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Deemed and Simplified M&V Guidelines for Replacement of Cooling Equipment

3.1 Overview

Cooling equipment retrofits involve the replacement of the existing equipment with high-efficiency equipment. This chapter presents both a deemed savings approach and a simple approach to the measurement and verification of savings from the retrofit of cooling equipment. In general, the measurement and verification (M&V) methods described in this chapter can be used for projects involving the one-for-one change-out of cooling equipment. Potential qualifying equipment includes:

- Unitary air conditioners (DX, air-cooled, evaporative, or water-cooled)
- Heat pumps (air-cooled, evaporative, or water-cooled)
- Chillers (air-cooled centrifugal, water-cooled centrifugal, air-cooled screw, etc.)
- Compressors (centrifugal, screw, reciprocating)
- Fuel switching from electric to gas-driven cooling equipment

The retrofits must have the following characteristics:

- The newly installed electric cooling equipment capacity must be within **80%** to **120%** of the replaced electric cooling equipment capacity.
- No additional measures are being installed that directly affect the operation of the cooling equipment (i.e., control sequences, cooling towers, condensers).

If the proposed retrofit does not meet these requirements, refer to the Full M&V guidelines presented in Chapters 7, 8, and 9 for appropriate M&V techniques.

The baseline efficiency used in the savings calculation is based on ASHRAE Standard 90.1-1989. Efficiency values from this standard can be found in the Standard Cooling Equipment Tables, Appendix A.

3.2 Deemed Savings for Cooling Equipment

The *deemed savings* approach to M&V for cooling equipment is applicable to both one-for-one equipment replacement as well as equipment replacement involving a change in equipment type, e.g. changing from air-cooled DX units to a water-cooled chiller.

Projects that are eligible to use the deemed savings approach meet the following requirements:

- The existing and proposed cooling equipment are electric.
- Coefficients are listed in Table A.10 for the type of building in which the retrofit occurs and the type of equipment involved.
- The building falls into one of the categories described in Table 3.1.

Table 3.1: Building descriptions for use in the air-conditioning equipment deemed savings M&V methodology

Building Type	Description
Religious Worship	A religious worship building that experiences full operation on Sundays, and a partial schedule on weekdays and Saturdays.
College	A multi-story college building that operates a full day five days per week and a partial day on weekends.
Convenience	A small convenience store that operates 24 hours per day, 7 days per week.
Fast-Food	A small fast food restaurant that operates a full day, seven days per week. Generally smaller than 3,000 sq. ft.
Grocery	Typical supermarket that operates between 16 and 24 hours per day, 7 days per week.
Hospital	A multi-story hospital building that operates 24 hours per day, 7 days per week.
Hotel	A typical multi-story hotel that operates 24 hours per day, 7 days per week. Usually larger than 50,000 sq. ft.
Motel	A low rise motel that operates 24 hours per day, 7 days per week. Usually smaller than 50,000 sq. ft.
Nursing Home	An assisted care facility that operates 24 hours per day, 7 days per week.
Office, Large	Typical multi-story office building that operates 12 to 16 hours per day, Monday through Friday, a half day on Saturday and a few hours on Sunday. Applicable for buildings greater than 50,000 sq. ft.
Office, Small	Typical low rise office building that is operated mostly Monday through Friday and a minimal number of hours on Saturday and Sunday. Applicable for buildings up to 50,000 sq. ft.
Public Assembly	A large public assembly building that operates on a partial schedule all days.
Retail	Retail store that operates typical business hours Monday through Saturday and a reduced day on Sundays.
Restaurant	Typical small restaurant operating full day six days per week with a reduced schedule on Sundays. Generally larger than 3,000 sq. ft.
School	A low rise elementary or high school that operates all day Monday through Friday, 50 weeks per year.
Service	A light commercial building that operates a full day six days per week. Examples include beauty parlors, automotive shops and so on.
Warehouse, Non Refrig.	A conditioned warehouse, not refrigerated, that operates 24 hours/ day, 7 days per week.

Table A.10 does not list coefficients for every type of cooling equipment in every building type. For example, the deemed savings M&V approach is not intended for use with retrofits

involving water-cooled chillers in small building types such as convenience stores and fast food restaurants because water-cooled chillers are uncommon in these types of buildings.

3.2.1 Pre-Installation M&V Activities

3.2.1.1 Pre-Installation Site Survey

The goals of the pre-installation site survey are to identify the cooling equipment and establish the baseline efficiency. The information collected should include: equipment type, year, make/model, rated capacity, rated efficiency. Record information about the cooling equipment in CalcSmart.

