California Statewide Measures

Statewide Measure Characterization

Chiller Systems

VERSION 0.9

Last Updated October 16, 2023

Revision Log

Version	Publish Date	Description of Revisions	Owner
0.1	n/a	Initial draft for Custom Subcommittee	Cal TF Custom Chillers Working Group
0.9	n/a	Draft for Cal TF	Cal TF Custom Chillers Working Group

Table of Contents

Section 1: Standard Measure Template

Measure Information

Measure Name	Chiller Systems
SW Measure ID	TBD
Use Category	HC-HVAC

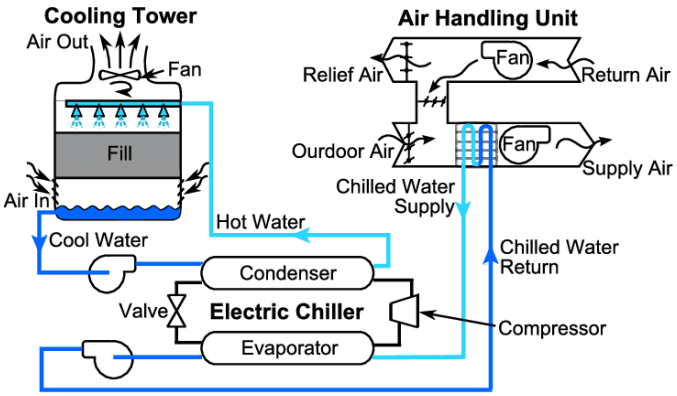
Technology Summary

Chilled water (CHW) systems use a central plant chiller(s) to cool and distribute chilled water that is used for space comfort and/or process cooling.

An **air-cooled CHW plant** consists of an air-cooled chiller (located outside the building), CHW pumps, expansion tank, air separator, and chemical treatment. The CHW pumps are arranged in a primary/secondary or primary pump arrangement. Typical primary/secondary system uses constant flow primary pumps and variable flow secondary pumps. A primary-only pump system is often variable flow, but constant flow systems are in operation. *This measure package does not include air-cooled chillers due to the proposed calculation tool (which will include air-cooled chillers in a future update). This measure package will be updated to include air-cooled chillers when the calculation tool is updated.*

A **water-cooled CHW plant** consists of a water-cooled chiller, CHW pumps, expansion tank, a separator, chemical treatment, cooling towers located outside of the building, condenser water (CW) pumps, and makeup water to accommodate evaporation of the condenser water. Water-cooled chillers are typically located inside the building but can also be placed outside the building. Typical CHW pump configurations are the same as described for the air-cooled CHW plant. Condenser water (CW) pump systems commonly operate as constant flow.

The figure below shows common components of a chiller plant:



Schematic of a typical chilled-water system. | Download Scientific Diagram (researchgate.net)

- **Chillers:**
  - **Air-cooled chillers** reject heat from the refrigeration cycle to the ambient air using fans (forced convection). Although air-cooled chillers are less efficient than water-cooled chillers, they provide other advantages: lower first cost, less complex technology, lower space requirements, and less water usage. Air-cooled chillers are common in commercial and industrial applications and are available in a wide range of capacities, from less than 50 tons to several hundred tons.
  - **Water-cooled chillers** use a condenser water loop and cooling towers to reject heat from the refrigeration cycle, generally achieving higher efficiencies relative to air-cooled chillers. Water-cooled chillers are common in commercial and industrial applications and are available in a wide range of capacities, generally from 100 tons to several thousand tons.
- **Cooling Tower:** Cooling towers use convection to cool down the heated condenser water coming from the chiller. Cooling towers generally use mechanical fans to achieve heat rejection. However, in certain load and ambient conditions, natural convection without fan operation can meet the service needs.
- **Pumps:** Chilled water pumps (CHWPs) control the CHW circulation around the building, and condenser water pumps (CWPs) control the CW circulation between the chiller and the cooling tower.
- **Water-side Economizer**: A water-side economizer exchanges heat between the cooling tower water and distribution system water. Water-side economizers enable “free” cooling when inserted into a facility's interior water loop and offer cooling redundancy because they can provide CHW in the event that a chiller goes offline.
- **Air Handling Units (AHUs) / Fan Coil Units (FCUs)**: While not part of the CHW plant, AHUs and FCUs are often part of the entire HVAC system. Although there are many types of AHUs, AHUs typically intake a mixture of indoor and outdoor air, filter for particulates, heat/cool and potentially humidify, and then distribute the conditioned air through ductwork to the desired area(s) within a building. FCUs are another type of AHU that typically do not involve outside air and ducting. FCUs generally recirculate and condition indoor air in individual rooms and/or smaller spaces.

