

<sup>370</sup> Efficiency Vermont TRM 10/26/11 for HVAC VSD motors

<sup>371</sup> DEER 2008

<sup>372</sup> 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.

**LOADSHAPE**

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**

$$\Delta kWh = BHP / EFFi * Hours * ESF$$

Where:

BHP = System Brake Horsepower  
(Nominal motor HP \* Motor load factor)

Motors are assumed to have a load factor of 65% for calculating kW if actual values cannot be determined<sup>373</sup>. Custom load factor may be applied if known.

EFFi = Motor efficiency, installed. Actual motor efficiency shall be used to calculate kW. If not known a default value of 93% shall be used.<sup>374</sup>

Hours = Default hours are provided for HVAC applications which vary by HVAC application and building type<sup>375</sup>. When available, actual hours should be used.

Building Type	Pumps and fans
College/University	4216
Grocery	5840
Heavy Industry	3585
Hotel/Motel	6872

---

<sup>373</sup> Del Balso, Ryan J. "Investigation into the Reliability of Energy Efficiency/Demand Side Management Savings Estimates for Variable Frequency Drives in Commercial Applications", University of Colorado, Department of Civil, Environmental and Architectural Engineering, 2013.

<sup>374</sup> Ohio TRM 8/6/2010 pp207-209, Com Ed TRM June 1, 2010.

<sup>375</sup> ComEd Trm June 1, 2010 page 139. The Office hours is based upon occupancy from the eQuest model developed for EFLH, since it was agreed the ComEd value was too low.

Building Type	Pumps and fans
Light Industry	2465
Medical	6871
Office	2301
Restaurant	4654
Retail/Service	3438
School(K-12)	2203
Warehouse	3222
Average = Miscellaneous	4103

ESF = Energy savings factor varies by VFD application. Units are kW/HP.

Application	ESF <sup>376</sup>
Hot Water Pump	0.424
Chilled Water Pump	0.411
Air Foil/backward incline	0.354
Air Foil/ backward incline 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

$$\Delta kW = BHP/EFFi * DSF$$

Where:

DSF = Demand Savings Factor varies by VFD application.<sup>377</sup> Units are kW/HP. Values listed below are based on typical peak load for the listed application.

Application	DSF
Hot Water Pump	0
Chilled Water Pump	0.299
Air foil / backward incline	0.260
Air Foil / backward incline inlet Guide Vanes	0.130
Forward Curved Fan, with discharge dampers	0.136

<sup>376</sup> Ibid.

<sup>377</sup> Ibid

Application	DSF
Forward Curved Inlet Guide Vanes	0.029

**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-VSDHP-V02-150601**

## 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<sup>378</sup> based upon equipment life only<sup>379</sup>. 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 and labor cost for this measure is assumed to be \$181 per thermostat<sup>380</sup>. For the purposes of screening and planning it should be assumed that one thermostat will serve 5 tons of Cooling Capacity at a cost of \$36.20 / ton or 115kBtuh of Heating Capacity at a cost of \$1.57 / kBtu.

### LOADSHAPE

N/A

---

<sup>378</sup> Table 1, HVAC Controls, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

<sup>379</sup> 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.

<sup>380</sup> 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<sup>381</sup>**

$$\Delta kWh = [\text{Baseline Energy Use (kWh/Ton)} - \text{Proposed Energy Use (kWh/Ton)}] * \text{Cooling Capacity (Tons)}$$

The following equations are used to calculate baseline and proposed electric energy use. The savings is the difference between the proposed and baseline calculated usage. This approach allows the savings estimate to account for the operational attributes of the baseline as well as the proposed case, yielding a better estimate than an approach that assumes a particular baseline or proposed energy use to determine savings.