The baseline efficiency is determined by comparing the rated efficiency of the existing unit to the minimum efficiency listed in the Standard Cooling Equipment Table, which are based on ASHRAE 90.1-1989, provided in Appendix A. The baseline efficiency is equal to the more efficient of the two values.

3.2.1.2 Pre-Installation Inspection

CenterPoint Energy or its contractor will conduct a pre-installation inspection to verify that the Sponsor has properly documented the baseline in the FA. **Demolition or removal of existing equipment and/or installation of new equipment cannot commence until the pre-installation inspection is completed and CenterPoint Energy has issued the Project Authorization.**

3.2.1.3 Pre-Installation Performance Monitoring

The deemed savings M&V procedure for electric-to-electric cooling equipment replacements does not require pre-installation monitoring of existing equipment. The existing equipment efficiency is determined from the Standard Cooling Equipment Tables, Appendix A. The existing equipment load and operating schedule are assumed to be the same as those of a typical facility in a specific building type group.

3.2.2 Post-Installation M&V Activities

3.2.2.1 Post-Installation Equipment Survey

Once the retrofit is complete, the Sponsor conducts and submits a post-installation equipment survey as part of the Installation Report (IR). The survey should include: installed equipment type, year, make/model, rated capacity, and rated efficiency. Record information about the cooling equipment in CalcSmart.

The Sponsor must submit manufacturer's documentation of the rated efficiency of all newly installed cooling equipment, based upon ARI test conditions. This documentation will be in the form of manufacturer cut sheets or factory performance test results that document the part load performance of the equipment.

3.2.2.2 Post-Installation Inspection

CenterPoint Energy or its contractor will conduct a post-installation inspection to verify that the equipment was installed as reported and is documented accurately.

3.2.3 Deemed Savings Calculations

The deemed savings methodology involves the application of two mathematical equations shown in Equation 3.1 and Equation 3.2. CalcSmart applies these equations automatically to calculate savings for retrofits of cooling equipment.

Equation 3.1: Calculation of peak demand savings for cooling equipment

$$kW_{\text{savings}} = \text{Tons} * (a \cdot \eta_{\text{baseline}} - b \cdot \eta_{\text{post-installation}})$$

Where:

kW_{savings}	=	Calculated demand savings
Tons	=	The rated equipment cooling capacity at ARI standard conditions
a	=	The demand coefficient from table A.10 in the Appendix for the appropriate climate zone, building type and baseline equipment type
η_{baseline}	=	Efficiency of the baseline equipment (kW/Ton)
b	=	The demand coefficient from table A.10 in the Appendix for the appropriate climate zone, building type and retrofit equipment type
$\eta_{\text{post-installation}}$	=	Rated efficiency of the installed equipment (kW/Ton)

Equation 3.2: Calculation of energy savings for cooling equipment

$$kWh_{\text{savings}} = \text{Tons} * (c \cdot \eta_{\text{baseline}} - d \cdot \eta_{\text{post-installation}})$$

Where:

kWh_{savings}	=	Calculated energy savings
Tons	=	The rated equipment cooling capacity at ARI standard conditions
c	=	The energy coefficient from table A.10 in the Appendix for the appropriate climate zone, building type and baseline equipment type
η_{baseline}	=	Efficiency of the baseline equipment (kW/Ton)
d	=	The energy coefficient from table A.10 in the Appendix for the appropriate climate zone, building type and retrofit equipment type
$\eta_{\text{post-installation}}$	=	Rated efficiency of the installed equipment (kW/Ton)

To calculate savings for cooling equipment retrofits using the deemed savings methodology, follow these steps:

1. Determine the applicable baseline efficiency for the existing equipment in kW/ton (η_{baseline}). Record either the minimum baseline efficiency (ASHRAE 90.1-1989), or the actual full load rated efficiency if it is better than ASHRAE 90.1-1989.

Use the following conversions to get kW/Ton where necessary¹:

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

$$\text{kW/ton} = 3.517 / \text{COP}$$

$$\text{kW/ton} = 12 / (\text{SEER} * 0.697 + 2.0394)$$

2. Determine the applicable efficiency for the new equipment in kW/ton ($\eta_{\text{post-installation}}$).
3. Determine the applicable equipment capacity (*Tons*). Record the lesser of the existing unit tonnage or the replacement unit tonnage.
4. Determine the applicable demand and energy coefficients (*a*, *b*, *c*, and *d*). Go to table A.10 in Appendix A. Look up the demand and energy coefficients for the appropriate building and equipment type.
5. Use equations 3.1 and 3.2 to calculate peak demand and energy savings.