This Custom Measure Package (CMP) involves equipment and/or controls upgrades on the water side of a CHW system (i.e., chilled water, condensing water, cooling tower) that improve the operating efficiency of the CHW plant. The CMP is paired with the PG&E HVAC Tool to calculate the energy savings estimates. The measures included in the CMP are:

- HVAC water-cooled chiller replacement with Measure Application Type (MAT) of Accelerated Replacement (AR). Note that air-cooled chillers are currently not available in the PG&E HVAC Tool.
- Various controls measures when included with other retrofits. These control measures are categorized as AOE when the existing system lacks capability to perform the control strategy prior to the retrofit and as retro-commissioning (RCx) when the system could perform the control but was not utilized or optimized.

Related Deemed Measures

The list below shows related, active deemed measure packages. Products that qualify as deemed measure packages must use the deemed measure package savings. [SOURCE]

- SWHC005-03: Water-Cooled Chiller

Commented [AR1]: PG&E Resource Rulebook points to EE Policy Manual page 36 and D.12-05-015p. 331. Current CPUC Staff has pointed to E-5152 page 18.

    - This measure is for non-lead variable speed centrifugal or screw water-cooled chillers for space conditioning loads in nonresidential buildings and consists of NR and NC MATs.
- SWHC020-03: Air-Cooled Chiller
    - This measure is for non-lead variable speed centrifugal or screw air-cooled chillers for space conditioning loads in nonresidential buildings and consists of NR and NC MATs.
- SWHC052-02: Air-Cooled Chiller, Path B
    - This measure is for non-lead variable speed centrifugal or screw air-cooled chillers for space conditioning loads using the Title-24 Path B efficiency rating in nonresidential buildings and consists of NR and NC MATs
- SWHC008-01: Variable Speed Drive for a Central Plant System
    - This measure includes VSDs installed on CHWP and CWPs in a water-cooled central plant serving space comfort loads in commercial buildings.

Measure Case Description

CHW plant upgrade projects often include a combination of measures. This custom measure package involves equipment and/or controls upgrades on the water side of the CHW system (i.e., chilled water, condensing water, cooling tower) that improve the operating efficiency of the CHW plant.

The following table represents the measure offerings included in this measure package.

Offering ID

MEASURE	STATEWIDE MEASURE OFFERING ID	MEASURE OFFERING DESCRIPTION
HVAC Water-Cooled Chiller Replacement	A	Efficient water-cooled chiller serving HVACs loads for AR MAT.
CHW Plant Lockout Control	B	Use of a lockout temperature set to the highest outdoor air temperature that the building can maintain the discharge air without cooling. (BRO)
Chiller Staging Sequence Optimization (for multi-chiller systems)	C	Chiller sequence to minimize energy consumption at given cooling loads through maintaining operation at efficient points of the chiller curves and/or staging chillers to minimize pump operation. (BRO)
CHW Supply Temperature Reset	D	Reset strategy to dynamically adjust the CHW supply temperature setpoint based on return temperature or cooling load. (BRO) The reset sequence should be consistent with the trim and response protocols of ASHRAE Guideline 36.
CW Supply Temperature Reset	E	Reset strategy to adjust the entering CW temperature setpoint based on the approach temperature of the cooling tower. Many recently manufactured chillers can operate with ECWT as low as 58 °F. (BRO)
Water-side Economizer Optimization	F	Inclusion or optimization of a water side economizer system to use cooling tower water to serve cooling loads rather than mechanical chilling. (BRO)
CT Staging Sequence Optimization (for multi-CT systems)	G	Cooling tower sequence to minimize energy consumption at given heat rejection demands through sequencing cell operation to minimize energy consumption of the CT fans and CW pumps. (BRO)

MEASURE	STATEWIDE MEASURE OFFERING ID	MEASURE OFFERING DESCRIPTION
CHW Differential Pressure Reset	H	Inclusion or optimization DP reset strategy based on cooling loads. (BRO)
CHW Plant Lockout Control	I	Use of a lockout temperature set to the highest outdoor air temperature that the building can maintain the discharge air without cooling. (AOE)
Chiller Staging Sequence Optimization (for multi-chiller systems)	J	Chiller sequence to minimize energy consumption at given cooling loads through maintaining operation at efficient points of the chiller curves and/or staging chillers to minimize pump operation. (AOE)
CHW Supply Temperature Reset	K	Reset strategy to dynamically adjust the CHW supply temperature setpoint based on return temperature or cooling load. (AOE) The reset sequence should be consistent with the trim and response protocols of ASHRAE Guideline 36.
CW Supply Temperature Reset	L	Reset strategy to adjust the entering CW temperature setpoint based on the approach temperature of the cooling tower. Many recently manufactured chillers can operate with ECWT as low as 58 °F. (AOE)
Water-side Economizer Optimization	M	Inclusion or optimization of a water side economizer system to use cooling tower water to serve cooling loads rather than mechanical chilling. (AOE)
CT Staging Sequence Optimization (for multi-CT systems)	N	Cooling tower sequence to minimize energy consumption at given heat rejection demands through sequencing cell operation to minimize energy consumption of the CT fans and CW pumps. (AOE)
CHW Differential Pressure Reset	O	Inclusion or optimization DP reset strategy based on cooling loads. (AOE)

Base Case Description

The base case is a CHW plant serving space conditioning in a nonresidential building.

