Work Paper SCE17HC030

**Revision 1**

**Southern California Edison**

**Air-Cooled Constant Speed Screw Chiller**

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Measure Codes** | AC-20094, AC-20095, AC-20096, AC-20097 |
| **Measure Description** | Air-Cooled Constant Speed Screw Chillers for use in non-residential buildings, exceeding the 2016 Title 24 minimum efficiency requirements in both full load AND part load conditions by 10% (Tier 1) and 20% (Tier 2). |
| **Base Case Description** | Air-Cooled Constant Speed Screw Chillers , for use in non-residential buildings, meeting the 2016 California Title 24 minimum efficiency standards in both full load AND part load conditions – Refer to Section 1.4.2 for equipment efficiency requirements |
| **Units** | Per Ton |
| **Energy Savings** | Refer to Excel Calculation Attachment 1 |
| **Full Measure Cost ($/unit)** | Refer to Excel Calculation Attachment 2 |
| **Incremental Measure Cost ($/unit)** | Refer to Excel Calculation Attachment 2 |
| **Effective Useful Life** | 20 years (DEER EUL ID: HVAC-Chlr, DEER2014 version) |
| **Measure Installation Type** | Replace on Burnout (ROB) |
| **Net-to-Gross Ratio** | 0.60 (DEER NTG ID: Com-Default>2yrs, DEER2014 version) |
| **Important Comments** | This work paper has a complementary Ex Ante Database data set that will be provided in a separate submission to the California Public Utilities Commission (CPUC). |

# Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Rev** | **Date** | **Author** | **Summary of Changes** |
| 1 | 11/14/2017 | Arvind Subramanya/TRC | - This work paper is an update of SCE17HC030.0  - New calculation template update for 2017 program year  - Measure impacts have been adopted from updated DEER2017  - New solution codes added replacing old solution codes.  - Baseline and Measure costs updated per manufacturers’ data.  - Work paper revised to include only “Com” building type.  - All (16) climate zones added |

# Commission Staff and Cal TF Comments

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Rev** | **Party** | **Submittal Date** | **Comment Date** | **Comments** | **WP Developer Response** |
|  |  |  |  |  |  |

Cal TF website: <http://www.caltf.org/>

# Section 1. General Measure & Baseline Data

## Measure Description & Background

**Measure Description**: Air-cooled constant speed screw chillers, for use in non-residential buildings, exceeding the 2016 California Title 24 minimum efficiency standards by 10% (Tier 1) and 20% (Tier 2) for both full load and integrated part load efficiency.

**Basecase Description**: Air-cooled constant speed screw chillers, for use in non-residential buildings, meeting the 2016 California Title 24 minimum efficiency standards.

**Base, Standard, and Measure Cases**

|  |  |
| --- | --- |
| **Case** | **Description of Typical Scenario** |
| Measure | Air-Cooled Constant Speed Screw Chillers, for use in non-residential buildings, exceeding the 2016 California Title-24 minimum efficiency standards requirements listed in Section 1.4.2 by 10% and 20% for both full load AND part load efficiencies |
| Existing Condition | N/A |
| Code/Standard | Air-Cooled Chillers Constant Speed, for use in non-residential buildings, meeting the 2016 California Title-24 minimum efficiency. |
| Industry Standard Practice | N/A |

Measures and Solution Codes

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Measure Codes** | | | |  | **Measure Name** |
| SCG | SDG&E | SCE | PG&E | Tier |
|  |  | AC-20094 |  | 1 | Air Cooled Constant Speed Screw Chiller (>= 150 tons, 11.1 Min EER, 15.4 Min IPLV) |
|  |  | AC-20095 |  | 2 | Air Cooled Constant Speed Screw Chiller (>= 150 tons, 12.1 Min EER, 16.9 Min IPLV) |
|  |  | AC-20096 |  | 1 | Air Cooled Constant Speed Screw Chiller (< 150 tons, 11.1 Min EER, 15.1 Min IPLV) |
|  |  | AC-20097 |  | 2 | Air Cooled Constant Speed Screw Chiller (< 150 tons, 12.1 Min EER, 16.6 Min IPLV) |

Units are required to meet both full (EER) AND part-load (IPLV) efficiency requirements.

These measures have tiered incentive levels. According to Resolution E-4867 [511], two tiers are defined:

1. Tier 1, the full load AND part load efficiencies of the chiller should exceed Title 24 requirement by 10%.
2. Tier 2, the full load AND part load efficiencies of the chiller should exceed Title 24 requirement by 20%.