**Electric Energy Use Equations (kWh / ton)**

Building Type	Fan Mode During Occupied Period (Fo)	Equation
Assembly	Continuous	$CZ+Fu*(0.83*Tc+0.83*Th+1.67*Ws-293.018)-0.0922*Tc*Th+1.291*Ws$
	Intermittent	$CZ+Fu*(1.911-0.12*Tc)+Tc*(0.00311*Ws-0.229)+0.11*Ws$
Convenience Store	Continuous	$CZ+Fu*(-28.629*Tc-11.69*Th+19.118*Ws-2935.12)+0.909*Ws$
	Intermittent	$CZ+Tc*(0.0863*Ws-12.688)+Th*(0.043*Ws-6.38)+1.669*Ws$
Office – Low Rise	Continuous	$CZ+Fu*(7.082*Tc-41.199*Th+18.734*Ws-3288.55)+Tc*(0.205*Ws-34.929)$
	Intermittent	$CZ+Tc*(0.0806*Ws-8.984)+Th*(0.0864*Ws-9.558)+1.178*Ws$
Religious	Continuous	$CZ+Fu*(-1.579*Tc-18.14*Th+15.01*Ws-2417.74)+Tc*(0.177*Ws-26.412)$
	Intermittent	$CZ+Fu*(0.266*Tc-2.067)+Tc*(0.0295*Ws-4.502)+Th*(0.0517*Ws-8.251)+0.735*Ws$
Restaurant – Fast Food	Continuous	$CZ+Fu*(0.678*Tc+0.257*Th+2.88*Ws-494.006)+Tc*(0.0231*Ws-4.074)+Th*(0.00936*Ws-1.655)+0.918*Ws$
	Intermittent	$CZ+Fu*(0.377*Tc+0.124*Th+0.13*Ws-24.893)+Tc*(-0.0143*Th+0.0166*Ws-2.691)+0.898*Ws$
Restaurant – Full Service	Continuous	$CZ+Fu*(-8.41*Th+11.766*Ws-1910.81)+Tc*(0.282*Ws-43.851)$
	Intermittent	$CZ+0.123*Fu*Tc+Tc*(0.0561*Ws-8.237)+Th*(0.0219*Ws-3.284)+1.038*Ws$
Retail – Department Store	Continuous	$CZ+Fu*(-1.475*Th+0.755*Ws-114.373)+Th*(0.151*Ws-24.016)+1.612*Ws$
	Intermittent	$CZ+Tc*(0.0173*Ws-1.912)+Th*(0.0249*Ws-3.29)+0.511*Ws$
Retail – Strip	Continuous	$CZ+Fu*(1.077*Tc-10.697*Th+6.91*Ws-1117.18)+Tc*(0.0583*Ws-7.54)+1.231*Ws$

<sup>381</sup> Savings equations and factors determined by regression of results of a series of eQuest simulations. See Programmable T-Stat Work Paper\_PECI\_FinalDraft\_140730\_Redline.docx for details.

Building Type	Fan Mode During Occupied Period (Fo)	Equation
Mall	Intermittent	$CZ+0.0894*Fu*Tc+Th*(-0.0142*Tc+0.04*Ws-5.278)+0.884*Ws$

Where:

- CZ = Climate Zone Coefficient  
=Depends on Building Type and Fan Mode During Occupied Period (see table below)
- Tc = Degrees of Cooling Setback °F  
= Must be between 0-15°F
- Th = Degrees of Heating Setback °F  
=Must be between 0-15°F
- Fo = Fan Mode During Occupied Period (Note: Commercial mechanical code requires continuous fan operation during occupied periods to meet ventilation requirements.)  
= Continuous for occupied fan that runs continuously (e.g. Fan Mode Set to 'On')  
= Intermittent for occupied fan that runs intermittently (e.g. Fan Mode Set to 'Auto')
- Fu = Fan Mode During Unoccupied Period  
= 0 for unoccupied fan that runs continuously (e.g. Fan Mode Set to 'On')  
= 1 for unoccupied fan that runs intermittently (e.g. Fan Mode Set to 'Auto')
- Ws = Weekly Hours thermostat is in Occupied mode  
= Minimum values depends on Building Type (see table below), maximum value of 168 (24/7)  
(e.g.: Weekly occupancy schedule of Mon-Sat 8AM-5PM, Sun 9AM-2PM, Ws = 59)

**Electric Energy Use Climate Zone Coefficients and Minimum Weekly Hours Occupied**

Building Type	Fan Mode During Occupied Period (Fo)	Climate Zone Coefficient (CZ) <sup>382</sup>					Minimum Ws
		1	2	3	4	5	
Assembly	Continuous	911.366	928.924	1152.83	1208.999	1210.173	98
	Intermittent	735.752	762.831	966.562	998.927	1028.906	
Convenience Store	Continuous	4817.094	4832.784	5139.133	5182.161	5208.608	108
	Intermittent	1478.133	1514.568	1784.384	1843.463	1930.47	
Office - Low Rise	Continuous	5047.662	5039.592	5187.924	5217.672	5177.449	55
	Intermittent	825.072	808.965	946.571	979.421	945.418	

