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| HVAC  Air cooled chiller  SWHC020-02 |

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Measure Name

Air-Cooled Chiller

Statewide Measure ID

SWHC020-02

Technology Summary

Chilled water systems use a central plant chiller(s) to cool and distribute water that is used to cool air to meet building cooling demand. An air-cooled chiller rejects heat from the refrigeration cycle to the ambient air using fans (forced convection). Even though an air-cooled chiller is less efficient than a water-cooled chiller, it provides other advantages: lower first cost, less complex technology, requires less space, 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.

Electrically operated air-cooled chillers are categorized by capacity tonnage for efficiency standards, such as the 2019 California Building Energy Efficiency Standards (Title 24).[[1]](#footnote-1)

The efficiency rating of an air-cooled chiller is based on the unit operation under standard test conditions, normally determined by AHRI Standard 550/590 – 2016.[[2]](#footnote-2) Chillers have two different measures of energy efficiency: 1) full load efficiency, represented by the energy efficiency ratio (EER), coefficient of performance (COP), or kW per ton; and 2) part load efficiency, represented by the integrated part load value (IPLV). For consistency with Title 24, efficiency refers to EER throughout this workpaper, for both full load and part load ratings.

Measure Case Description

The measure case is defined as a constant speed air-cooled (screw) chiller for use in a nonresidential building that exceeds the minimum efficiency requirements set forth by the California 2019 Building Energy Efficiency Standards (Title 24) in both full load AND integrated part load conditions under Path A. In conformance to Resolution E-4952,[[3]](#footnote-3) measure offerings are defined as follows:

* Tier 1, both the full load AND integrated part load efficiency of the chiller technology should exceed Title 24 minimum requirement by 10%.
* Tier 2, both the full load AND integrated part load efficiency of the chiller technology should exceed Title 24 minimum requirement by 20%.

Measure offering are required to meet both full load AND integrated part load efficiency requirements specified below.

Measure Case Specification

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Offering ID** | **Measure Offering** | **Capacity  (tons)** | **Full Load EER** | **IPLV** |
| SWHC020A | Air Cooled Chiller | ≥ 150 | 11.1 | 15.4 |
| SWHC020B | Air Cooled Chiller | ≥ 150 | 12.1 | 16.9 |
| SWHC020C | Air Cooled Chiller | < 150 | 11.1 | 15.1 |
| SWHC020D | Air Cooled Chiller | < 150 | 12.1 | 16.6 |

Base Case Description

The base case is defined as a constant speed air-cooled (screw) chiller for use in nonresidential buildings that meets the minimum efficiency requirements set forth by the 2019 California Building Energy Efficiency Standards (Title 24) in both full load and integrated part load conditions. (See Code Requirements.)

Code Requirements

Applicable state and federal codes and standards for air-cooled chillers are specified below.

Applicable State and Federal Codes and Standards

|  |  |  |
| --- | --- | --- |
| **Code** | **Applicable Code Reference** | **Effective Date** |
| CA Appliance Efficiency Regulations – (Title 20 2018) | n/a | n/a |
| CA 2019 Building Energy Efficiency Standards – (Title 24 2019) | Section 110.2 (a), Table 110.2-D | January 1, 2020 |
| Federal Standards | None | n/a |

The 2019 California Building Energy Efficiency Standards (Title 24)[[4]](#footnote-4) requires air cooled chillers to meet minimum full-load efficiency (EER) and integrated part-load efficiency (IPLV) ratings. The Title 24 base case for this above-code measure is listed in section 110.2 (a) Table 110.2-D.

Table 110.2-D Air Chilling Packages – Minimum Efficiency Requirements (2019 Title 24)[[5]](#footnote-5)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Equipment Types** | **Size Category (tons)** | **Path A Efficiency** | **Path B Efficiency** | **Test Procedure** |
| Air-cooled, with condenser, electrically operated | < 150 | ≥ 10.1 EER  ≥ 13.7 IPLV | ≥ 9.7 EER  ≥ 15.8 IPLV | AHRI 550/590 |
| ≥ 150 | ≥ 10.1 EER  ≥ 14.0 IPLV | ≥ 9.7 EER  ≥ 16.1 IPLV |
| Air-cooled, without condenser, electrically operated | All capacities | Air-cooled chillers without condensers must be rated with matching condensers and comply with the air-cooled chiller efficiency requirements. | |

Title 24 also specifies alternate efficiency compliance paths for chiller types. 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. The 2020 version of the Database for Energy Efficient Resources (DEER) only supports measure impacts for Path A.