Refer to Section 1.4.2 Codes and Standards Analysis for Code requirements.

## 1.2 Technical Description

Chillers have two different measures of energy efficiency: 1) Full load efficiency measured in Energy Efficiency Ratio (EER), Coefficient of Performance (COP), or kW per Ton; and 2) part load efficiency measured as an Integrated Part Load Value (IPLV). Full load Efficiency is the measure of energy efficiency corresponding to peak loading (kW) and part load efficiency corresponds to total energy usage (kWh).

## 1.3 Installation Types and Delivery Mechanisms

The delivery method is:

* **Up-Stream Incentive / Up-Stream Buy Down**
* **Mid-Stream Incentive / Mid-Stream Buy Down**

The install type is:

* **Replace on Burnout (ROB)**

**Installation Type Descriptions**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Installation Type** | **Savings** | | **Life** | |
| 1st Baseline (BL) | 2nd BL | 1st BL | 2nd BL |
| Replace on Burnout (ROB) | Above Code or Standard | N/A | EUL | N/A |

A delivery mechanism is a delivery method paired with an incentive method. Delivery mechanisms are used by programs to obtain program participation and energy savings.

**Delivery Method Descriptions**

|  |  |
| --- | --- |
| **Delivery Method** | **Description** |
| Up-Stream Programs | See Up-Stream Incentive in the Incentive Method Descriptions table. |
| Mid-Stream Programs | See Mid-Stream Incentive in the Incentive Method Descriptions table. |

**Incentive Method Descriptions**

|  |  |
| --- | --- |
| **Incentive Method** | **Description** |
| Up-Stream Incentive | The program gives a financial incentive to an upstream market actor (manufacturer or distributor) to encourage the manufacture, provision, or distribution of efficient measures. Buy Down means that the incentive is required to be passed down to the end-use customer. |
| Mid-Stream Incentive | The program gives a financial incentive to a midstream market actor (distributor, vendor, or retailer) to encourage the promotion of efficient measures. Buy Down means that the incentive is required to be passed down to the end-use customer. |

## 1.4 Measure Parameters

### 1.4.1 DEER Data

All measure impacts for air-cooled screw chillers in this version of the workpaper are adopted directly from DEER.

DEER Difference Summary

|  |  |
| --- | --- |
| **DEER Item** | **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 2017 v3, READI v2.4.7 |
| Reason for Deviation from DEER | N/A |
| DEER Measure IDs Used | Yes, Refer to Attachment #1. |

Per policy E-4867 [511], DEER2017 is revised to include measures for “all” chillers that are 10% better than 2016 Title 24 requirements for both full-load and part-load efficiencies. For air-cooled chillers, additional measures are added for chillers that exceed 2016 Title 24 requirements by 20%. DEER requires that all measures included in programs must be at least 10% better than 2016 Title 24 minimum requirements for both full-load and integrated part-load efficiency.

Note that some chiller technology, including but not limited to Title 24 “Path B” chillers (e.g., variable speed chillers with higher part-load efficiency including frictionless compressor chillers) are current not supported by DEER2017; hence, these cannot be incentivized at this time.

Additionally, given the stringency of DEER2017 tier 2 (at 20% above Title 24) with technology meeting this requirement very limited in the market, the program expects nearly no customer participation at this efficiency level.

**Net-to-Gross Ratio**

The NTG values were obtained using the DEER READI tool. The relevant NTG values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **NTGR ID** | **Description** | **Sector** | **BldgType** | **Measure Delivery** | **NTGR** |
| Com-Default>2yrs | All other EEMs with no evaluated NTGR; existing EEM in programs with same delivery mechanism for more than 2 years | Com | Any | Any | 0.60 |

**Spillage Rate**

Spillage rates are not tracked in work papers; they are tracked in an external document which will be supplied to the Commission Staff.