<sup>382</sup> Climate Zones Referenced in Section 3.7, Table 3.6

Building Type	Fan Mode During Occupied Period (Fo)	Climate Zone Coefficient (CZ) <sup>382</sup>					Minimum W/s
		1	2	3	4	5	
Religious Facility	Continuous	4197.117	4172.858	4380.025	4370.008	4356.054	133
	Intermittent	632.404	603.395	678.294	664.717	616.853	
Restaurant – Fast Food	Continuous	1342.988	1378.661	1664.018	1714.201	1727.841	108
	Intermittent	993.764	1039.643	1307.8	1340.544	1389.791	
Restaurant – Full Service	Continuous	4070.35	4094.742	4428.966	4501.829	4522.522	117
	Intermittent	1472.014	1516.05	1856.108	1938.441	2056.45	
Retail – Department Store	Continuous	1510.201	1496.47	1706.105	1716.128	1688.464	93
	Intermittent	701.27	702.129	847.735	875.12	881.677	
Retail – Strip Mall	Continuous	1926.294	1930.137	2156.856	2174.435	2165.03	93
	Intermittent	656.479	673.257	835.906	850.322	869.921	

**EXAMPLE**

A low rise office in Rockford (Climate Zone 1) is occupied Mon-Fri 7AM-6PM and has a 10 ton DX RTU controlled by a manual thermostat. The fan runs continuously during the occupied hours and building staff do not manually change the fan mode, cooling or heating setpoints during unoccupied periods.

A programmable thermostat is installed by a contractor who sets the occupied schedule to Mon-Fri 7AM-6PM with a 10°F cooling and heating unoccupied temperature setback. The contractor also programs the fan to operate continuously during the occupied periods and to intermittent “auto” during the unoccupied periods.

$$\Delta kWh = [\text{Baseline Energy Use (kWh/Ton)} - \text{Proposed Energy Use (kWh/Ton)}] * \text{Cooling Capacity (Tons)}$$

$$\text{Baseline Energy Use (kWh/Ton)} = \text{Equation for Office Low Rise, } Fo = \text{Continuous}$$

$$= CZ + Fu * (7.082 * Tc - 41.199 * Th + 18.734 * Ws - 3288.55) + Tc * (0.205 * Ws - 34.929)$$

$$= 5047.662 + 0 * (7.082 * 0 - 41.199 * 0 + 18.734 * 168 - 3288.55) + 0 * (0.205 * 168 - 34.929)$$

$$= 5,047.662 \text{ kWh/Ton}$$

$$\text{Proposed Energy Use (kWh/Ton)} = \text{Equation for Office Low Rise, } Fo = \text{Continuous}$$

$$= CZ + Fu * (7.082 * Tc - 41.199 * Th + 18.734 * Ws - 3288.55) + Tc * (0.205 * Ws - 34.929)$$

$$= 5047.662 + 1 * (7.082 * 10 - 41.199 * 10 + 18.734 * 55 - 3288.55) + 10 * (0.205 * 55 - 34.929)$$

$$= 2,211.722 \text{ kWh/Ton}$$

$$\Delta kWh = [5,047.622 \text{ (kWh/Ton)} - 2,211.722 \text{ (kWh/Ton)}] * 10 \text{ Tons}$$

$$= 2,835.89 \text{ kWh/Ton} * 10 \text{ Tons}$$

$$= 28,358.9 \text{ kWh}$$

**SUMMER COINCIDENT PEAK DEMAND SAVINGS**

N/A

**NATURAL GAS ENERGY SAVINGS**

$$\Delta\text{Therms} = [\text{Baseline Energy Use (Therms/kBtuh)} - \text{Proposed Energy Use(Therms/kBtuh)}] * \text{Output Heating Capacity (kBtuh)}$$

The following equations are used to calculate baseline and proposed natural gas energy use. The savings is the difference between the proposed and baseline calculated usage. This approach allows the savings estimate to account for the operational attributes of the baseline as well as the proposed case, yielding a better estimate than an approach that assumes a particular baseline or proposed energy use to determine savings.