For a given chiller, there will always be both a rated full-load efficiency (EER for air cooled units) and a rated IPLV. The selection of an efficiency tier level must be based on both parameters. If the rated full-load efficiency and the rated IPLV are both greater than or equal to the tier level values, then that tier is valid.

Air cooled chillers with a leaving evaporator fluid temperature higher than 32 °F must comply with Title 24 Table 110.2-D when tested or certified with water at standard rating conditions.

Normalizing Unit

Tons of cooling capacity (Cap-tons).

Program Requirements

Measure Implementation Eligibility

All combinations of measure application type, delivery type, and sector that are established for this measure are specified below. Measure application type is a categorization based on the circumstances and timing of the measure installation; each measure application type 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.*

Implementation Eligibility for Investor-Owned Utilities

| **Measure Application Type** | **Delivery Type** | **Sector** |
| --- | --- | --- |
| Normal replacement (NR) | UpDeemed | Com |
| New construction (NC) | UpDeemed | Com |
| Normal replacement (NR) | DnDeemed | Com |
| New construction (NC) | DnDeemed | Com |
| Normal replacement (NR) | DnDeemDI | Com |
| New construction (NC) | DnDeemDI | Com |
| Normal replacement (NR) | UpDeemed | Ind |
| New construction (NC) | UpDeemed | Ind |
| Normal replacement (NR) | DnDeemed | Ind |
| New construction (NC) | DnDeemed | Ind |
| Normal replacement (NR) | DnDeemDI | Ind |
| New construction (NC) | DnDeemDI | Ind |

For midstream and upstream deliveries, when possible, the program administrator (PA) shall claim the “specific building type savings” in which the equipment will be installed and submit that information at claims level on CEDARS website. In cases where there is no “building type” information available for a given project, program administrator shall claim the weighted savings of “Com” building type.

Eligible Products

Products are required to meet both full load and integrated part load efficiency requirements specified in the Measure Case Description.

The energy and demand impacts of this measure are applicable only to commercial buildings with chiller equipment serving space comfort. Other chiller measures serving non-space comfort and/or processes and/or industrial applications shall be evaluated and incentivized under custom programs.

Eligible Building Types and Vintages

This measure is applicable for new construction and existing nonresidential buildings of any vintage.

Eligible Climate Zones

This measure is applicable in any California climate zone.

Program Exclusions

Per Section 140.4 (j) of the 2019 California Building Energy Efficiency Standards (Title-24),[[6]](#footnote-6) chilled water plants 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 water-cooled chillers, chillers that are used to charge a thermal energy storage system with a design temperature of less than 40 °F, or systems serving healthcare facilities.

Data Collection Requirements

Data collection requirements are to be determined.

Use Category

HVAC

Electric Savings (kWh)

The electric unit energy savings (UES) of an air-cooled chiller were retrieved directly from the Database of Energy Efficient Resources (DEER). The version used to calculate savings for these measures is DEER 2020 (version D20 v0). The results were reported in READI v2.5.1

The DEER Measure IDs and associated Statewide Measure Offering IDs and description are provided below.

Measure Offering IDs and DEER Measure IDs

| **Statewide Measure Offering ID** | **DEER Measure ID** | **Measure Offering Description** |
| --- | --- | --- |
| SWHC020A | NE-HVAC-Chlr-AirCldScrewChlr-gte150tons-11.1EER-15.4IPLV | Air Cooled Constant Speed Screw Chiller (>= 150 tons, 11.1 Min EER, 15.4 Min IPLV) |
| SWHC020B | NE-HVAC-Chlr-AirCldScrewChlr-gte150tons-12.1EER-16.9IPLV | Air Cooled Constant Speed Screw Chiller (>= 150 tons, 12.1 Min EER, 16.9 Min IPLV) |
| SWHC020C | NE-HVAC-Chlr-AirCldScrewChlr-lt150tons- 11.1EER-15.1IPLV | Air Cooled Constant Speed Screw Chiller  (< 150 tons, 11.1 Min EER, 15.1 Min IPLV) |
| SWHC020D | NE-HVAC-Chlr-AirCldScrewChlr-lt150tons- 12.1EER-16.6IPLV | Air Cooled Constant Speed Screw Chiller  (< 150 tons, 12.1 Min EER, 16.6 Min IPLV) |

