**PGECOHVC120**

**Air-Cooled Packaged Chiller**

**Revision # 4**

**Pacific Gas & Electric Company**

**Customer Energy Solutions**

**Air-Cooled Packaged Chiller**

**Measure Codes HV227 – HV232**

**PGECOHVC120**

**Air-Cooled Packaged Chiller**

PG&E is using the SCE workpaper **SCE13HC030** **Revision 1** ex-ante values for PG&E measure codes HV227- HV232.

The measure codes are listed below:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| PG&E Measure Codes | SCE Solution Code | Measure Name | Size Category | Program Tier | Minimum EER | Minimum IPLV |
| HV227 | AC-48031 | Air-Cooled Chiller-<150 tons- Tier 1- 10.07 EER or 14.29 IPLV | <150 Tons | Tier 1 | 10.07 | 14.29 |
| HV228 | AC-85838 | Air-Cooled Chiller-<150 tons- Tier 2- 10.90 EER or 15.00 IPLV | <150 Tons | Tier 2 | 10.90 | 15.00 |
| HV229 | AC-29666 | Air-Cooled Chiller-<150 tons- Tier 3- 11.50 EER or 16.00 IPLV | <150 Tons | Tier 3 | 11.50 | 16.00 |
| HV230 | AC-52814 | Air-Cooled Chiller-≥150 tons- Tier 1- 10.07 EER or 14.29 IPLV | ≥150 Tons | Tier 1 | 10.07 | 14.29 |
| HV231 | AC-11179 | Air-Cooled Chiller-≥150 tons- Tier 2- 10.90 EER or 15.00 IPLV | ≥150 Tons | Tier 2 | 10.90 | 15.00 |
| HV232 | AC-14285 | Air-Cooled Chiller-≥150 tons- Tier 3- 11.50 EER or 16.00 IPLV | ≥150 Tons | Tier 3 | 11.50 | 16.00 |

# Work Paper Approvals

The following Manager(s) approved this workpaper through the PG&E Electronic Data Routing System under Routing Requisition # \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

|  |
| --- |
|  |
| **Grant Brohard**  Manager, Technical Product Support |
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| **Carolyn Weiner**  Manager, Products and Programs |
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**Work Paper SCE13HC030**

**Revision 1**

**Southern California Edison Company**

**Air-Cooled Packaged Chiller**

**At-a-Glance Summary**

|  |  |
| --- | --- |
| Applicable Measure Codes: | *AC-48031, AC-85838, AC-29666, AC-52814, AC-11179, AC-14285* |
| **Measure Description:** | Air-Cooled Chillers, for use in non-residential buildings, meeting the minimum efficiency requirements listed in Table 1. |
| **Base Case Description:** | Air-Cooled Chillers, for use in non-residential buildings, meeting the California Title 24 minimum efficiency standard of 9.562 EER and 12.500 IPLV for less than 150 Tons and 9.562 EER and 12.750 IPLV for greater than equal to 150 Tons. |
| **Energy Impact Common Units:** | Per Ton |
| **Energy Savings :** | Refer to Excel Calculation Attachment |
| **Gross Measure Cost ($/unit)** | Refer to Excel Calculation Attachment |
| **Measure Incremental Cost ($/unit):** | Refer to Excel Calculation Attachment |
| **Effective Useful Life (years):** | 20 years, Source: DEER 2014 |
| **Measure Application Type:** | Replace on Burnout (ROB) |
| **Net-to-Gross Ratios:** | 0.6, Source: DEER 2011 |
| **Important Comments:** | **This work paper document does not contain a data set in conformance with the 4/1/14 CPUC Ex Ante Database Specification; SCE will provide that data set separately.** |

**Document Revision History**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Workpaper and Revision # | Tech. Revision | MM/DD/YY | Author/Affiliation | Summary of Changes |
| SCE13HC030.0 | No | 05/31/2012 | Alex MacCurdy/ Jun Furuta / Energy Solutions | - New template for 2013-14 program cycle.  - Workpaper adapted from WPSCNRHC0030  - All Climates Zones and DEER building types added to workpaper  - Separate savings calculation added for IPLV qualifying measures |
| SCE13HC030.1 | Yes | 07/01/2014 | Ryan Cho/SCE | - Work paper updated for the reporting period, effective 7/1/14 – 12/31/14.  - Added solution codes and updated measure names.  - Updated to 2013 Title 24 Building Codes.  - Updated to DEER2014 CZ2010 weather data files. |

**Section 1. General Measure & Baseline Data**

**1.1 Measure Description & Background**

Measure Description: Air-Cooled Chillers, for use in non-residential buildings, meeting the minimum efficiency requirements listed in **Table 1**.

Basecase Description: Air-Cooled Chillers, for use in non-residential buildings, meeting the California Title 24 minimum efficiency standard of 9.562 EER and 12.500 IPLV for less than 150 Tons and 9.562 EER and 12.750 IPLV for greater than equal to 150 Tons.