**Natural Gas Energy Use Equations (therms / kbtu output)**

Building Type	Fan Mode During Occupied Period (Fo)	Equation
Assembly	Continuous	$CZ+Fu*(0.232*Th+0.0984*Ws-18.79)+Th*(0.00271*Ws-0.535)+0.0142*Ws$
	Intermittent	$CZ+Fu*(0.00405*Th+0.000519*Ws-0.11)+Th*(0.0000689*Ws-0.0118)+0.0022*Ws$
Convenience Store	Continuous	$CZ+Fu*(0.00545*Th-0.00251*Ws+0.416)+Th*(0.000123*Ws-0.0204)+0.00183*Ws$
	Intermittent	$CZ+Fu*(0.00231*Th-0.0349)+Th*(0.000309*Ws-0.0494)+0.00266*Ws$
Office – Low Rise	Continuous	$CZ+Fu*(0.0205*Th+0.364)+Th*(0.00046*Ws-0.0554)+0.00169*Ws$
	Intermittent	$CZ+Fu*(0.00745*Th-0.142)+Th*(0.00077*Ws-0.111)+0.00199*Ws$
Religious	Continuous	$CZ+0.00791*Fu*Th+Th*(0.00096*Ws-0.167)+0.00184*Ws$
	Intermittent	$CZ+Fu*(0.00143*Th-0.0309)+Th*(0.0008*Ws-0.134)+0.00219*Ws$
Restaurant – Fast Food	Continuous	$CZ+Fu*(0.0431*Th+0.0424*Ws-7.517)+Th*(0.00113*Ws-0.213)+0.0119*Ws$
	Intermittent	$CZ+Fu*(0.0125*Th+0.0036*Ws-0.71)+Th*(0.000329*Ws-0.0615)+0.00738*Ws$
Restaurant –Full Service	Continuous	$CZ+Fu*(0.00445*Ws-0.535)+Th*(0.000679*Ws-0.1)+0.00218*Ws$
	Intermittent	$CZ+Fu*(0.00144*Th+0.000262*Ws-0.0553)+Th*(0.00018*Ws-0.0299)+0.00166*Ws$
Retail – Department Store	Continuous	$CZ+0.00203*Fu*Th+Th*(0.000591*Ws-0.0812)+0.00194*Ws$
	Intermittent	$CZ+Th*(0.000406*Ws-0.0611)+0.00228*Ws$
Retail – Strip Mall	Continuous	$CZ+Fu*(0.00998*Th+0.00207*Ws-0.206)+Th*(0.000665*Ws-0.101)+0.00292*Ws$
	Intermittent	$CZ+Fu*(0.00383*Th-0.0656)+Th*(0.000575*Ws-0.0912)+0.00249*Ws$

Where:

- CZ = Climate Zone Coefficient  
= Depends on Building Type and Fan Mode During Occupied Period (see table below)
- Th = Degrees of Heating Setback °F  
= Must be between 0-15°F

- Fo = Fan Mode During Occupied Period (Note: Commercial mechanical code requires continuous fan operation during occupied periods to meet ventilation requirements.)
  - = Continuous for occupied fan that runs continuously (e.g. Fan Mode Set to 'On')
  - = Intermittent for occupied fan that runs intermittently (e.g. Fan Mode Set to 'Auto')
- Fu = Fan Mode During Unoccupied Period
  - = 0 for unoccupied fan that runs continuously (e.g. Fan Mode Set to 'On')
  - = 1 for unoccupied fan that runs intermittently (e.g. Fan Mode Set to 'Auto')
- Ws = Weekly Hours thermostat is in Occupied mode
  - = Minimum values depends on Building Type (see table below), maximum value of 168 (24/7)
  - (e.g.: Weekly occupancy schedule of Mon-Sat 8AM-5PM, Sun 9AM-2PM, Ws = 59)

**Natural Gas Energy Use Climate Zone Coefficients and Minimum Weekly Hours Occupied**

Building Type	Fan Mode During Occupied Period (Fo)	Climate Zone Coefficient (CZ)					Minimum Ws
		1	2	3	4	5	
Assembly	Continuous	19.872	17.83	15.828	15.282	13.482	98
	Intermittent	0.237	0.0989	0.0267	-0.0131	-0.0871	
Convenience Store	Continuous	1.493	1.081	0.782	0.544	0.114	108
	Intermittent	1.128	0.854	0.619	0.437	0.0854	
Office - Low Rise	Continuous	1.718	1.317	0.971	0.739	0.319	55
	Intermittent	3.447	3.022	2.503	2.251	1.646	
Religious Facility	Continuous	6.294	5.55	4.678	4.202	3.122	133
	Intermittent	5.914	5.368	4.557	4.137	3.246	
Restaurant – Fast Food	Continuous	8.383	7.211	6.034	5.767	4.71	108
	Intermittent	1.227	0.636	0.302	0.102	-0.262	
Restaurant – Full Service	Continuous	5.247	4.484	3.753	3.465	2.627	117
	Intermittent	0.951	0.704	0.51	0.381	0.0746	
Retail – Department Store	Continuous	4.385	3.854	3.192	2.784	1.858	93
	Intermittent	3.061	2.672	2.182	1.829	1.008	
Retail – Strip Mall	Continuous	3.917	3.394	2.728	2.394	1.617	93
	Intermittent	2.659	2.292	1.811	1.543	0.909	

**WATER IMPACT DESCRIPTIONS AND CALCULATION**

N/A

**DEEMED O&M COST ADJUSTMENT CALCULATION**

N/A

**MEASURE CODE: CI-HVC-PROG-V02-150601**

