2 M&V Guidelines for High-Efficiency Cooling Equipment in New Construction

2.1 Overview

Cooling equipment measures must involve the installation of equipment that exceeds current energy efficiency standards. This chapter presents both a deemed savings approach and a simplified approach to the measurement and verification of savings from the installation of high-efficiency cooling equipment. High-efficiency equipment for which savings may be measured using the methods described in this chapter include:

- 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)
- Compressors (centrifugal, screw, reciprocating)

The projects should have the following characteristics:

- Documented cooling load calculations for the affected facility.
- The scope of the project for which incentives are requested is limited to individual pieces of equipment, e.g. two 500-ton chillers, and not entire building systems.

If the project does not meet these requirements, please refer to Chapter 5 or Chapter 6 for the appropriate M&V approach.

The applicable baseline efficiencies for new construction cooling equipment are from ASHRAE Standard 90.1-1999; these values are provided in the Standard Cooling Equipment Tables in Appendix A of this document. The applicable column in the Standard Cooling Equipment Tables is titled "Minimum Performance Standard."

2.2 Deemed Savings for Cooling Equipment

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

- The installed cooling equipment is electric.
- Coefficients are listed in Table A.10 for the type of building in which the project occurs and the type of equipment involved.
- The building falls into one of the categories described in Table 2.1.

Table 2.1: Building descriptions for use in the cooling equipment deemed savings M&V methodology

Building Type	Description
Religious Worship	A religious worship building that experiences full operation on Sundays, and a partial schdule 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 convience 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 available for water-cooled chillers for small building types such as convenience stores and fast food restaurants because water-cooled chillers are uncommon in these types of buildings.

2.2.1 Pre-Installation M&V Activities

2.2.1.1 Pre-Installation Site Survey

Prior to installing the cooling equipment measures, the Project Sponsor prepares a pre-installation equipment specification sheet by filling out CalcSmart. CalcSmart is available for downloading from the program Web site, www.centerpointefficiency.com/cisop. CalcSmart requires the Project Sponsor to input information about the baseline equipment and the specified equipment's type, size, make/model and efficiency. When using CalcSmart, please input the same equipment type and size for both the baseline equipment and the specified high-efficiency equipment. The Project Sponsor submits CalcSmart as part of the Final Application.

2.2.1.2 Pre-Installation Site Inspection

A pre-construction site inspection is generally not required, but in some cases – such as projects involving additions to existing facilities – this inspection may be requested at CenterPoint Energy's discretion.

2.2.2 Post-Installation M&V Activities

2.2.2.1 Post-Installation Equipment Survey

Once the construction project is complete, the Project Sponsor revises CalcSmart as necessary to reflect as-built conditions. An updated copy of CalcSmart should be included with the Installation Report.

The Project Sponsor must submit manufacturer's documentation of the rated efficiency of all 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.

2.2.2.2 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.

2.2.3 Deemed Savings Calculations

The deemed savings methodology involves the application of two mathematical equations shown in Equation 2. and Equation 2.2. CalcSmart uses these equations to calculate savings automatically.

Equation 2.1: Calculation of peak demand savings for cooling equipment

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

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 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 building type and new equipment type
$\eta_{\text{post-installation}}$	=	Rated efficiency of the installed equipment (kW/Ton)

Equation 2.2: Calculation of energy savings for cooling equipment

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

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 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 building type and new equipment type
$\eta_{\text{post-installation}}$	=	Rated efficiency of the installed equipment (kW/Ton)

To calculate savings by hand for cooling equipment measures using the deemed savings methodology, follow these steps:

1. Determine the applicable baseline efficiency for the specified equipment in kW/ton (η_{baseline}). Record the minimum baseline efficiency (ASHRAE 90.1-1999). Use the following conversions to get kW/Ton where necessary[1]:

   kW/ton = 12 / EER

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

kW/ton = 3.517 / COP

kW/ton = 12 / (SEER*0.697 + 2.0394)

2. Determine the applicable efficiency for the new equipment in kW/ton ($\eta_{post\text{-}installation}$).
3. Determine the applicable equipment capacity (*Tons*). Record the unit tonnage.
4. Determine the applicable demand and energy coefficients (*a, b, c,* and *d*). The equipment will be of the same type and technology, so a = b and c = d. Go to the Table A.10 in Appendix A. Look up the demand and energy coefficients for the appropriate building and equipment type.
5. Use equations 2.1 and 2.2 to calculate peak demand and energy savings.

Example

A 150-ton air-cooled packaged unit in a retail application is a more efficient unit than required by current energy codes in Galveston, TX.