UES values in READI were available for variables of climate zone, nonresidential building types[[7]](#footnote-7) , vintage (old, existing, recent and new) and PA (SCE, PGE and SDGE).

Since certain chiller upstream programs may not be able to track the specific building type where the chiller installation occurs, commercial “Com” building type was created by consolidating the energy impacts of specific building type.

Additionally, for ease of implementation, the old and existing vintages were consolidated into existing “Ex” vintage, recent vintage (2017 to 2020) was eliminated because normal replacement typically do not happen for equipment installed in these years, and the PAs were consolidated to “Any” for climates zones falling in multiple PA territories.

All these consolidations were performed using DEER2020 building weights.[[8]](#footnote-8)

DEER2020 building weights are available as a function of program administrator (PA), building type, building location (CZ), and building vintage (by model year). Year-style vintages were mapped to DEER2020 style vintages, also known as eras (old, “ex” representing median existing, recent and new), according to the DEER 2020 update, page A-22, table 4. Consolidation of building weights and UES was performed as follows to match with the measure offerings.

1. Since the measure offerings distinguish building age at the era level (“ex” or “new”), the weights table as indexed by year-style vintage needed to be transformed to align with the indexing of the DEER measure UES and measure offerings. Weights for model year vintages 2003 to 2015 (representing buildings with actual vintages from 2002 to 2016) were summed to determine the weights of the “ex” era for each combination of PA, building type, and building location. For “new” era, there is only one corresponding model year and weight and hence no consolidation was required.
2. DEER2020 UES for “new” are provided for “Any” PA; however, the weights table is indexed by specific PAs. Hence, for “new”, the weights of all the PAs were combined in each climate zone that intersects the service areas of more than one PA.[[[9]](#footnote-9)](file:///C:\Users\nfette\OneDrive%20-%20Lincus,%20Inc\TS\For-Akhilesh\2019-05-20%20QC%20Water-cooled%20chiller%20step7\07_Solaris_2019-05-20\SWHC005-01%20Water-cooled%20chiller_07_Solaris_05192020.docx#_ftn2)
3. DEER2020 UES for “old, ex, recent” are provided for each specific PA (SCE, PGE, SDG), so there are multiple UES entries in each climate zone that intersects more than one PA service area. For example, “ex” vintage UES for CZ15 are provided for SCE, PGE, and SDG. In such cases the corresponding PA specific weights from Step 1 are applied.
4. For ease of implementation UES for “old” and “ex” are consolidated using weighted average into “ex”, and “rec” was removed.
5. Finally, using the above steps, weighted average energy and demand UES were calculated and presented as combinations for any PA; commercial (com) building type; ex and new vintages and all 16 CZs. Please refer to the calculation file[[10]](#footnote-10) for details.

Note that the measure impacts were based on DEER2020 impact IDs “AStdWBkWh” for energy, “AStdWBkW” for peak demand, and “AstdWBtherm” for fuel consumption; for all nonresidential building types and all 16 California climate zones.

Peak Electric Demand Reduction (kW)

The peak demand reduction values for an air-cooled chiller were retrieved directly from the Database of Energy Efficient Resources (DEER). See Electric Savings for an explanation of the approach.

Gas Savings (Therms)

Not applicable.

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.

The EUL and RUL specified for the air cooled chiller measure are presented below. The estimated lifetime of an air-cooled chiller was derived as the median of estimates reported in various retention studies conducted in California. (A New England study reported an estimated life of 23 years[[11]](#footnote-11) that was not accounted for in the EUL adopted for this measure, due to the 20 year cap imposed by the California Public Utilities Commission.[[12]](#footnote-12) Note that RUL is only applicable for add-on equipment, and thus not applicable for this measure.

