Work Paper SCE17HC043

**Revision 0**

**Southern California Edison**

**Water Cooled Chiller**

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Measure Codes** | Refer to Section 1.1 |
| **Measure Description** | Variable speed Water-Cooled Chillers, for use in non-residential buildings, exceeding the Title 24 minimum efficiency requirements in both full load and integrated part load conditions by 10% and 15%. |
| **Base Case Description** | Variable speed Water-Cooled chillers, for use in non-residential buildings, meeting the 2016 California Title 24 minimum efficiency standards in both full load and integrated 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, DEER2017 version) |
| **Measure Installation Type** | Replace on Burnout (ROB) |
| **Net-to-Gross Ratio** | 0.60 (DEER NTG ID: Com-Default>2yrs, DEER2014 |
| **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** |
| 0 | 11/14/2017 | Arvind Subramanya/TRC | - This work paper is an update of SCE13HC043.2  - New calculation template update for 2017 program year.  - Baseline chiller efficiencies updated per 2016 Title 24.  - Measure impacts adopted directly from DEER 2017.  - New solution codes added replacing old solution codes.  - Baseline and Measure costs updated as indicated per manufacturer data.  - Building type updated “Com”.  - All (16) climate zones supported.  - Enabled Mid-Stream incentive method |

# 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: Variable Speed Water-Cooled Chillers, for use in non-residential buildings, exceeding the 2016 California Title 24 minimum efficiency standards by 10% and 15% for both full load and integrated part load efficiency.

Basecase Description: Variable Speed Water-Cooled 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 | Variable Speed Water-Cooled Chillers, for use in non-residential buildings, exceeding the 2016 California Title-24 minimum efficiency standards requirements by 10% and 15% for both full load and integrated part load efficiency |
| Existing Condition | N/A |
| Code/Standard | Variable Speed Water-Cooled Chillers, for use in non-residential buildings, meeting 2016 Title-24 minimum efficiency |
| Industry Standard Practice | N/A |

Measures and Solution Codes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Codes** | | | | **Measure Name** |
| SCG | SDG&E | SCE | PG&E |
|  |  | AC-20033 |  | Water Cooled Centrifugal Chiller w/1 conventional VSD compressor and condenser relief (150 to 299 tons, 0.54 Max kW/ton, 0.34 Max IPLV) |
|  |  | AC-20034 |  | Water Cooled Centrifugal Chiller w/1 conventional VSD compressor and condenser relief (150 to 299 tons, 0.572 Max kW/ton, 0.36 Max IPLV) |
|  |  | AC-20035 |  | Water Cooled Centrifugal Chiller w/1 conventional VSD compressor and condenser relief (300 to 399 tons, 0.506 Max kW/ton, 0.332 Max IPLV) |
|  |  | AC-20036 |  | Water Cooled Centrifugal Chiller w/1 conventional VSD compressor and condenser relief (300 to 399 tons, 0.536 Max kW/ton, 0.351 Max IPLV) |
|  |  | AC-20037 |  | Water Cooled Centrifugal Chiller w/1 conventional VSD compressor and condenser relief (400 to 599 tons, 0.497 Max kW/ton, 0.323 Max IPLV) |
|  |  | AC-20038 |  | Water Cooled Centrifugal Chiller w/1 conventional VSD compressor and condenser relief (400 to 599 tons, 0.527 Max kW/ton, 0.342 Max IPLV) |
|  |  | AC-20039 |  | Water Cooled Centrifugal Chiller w/1 conventional VSD compressor and condenser relief (>= 600 tons, 0.497 Max kW/ton, 0.323 Max IPLV) |
|  |  | AC-20040 |  | Water Cooled Centrifugal Chiller w/1 conventional VSD compressor and condenser relief (>= 600 tons, 0.527 Max kW/ton, 0.342 Max IPLV) |
|  |  | AC-20041 |  | Water Cooled Centrifugal Chiller w/1 conventional VSD compressor and condenser relief (< 150 tons, 0.591 Max kW/ton, 0.374 Max IPLV) |
|  |  | AC-20043 |  | Water Cooled Centrifugal Chiller w/1 conventional VSD compressor and condenser relief (< 150 tons, 0.626 Max kW/ton, 0.396 Max IPLV) |
|  |  | AC-20074 |  | Water Cooled Variable Speed Screw Chiller (150 to 299 tons, 0.578 Max kW/ton, 0.374 Max IPLV) |
|  |  | AC-20076 |  | Water Cooled Variable Speed Screw Chiller (150 to 299 tons, 0.612 Max kW/ton, 0.396 Max IPLV) |
|  |  | AC-20078 |  | Water Cooled Variable Speed Screw Chiller (300 to 599 tons, 0.531 Max kW/ton, 0.349 Max IPLV) |
|  |  | AC-20080 |  | Water Cooled Variable Speed Screw Chiller (300 to 599 tons, 0.563 Max kW/ton, 0.369 Max IPLV) |
|  |  | AC-20082 |  | Water Cooled Variable Speed Screw Chiller (75 to 149 tons, 0.638 Max kW/ton, 0.417 Max IPLV) |
|  |  | AC-20084 |  | Water Cooled Variable Speed Screw Chiller (75 to 149 tons, 0.675 Max kW/ton, 0.441 Max IPLV) |
|  |  | AC-20086 |  | Water Cooled Variable Speed Screw Chiller (>= 600 tons, 0.497 Max kW/ton, 0.323 Max IPLV) |
|  |  | AC-20089 |  | Water Cooled Variable Speed Screw Chiller (>= 600 tons, 0.527 Max kW/ton, 0.342 Max IPLV) |
|  |  | AC-20091 |  | Water Cooled Variable Speed Screw Chiller (< 75 tons, 0.663 Max kW/ton, 0.425 Max IPLV) |
|  |  | AC-20093 |  | Water Cooled Variable Speed Screw Chiller (< 75 tons, 0.702 Max kW/ton, 0.45 Max IPLV) |