For AR application types, the first base case is the existing CHW plant, and the second base case is a that exceeds the minimum efficiency requirements set forth by the 2022 Building Energy Efficiency Standards (Title 24, Parts 6 and 11) in both full load and integrated part load conditions by 10 percent. R1557 See Code Requirements section.

Typical existing conditions for the controls measures are described in the tables below. These controls measures use an existing conditions baseline.

Base Case Descriptions

MEASURE	EXISTING DESCRIPTION	STANDARD DESCRIPTION
HVAC Water-Cooled Chiller Replacement	Water-cooled chiller serving HVAC loads.	DEER compliant chiller [1]
CHW Plant Lockout Control	Lockout temperatures do not exist or prevent the CHW plant from operating below a specified temperature. If this temperature is set too low the CHW plant will provide cooling when it is not needed.	n/a
Chiller Staging Sequence Optimization (for multi-chiller systems)	Existing chiller operation includes more chillers operating than required and/or chillers operating at inefficient points on the chiller curves.	n/a

MEASURE	EXISTING DESCRIPTION	STANDARD DESCRIPTION
CHW Supply Temperature Reset	Constant CHW supply temperature setpoint or inefficient CHW supply temperature reset strategy. The CHW system must be controlled by a Direct Digital Control (DDC) system or equivalent level of control service.	n/a
CW Supply Temperature Reset	Constant CW supply temperature setpoint or inefficient CW reset strategy.	n/a
Water-side Economizer Optimization	Mechanical chilling used for cooling loads.	n/a
CT Staging Sequence Optimization (for multi-CT systems)	Existing cooling tower operation includes an inefficient use of the cooling tower cells resulting in more CT fan and CW pump energy than required.	n/a
CHW Differential Pressure Reset	Fixed DP setpoint or inefficient DP reset strategy.	n/a

[1] DEER Path A chillers are defined with 10% incremental improvement in efficiency over full load and part load Title-24 efficiencies. DEER Path B chillers are defined as 7% improvement from Title-24 at full load and 12% at part load.

Commented [SL2]: Source E-5152 Section 2.2 page A-17

Code Requirements

Applicable state and federal codes and standards for relevant CHW plant equipment and controls are specified below.

CHILLERS

Applicable State and Federal Codes and Standards – Chillers

Code	Applicable Code Reference	Effective Date
CA Appliance Efficiency Regulations – Title 20	None	n/a
CA Building Energy Efficiency Standards – Title 24 (*2022*)	Section 110.2 (a), Table 110.2-D	January 1, 2023
Federal Standards	None	n/a

The 2022 Building Energy Efficiency Standards (Title 24, Parts 6 and 11) require water-cooled and air-cooled chillers to meet minimum full-load efficiency (kW/ton for water cooled and EER for air-cooled) and integrated part-load efficiency (IPLV) ratings. R1557 Title 24 also specifies alternate efficiency compliance paths for chiller technology. Path A requires a high full-load efficiency; Path B sets a lower minimum full-load efficiency than Path A but requires a higher minimum integrated part-load efficiency.

Title 24 Part 6 Section 140.4(j) specifies a CHW plant shall not have more than 300 tons provided by air-cooled chillers, except where the water quality at the building site fails to meet the manufacturer specifications for the use of a water-cooled chiller, a chiller that is used to charge a thermal energy storage system with a design temperature of less than 40 °F, or a system with air-cooled chillers with minimum efficiencies approved by the California Energy Commission (CEC) pursuant to Section 10-109(d).

VARIABLE SPEED DRIVES

Applicable State and Federal Codes and Standards – Variable Speed Drives

Code	Applicable Code Reference	Effective Date
CA Appliance Efficiency Regulations – Title 20	None	n/a
CA Building Energy Efficiency Standards – Title 24 (2022)	Sections 140.4(k)1 and 140.4(k)6	January 1, 2020
Federal Standards	None	n/a

The 2022 California Building Energy Efficiency Standards (Title 24), stipulates the following: R1557

"HVAC chilled and hot water pumping shall be designed for variable fluid flow and shall be capable of reducing pump flow rates to no more than the larger of: a) 50 percent or less of the design flow rate; or b) the minimum flow required by the equipment manufacturer for the proper operation of equipment served by the system". (Section 140.4(k)1, page 256)

The exception to this requirement is systems that include no more than three control valves or total pumping power less than or equal to 1.5 hp.