Example

A 150-ton air-cooled packaged unit in a retail application is being replaced with a more efficient unit (of similar size and type) in Galveston, TX.

Step 1 The Sponsor finds the appropriate baseline efficiency from Appendix A, Table A.6. A 150-ton air-cooled packaged unit has an EER of 8.2. Using the conversion, kW/Ton = 12/EER, the sponsor finds that $\eta_{\text{baseline}} = 1.46$ kW/Ton.

Step 2 The manufacturer’s data for the new equipment shows that the EER = 9.5. Using the conversion, kW/Ton = 12/EER, the sponsor finds that $\eta_{\text{post-installation}} = 1.26$ kW/Ton.

Step 3 The existing and new packaged units are each 150-ton units.

Step 4 The sponsor looks in Appendix A, Table A.10 to find the appropriate coefficients. The demand coefficient for a retail building with a DX air-cooled unit in Galveston is 0.80, so $a = b = 0.84$. The energy coefficient for a retail building with a DX air-cooled unit in Galveston is 2,003, so $c = d = 2,381$.

Step 5 By inserting the information gathered in Steps 1-4 into Equations 3.1 and 3.2, the Sponsor calculates the savings:

$$kW_{\text{savings}} = 150 * (0.84 * 1.46 - 0.84 * 1.26) = 25.2\text{kW}$$

$$kWh_{\text{savings}} = 150 * (2,381 * 1.46 - 2,381 * 1.26) = 71,430 \text{ kWh}$$

In some cases where a piece of cooling equipment is replaced with a different type of cooling equipment, adjustments must be made to the savings calculations. The replacement of an air-cooled machine with a water-cooled machine is an example. In this case, the savings calculations must consider the additional auxiliary loads for the condenser water pump and the cooling tower fan. Energy and peak demand savings will need to be adjusted downward to account for the peak demand and energy consumption of the auxiliary equipment. The next example, below, provides an illustration of the required calculation. The Project Sponsor must include information about the auxiliary equipment in the required SOP submittals.

¹ The conversion from SEER to kW/ton is an approximation based on published data from the Carrier Corporation.

Example

A 200 ton air-cooled chiller with condenser is replaced with a water-cooled chiller of the same size in a large office building in Houston, TX.

Step 1 The Sponsor finds the appropriate baseline efficiency from Appendix A, Table A.7. A 200-ton air-cooled chiller with condenser has an COP = 2.50. Using the conversion, kW/ton = 3.517 / COP, the sponsor finds that $\eta_{baseline} = 1.407$ kW/Ton.

Step 2 The manufacturer's data for the new equipment shows that the COP = 4.9. Using the conversion, kW/ton = 3.517 / COP, the sponsor finds that $\eta_{post-installation} = 0.718$ kW/Ton.

Step 3 The existing and new chillers are each 200-ton units.

Step 4 The sponsor looks in Appendix A, Table A.10 to find the appropriate coefficients. The demand coefficient for a large office building with an air-cooled chiller in Houston is 0.81, so $a = 0.81$. The demand coefficient for a large office building with a water-cooled chiller in Houston is 0.90, so $b = 0.90$. The energy coefficient for a large office building with air-cooled chiller in Houston is 2,501, so $c = 2,501$. The energy coefficient for a large office building with a water-cooled chiller in Houston is 2,786, so $d = 2,786$.

Step 5 By inserting the information gathered in Steps 1-4 into Equations 3.1 and 3.2, the Sponsor calculates the savings:

$$kW_{savings,GROSS} = 200 * (0.81 * 1.407 - 0.90 * 0.718) = 98.7 \text{ kW}$$

$$kWh_{savings,GROSS} = 200 * (2,501 * 1.407 - 2,786 * 0.718) = 303,712 \text{ kWh}$$

Extra Step:
Additional
Adjustments
for Auxiliary
Equipment

The equipment efficiency for the air-cooled chiller includes the condenser fans, but the equipment efficiency for the water-cooled chiller does not include the condenser water pump and cooling tower. Therefore, the savings must be reduced to account for the peak demand and energy consumption of the water-cooled system's additional equipment. Assuming a 5 hp condenser pump and a 5 hp cooling tower fan is added as a part of the retrofit, the kW and kWh savings are reduced as follows:

$$kW_{CW \text{ pump and CT fan}} = (5 + 5)\text{hp} * .746 \text{ kW/hp} / .86 \text{ (efficiency)} * .80 \text{ (load factor)} = 7 \text{ kW}$$

$$kWh_{CW \text{ pump and CT fan}} = 7 \text{ kW} * 8760 \text{ hours} = 61,320 \text{ kWh}$$

$$kW_{savings, NET} = 98.7 - 7.0 = 91.7 \text{ kW}$$

$$kWh_{savings, NET} = 303,712 - 61,320 = 242,392 \text{ kWh}$$

3.3 Simplified M&V for Cooling Equipment

The simple M&V procedure for electric-to-electric cooling equipment replacement involves collecting one year of post-consumption kWh data. To determine demand savings, the maximum equipment demand that occurs during the utility peak summer hours must be measured. This can be accomplished with continuous demand metering or spot metering during peak conditions.