Units are required to meet both full load AND integrated part load efficiency requirements.

Note that there are various chiller technologies including constant speed centrifugal and screw technology that is not supported in this version of the workpaper since it is currently not available in the market for DEER2017 tiers.

These measures have tiered incentive levels. According to Resolution E-4867 [511] (updated DEER2017), two tiers are defined:

1. Tier 1, both the full load AND integrated part load efficiency of the chiller technology should exceed Title 24 minimum requirement by 10%.
2. Tier 2, both the full load AND integrated part load efficiency of the chiller technology should exceed Title 24 minimum requirement by 15%.

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

## 1.2 Technical Description

Chilled water systems use a central plant chiller(s) to cool and distribute water that is in turn used to cool air to meet a building’s cooling demand. Water-cooled chillers use a condenser water loop and cooling towers to reject heat from the refrigeration cycle, achieving higher efficiencies relative to air-cooled systems. Water-cooled chillers are common in commercial and industrial applications and are available in a wide range of capacities, from under 50 tons to several thousand tons.

Electrically operated water-cooled chillers are categorized by compressor type and tonnage capacity in efficiency standards such as ASHRAE 90.1 2013 [347] and California 2016 Building Energy Efficiency Standards (Title 24) [496]. Compressor technologies include Positive Displacement (reciprocating and rotary screw or scroll) and Centrifugal.

The efficiency ratings for a water-cooled chiller are based on the unit operating under standard test conditions, normally determined by AHRI Standard 550/590 - 2011 [511]. Chillers are rated at both full-load and part load (IPLV) operating conditions, expressed in Coefficient of Performance (COP) or in commonly industry terms, kW/ton.

High efficiency chillers range widely in rated kW/ton performance, therefore (20) combinations of chiller technologies with varying technology type and efficiencies in accordance with updated DEER2017 measure definitions are used to document savings in this revision of the workpaper. Centrifugal chillers are often designed to operate at conditions other than those specified by AHRI 550/590 [511]. 2016 Title 24 has established tables that show the different full and part load minimum operating efficiencies required at non-standard operating conditions.

## 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  Up-Stream Buy Down | 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  Mid-Stream Buy Down | 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

Savings per ton for the chiller measure included in this work paper revision is directly taken from 2017 DEER database. Please refer to Section 2 for details.

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, 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 efficiency. For water-cooled chillers, additional measures are added for chillers that exceed 2016 Title 24 requirements by 15%. 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 constant speed centrifugal and screw chillers and centrifugal chillers with frictionless compressor, are currently not available in the market for established DEER2017 tiers; hence, these cannot be incentivized at this time.