Section 140.4(k)6A of Title 24, specifies requirements for variable flow controls:

"Individual pumps serving variable flow systems and having a motor horsepower exceeding 5 hp shall have controls or devices (such as variable speed control) that will result in pump motor demand of no more than 30 percent of design wattage at 50 percent of design water flow. The pumps shall be controlled as a function of required differential pressure." (Section 140.4(k)6, page 257)

Additionally, Section 140.4(k)6B provides requirements for pressure sensor location and setpoint. The exceptions to Section 140.4(k)6 are heating hot water pumps and condenser water pumps (CWPs) serving only water-cooled chillers.

VARIOUS CONTROL MEASURES

Applicable State and Federal Codes and Standards – Various Control Measures

Code	Applicable Code Reference	Effective Date
CA Appliance Efficiency Regulations – Title 20	None	n/a
CA Building Energy Efficiency Standards – Title 24 (2022)	Sections 140.4(k)4, 140.4(h)4 and140.4(k)6	January 1, 2022
Federal Standards	None	n/a

The 2022 California Building Energy Efficiency Standards (Title 24), stipulates the following: R1557

"Systems with a design capacity exceeding 500,000 Btu/hr supplying chilled or heated water shall include controls that automatically reset supply water temperatures as a function of representative building loads or outside air temperature." (Section 140.4(k)4, page 257)

Exceptions to this requirement include hydronic systems that use variable flow to reduce pumping energy in accordance with 140.4(k)1 above and systems serving healthcare facilities.

"Multiple cell heat rejection equipment with variable speed fan drives shall:

A. *Operate the maximum number of fans allowed that comply with the manufacturer's requirements for all system components, and*
B. *Control all operating fans to the same speed. Minimum fan speed shall comply with the minimum allowable speed of the fan drive as specified by the manufacturer's recommendation. Staging of fans is allowed once the fans are at their minimum operating speed." (Section 140.4(h)4, page 256)*

Variable flow controls in Section 140.4(k)4 as described above.

Program Requirements

MEASURE IMPLEMENTATION ELIGIBILITY

All MATs, delivery type, and sector combinations for this measure package are specified below. MAT is a categorization based on the circumstances and timing of the measure installation; each MAT is distinguished by its baseline determination, cost basis, eligibility, and documentation requirements. Delivery type is the broad categorization of the delivery channel through which the market intervention strategy (financial incentives or other services) is targeted. This table also designates the broad market sector(s) that are applicable for this measure.

Note that some of the implementation combinations below may not be allowed for some measure offerings by all program administrators.

The chiller equipment replacement measures are characterized as Accelerated Replacement (AR).

The controls measures are categorized as AOE or BRO depending on the functionality of the existing control system and the installation activities. CPUC Track 1 Working Group Report provides examples of AOE and BRO measures that were adopted in E-4818. Specifically, AOE #4 and AOE #5 indicated below.

> *"AOE #4: An investigation of an EMS resulted in fine-tuning of equipment schedules and reset schedules. Since no actual equipment was replaced or added, this does not qualify as an AOE measure; however, it is a valid BRO-type installation.*
>
> *AOE #5: An existing controls system with scheduling features only is replaced with a new system capable of multiple additional functions including optimized start/stop, local occupancy override, and other functions that are not present in the old system. The implementation plan includes the replacement of existing on/off actuators and temperature sensors.*
>
> *This measure is largely an AOE since controls are an add-on measure and the proposed system is a nominal improvement over the old system with additional energy functionality. However, the replacement of like-with-like components (actuators and sensors) is restorative."*

Based on these examples, the control measures are BRO when no equipment is added or replaced. The control measures are AOE when additional functionality is added to the system as a result of the measure (even if some like-for-like components are replaced).

Implementation Eligibility

Commented [SL3]: https://www.cpuc.ca.gov/-/media/cpuc-website/files/legacyfiles/c/6442451953-cpuc-ml-poe-dec12.pdf

MEASURE APPLICATION TYPE	DELIVERY TYPE	SECTOR
AR	DnCust	Com
AR	DnCustDI	Com
AR	DnCust	Ind [1]
AR	DnCustDI	Ind [1]
AOE	DnCust	Com
AOE	DnCustDI	Com
AOE	DnCust	Ind [1]
AOE	DnCustDI	Ind [1]
BRO	DnCust	Com
BRO	DnCustDI	Com
BRO	DnCust	Ind [1]
BRO	DnCustDI	Ind [1]

[1] Represents non-process, space conditioning applications that are included within the Industrial sector.

PREPONDERANCE OF EVIDENCE (POE) REQUIREMENTS

POE must be documented for all AR application types. AR options must fulfill two points:

- Viability – The existing equipment would continue to operate through the RUL.
- Influence – The program has influenced the accelerated replacement of the equipment.

Per E-5115 and subsequent E-5115 pilot documents, the type and amount of required documentation depends on the size of the project as determined by the incentive levels.