**Table 1: Packaged Air-Cooled Chiller Tier Minimum Efficiency Requirements**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Solution Code | Measure Name | Size Category | Program Tier | Minimum EER | Minimum IPLV |
| AC-48031 | Air-Cooled Chiller-<150 tons- Tier 1- 10.07 EER or 14.29 IPLV | <150 Tons | Tier 1 | 10.07 | 14.29 |
| AC-85838 | Air-Cooled Chiller-<150 tons- Tier 2- 10.90 EER or 15.00 IPLV | <150 Tons | Tier 2 | 10.90 | 15.00 |
| AC-29666 | Air-Cooled Chiller-<150 tons- Tier 3- 11.50 EER or 16.00 IPLV | <150 Tons | Tier 3 | 11.50 | 16.00 |
| AC-52814 | Air-Cooled Chiller-≥150 tons- Tier 1- 10.07 EER or 14.29 IPLV | ≥150 Tons | Tier 1 | 10.07 | 14.29 |
| AC-11179 | Air-Cooled Chiller-≥150 tons- Tier 2- 10.90 EER or 15.00 IPLV | ≥150 Tons | Tier 2 | 10.90 | 15.00 |
| AC-14285 | Air-Cooled Chiller-≥150 tons- Tier 3- 11.50 EER or 16.00 IPLV | ≥150 Tons | Tier 3 | 11.50 | 16.00 |

Units are required to meet either EER or IPLV requirements. Units do not have to meet both requirements. There is no additional Eligibility of Implementation Requirements. All building types, climate zones, and vintages are eligible for the upstream rebate.

**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 in 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). Both are important. Some manufacturers specifically design for higher IPLVs because this efficiency more closely predicts seasonal consumption and energy savings. Because manufacturers usually design units to emphasize either full or part load efficiency, many units that have very high IPLVs just miss the full load efficiency requirements and would not qualify for incentives if both full and part load efficiency ratings are required. Units with high IPLV values are desirable because they result in high kWh savings. Therefore, allowing very-high IPLV units to qualify for the Program sends the correct market signal (to manufacturers and distributors) that kW reduction and kWh savings both matter.

**1.3 Measure Application Type**

Note: See Appendix A for a comparison of the application types used by and incorporated into SCE systems versus the application types available in the newest revision of DEER 2014. Appendix A will serve as a translation between the outputs of this workpaper and application types used by READi.

The Program Delivery Method is “Upstream Programs – Up-Stream Incentive.” The incentives are provided to the HVAC equipment distributor who in part provides site installation information for each unit. The install type for the Upstream Prescriptive rebate is Replacement on Burnout (ROB).

**1.4 Measure and Base Case Cost Effectiveness Data**

**1.4.1 DEER Measure and Base Case Analysis**

The applicable DEER 2014 measure codes are NE-HVAC-Chlr-AirPkgRecip-AllSizes-1p008kwpton and NE-HVAC-Chlr-AirScrew-AllSizes-1p008kwpton, reciprocating Air-Cooled Chillers with improved kW/ton and air-cooled screw chillers with improved kW/ton, respectively. However, the DEER data is not the appropriate information for this measure because the data cited by DEER uses unachievable above code savings levels, does not include data for all compressor types, and it deviates from the cost of its above code efficient measure. For these reasons, work papers are used to modify the available DEER information. These reasons are detailed below:

1) The Title 24 efficiency baseline for DEER is the same as the Program baseline, which is 9.562 EER or 1.260 kW/ton for all capacities [355]. The DEER air-cooled package chiller measures are based on an above code efficiency of 11.9 EER or 1.008kW/ton (20% savings). This efficiency level is currently achievable by only one model of one major manufacturer, and a few smaller chiller manufacturers. In order for the program to reach any significant market, the minimum requirements must be achievable by a larger share of the market. The maximum efficiency of air-cooled packaged chillers made by most major manufacturers, at the time this work paper was written, is approximately 11.5 EER (17.4% above code). Therefore, DEER data was scaled down to account for the difference between the DEER measure efficiency and the program measure efficiency.

2) DEER air-cooled chiller measures are based on two compressor types: reciprocating and screw. There are no reciprocating air-cooled packaged chillers made by the major manufacturers. These manufacturers only make air-cooled package chillers with screw compressors; one-third is reciprocating and two-thirds are screw. Therefore DEER data on reciprocating chillers was not used for this analysis.

3) DEER Incremental Measure Cost (IMC) is based on its above code efficiency of 11.9 EER, which are not the same units that this work paper is based on. Based on research from data received from major manufacturers, the IMC (per Ton) for Tier 1 is $20, Tier 2 is $76, and Tier 3 is $104 [C].

4) The DEER air-cooled packaged chiller measure only provides data on the chiller’s full load efficiency.