**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 | 0.6 |

**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.

Current programs offer incentives within Path A or Path B for the following categories:

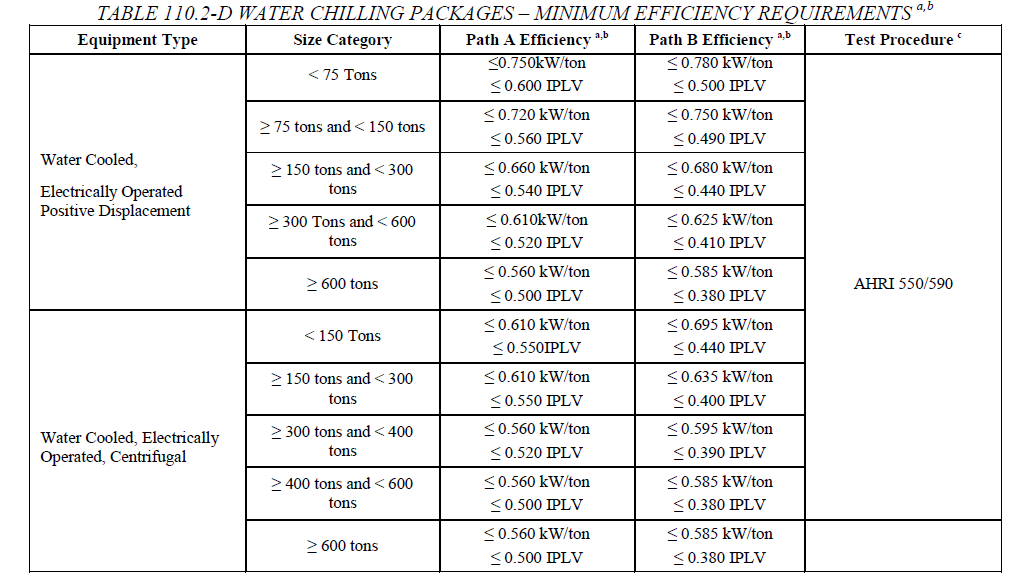
1. Exceed Path A requirements for full-load and integrated part-load efficiency

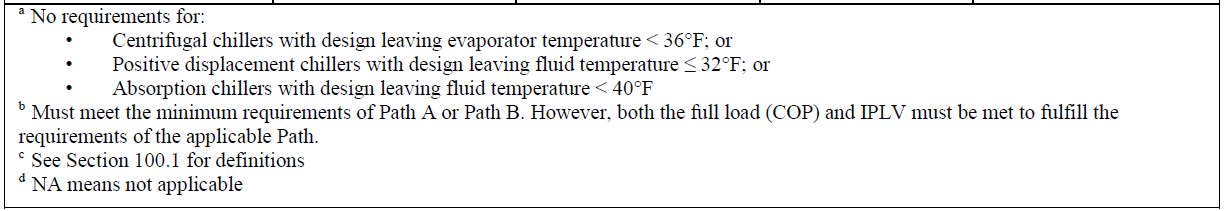
3. Exceed Path B requirements for full-load and integrated part-load efficiency

For a given chiller, there will always be both a rated full-load efficiency (kW/ton for water-cooled units) and a rated IPLV. The selection of an efficiency tier level must be based on both of these 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.

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

Water-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

* **Resolution E-4867** 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. In this revision of the work paper, all the measures related to constant speed screw, constant speed centrifugal, and frictionless chillers were removed from the scope since these cannot be incentivized given stringency of updated DEER2017 tiers and current equipment availability in the market. Only chillers with VSD were considered.

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 |
| SDGE | CZ07 |

This workpaper update is limited to DEER2017 measures.

# 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 shape that is applicable to the measures in this work paper is 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

## 4.1 Base Case Cost

Chillers considered in this work paper include both centrifugal and positive displacement type units with Variable Speed Drives (VSD). Baseline (Material) costs for both chiller technology types were established. Refer below for baseline cost calculation methodology:

1. 2017 manufacturer pricing information was collected from a single manufacturer for water cooled variable speed centrifugal chiller for varying capacity ranges meeting 2016 Title-24 minimum efficiency requirements. Table below shows baseline (material) costs for water cooled centrifugal chillers:

|  |  |  |
| --- | --- | --- |
| **Chiller Type** | **Capacity Range** | **Baseline Cost ($/Ton)** |
| Water Cooled Variable Speed Centrifugal Chiller (Conventional Compressor) | < 150 tons | $642.21 |
| 150 to 299 tons | $399.24 |
| 300 to 399 tons | $301.58 |
| 400 to 599 tons | $284.13 |
| >= 600 tons | $212.11 |