The following are the types of information that can show viability. Note that not all evidence is required. See E-5115 and CPUC E-5115 viability pilot document.

- Specifications of existing equipment including:
  - nameplate,
  - manufacturer specification sheet, and
  - on-site evaluation result.
- Proof that the existing chiller is still operating as intended and would continue to operate through the RUL, which may include:
  - maintenance logs,
  - maintenance repair documentation (e.g., invoices),
  - prior overhaul documentation (e.g., invoices, including barrel rebuild activities),
  - data supporting that the existing chillers are meeting the customer's needs, and
  - documentation that the customer would intend to use the boiler as it is currently used into the future.

Program influence can be in the form of financial and/or technical influence and should be documented in the Project Feasibility Study (PFS). The following represent some common influential aspects of CHW systems projects. As each customer and project may have different circumstances, there may be other aspects for consideration, and the documentation examples below may or may not satisfy the "more likely than not" POE criteria.

- Technical Influence:

    - Customers may have internal factors such as typical replacement cycle or building changes driving chiller plant upgrades. Accelerating a planned replacement or influencing a higher than typical efficiency level may show program influence.
        - Documentation should be collected to show the customer's typical chiller equipment repair and/or replacement cycles and the typical replacement efficiencies. Influence can still be shown if an improvement in efficiency from typical replacement efficiency levels is documented. Typical replacement comparisons can be made within the same facility as the project or from other facility locations.
        - Documentation should be collected of any known future plans or equipment replacement schedule.
    - Customers can be driven to upgrade central plant equipment and controls when reliability becomes a concern.
        - Documentation should be collected to understand the customer's perception of the equipment meeting the space conditioning needs.
    - Increases in the frequency of hot space calls can be an indicator for non-energy related reasons for upgrading central plant equipment.
        - Request qualitative information regarding the customer's view of frequency of hot space calls and the relative importance of these calls in the day-to-day operation of the building.
- Financial Influence:
    - CHW plant projects can have long payback periods based on energy savings. Payback periods above the customer's criteria, including those payback periods that exceed the measure EUL, are indicative of non-energy efficiency factors driving the customer's decision.
        - Support customer decision-making by including additional cost savings such as maintenance in the payback calculation and analysis.

ELIGIBLE PRODUCTS

Chillers must exceed the DEER chiller efficiency levels of at least 10% better than Title 24 minimum efficiency requirements on a full load and part load basis.

CHW plant upgrades under this measure package, must:

- Have three or fewer chillers of the same type and rated efficiency serving the load.
- Serve space-conditioning or other weather-dependent cooling load; a constant cooling load (e.g., data center cooling) is allowed.
- Consist of water-cooled chillers only (air-cooled option may be added in the future)
- Eligible chiller types include positive displacement (e.g., screw, centrifugal, and centrifugal with VFD chillers only) and magnetic bearing chillers (modeled as centrifugal with VFD).
- Use an eligible pumping configuration:
    - Primary-Only
        - All CHW pumps must be of equal size with the same design parameters (head and flow rate).
    - Primary-secondary system
        - Dedicated primary CHW pumping (i.e., one primary chilled water pump operates per chiller).
        - Primary CHW pumps operate at constant flow.

        - All secondary CHW pumps must be of equal size with the same design parameters (head and flow rate).
- Have dedicated CW pumps (i.e., one CW pump per chiller) that operate at constant flow and head.

For this measure package, any water-side economizers must be non-integrated such that the water-side economizer provides cooling in either mechanical cooling or economizer mode. The measure package methodology does not support integrated water-side economizers that can provide mechanical and economizer cooling simultaneously.

ELIGIBLE BUILDING TYPES AND VINTAGES

This measure is applicable for all nonresidential building types of any vintage for which the PG&E HVAC Tool accurately models the CHW system (See Electric Savings Section).

ELIGIBLE CLIMATE ZONES

This measure is applicable in all California climate zones.

Program Exclusions

This measure is not applicable to:

- CHW plant upgrades included in an active deemed measure package as noted under the Technology Summary
- CHW systems that do not meet the requirements in the Eligible Products section.
- Systems with adsorption or absorption chillers

CHW plant operation must be able to be reasonably modeled by the PG&E HVAC Tool (See Electric Savings section).

Data Collection Requirements

Relevant project installation and product data shall be collected to ensure that measures conform to requirements described in the Eligible Products section.

The following represents data collection parameters to complete the initial set-up of the PG&E HVAC Tool. Specific measure information is provided in the M&V Section.

PRE-INSTALLATION DATA COLLECTION

Building Information

The following information is used in the Customer Information tab of the PG&E HVAC Tool. Thus, it should be provided to utilize the calculation tool.