This section of the work paper explains the reasoning behind using a calculation method that deviates from the DEER database.

**Table 2 DEER Difference Summary**

|  |  |
| --- | --- |
| DEER Difference Summary Table | |
| Modified DEER Methodology | Yes |
| Scaled DEER Measure | Yes |
| DEER Building Prototypes Used | Yes |
| Deviation from DEER | Savings for EER qualifying units scaled from DEER2014. Savings for IPLV qualifying units use ACH \* delta kW/ton savings calculation. ACH derived from DEER2014 MAS Control files. Demand reduction for all units scaled from DEER2014. |
| DEER Version | DEER 2014 & DEER 2014 MAS Control Files |
| DEER Run ID and Measure Name (Sample) | NE-HVAC-Chlr-AirScrew-AllSizes-1p008kwpton |

**Net to Gross**

The NTG value was obtained from the “DEER2011\_NTGR\_2012-05-16.xls” on the DEER website as required by Version 5 of the California Public Utilities Commission (CPUC) Energy Efficiency Policy Manual [351]. The relevant NTGR for this measure is shown in **Error! Reference source not found.Table 3** below.

**Table 3 Net-to-Gross Ratio**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| NTGR\_ID\* | Description\* | Sector\* | BldgType\* | ProgDelivID | NTG\* |
| Com-Default>2yrs | All other EEMs with no evaluated NTGR; existing EEM in programs with same delivery mechanism for more than 2 years | Com | Com | All | 0.60 |

\*Denotes that the column is taken from the DEER NTG Table.

**Installation Rate**

The installation rate (IR) is identified in the calculation attachment. This value is obtained from the support table available in READi. Currently there is no versioning on the installation rate table. To address appropriate selection of the installation rate the date of the workpaper will serve as the last date checked for updated IR values. The installation rate varies by end use, sector, technology, application, and delivery method. The relevant IR values for this measure are shown in Table 4 below.

**Table 4 Installation Rate**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| GSIA\_ID | Description | Sector | BldgType | ProgDelivID | GSIAValue |
| Def-GSIA | Default GSIA values | Any | Any | Any | 1.0 |

**Spillage Rate**

Spillage rate will also be applied to measures however the values will not be tracked in the workpapers. The spillage rate will be tracked in an external table to be supplied to the Energy Division.

**READi Technology Fields**

To support the development of the ED ex ante tables, select fields from the ex ante database will be identified in the workpaper. For a full set of values associated with the measures in the workpaper refer the Excel calculation template.

**Table 5 READi Tech IDs**

|  |  |
| --- | --- |
| READi Field Name | Values included in this workpaper |
| Measue Case UseCategory | HVAC |
| Measure Case UseSubCats | SpaceCool |
| Measure Case TechGroups | Chiller |
| Measure Case TechTypes | Screw |
| Base Case TechGroups | Chiller |
| Base Case TechTypes | Screw |

**1.4.2 Codes and Standards Analysis**

The California Title 24 2013 [355] base case for this above-code measure is listed in section 110.2 (a), “Equipment shall meet the applicable requirements Table 110.2-A through Table 110.2-M.” Efficiency requirements for air-cooled packaged chillers are identified in Table 110.2-D.



**Table 6 Code Summary**

|  |  |  |
| --- | --- | --- |
| Code | Applicable Code Reference | Effective Dates |
| Title 24 (2013) | 2013 Building Energy Efficiency Standards, Section 110.2 (a), Table 110.2-D | July 1, 2014 |
| Title 20 (2014) | N/A | N/A |

**1.4.3 Non-DEER Study Review**

The analysis in this workpaper utilizes 2014 DEER.

**1.4.4 Measure and Base Case Effective Useful Life**

DEER14 update documentation provides EUL and RUL information to be used for the 2013-2014 program cycle extension on [www.deeresources.com](http://www.deeresources.com). The DEER documentation “Summary of EUL-RUL Analysis for the April 2008 Update to DEER” provides the RUL value as a flat 1/3 of the EUL value. The RUL value will only be applied to the first baseline period for retrofit measures that have applicable code that will affect the energy savings. In all other installation types and retrofit with no applicable code that affects the energy savings, the RUL is not applicable to either the first or second baseline period.

To obtain the EUL value the DEER14 update documentation, EUL\_Summary\_10-1-08.xls [213], was consulted. **Table 7** below identifies the value/methodology used for the measures in this work paper.