Effective Useful Life and Remaining Useful Life

| **Parameter** | **Value** | **Source** |
| --- | --- | --- |
| EUL (yrs) – measure | 20.0 | San Diego Gas & Electric (SDG&E), Marketing Programs & Planning. 2004. 1994 & 1995 Commercial Energy Efficiency Incentives Ninth Year Retention Evaluation. Study ID Nos. 925 & 961.  Southern California Edison Company. 2006. Southern California Edison Commercial/ Industrial/ Agricultural Energy Efficiency Incentives Program Ninth Year Retention Study. CEC Study ID #558 Calmac Study ID: SCE 0243.01.  ADM Associates, Inc. 2003. Southern California Edison Commercial/Industrial/Agricultural Energy Efficiency Incentives Program Retention Study. Prepared for Southern California Edison Company.  San Diego Gas & Electric. 2006. 1996 & 1997 Nonresidential New Construction Program Ninth Year Retention Evaluation. Study ID No. 1006. |
| RUL (yrs) | n/a | - |

Base Case Material Cost ($/unit)

The material cost data for baseline and measure case air -cooled chillers was gathered from two equipment manufacturers who also participate in Upstream HVAC program. This data was collected in October - November 2020 and includes the average equipment cost per ton for the two capacity ranges and three efficiency tiers (baseline, Tier 1 and Tier 2). The average of the two manufactures cost was used as the average equipment cost. See the cost calculation[[13]](#footnote-13) for details.

Measure Case Material Cost ($/unit)

Same methodology as base case material cost.

Base Case Labor Cost ($/unit)

The labor cost is expected to be the same for the installations of base case and measure case equipment. Because the labor cost cancels out in the incremental measure cost calculation, the labor cost was not determined.

Measure Case Labor Cost ($/unit)

The labor cost is expected to be the same for the installations of base case and measure case equipment. Because the labor cost cancels out in the incremental measure cost calculation, the labor cost was not determined.

Net-to-Gross (NTG)

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 programs, as documented in the 2011 DEER Update Study conducted by Itron, Inc. This sector average NTG (“default NTG”) is 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 Ratios

| **Parameter** | **Value** | **Source** |
| --- | --- | --- |
| NTG – Commercial and Industrial | 0.60 | Itron, Inc. 2011. *DEER Database 2011 Update Documentation.* Prepared for the California Public Utilities Commission. Page 15-4 Table 15-3. |

Gross Savings Installation Adjustment (GSIA)

The gross savings installation adjustment (GSIA) rate represents the ratio of the number of verified installations of the measure to the number of claimed installations reported by the utility. This factor varies by end use, sector, technology, application, and delivery method. This GSIA rate is the current “default” rate specified for measures for which an alternative GSIA has not been estimated and approved.

Gross Savings Installation Adjustment Rate

| **Parameter** | **Value** | **Source** |
| --- | --- | --- |
| GSIA | 1.0 | California Public Utilities Commission (CPUC), Energy Division. 2013. *Energy Efficiency Policy Manual Version 5*. Page 31. |

Non-Energy Impacts

Non-energy impacts for this measure have not been quantified.

DEER Differences Analysis

This section provides a summary of inputs and methods from the Database of Energy Efficient Resources (DEER), and the rationale for inputs and methods that are not DEER-based.

DEER Difference Summary

| **DEER Item** | **Comment / Used for Workpaper** |
| --- | --- |
| Modified DEER methodology | No |
| Scaled DEER measure | No |
| DEER Base Case | Yes |
| DEER Measure Case | Yes |
| DEER Building Types | Yes |
| DEER Operating Hours | Yes |
| DEER eQUEST Prototypes | Yes |
| DEER Version | DEER 2020, READI v2.5.1 |
| Reason for Deviation from DEER | n/a |
| DEER Measure IDs Used | NE-HVAC-Chlr-AirCldScrewChlr-gte150tons-11.1EER-15.4IPLV  NE-HVAC-Chlr-AirCldScrewChlr-gte150tons-12.1EER-16.9IPLV  NE-HVAC-Chlr-AirCldScrewChlr-lt150tons-11.1EER-15.1IPLV  NE-HVAC-Chlr-AirCldScrewChlr-lt150tons-12.1EER-16.6IPLV |
| NTG | Source: DEER2019. The NTG of 0.60 is associated with NTG ID: *Com-Default>2yrs and Ind-Default>2yrs* |
| GSIA | Source: DEER. The GSIA of 1.0 is associated with GSIA ID: *Def-GSIA* |
| EUL/RUL | Source: DEER2014. The value of 20 years is associated with EUL ID: *HVAC-Chlr*. |