DATA COLLECTION PARAMETERS
Customer name and contact information (name, phone, email)

DATA COLLECTION PARAMETERS
Site Address
Site City
Site Zip Code *
Building Type
Conditioned/Heated Area
Building Vintage
Customer/Building Monthly peak demand (kW), electric (kWh), and gas (therms) usage data (whole-building meter data)
Monthly electric and gas bundled cost

* Required information for the PG&E HVAC Tool to calculate savings

Refrigerants Avoided Cost Calculator (RACC) Requirements

Decision D.21-05-031 directs the use of the RACC to determine global warming potential (GWP) impacts 1) when a retrofit involves adding (not replacing) equipment with refrigerant or 2) where low-GWP refrigerant benefits will be claimed. Since this measure only involves the replacement of similar capacity chillers, the first RACC requirement is not relevant. For chiller replacement projects that claim low-GWP refrigerant benefits, the RACC is required. Specific instructions for data and inputs are provided in the RACC Cover Sheet tab.

Commented [SL4]: https://cedars.sound-data.com/deer-resources/tools/supporting-files/

PRE- AND POST-INSTALLATION M&V REQUIREMENTS

Tiered M&V requirements for each measure have different requirements based on the estimated size of the incentive and energy savings. For small measures, the data parameter can generally be collected using a spot measurement, EMS screenshot, or photo as noted in the tables below. For large measures, a minimum of two weeks trend data is required. For all measures, calculation inputs should be consistent with verification documentation or trend data as applicable by the savings for the measure.

The following table describes the required M&V.

MEASURE	REQUIREMENTS FOR SMALL MEASURES (<$25,000, OR <250,000 KWH)	REQUIREMENTS FOR LARGE MEASURES (≥$25,000, OR ≥250,000 KWH AND)
HVAC Water-Cooled Chiller Replacement	Pre: Picture of the chiller nameplate and/or manufacturer specifications for chiller type, rated capacity, and efficiency. BAS screenshot or picture of LCD display showing chilled water supply temperature (CHWST) and entering condenser water temperature (ECWT). If these parameters are reset, min/max needs to be captured in the screenshot or picture. BAS screenshot or picture of LCD display showing chiller plant lockout temperature.	Pre: Picture of the chiller nameplate and/or manufacturer specifications for chiller type, rated capacity, and efficiency. Trend data of chiller amperage or power, outdoor air temperature (OAT), and cooling load [1]. For multiple chiller systems, trend data should be collected to understand chiller on/off sequencing based on chiller plant cooling load. Trend data of the CHWST and ECWT. If these parameters are reset, min/max needs to be estimated based on the data and validated with BAS screenshots or LCD display. BAS screenshot or picture of LCD display showing chiller plant lockout temperature.

MEASURE	REQUIREMENTS FOR SMALL MEASURES (<$25,000, OR <250,000 KWH)	REQUIREMENTS FOR LARGE MEASURES (≥$25,000, OR ≥250,000 KWH AND)
	Information collected to understand staging and sequence operation for multiple chiller systems. Post: Picture of the chiller nameplate and/or manufacturer specifications for chiller type, rated capacity, and efficiency. Confirmation that CHWST, ECWT, lockout temperature, and chiller sequencing have not changed. If they have changed outside of program activities, collect information noted in the Pre section above.	Information collected to understand staging and sequence operation for multiple chiller systems. Post: Picture of the chiller nameplate and/or manufacturer specifications for chiller type, rated capacity, and efficiency. Confirmation that CHWST, ECWT, lockout temperature, and chiller sequencing have not changed. If they have changed outside of program activities, collect information noted in the Pre section above.
CHW Plant Lockout Control	Pre/Post: BAS screenshot of CHW plant graphics with lockout temperature or control logic showing cooling lockout	Pre/Post: Trend data of OAT dry bulb, chiller status (on/off, amps, or kW), and chiller plant cooling load [1]
Chiller Staging Sequence Optimization	Pre/Post: BAS screenshot of chiller staging sequence or procedure documented from the customer	Pre/Post: Trend data of OAT dry bulb, chiller status (on/off, amps, or kW), and chiller plant cooling load [1]
CHW Temperature Reset	For no existing CHW reset control Pre: BAS screenshot showing constant CHW setpoint Post: BAS screenshot of graphic of CHW reset control parameters or programming logic For not-enabled or unoptimized CHW reset control Pre/Post: Trend data OAT dry bulb and CHWST	Pre/Post: Trend data OAT dry bulb and CHWST, CHWST setpoint, and chiller plant cooling load [1]
CW Temperature Reset	For no existing CH reset control Pre: BAS screenshot showing constant CW setpoint Post: BAS screenshot of graphic of CW reset control parameters or programming logic For not-enabled or unoptimized CH reset control Pre/Post: Trend data OAT dry bulb and ECWT	Pre/Post: Trend data OAT dry bulb and ECWT, ECWT setpoint, and chiller plant cooling load [1]
Water-side Economizer Optimization	Pre/Post: BAS screenshot, equipment specifications, or design documents for cooling tower approach temperature, OAT wet bulb enable, heat exchanger approach temperature, and average CW flow	Pre/Post: Trend data for economizer enable, OAT wet bulb, CW flow, and cooling load [1]. Equipment specifications, or design documents for cooling tower approach temperature and heat exchanger approach temperature
CT Staging Sequence Optimization	Pre/Post: BAS screenshot showing CT staging sequence	Pre/Post: Trend data on CT fan status or speed to establish the staging and cooling load [1]