**Table 7 DEER14 EUL Value/Methodology**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| READi EUL ID | Market | Enduse | Measure | EUL (Years) | RUL (Years) |
| HVAC-Chlr | Non-Residential | HVAC – Chillers | High Efficiency Chillers | 20 | 6.7 |

**Section 2. Energy Savings & Demand Reduction Calculations**

**2.1 Electric Energy Savings Estimation Methodologies**

As discussed in Section 1.4.1, the DEER measure efficiency does not appropriately reflect the chiller products available on the market; therefore data from the 2013-2014 SCE & PG&E Upstream HVAC Programs was utilized to develop adjustment factors and calculate energy savings and demand reduction. Data is for only eligible and approved application for both SCE and PG&E with a sales date from 1/1/2013 to 2/4/2014. For each tier, equipment may qualify based on their EER (full load) or their IPLV (part load) rating. The savings attributed to each qualifying EER are determined by DEER measures with a scaling factor and the savings attributed to each qualifying IPLV are determined by an IPLV part load calculation using DEER annual cooling hours. These two sets of savings were weighted by the percentage of equipment qualifying under their respective program efficiency criteria and combined into an average savings value for the program.

Table 8 contains the data files for measures that are taken directly from the DEER 2014 READi Tool or were created using the READi Tool. These results have not been modified and are only being included in the workpaper for reference.

**Table 8 READi Tool Outputs**

|  |  |  |
| --- | --- | --- |
| Solution Code | Measure Name | READi Results |
| *AC-48031, AC-85838, AC-29666, AC-52814, AC-11179, AC-14285* | Air cooled screw chiller (1.008 kW/ton) |  |

Data from the 2013-2014 SCE & PG&E Upstream HVAC Programs, show that the average efficiency for equipment submitted in Tiers 1-3 are higher than the minimum qualifying efficiency requirements. For example, a Tier 1 chiller that qualifies under EER has a minimum tier requirement of 10.07 EER, but program data shows that Tier 1 equipment under 150 Tons qualifying under EER has an average EER of 10.33. Similarly, a Tier 3 chiller that qualifies under IPLV has a minimum tier requirement of 16 IPLV, but program data shows that Tier 3 equipment under 150 Tons qualifying under IPLV has an average IPLV of 18.25.

**Table 9** below shows the average EER and IPLV of units qualifying under EER only, IPLV only, and both EER and IPLV.

**Table 9 Program Average EER and IPLV**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Size Category | Tier | Minimum EER | Minimum IPLV | EER Only  Average EER | IPLV Only | |
| **Average EER** | **Average IPLV** |
| ≥150 Tons | 1 | 10.07 | 14.29 | 10.33 | 10.55 | 14.60 |
| ≥150 Tons | 2 | 10.9 | 15 | N/A\* | 10.48 | 15.43 |
| ≥150 Tons | 3 | 11.5 | 16 | N/A\* | 10.81 | 18.25 |
| <150 Tons | 1 | 10.07 | 14.29 | 10.33 | 10.24 | 14.64 |
| <150 Tons | 2 | 10.9 | 15 | N/A\* | 10.34 | 15.28 |
| <150 Tons | 3 | 11.5 | 16 | 12.45  (11.50)\*\* | 10.50 | 16.58 |

\*No data is available based on the 2013-2014 SCE and PG&E Upstream HVAC Programs.

\*\* Only 2 chiller model from the 2013-2014 SCE and PG&E Upstream HVAC Programs has qualified for Tier 3 based on EER only. This is not a statistically valid sample; therefore, the minimum EER for Tier 3 (11.50) will be used to scale savings.

2013-2014 program data can be found in the attached excel sheet, Air-Cooled Chiller EER and IPLV Program Data 2013-2014.xlsx [A].

**EER Qualifying Units - Estimated Savings**

Savings estimates based on equipment qualifying under EER come from the DEER 2014 database accessed through the Remote Ex-Ante Database Interface (READi v2.0.1). However, the DEER 2014 measure efficiency for air-cooled packaged chillers is higher than the program measure efficiency; therefore a scaling factor based on kW/ton was applied to the DEER impact values in order to adjust savings for the program measures. The scaling factors are derived in Table 10.

**Table 10: Comparison of Program Requirements to DEER Measure**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Size Category | Tier | DEER Base Efficiency  (Full Load) | Program Base Efficiency  (Full Load)\*\* | DEER Measure Efficiency  (Full Load) | Program Measure Average Efficiency (Full Load) | DEER Efficiency Improvement (∆kW/ton) | | Program Efficiency Improvement (∆kW/ton) | Scaling Factor  (Program ∆kW/ton / DEER ∆kW/ton) |
| ≥150 Tons | 1 | 1.260 kW/ton | 1.260 kW/ton | 1.008 kW/ton | 1.161 kW/ton | | 0.252 | 0.099 | 0.393 |
| ≥150 Tons | 2 | 1.260 kW/ton | 1.260 kW/ton | 1.008 kW/ton | N/A\* | | 0.252 | N/A\* | N/A\* |
| ≥150 Tons | 3 | 1.260 kW/ton | 1.260 kW/ton | 1.008 kW/ton | N/A\* | | 0.252 | N/A\* | N/A\* |
| <150 Tons | 1 | 1.260 kW/ton | 1.260 kW/ton | 1.008 kW/ton | 1.162 kW/ton | | 0.252 | 0.098 | 0.389 |
| <150 Tons | 2 | 1.260 kW/ton | 1.260 kW/ton | 1.008 kW/ton | N/A\* | | 0.252 | N/A\* | N/A\* |
| <150 Tons | 3 | 1.260 kW/ton | 1.260 kW/ton | 1.008 kW/ton | 1.043  kW/ton | | 0.252 | 0.217 | 0.859 |

\*No data is available based on the 2013-2014 SCE and PG&E Upstream HVAC Programs.