**Installation Rate**

The IR values were obtained using the DEER READI tool. The relevant IR values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **GSIA ID** | **Description** | **Sector** | **BldgType** | **ProgDelivID** | **GSIAValue** |
| Def-GSIA | Default GSIA values | Any | Any | Any | 1 |

**Effective and Remaining Useful Life**

The EUL and RUL values were obtained using the DEER READI tool. DEER defines the RUL as 1/3 of the EUL value. The RUL value is only applicable to the first baseline period for an RET measure with an applicable code baseline. The relevant EUL and RUL values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| HVAC-Chlr | High Efficiency Chillers | Com | HVAC | 20 | 6.7 |

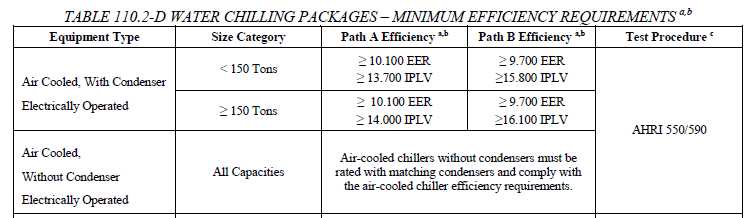
### 1.4.2 Codes and Standards Analysis

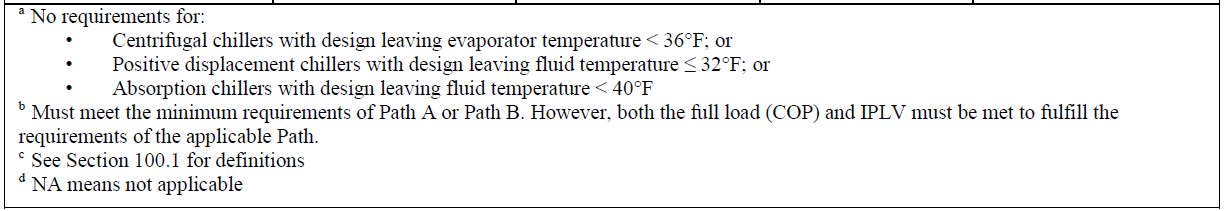
2016 Title 24 has required water chillers to meet minimum full-load efficiency (kW/ton) and minimum integrated part-load efficiency (IPLV) values. Additionally, Title 24 also included alternate efficiency paths for chiller types. Path A requires a fairly high full-load efficiency. Path B sets a lower minimum full-load efficiency than Path A, but requires a much higher minimum integrated part-load efficiency compared to Path A. DEER2017 only supports measure impacts for Path A technology.

For a given chiller, there will always be both a rated full-load efficiency (kW/ton) AND a rated part-load efficiency (IPLV). The selection of an efficiency tier level must be based on both of these parameters. If the rated full-load and part load efficiencies are both greater than or equal to the tier level values, then that tier is valid.

The California Title 24 2016 [496] base case for this above-code measure is listed in section 110.2 (a).

Air-cooled chillers with a leaving evaporator fluid temperature higher than 32°F shall show compliance with TABLE 110.2-D of the Energy Standards when tested or certified with water at standard rating conditions.





Code Summary

|  |  |  |
| --- | --- | --- |
| **Code** | **Reference** | **Effective Dates** |
| Title 24 (2016) | 2016 Building Energy Efficiency Standards, Section 110.2 (a), Table 110.2-D | January 1, 2017 |

## 1.5 EM&V, Market Potential, and Other Studies – Base Case and Measure Case Information

### E-4867 - Resolution E-4867 N/A approves updates to the Database for Energy-Efficient Resources (DEER) for 2019 and revised versions for 2017 and 2018 in Compliance with D.15-10-028 and Resolution E-4818.

### Impact Evaluation of 2015 Upstream HVAC Programs (HVAC 1), Dated April 4, 2017 - CALMAC Study ID CPU0116 - the main goal of this evaluation was to determine the best estimate of actual energy and demand savings achieved through incentivized upstream HVAC measures during the 2015 program year. A secondary objective was to provide information that can be used to develop more accurate savings estimates for future program cycles.

### 1.5.1 Non-DEER Study Review

N/A

## 1.6 Data Quality and Future Data Needs

N/A

# Section 2. Calculation Methodology

Revised DEER2017 per Policy E-4867 [511] provides latest impact values for all the chiller sizes and tiers, therefore, 2017 DEER Impact values were directly used in this workpaper update. Refer to Attachment 3 for DEER2017 energy impact values.

Calculation methodology was revised in this work paper as below:

1. Savings impacts are adopted directly without deviations from DEER2017
2. Measure impacts for ROB are based on DEER2017 “AStdWBkWh” for energy and “AStdWBkW” for demand per building type “COM” per corresponding Climate Zones for all (16) territories. The table below shows the combinations used to select the DEER impacts for the respective program type:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Program Type** | **HVAC Vintage** | **Building Type** | **PA** | **Climate Zone** |
| ROB | Ex | Com | SCE | CZ06, CZ08, CZ09, CZ10, CZ13, CZ14, CZ15, CZ16 |
| PGE | CZ01, CZ02, CZ03, CZ04, CZ05, CZ11, CZ12 |
| SDG | CZ07 |

# Section 3. Load Shapes

The ideal load shape for net benefits estimates would represent the difference between the base case and measure case. The closest load shapes that are applicable to the measures in this work paper are listed in the table below.

Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| **Building Type** | **Load Shape** | **E3 Alternate Building Type** |
| Weighted Commercial “Com” | DEER:HVAC\_Chillers | NON\_RES |

# Section 4. Costs

For ROB measures, the cost of the measure is the difference between the measure cost and the base case cost (including in both the material and labor costs). Since the labor cost for the base case and measure cost is expected to be the same, then the cost of the measure simply equates to the incremental (material) cost between the base case and the measure case.

## 4.1 Base Case Cost

Base case cost was gathered from two manufacturers based on 2016-2017 equipment availability in the market. Manufacturers provided costs for tier 1 and tier 2 equipment for both units under and above 150 tons. In some cases, only incremental costs were provided and actual cost were not provided. Therefore, baseline costs were determined by subtracting IMCs from Tier 2 cost data.

Data collection is summarized in the “SCE Measure Summary tab.” The raw data is provided in the <150 tons Data and >150 tons Data tabs in Attachment #2 - Cost Calculation. Refer to the below table for baseline chiller cost.

|  |  |  |
| --- | --- | --- |
| **Chiller Type** | **Capacity Range** | **Base Case Cost**  **($/Ton)** |
| Air Cooled Chiller | < 150 tons | $477.58 |
| $477.58 |
| ≥ 150 tons | $450.09 |
| $450.09 |

## 4.2 Measure Case Cost

Measure costs were gathered from two manufacturers. Information was collected directly from the market and not from Program data. Data was a combination of data from 2017 and 2016. Manufacturers provided costs for tier 1 and tier 2 equipment for both units under 150 tons and those greater than or equal to 150 tons. In some cases, only incremental costs were provided and actual prices were not provided. Therefore, measure costs were determined by adding IMCs from Tier 2 cost data.

Data collection is summarized in the SCE Measure Summary tab. The raw data is provided in the <150 tons Data and >150 tons Data tabs in Attachment #2 Cost Calculation. Refer to the below table for measure chiller cost. Refer to Attachment #2 for cost calculation.

|  |  |  |  |
| --- | --- | --- | --- |
| **Chiller Type** | **Capacity Range** | **Tier** | **Measure Cost**  **($/Ton)** |
| Air Cooled Chiller | < 150 tons | 1 | $658.26 |
| 2 | $803.66 |
| ≥ 150 tons | 1 | $589.32 |
| 2 | $639.15 |

## 4.3 Full and Incremental Measure Cost

**Full and Incremental Measure Cost Equations**

|  |  |  |  |
| --- | --- | --- | --- |
| **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| ROB | (MEC + MLC) – (BEC + BLC) | (MEC + MLC) – (BEC + BLC) | N/A |

MEC = Measure Equipment Cost; MLC = Measure Labor Cost

BEC = Base Case Equipment Cost; BLC = Base Case Labor Cost

**Full and Incremental Costs**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Measure** | **Measure Name** | **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| AC-20094 | Air Cooled Constant Speed Screw Chiller (>= 150 tons, 11.1 Min EER, 15.4 Min IPLV) (Tier 1) | ROB | $139.23 | $139.23 | N/A |
| AC-20095 | Air Cooled Constant Speed Screw Chiller (>= 150 tons, 12.1 Min EER, 16.9 Min IPLV) (Tier 2) | ROB | $189.05 | $189.05 | N/A |
| AC-20096 | Air Cooled Constant Speed Screw Chiller (< 150 tons, 11.1 Min EER, 15.1 Min IPLV) (Tier 1) | ROB | $180.68 | $180.68 | N/A |
| AC-20097 | Air Cooled Constant Speed Screw Chiller (< 150 tons, 12.1 Min EER, 16.6 Min IPLV) (Tier 1) | ROB | $326.08 | $326.08 | N/A |

# Attachments

1. SCE17HC030.1 – Calculation Template
2. SCE17HC030.1 – Cost Calculation
3. SCE17HC030.1 –Energy Impacts

# References

# References in this version of the work paper is based on the references file *“[References\_11152017\_131456]”*.

# References used in this work paper are listed below:

[496]

[511]