MEASURE	REQUIREMENTS FOR SMALL MEASURES (<$25,000, OR <250,000 KWH)	REQUIREMENTS FOR LARGE MEASURES (≥$25,000, OR ≥250,000 KWH AND)
CHW Differential Pressure Reset	Pre: BAS screenshot showing no reset. Post: BAS screenshot showing reset enabled and minimum and maximum parameters	Pre/Post: Trend data OAT, DP, and DP Setpoint

[1] Cooling load preferred derivation method is trend data of CHWST, return temperatures, and flow. If not available, trend data of chiller amps or kW and chiller curves. Chiller efficiencies are dependent on CHWST and ECWT. Depending on the curves used and operation of the plant, CHWST and ECWT trend data may be required. The Title-24 Alternative Calculation Method includes generic biquadratic chiller curves based on chiller type. Note that constant flow applications may not require trend data. Also note that cooling load may be derived from secondary loop or individual chiller data.

Commented [SL5]: https://www.energy.ca.gov/sites/default/files/2023-07/CEC-400-2022-009-CMF-REV2-AP5.7.xlsx

Electric Savings (kWh)

METHODOLOGY

Electric and gas savings from the chiller system measures included in this measure package should be calculated using the PG&E HVAC Tool. The annual energy savings are calculated as the difference between the annual energy consumption of the baseline system and the annual energy consumption of the measure case system with the energy efficiency measure(s) installed. The calculation methodology uses CZ2022 weather data in a temperature bin analysis.

Commented [SL6]: Source https://www.calmac.org/weather.asp

CALCULATION TOOLS

Electric and gas savings from the chiller system measures included in this measure package should be calculated using the PG&E HVAC Tool.

There are three modules: Air-Side System, Chilled Water-Side System, and Hot Water System. This measure package only uses the Chilled Water-Side System module. Users input baseline data in the green cells and proposed data, as applicable, in the blue cells. The tool's processing component cascades each measure in the module such that the proposed energy consumption of the previous measure is the baseline for the next measure.

See the PG&E HVAC Tool Methodology for specific information on the inputs and requirements. Users have the option to use simple or trend data inputs. Users should be consistent with the use of simple or complex data within each project. Simple data inputs may still be used even if trend data are required. If simple data are used, the calculation assumes a standard extrapolation. Charts are embedded in the workbook, and these should be compared to trend data, where required, to ensure that the workbook is reasonably characterizing the actual operation. There are situations of deficient operation where the simple data will not accurately characterize the actual conditions. For example, faulty or sensors exposed to the sun will cause economizer functionality to operate unpredictably.

If trend data are used within the PG&E HVAC Tool's complex calculation module, the data will need to be analyzed against outdoor air temperature prior to inputting into the tool.

If any measures on the CHW side tab are enabled, baseline data for each measure should be input and accurate even if that measure is not enabled. This is because the calculation engine references this information to properly calculate the energy consumptions. Please see **PG&E HVAC Tool Methodology** for detailed descriptions of the inputs.

KEY PARAMETERS AND SOURCES

See Data Collection Requirements for key parameters and source requirements for each measure.

Peak Electric Demand Reduction (kW)

See Electric Savings section.

Peak kW calculations are based on CPUC Resolution E-5152 which states that the DEER peak kW be calculated as the average kW calculated from the period of 4pm to 9pm over a three-day period determined by California Climate Zone. The DEER peak dates for each climate zone are listed below:

CLIMATE ZONE	START DATE	END DATE
1	26-Aug	28-Aug
2	26-Aug	28-Aug
3	26-Aug	28-Aug
4	26-Aug	28-Aug
5	16-Sep	18-Sep
6	2-Sep	4-Sep
7	2-Sep	4-Sep
8	2-Sep	4-Sep
9	1-Sep	3-Sep
10	29-Jun	1-Jul
11	29-Jun	1-Jul
12	29-Jun	1-Jul
13	29-Jun	1-Jul
14	29-Jun	1-Jul
15	29-Jun	1-Jul
16	12-Aug	14-Aug

Gas Savings (Therms)

Not applicable for this measure package.

Life Cycle

Effective useful life (EUL) is an estimate of the median number of years that a measure installed through a program is still in place and operable. Remaining useful life (RUL) is an estimate of the median number of years that a technology or piece of equipment replaced or altered by an

energy efficiency program would have remained in service and operational had the program intervention not caused the replacement or alteration.