Step 1	The Project Sponsor finds the appropriate baseline efficiency from Appendix A, Table A.6. A 150-ton air-cooled packaged unit has an EER of 9.2. Using the conversion, kW/Ton = 12/EER, the Project Sponsor finds that $\eta_{baseline}$ = 1.30 kW/Ton.
Step 2	The manufacturer's data for the new equipment shows that the EER = 10.0. Using the conversion, kW/Ton = 12/EER, the Project Sponsor finds that $\eta_{post\text{-}installation}$ = 1.20 kW/Ton.
Step 3	The new packaged unit is a 150-ton unit.
Step 4	The Project 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 0.84, so $a = b$ = 0.84. The energy coefficient for a retail building with a DX air-cooled unit in Galveston is 2,318, so $c = d$ = 2,318.
Step 5	By inserting the information gathered in Steps 1-4 into Equations 3.1 and 3.2, the Project Sponsor calculates the savings:

$$kW_{savings} = 150 * (0.84 * 1.30 - 0.84 * 1.20) = 12.6\,\text{kW}$$

$$kWh_{savings} = 150 * (2{,}318 * 1.30 - 2{,}318 * 1.20) = 34{,}770\,\text{kWh}$$

2.3 Simplified M&V – Limited Measurement

The simplified M&V procedure for cooling equipment involves collecting one year of consumption data after the project is complete. 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.

2.3.1 Pre-Construction M&V Activities

2.3.1.1 Equipment Survey

As part of the application process, the Project Sponsor provides an inventory of *all* specified cooling equipment by filling out the Cooling Equipment Inventory Form, available for downloading from the program Web site at www.centerpointefficiency.com/cisop. The information provided should include:

- equipment type
- year
- make/model
- rated capacity
- rated efficiency
- operating schedule
- operating sequence

2.3.1.2 Site Inspection

A pre-construction site inspection is generally not required, but in some cases—such as projects involving additions to existing facilities—this inspection may be requested at CenterPoint Energy's discretion.

2.3.2 Post-Installation M&V Activities

2.3.2.1 Equipment Survey

After construction is complete, the Project Sponsor provides an updated Cooling Equipment Inventory Form to CenterPoint Energy as part of the Installation Report (IR). This survey must include the same information itemized above, and be accompanied by a description of the cooling equipment and its location as well as mechanical design drawings.

The Project Sponsor also submits manufacturer documentation of the rated efficiency of all installed cooling equipment, based on ARI test conditions. This documentation should be in the form of manufacturer cut sheets or factory performance test results that show the part load performance of the equipment.

2.3.2.2 Site Inspection

Either CenterPoint Energy or its contractor conducts a post-construction inspection to verify that the specified equipment has been installed as reported and has been documented accurately.

2.3.2.3 Performance Monitoring

To verify the energy consumption (kWh) impacts of the higher efficiency cooling equipment, the Project Sponsor collects consumption data, continuously, for a 12-month period. To verify the impacts on demand (kW), the Project Sponsor measures demand for a one-hour period either through continuous demand metering (at 15-minute intervals) or with spot measurements, conducted between the hours of 1 PM and 7 PM on weekdays during the months of May through September.

2.3.3 Calculation of Demand and Energy Savings

2.3.3.1 High-efficiency Cooling Equipment

Project Sponsors can claim demand savings only for equipment that operates on weekdays between the hours of 1 PM and 7 PM, Monday through Friday, during the months of May through September. Peak demand and energy savings are calculated according to Equation 2.3 and Equation 2.4, respectively.

Equation 2.3 Peak Demand Savings

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

Where:

kW_{meter} = Maximum 15-minute cooling equipment demand measured during the utility peak-demand period.

COP_{new} = High-efficiency cooling equipment coefficient-of-performance (COP) at ARI design conditions.

COP_{base} = Baseline efficiency for cooling equipment from Appendix A.

Equation 2.4 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} = High-efficiency cooling equipment coefficient-of-performance (COP) at ARI design conditions.

COP_{base} = Baseline efficiency for baseline 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 NCDC station nearest the site. The value is determined by CenterPoint Energy based on the metering period start and stop dates.

Example

For a Houston office building, a 600-ton, water-cooled, high-efficiency electric centrifugal chiller is specified. The high-efficiency chiller has an ARI-rated COP of 6.6 (0.530 kW/ton). One year of post-construction metering shows the chiller energy use to be 697,374 kWh. The maximum demand recorded for the chiller during the metering period coincident with CenterPoint Energy's peak demand period is 286 kW.

One year of continuous energy-consumption data was collected. To complete the simple M&V savings calculation, the following information is also needed:

- ASHRAE 90.1-1999 minimum chiller efficiency
- The NCDC station nearest the site
- The NCDC station TMY CDD (65)
- The NCDC station CDD (65) determined for the metering period

From the Standard Equipment Tables, the minimum COP for a water-cooled centrifugal chiller of 300 tons or more is **6.1** (or 0.577 kW/ton). The NCDC weather station is the **Houston** station. The cooling degree day data for the station are **2810 °F** day for TMY and **2675 °F** day for the metering year.

Based on the collected data and system characteristics, the demand savings are determined as follows:

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

$$\Delta \text{kW} = 286 * \left\{ \left[\frac{6.6}{6.1} \right] - 1 \right\}$$

The estimated demand savings equal **23.4 kW**.

The energy savings are determined as follows:

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

$$\Delta \text{kWh} = 697{,}374 * \left\{ \left[\frac{6.6}{6.1} \right] - 1 \right\} * \left(\frac{2810}{2675} \right)$$

The energy savings equal **60,047 kWh**.