3.3.1 **Pre-Installation M&V Activities**

3.3.1.1 **Pre-Installation Site Survey**

The goals of the pre-installation site survey are to identify the existing equipment, evaluate its schedule of use, and establish the baseline efficiency or coefficient of performance (COP). The Project Sponsor will conduct a survey of all the existing cooling equipment for buildings with a central plant, regardless of whether they will be retrofitted. The information collected should include: equipment type, year, make/model, rated capacity, rated efficiency, operating schedule, and operating sequence. Record the equipment information in the Cooling Equipment Inventory Form.

The baseline efficiency is determined by comparing the rated efficiency of the existing unit to the minimum efficiency listed in the Standard Cooling Equipment Table, which are based on ASHRAE 90.1-1989, provided in Appendix A. The baseline efficiency is equal to the more efficient of the two values.

3.3.1.2 **Pre-Installation Inspection**

CenterPoint Energy or its contractor will conduct a pre-installation inspection to verify that the Sponsor has properly documented the baseline in the FA. The M&V administrator will make any necessary corrections to the pre-installation survey based on the results of the inspection. **Demolition or removal of existing equipment and/or installation of new equipment cannot commence until the pre-installation inspection is completed and CenterPoint Energy has issued the Project Authorization**

3.3.1.3 **Pre-Installation Performance Monitoring**

The simple M&V procedure for electric-to-electric cooling equipment replacements does not require pre-installation monitoring of existing equipment. The existing equipment efficiency is determined from the Standard Cooling Equipment Tables, Appendix A. The existing equipment load and operating schedule are assumed to be the same as those of the post-retrofit equipment.

The simple M&V procedure for electric-to-gas cooling equipment replacement does require pre-installation monitoring of the existing equipment. The maximum demand (measured for a one-hour period) that coincides with the utility peak demand period must be determined, through spot measurements or continuous metering.

3.3.2 **Post-Installation M&V Activities**

3.3.2.1 **Post-Installation Equipment Survey**

Once the new equipment retrofit is complete, the Sponsor conducts and submits a post-installation equipment survey as part of the Installation Report (IR). The survey should include: installed equipment type, year, make/model, rated capacity, rated efficiency, operating schedule, and operating sequence. Record the cooling equipment information in the Cooling Equipment Inventory Form. The cooling equipment description, its location, as well as mechanical design drawings should be included with the IR submittal.

The Sponsor must submit manufacturer's documentation of the rated efficiency of all newly installed cooling equipment, based upon ARI test conditions. This documentation will be in the form of manufacturer cut sheets or factory performance test results that document the part load performance of the equipment.

3.3.2.2 **Post-Installation Inspection**

CenterPoint Energy or its contractor will conduct a post-installation inspection to verify that the retrofit was installed as reported.

3.3.2.3 Post-Installation Performance Monitoring

Two basic steps comprise the necessary post-retrofit M&V monitoring activities for electric-to-electric cooling equipment replacements:

1. Measure the maximum demand (measured for a one hour period) that occurs between the hours of 1 PM and 7 PM on weekdays during the months of May through September. This can be accomplished with continuous demand metering (at 15-minute intervals) or a spot measurement during peak conditions.
- Collect twelve months of post-installation consumption (kWh) data.

For electric-to-gas fuel switching cooling equipment replacements, there are no post-installation metering requirements in the simple M&V procedure.

3.3.3 Calculation of Demand and Energy Savings

3.3.3.1 Electric to Electric Equipment Replacements

Incentive payments based on demand and energy savings are made for electric-to-electric cooling equipment replacement measures. However, demand savings are allowed only for new equipment that will be in operation on weekdays between the hours of 1 PM and 7 PM Monday through Friday for the months of May through September. Peak demand and energy savings are calculated according to Equation 3.3 and Equation 3.4, respectively.