Revision History

Measure Characterization Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Revision Number** | **Date** | **Primary Author, Title, Organization** | **Revision Summary and Rationale for Revision**  **Effective Date and Approved By** |
| 01 | 2018-06-30 | Jennifer Holmes  Cal TF Staff | Draft of consolidated text for this statewide measure is based upon:  SCE17HCO43, Revision 0 (November 14, 2017)  SCE13HC043, Revision 2 (January 15, 2016)  SCE13HC043, Revision 1 (May 14, 2014)  Consensus reached among Cal TF members. |
|  | 2019-05-21 | Akhilesh Endurthy Solaris-Technical | Updated based on DEER2020/ E-4952  New Statewide workpaper template  Add New Construction (NC) MAT |
|  | 2020-11-19 | Akhilesh Endurthy Solaris-Technical | Updated costs using data collected in October-November 2020  Added building specific energy impacts and added “Ind” sector for “MBT” building type  Added SCE’s data tracking requirements |

1. California Energy Commission (CEC). 2018. *2019 Building Energy Efficiency Standards for Residential and Nonresidential Buildings.* CEC-400-2018-020-CMF. [↑](#footnote-ref-1)
2. Air-Conditioning, Heating, and Refrigeration Institute (AHRI). 2016. AHRI Standard 550/590 (I-P): *Standard for Performance Rating of Water-chilling and Heat Pump Water-heating Packages Using the Vapor Compression Cycle.* Arlington (VA): AHRI. Re-published with Errata Sheet. February. [↑](#footnote-ref-2)
3. California Public Utilities Commission (CPUC). 2018. *Resolution E-4952*. October 11. Page A-64. [↑](#footnote-ref-3)
4. California Energy Commission (CEC). 2018. *2019 Building Energy Efficiency Standards for Residential and Nonresidential Buildings.* CEC-400-2018-020-CMF. [↑](#footnote-ref-4)
5. California Energy Commission (CEC). 2018. *2019 Building Energy Efficiency Standards for Residential and Nonresidential Buildings.* CEC-400-2018-020-CMF. Table 110.2-D. [↑](#footnote-ref-5)
6. California Energy Commission (CEC). 2018. *2019 Building Energy Efficiency Standards for Residential and Nonresidential Buildings.* CEC-400-2018-020-CMF. [↑](#footnote-ref-6)
7. Values were available for the following building types: education - community college (ECC), education - secondary school (Ese), education - university (EUn), health/medical – hospital (Hsp), lodging – hotel (Htl), manufacturing – biotech (MBT), health/medical – nursing home (Nrs), office – large (OfL), office – small (OfS), retail – multi-story large (Rt3). [↑](#footnote-ref-7)
8. California Public Utilities Commission (CPUC), Energy Division. (n.d.) “DEER2020-Building-Weights.xlsx.” [↑](#footnote-ref-8)
9. Southern California Edison (SCE). 2019. “SWHC020-02 Air-cooled chiller-DEER2020-Bldg\_wts\_analysis.xlsx.” [↑](#footnote-ref-9)
10. “SWHC020-02 Air-cooled chiller energy impacts.xlsx.” [↑](#footnote-ref-10)
11. GDS Associates, Inc. 2007. Measure Life Report Residential and Commercial/Industrial Lighting and HVAC Measures. Prepared for the New England State Program Working Group (SPWG).  [↑](#footnote-ref-11)
12. California Public Utilities Commission (CPUC), Energy Division.  2003. Energy Efficiency Policy Manual v 2.0. Page 16. [↑](#footnote-ref-12)
13. Southern California Edison (SCE). 2017. “SWHC020-02 Air-Cooled Chiller-Cost Calculations.xlsx.” [↑](#footnote-ref-13)