Note that RUL is only applicable for add-on equipment and accelerated replacement measures.

Effective Useful Life and Remaining Useful Life

MEASURE OFFERING	EUL ID	EUL YRS	RUL YRS	SOURCE	START DATE	EXPIRE DATE
A, K-Q [1]	HVAC-Chlr	20	6.7	DEER2014	1/1/2013	
B-H	NonRes-RCx-Operational	3	N/A	E-4818 OP2	1/1/2017	
K, L, P, Q	HVAC-EMS	15	N/A	DEER2014	1/1/2013	
M, N	HVAC-Reset	10	N/A	DEER2014	1/1/2013	
O	HVAC-WtrEcon	15	N/A	DEER2014	1/1/2013	

[1] Chiller is the host equipment for the AOE controls measures K-Q. EUL is the lesser of the host equipment RUL and measure EUL.

Commented [AR7]: OP2: "We direct the Program Administrators to ensure that all program activities and installations resulting in performance that does not exceed the nominal efficiency (i.e., rated, intended, or original efficiency) of the pre-existing condition are offered through a behavioral, retrocommissioning or operational program framework, with an effective useful life not to exceed three years."

Base Case Cost

The base cost refers to the Standard Practice Cost and applies to the NR and the AR second baseline. This cost is for the purchase and installation of a standard efficiency chiller. Included in this cost estimate is the cost of the materials purchased, including sales tax, installation labor, and other related costs (e.g., disposal costs less salvage value).

An itemized vendor bid or quote from the same contractor as the measure cost is the preferred source of the base case cost. Section 2.5.2 of the Statewide Custom Project Guidance Document v1.4 lists alternative methods for obtaining costs. These include, in preferred order, DEER look-up, cost estimating reference (e.g., RSMeans data), and DEER approximation.

Measure Case Cost

Measure case costs for custom measures should be calculated based on project-specific information.

The measure case cost refers to the full measure cost and is relevant for NR, AR first baseline, AOE, and BRO measures in this measure package. This cost is for the purchase, where applicable, and installation of the chiller and controls equipment. At the pre-installation stage, cost estimate should include the cost of the materials (including sales tax), installation labor, and other related costs (e.g., disposal costs less salvage value). An itemized vendor bid or quote is the preferred source of the measure case cost. Section 2.5.2 of the Statewide Custom Project Guidance Document v1.4 lists alternative methods for obtaining costs. These include, in preferred order, DEER look-up, cost estimating reference (e.g., RSMeans data), and DEER approximation.

Commented [SL8]: https://file.ac/OEr-2p-bk3A/

For post-installation, an itemized invoice should be provided to document the separate eligible materials and labor costs. Other eligible costs such as permits, taxes, design work, and M&V may be included as well, where applicable. Eligible costs are those cost elements that are part of the energy efficiency measure.

Net-to-Gross

The net-to-gross (NTG) ratio represents the portion of gross impacts that are determined to be directly attributed to a specific program intervention.

These NTG values are based upon the average of all NTG ratios for all evaluated 2006 – 2008 **commercial** sector programs, as documented in the *2011 DEER Update Study* conducted by Itron, Inc. These sector average NTGs ("default NTGs") are applicable to all energy efficiency measures that have been offered through commercial sector programs for more than two years and for which impact evaluation results are not available.

Net to Gross Ratio - Nonresidential

NET TO GROSS RATIO ID	NTGKWH	NTGTHERM	EXPIRE DATE
NonRes-sAll-mCust-Elec	0.6000	0.6000	
Agricult-Default-HTR-di	0.8500	0.8500	
Com-Default-HTR-di	0.8500	0.8500	
Ind-Default-HTR-di	0.8500	0.8500	

Gross Realization Rate

The gross realization rate (GRR) is a multiplier that attempts to take into account the likelihood that not all Commission-approved projects undertaken by utilities will come to fruition.

Decision 11-07-030 set default gross realization rates to apply to all custom projects which do not have an alternate value or specific gross energy savings values set because of an ex ante review process disposition.

If the CPUC ex-ante team pulls and reviews a specific project then that project gets a 1.0 GRR.

Gross Realization Rates

GRR ID	GRR VALUE
Def-GRR	0.900

Non-Energy Impacts

Non-energy impacts (NEIs) are not quantified for this measure.

Qualitative non-energy impacts for chiller system measures include:

- Longer equipment life,
- Improved occupant comfort,
- More stable water temperatures,
- Improved operator interface and controls,
- Reduced O&M costs, and
- Increased productivity/safety. [5]

Commented [SL9]: https://www.facilitiesnet.com/hvac/article/Replacing-Chillers-Benefits-Beyond-Energy-Efficiency--10648