\*\* Program Base Efficiency is same as DEER Base Efficiency.

The scaling factors shown above were then applied to DEER impact values, resulting in the total average energy and demand savings for units qualifying under EER. Furthermore, Tier 2 and 3 for ≥150 Tons and Tier 2 for <150 Tons do not have scaling factor because no data is available from the 2013-2014 SCE and PG&E Upstream HVAC Programs.

**IPLV Qualifying Units - Estimated Savings**

Savings estimates based on equipment qualifying under IPLV come from using the average annual cooling hours (ACH) and multiplying them against the delta IPLV kW/ton values. ACH is obtained by performing the eQuest model simulation using the 2014 DEER models generated by MASControl v3.00.20 and DEER 2014 CZ2010 weather data files. IPLV is an estimate of the part load efficiency of the equipment in units of Btuh/Watt and can be converted to an average part load kW/ton using the following formula:

Equation 1: kW/ton = 12 / IPLV

By determining the kW/ton of the base and measure case equipment and multiplying the difference in efficiency by the annual cooling hours, it is possible to estimate the annual energy savings of the measure as shown by the following equation:

Equation 2: Annual Energy Savings [kWh/ton] = (12 / IPLVbc- 12 / IPLVmc) x ACH

Where,

IPLVbc is the base (code) case IPLV

IPLVmc is the 2013-2014 program average IPLV for each measure tier

ACH is the annual hours where mechanical cooling is required for the building and climate zone

For example, the tier 2 under 150 Tons for Office Large and CZ01 minimum IPLV is 15.00 IPLV and the base case is 12.500 IPLV. If the MAS Control models indicate an ACH of 770 hours annually, then the weighted average savings would be calculated as follows:

Weighted Average Annual

Annual Energy Savings [kWh/ton] = (12 / IPLVbc- 12 / IPLVmc) x ACH

= (12 / 12.50 - 12 / 15.28) x 770 hours

= 134.55 kWh/ton

The annual operating hours were derived using the average of the annual cooling hours (ACH) collected from the DEER2014 models in MAS Control v3.00.20. The cooling hours were compiled from all the system annual cooling load hours in the DOE 2 SS-C reports and it was determined from the models of customer average case (CAv) in DEER.

For example, the large office building model contained three multi-zone HVAC systems serving the ground, middle and top floors of the building. To determine the average ACH for the building in a specific climate zone, the models were run for all seven vintages available in MAS Control, using both the customer average and code base line systems. The table below represents the runs averaged for Large Office in climate zone 6.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **BLDG** | **CZ** | **VINT** | **MEAS** | **Equip** | **System** | **ACH** |
| OfL | w06 | v03 | cCAv | Chlr AirScrew | EL1 Sys1 (VAVS) (G) | 2960 |
| OfL | w06 | v03 | cCAv | Chlr AirScrew | EL1 Sys1 (VAVS) (M) | 3139 |
| OfL | w06 | v03 | cCAv | Chlr AirScrew | EL1 Sys1 (VAVS) (T) | 3097 |
| OfL | w06 | v07 | cCAv | Chlr AirScrew | EL1 Sys1 (VAVS) (G) | 2959 |
| OfL | w06 | v07 | cCAv | Chlr AirScrew | EL1 Sys1 (VAVS) (M) | 3100 |
| OfL | w06 | v07 | cCAv | Chlr AirScrew | EL1 Sys1 (VAVS) (T) | 3068 |
| OfL | w06 | v11 | cCAv | Chlr AirScrew | EL1 Sys1 (VAVS) (G) | 2961 |
| OfL | w06 | v11 | cCAv | Chlr AirScrew | EL1 Sys1 (VAVS) (M) | 3112 |
| OfL | w06 | v11 | cCAv | Chlr AirScrew | EL1 Sys1 (VAVS) (T) | 3072 |
| OfL | w06 | v14 | cCAv | Chlr AirScrew | EL1 Sys1 (VAVS) (G) | 2585 |
| OfL | w06 | v14 | cCAv | Chlr AirScrew | EL1 Sys1 (VAVS) (M) | 2757 |
| OfL | w06 | v14 | cCAv | Chlr AirScrew | EL1 Sys1 (VAVS) (T) | 2726 |
| OfL | w06 | v75 | cCAv | Chlr AirScrew | EL1 Sys1 (VAVS) (G) | 3316 |
| OfL | w06 | v75 | cCAv | Chlr AirScrew | EL1 Sys1 (VAVS) (M) | 3321 |
| OfL | w06 | v75 | cCAv | Chlr AirScrew | EL1 Sys1 (VAVS) (T) | 3355 |
| OfL | w06 | v85 | cCAv | Chlr AirScrew | EL1 Sys1 (VAVS) (G) | 3111 |
| OfL | w06 | v85 | cCAv | Chlr AirScrew | EL1 Sys1 (VAVS) (M) | 3144 |
| OfL | w06 | v85 | cCAv | Chlr AirScrew | EL1 Sys1 (VAVS) (T) | 3163 |
| OfL | w06 | v96 | cCAv | Chlr AirScrew | EL1 Sys1 (VAVS) (G) | 3122 |
| OfL | w06 | v96 | cCAv | Chlr AirScrew | EL1 Sys1 (VAVS) (M) | 3212 |
| OfL | w06 | v96 | cCAv | Chlr AirScrew | EL1 Sys1 (VAVS) (T) | 3234 |
|  |  |  |  |  | **Average ACH** | **3072** |