1. A regression equation was developed by plotting a trend line for centrifugal chiller using size categories and costs.
2. Baseline costs for screw type chillers were then calculated using the regression equation from Step 2.
3. For each size category, the trend line for the centrifugal units was used to estimate missing base case costs for screw chiller technology. For this analysis, it was assumed that the cost by size category for positive displacement chillers approximates that of centrifugal chillers.
4. Cost projections on screw chiller technology were based on limited data but expected to be improved in future versions of the workapaper once more technology representative of DEER2017 tiers is available in the market. See Attachment #2 for details.
5. Table below shows baseline costs for water cooled screw chillers :

|  |  |  |
| --- | --- | --- |
| **Chiller Type** | **Capacity Range** | **Baseline Cost**  **($/Ton)** |
| Water Cooled Variable Speed Screw Chiller | < 75 tons | $636.30 |
| 75 to 149 tons | $448.32 |
| 150 to 299 tons | $320.64 |
| 300 to 599 tons | $253.26 |
| >= 600 tons | $246.19 |

## 4.2 Measure Case Cost

Measure case material costs were developed as indicated below:

1. Measure case cost is based on 2017 pricing provided by a single manufacturer given current market availability. Some level of verification was done on the new cost using older program participation – for instance (and when available) measure’s cost including magnitude of the cost value and deviation between the new material cost and historical cost were compare.
2. Each chiller technology was classified into a tier based on DEER 2017 requirements, e.g., tier 1 and tier 2 at 10 and 15 percent above 2016 Title 24 respectively. An average IMC for each capacity range was established under each tier based on manufacturer’s data.
3. A regression equation was developed by plotting a trend line for centrifugal chiller using size categories and Incremental Measure Costs (IMC).
4. Incremental Measure Costs (IMC) for screw type chillers were then calculated using the regression formula from Step 2.
5. For this analysis, it was assumed that the cost by size category for positive displacement chillers approximates that of centrifugal chillers. Cost projections on screw chiller technology were based on limited data but expected to be improved in future versions of the workpaper once more technology representative of DEER2017 tiers is available in the market.

1. Baseline cost and IMC were added for each chiller type and capacity to establish Gross Measure Costs (GMC).
2. Table below shows measure and incremental costs for all chiller types and capacities.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Chiller Type** | **Capacity Range** | **Gross Measure Cost (Tier 1 GMC)** | **Incremental Measure Cost**  **(Tier 1 IMC)** | **Gross Measure Cost (Tier 2 GMC)** | **Incremental Measure Cost**  **(Tier 2 IMC)** |
| Water Cooled Variable Speed Screw Chiller | < 75 tons | $797.90 | $161.60 | $931.83 | $295.53 |
| 75 to 149 tons | $591.86 | $143.54 | $693.11 | $244.79 |
| 150 to 299 tons | $444.07 | $123.43 | $527.40 | $206.76 |
| 300 to 599 tons | $354.53 | $101.27 | $434.69 | $181.43 |
| >= 600 tons | $323.24 | $77.05 | $415.00 | $168.82 |
| Water Cooled Variable Speed Centrifugal Chiller (Conventional Compressor) | < 150 tons | $774.64 | $132.43 | $890.82 | $248.61 |
| 150 to 299 tons | $497.36 | $98.13 | $567.74 | $168.50 |
| 300 to 399 tons | $399.47 | $97.89 | $445.71 | $144.13 |
| 400 to 599 tons | $352.59 | $68.46 | $434.34 | $150.21 |
| >= 600 tons | $253.68 | $41.57 | $311.47 | $99.35 |