Equation 3.3: Peak Demand Savings	
$\Delta kW = kW_{meter} \cdot \left\{ \left[\frac{COP_{new}}{COP_{base}} \right] - 1 \right\}$	
<p>Where:</p>	
kW_{meter}	= Maximum 15-minute cooling equipment demand measured during the utility peak-demand period.
COP_{new}	= Newly-installed cooling equipment coefficient-of-performance (COP) at ARI design conditions.
COP_{base}	= Baseline efficiency for retrofitted cooling equipment from Appendix A.

Equation 3.4: Energy Savings

$$\Delta kWh = kWh_{meter} \cdot \left\{ \left[\frac{COP_{new}}{COP_{base}} \right] - 1 \right\} * \left(\frac{CDD(65)_{TMY}}{CDD(65)_{meter}} \right)$$

Where:

- kWh_{meter} = Summed metered kWh cooling equipment energy use determined for one year.
- COP_{new} = Newly-installed cooling equipment coefficient-of-performance (COP) at ARI design conditions.
- COP_{base} = Baseline efficiency for retrofitted cooling equipment from Appendix A.
- $CDD(65)_{TMY}$ = Cooling degree days (base 65 F) for a typical meteorological year (TMY) for the National Climatic Data Center (NCDC) station nearest the site. The value is available in Appendix A, Table A.9.
- $CDD(65)_{meter}$ = Cooling degree days (base 65 F) determined for the metering period for the National Climatic Data Center (NCDC) station nearest the site. The value is determined by CenterPoint Energy based on the metering period start and stop dates.

Example

In a Houston office building, a 600-ton, water-cooled, electric centrifugal chiller is replaced with a new chiller of the same type and capacity. The new chiller has an ARI rated COP of 6.6 (0.530 kW/ton). After one year of metering the new chiller energy use totals 697,374 kWh. The maximum demand recorded for the chiller during the metering period that coincided with the utility peak demand period was 286 kW.

This measure is a one-for-one electric chiller replacement. The chiller’s performance exceeds the minimum COP (has a higher efficiency) required by the program. One year of continuous, energy-consumption data has been collected. Thus, this measure qualifies for the simple M&V analysis procedure. To complete the savings calculation for the simple M&V, the following additional information is required:

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From Standard Cooling Equipment Tables, the minimum COP for a water-cooled centrifugal chiller of 300 tons or more is **4.7** (or 0.748 kW/ton; see the Standard Cooling Equipment Tables). The NCDC weather station is the **Houston** station. The cooling degree day data for the station are **2810 (°F day) for TMY2** and **2675 (°F day) for the metering year**.

Based on the collected data and system characteristics, the demand savings are determined to be:

$$\Delta kW = kW_{meter} * \left\{ \left[\frac{COP_{new}}{COP_{base}} \right] - 1 \right\}$$

$$\Delta kW = 286 * \left\{ \left[\frac{6.6}{4.7} \right] - 1 \right\}$$

Thus, the estimated demand savings are **115.6 kW**.

Based on the collected data and system characteristics, the energy savings are determined to be:

$$\Delta kWh_{chiller} = kWh_{meter} * \left\{ \left[\frac{COP_{new}}{COP_{base}} \right]_{rated} - 1 \right\} * \left(\frac{CDD(65)_{TMY}}{CDD(65)_{meter}} \right)$$

$$\Delta kWh = 697,374 * \left\{ \left[\frac{6.6}{4.7} \right] - 1 \right\} * \left(\frac{2810}{2675} \right)$$

Thus, the energy savings are **296,145 kWh**.

3.3.3.2 Electric to Gas Equipment Replacements (Fuel switching)

Incentive payments based on demand and energy savings are made for electric-to-gas fuel switching projects involving the replacement of cooling equipment. Demand savings are allowed only for equipment that operates on weekdays between the hours of 1 P.M. and 7 P.M. Monday through Friday for the months of May through September. Peak demand savings are calculated according to Equation 3.5.

Equation 3.5: Peak Demand Savings for Fuel Switching Measures

$$\Delta kW = kW_{meter}$$

Where:

kW_{meter} = Maximum existing, electric, cooling equipment demand measured during the utility peak-demand period

Energy savings are calculated by subtracting the new fuel consumption (converted to kWh using a heat rate of 10,500 Btu/kWh) from the pre-installation energy consumption. Energy savings are calculated according to Equation 3.6.

Equation 3.6: Energy Savings for Fuel Switching Measures

$$\Delta kWh = kWh_{meter} - Btu_{gas} \times \left(\frac{1}{10,500 \text{ (Btu/kWh)}} \right)$$

Where:

kWh_{meter} = Existing, electric, cooling equipment annual energy consumption measured or predicted

Btu_{gas} = Measured annual post-retrofit gas consumption