**Combined EER and IPLV Savings**

Using the energy savings estimates from the DEER measure EER and the IPLV calculations, a combined savings value was determined for each end use within each measure code. The combined value was calculated by taking a weighted average of the savings based on the percentage of equipment submitted in the 2013-2014 SCE & PG&E Upstream Programs that qualified under either the EER or IPLV ratings.

Because part load operating conditions represents the majority of the operating hours for this equipment, the IPLV part load energy savings best represents the expected savings when the equipment qualified under both EER and IPLV. Thus, for this percentage of equipment, the energy savings value was taken from the IPLV estimate. The weighted average savings was calculated using the following equation:

Equation 3: Weighted Average Annual

Energy Savings [kWh/ton] = (EER Savings [kWh/ton] x % EER Qualified) + (IPLV Savings [kWh/ton] x (% IPLV Qualified + % Both Qualified))

Where,

EER Savings is the annual energy savings determined from the program EER using the DEER measures

IPLV Savings is the annual energy savings determined from the program IPLV and the delta IPLV calculation

% EER Qualified is the percentage of equipment submitted under the 2013-2014 programs that qualified for the measure under the EER requirement

% IPLV Qualified is the percentage of equipment submitted under the 2013-2014 programs that qualified for the measure under the IPLV requirement

% Both Qualified is the percentage of equipment submitted under the 2013-2014 programs that qualified for the measure under both the EER and IPLV requirements

For example, the Tier 1 under 150 Tons for Office Large and CZ01 minimum rating requirements are 10.07 EER or 14.29 IPLV. Scaling DEER 2014 indicates the energy savings for 10.07 EER is 40.80 kWh/ton and the delta IPLV calculation shows a savings of 108.11 kWh/ton for a 14.29 IPLV measure. If the 2013 - 2014 program application data shows 44% of the applications would have qualified for this tier under the EER rating alone, 27% under just the IPLV rating, and 28% under either rating. Therefore, the average estimated savings will be 44% from the DEER EER scaling approach, and 55% from the IPLV scaling approach. The weighted average savings would be calculated as follows:

Tier 1 EER Savings (kWh/ton) = DEER 2014 Air-Cooled Screw Chiller Savings (1.008 kW/ton) \* Tier 1 Scaling Factor

= 40.80 kWh/ton \* .390

= 15.92 kWh/ton

Tier 1 IPLV Savings (kW/ton) = (12 / IPLVbc- 12 / IPLVmc) x ACH

= (12 / 12.50 - 12 / 14.64 x 770 hours

= 108.11 kWh/ton

Weighted Average Annual

Energy Savings [kWh/ton] = (EER Savings [kWh/ton] x % EER Qualified) + (IPLV Savings [kWh/ton] x (% IPLV Qualified + % Both Qualified))

= (15.92 kWh/ton x 44%) + (108.11 kWh/ton x (27% + 28%))

= 67.37 kWh/ton

2013-2014 program data that documents the percent of equipment qualifying under EER and IPLV for each tier and size category can be found in the attached excel sheet “Air-Cooled Chiller EER and IPLV Program Data 2013-2014.xlsx” [A].

The final estimated savings are derived in the attached excel sheet “ACC IPLV Savings.xlsx”[B].

**2.2 Demand Reduction Estimation Methodologies**

Similar to the energy savings estimation, the peak demand reduction was also determined from a weighted average of the EER based DEER peak demand reduction values and the calculated IPLV peak demand reduction estimates, using the percentage of equipment qualifying under their respective program efficiency criteria and size category.

**EER Qualifying Units - Estimated Demand Reduction**

The demand reduction for EER qualifying units was derived using the same method as the EER qualifying energy savings.