## 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-20033 | Water Cooled Centrifugal Chiller w/1 conventional VSD compressor and condenser relief (150 to 299 tons, 0.54 Max kW/ton, 0.34 Max IPLV) | ROB | $168.50 | $168.50 | N/A |
| AC-20034 | Water Cooled Centrifugal Chiller w/1 conventional VSD compressor and condenser relief (150 to 299 tons, 0.572 Max kW/ton, 0.36 Max IPLV) | ROB | $98.13 | $98.13 | N/A |
| AC-20035 | Water Cooled Centrifugal Chiller w/1 conventional VSD compressor and condenser relief (300 to 399 tons, 0.506 Max kW/ton, 0.332 Max IPLV) | ROB | $144.13 | $144.13 | N/A |
| AC-20036 | Water Cooled Centrifugal Chiller w/1 conventional VSD compressor and condenser relief (300 to 399 tons, 0.536 Max kW/ton, 0.351 Max IPLV) | ROB | $97.89 | $97.89 | N/A |
| AC-20037 | Water Cooled Centrifugal Chiller w/1 conventional VSD compressor and condenser relief (400 to 599 tons, 0.497 Max kW/ton, 0.323 Max IPLV) | ROB | $150.21 | $150.21 | N/A |
| AC-20038 | Water Cooled Centrifugal Chiller w/1 conventional VSD compressor and condenser relief (400 to 599 tons, 0.527 Max kW/ton, 0.342 Max IPLV) | ROB | $68.46 | $68.46 | N/A |
| AC-20039 | Water Cooled Centrifugal Chiller w/1 conventional VSD compressor and condenser relief (>= 600 tons, 0.497 Max kW/ton, 0.323 Max IPLV) | ROB | $99.35 | $99.35 | N/A |
| AC-20040 | Water Cooled Centrifugal Chiller w/1 conventional VSD compressor and condenser relief (>= 600 tons, 0.527 Max kW/ton, 0.342 Max IPLV) | ROB | $41.57 | $41.57 | N/A |
| AC-20041 | Water Cooled Centrifugal Chiller w/1 conventional VSD compressor and condenser relief (< 150 tons, 0.591 Max kW/ton, 0.374 Max IPLV) | ROB | $248.61 | $248.61 | N/A |
| AC-20043 | Water Cooled Centrifugal Chiller w/1 conventional VSD compressor and condenser relief (< 150 tons, 0.626 Max kW/ton, 0.396 Max IPLV) | ROB | $132.43 | $132.43 | N/A |
| AC-20074 | Water Cooled Variable Speed Screw Chiller (150 to 299 tons, 0.578 Max kW/ton, 0.374 Max IPLV) | ROB | $206.76 | $206.76 | N/A |
| AC-20076 | Water Cooled Variable Speed Screw Chiller (150 to 299 tons, 0.612 Max kW/ton, 0.396 Max IPLV) | ROB | $123.43 | $123.43 | N/A |
| AC-20078 | Water Cooled Variable Speed Screw Chiller (300 to 599 tons, 0.531 Max kW/ton, 0.349 Max IPLV) | ROB | $181.43 | $181.43 | N/A |
| AC-20080 | Water Cooled Variable Speed Screw Chiller (300 to 599 tons, 0.563 Max kW/ton, 0.369 Max IPLV) | ROB | $101.27 | $101.27 | N/A |
| AC-20082 | Water Cooled Variable Speed Screw Chiller (75 to 149 tons, 0.638 Max kW/ton, 0.417 Max IPLV) | ROB | $244.79 | $244.79 | N/A |
| AC-20084 | Water Cooled Variable Speed Screw Chiller (75 to 149 tons, 0.675 Max kW/ton, 0.441 Max IPLV) | ROB | $143.54 | $143.54 | N/A |
| AC-20086 | Water Cooled Variable Speed Screw Chiller (>= 600 tons, 0.497 Max kW/ton, 0.323 Max IPLV) | ROB | $168.82 | $168.82 | N/A |
| AC-20089 | Water Cooled Variable Speed Screw Chiller (>= 600 tons, 0.527 Max kW/ton, 0.342 Max IPLV) | ROB | $77.05 | $77.05 | N/A |
| AC-20091 | Water Cooled Variable Speed Screw Chiller (< 75 tons, 0.663 Max kW/ton, 0.425 Max IPLV) | ROB | $295.53 | $295.53 | N/A |
| AC-20093 | Water Cooled Variable Speed Screw Chiller (< 75 tons, 0.702 Max kW/ton, 0.45 Max IPLV) | ROB | $161.60 | $161.60 | N/A |

# Attachments

1. SCE17HC043.0 – Calculation Template
2. SCE17HC043.0 – Costing
3. SCE17HC043.0 – 2017 DEER Energy Impacts
4. SCE17HC043.0 - WCChiller Market Assessment Supporting WP Development-04-28-2017

# References

# References in this version of the work paper is based on the references file *“[References\_08212017\_083127]”*.

# References used in this work paper are listed below:

[347]

[475]

[496]

[511]