**IPLV Qualifying Units - Estimated Demand Reduction**

The demand reduction for IPLV qualifying units was derived using a similar method as the EER qualifying energy savings. DEER savings are based on EER therefore; DEER can be scaled to determine peak demand reduction for units qualifying under only IPLV. Because equipment qualifying under only IPLV, does not require the same EER as units qualifying under EER, a different scaling factor was developed to correspond to the average EER of units qualifying only under IPLV. 2013-2014 PGE and SCE Upstream Program data was gathered to determine the average Program Measure Efficiency (Full Load) of chillers qualifying for each tier and size category based only on IPLV.

**Table 11: Scaling factors for IPLV Qualifying Units**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Size Category | Tier | DEER Base Efficiency  (Full Load) | Program Base Efficiency  (Full Load) | DEER Measure Efficiency  (Full Load) | Program Measure Efficiency (Full Load) | DEER Efficiency Improvement (∆kW/ton) | Program Efficiency Improvement (∆kW/ton) | Scaling Factor  (Program ∆kW/ton / DEER ∆kW/ton) |
| ≥150 Tons | 1 | 1.260 kW/ton | 1.260 kW/ton | 1.008 kW/ton | 1.137 kW/ton | 0.252 | 0.123 | 0.486 |
| ≥150 Tons | 2 | 1.260 kW/ton | 1.260 kW/ton | 1.008 kW/ton | 1.145 kW/ton | 0.252 | 0.115 | 0.456 |
| ≥150 Tons | 3 | 1.260 kW/ton | 1.260 kW/ton | 1.008 kW/ton | 1.110 kW/ton | 0.252 | 0.150 | 0.595 |
| <150 Tons | 1 | 1.260 kW/ton | 1.260 kW/ton | 1.008 kW/ton | 1.171 kW/ton | 0.252 | 0.089 | 0.350 |
| <150 Tons | 2 | 1.260 kW/ton | 1.260 kW/ton | 1.008 kW/ton | 1.160 kW/ton | 0.252 | 0.100 | 0.395 |
| <150 Tons | 3 | 1.260 kW/ton | 1.260 kW/ton | 1.008 kW/ton | 1.143 kW/ton | 0.252 | 0.117 | 0.465 |

**Combined EER and IPLV Demand Reduction**

Using the peak demand reduction values from the DEER measures and EER calculations, a combined peak demand reduction value was determined for each end use within each measure code. The combined value was calculated by taking a weighted average of the peak demand reduction values based on the percentage of equipment submitted in the 2013-2014 SCE & PG&E Upstream Programs that qualified under either the EER or IPLV ratings. Because peak demand reduction is determined by the full load performance, when the equipment qualified under both EER and IPLV, the peak demand reduction value was taken from the DEER measure. This value better represents the peak demand reduction of the actual EER of the equipment compared to the average EER from AHRI used in the IPLV calculated value. The weighted average peak demand reduction value was determined using the following equation.

Equation 4: Weighted Average Peak

Demand Reduction [kW/ton] = (EER Demand Reduction [kW/ton] x (% EER Qualified + % Both Qualified)) + (IPLV Demand Reduction [kW/ton] x % IPLV Qualified)

Where,

EER Demand Reduction is the peak demand reduction determined from the program EER using the DEER measures

IPLV Demand Reduction is the peak demand reduction determined from the program IPLV and the delta EER calculation

% EER Qualified is the percentage of equipment submitted under the 2013-2014 programs that qualified for the measure under the EER requirement

% IPLV Qualified is the percentage of equipment submitted under the 2013-2014 programs that qualified for the measure under the IPLV requirement

% Both Qualified is the percentage of equipment submitted under the 2013-2014 programs that qualified for the measure under both the EER and IPLV requirements

The final estimated demand reductions per climate zone and building type are derived in the attached excel sheet “ACC IPLV Savings.xlsx”[B].

**Section 3. Load Shapes**

The difference between the base case load shape and the measure load shape would be the most appropriate load shape; however, only end-use profiles are available. Therefore, the closest load shape chosen for this measure is the DEER:HVAC\_Chillers load shape. See **Table 12** for a list of all Building Types and Load Shapes. See the KEMA report [31] for a more thorough discussion regarding the load shapes for this measure.

**Table 12 Building Types and Load Shapes**

|  |  |  |
| --- | --- | --- |
| **Building Type** | **E3 Alt. Building Type** | **Load Shape** |
| Education - Community College | NON\_RES | DEER:HVAC\_Chillers |
| Education - Secondary School | NON\_RES | DEER:HVAC\_Chillers |
| Education – University | NON\_RES | DEER:HVAC\_Chillers |
| Health/Medical - Hospital | NON\_RES | DEER:HVAC\_Chillers |
| Lodging – Hotel | NON\_RES | DEER:HVAC\_Chillers |
| Manufacturing - Bio/Tech | NON\_RES | DEER:HVAC\_Chillers |
| Health/Medical - Nursing Home | NON\_RES | DEER:HVAC\_Chillers |
| Office – Large | NON\_RES | DEER:HVAC\_Chillers |
| Office – Small | NON\_RES | DEER:HVAC\_Chillers |
| Retail - Multistory Large | NON\_RES | DEER:HVAC\_Chillers |

**Section 4. Base Case & Measure Costs**

**4.1 Base Case Cost**

DEER cost data cannot be used because the air cooled chiller measure in DEER is unachievable in the market. Therefore, data was taken from manufacturer cost data (names omitted for price confidentiality). This data can be found in the attachment “Manufacturer IMC Data.xlsx” [C].

**Table 13: Manufacturer Baseline Cost Data Table**

| **Cost Case Description** | **Measure Minimum** | | **Material Cost (per Ton)** |
| --- | --- | --- | --- |
| **EER** | **IPLV** |
| Air-Cooled Chiller –Code Baseline | 9.55 | 10.41 | $404.99 |
| Air-Cooled Chiller – Tier 1 | 10.07 | 14.29 | $425.43 |
| Air-Cooled Chiller – Tier 2 | 10.90 | 15.00 | $480.49 |
| Air-Cooled Chiller – Tier 3 | 11.50 | 16.00 | $509.43 |

**4.2 Measure Case Cost**

DEER cost data cannot be used because the air cooled chiller measure in DEER is unachievable in the market. Therefore, data was taken from manufacturer cost data (names omitted for price confidentiality). This data can be found in the attachment “Manufacturer IMC Data.xlsx” [C].

**4.3 Gross and Incremental Measure Cost**

**4.3.1 Gross Measure Cost**

For ROB, GMC is represented by the equation below:

Equation 1: GMC = (Measure Equipment Cost + Measure Labor Cost) – (Base Case Equipment Cost + Base Case Labor Cost)

\*Note: The measure case labor and base case labor are assumed to be the same value reducing the equation to the following:

Equation 2: GMC = Measure Equipment Cost – Base Case Equipment Cost

The gross measure costs are listed in Table 13.

**Table 14: Work Paper Gross Measure Cost Data Table**

| **Cost Case Description** | **Measure Minimum** | | **Gross Measure Cost (per Ton)** |
| --- | --- | --- | --- |
| **EER** | **IPLV** |
| Air-Cooled Chiller – Tier 1 | 10.07 | 14.29 | $20.44 |
| Air-Cooled Chiller – Tier 2 | 10.90 | 15.00 | $75.50 |
| Air-Cooled Chiller – Tier 3 | 11.50 | 16.00 | $104.43 |

**4.3.2 Incremental Measure Cost**

For ROB, IMC is represented by the equation below:

Equation 1: IMC = (Measure Equipment Cost + Measure Labor Cost) – (Base Case Equipment Cost + Base Case Labor Cost)

\*Note: The measure case labor and base case labor are assumed to be the same value reducing the equation to the following:

Equation 2: IMC = Measure Equipment Cost – Base Case Equipment Cost

**Table 15: Manufacturer Incremental Measure Cost Data Table**

| **Cost Case Description** | **Measure Minimum** | | **Gross Measure Cost (per Ton)** |
| --- | --- | --- | --- |
| **EER** | **IPLV** |
| Air-Cooled Chiller – Tier 1 | 10.07 | 14.29 | $20.44 |
| Air-Cooled Chiller – Tier 2 | 10.90 | 15.00 | $75.50 |
| Air-Cooled Chiller – Tier 3 | 11.50 | 16.00 | $104.43 |

Attachments

1.2. 3.4.

**References**



[31]

[213]

[351]

[355]

[A] Attachment 2 – Air-Cooled Chiller EER and IPLV Program Data 2013-2014.xlsx

[B] Attachment 3 – ACC IPLV Savings.xlsx

[C] Attachment 4 – Manufacturer IMC Data.xlsx

**Appendix A – SCE/ED Application Types**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| SCE Program Type | ED Application Type | 1st Baseline Savings | 2nd Baseline Savings | 1st Baseline Cost | 2nd Baseline Cost | 1st Baseline Life | 2nd Baseline Life |
| New | New Construction (Nc) | Above Code/Standard | N/A | Incremental Cost | N/A | EUL | 0 |
| Replace on Burnout (ROB) | Replace on Burnout (Rob)/Normal Replacement (NR) | Above Code/Standard | N/A | Incremental Cost | N/A | EUL | 0 |
| Retrofit (RET) | Early Replacement (ER) | Above Cust. Existing | Above Code/Standard | Full Cost | Incremental Cost | RUL | EUL-RUL |
| Retrofit – First Baseline Only (REF) | Early Replacement RUL (ErRul) | Above Cust. Existing | N/A | Full Cost | N/A | EUL | 0 |
| Retrofit Add-on (REA) | N/A | Above Cust. Existing | N/A | Full Cost | N/A | EUL | 0 |