

**HV A C**

HE A T P U MP , U N I T A R Y A I R - C OOL ED HV A C , C OM M ER C I A L - F U E L SU B S TI TU TI O N

S WH C0 4 6 - 01

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# MEASURE NAME

Commercial Unitary Air-Cooled Heat Pump replacing Unitary Air-Conditioner and Gas Furnace

# STATEWIDE MEASURE ID

SWHC046-01

# TECHNOLOGY SUMMARY

Air-source heat pump provides cooling and heating using electric energy. Like other mechanical air conditioning system, heat pump provides cooling using direct expansion vapor compression and expansion, which expends work to move thermal energy against a thermal gradient, and transfer "reject" heat from the exterior coil to outdoor air. During the heating mode, the heat pump reverses the configuration of the equipment to transfer product heat from the interior coil. This stands in contrast to systems that heat by gas combustion or electric resistive heating. When installed properly, air-source heat pump delivers 1.5 times to 3 times more than the electricity consumed (energy.gov)[1](#_bookmark0). For sites when heat pump cannot serve all the heating loads, supplemental heating is provided through electric resistance heating coil. This technology will use only electricity and no other fuel to serve heating and cooling requirements.

A single-package air conditioning heat pump (HP) unit consists of a single package (or cabinet housing) that includes a condensing unit, a compressor, and an indoor fan/coil. A single-package unit is typically installed on the roof of a building and will sit on a "roof-curb" or supporting beams. Colloquially, these are also called Roof Top Units (RTUs). An additional benefit of a package unit is that there is no need for field- installed refrigerant piping, which minimizes labor costs and the possibility of contaminating the system with dirt, metal, oxides or noncondensing gases.

Certain small capacity heat pumps are available as split systems. A split system consists of two major parts in separate housings: a remote condensing unit and an indoor fan/coil. These system components are connected by a set of refrigerant lines. The fan/coil includes a furnace section for a gas-fired heating system. Typical locations for the fan/coil are the attic space, under-floor, or in a closet or mechanical room. Locating the fan/coil in a conditioned or semi-conditioned space will help the system operate more efficiently by cutting down the thermal gains and losses to the unit and ducting.

The efficiency ratings of the air-source heat pump depend on capacity and manufacturer's preference. Generally, the small capacity heat pumps both packaged and split are rated using Seasonal Energy Efficiency Ratio (SEER) metric for the cooling mode and Heating Season Performance Factor (HSPF) for the heating mode. Higher capacity heat pumps typically available as packaged units are rated using metrics Energy Efficiency Ratio (EER) and Integrated Energy Efficiency Ratio (IEER) for the cooling mode and Coefficient of Performance (COP) for the heating mode.

1 <https://www.energy.gov/energysaver/heat-pump-systems/air-source-heat-pumps>

This workpaper recommends replacement of gas-electric packaged and split commercial air conditioning units (those with integrated gas furnace) with all-electric, heat pump RTUs. This is a fuel substitution measure meeting the eligibility requirements of CPUC Decision 19-08-009.[2](#_bookmark1)

# MEASURE CASE DESCRIPTION

The measure case is an all-electric commercial air-source heat pump using electric resistance heating only if supplemental heating is required. The measure case exceeds the prevailing code requirements and is available in the size and equipment categories and efficiency tiers as listed below. The heat pump must meet or exceed both the cooling and heating efficiency ratings listed below. For equipment in the larger equipment classes (≥ 65 kBtuh), effective in 2018, the IEER-rated requirement for cooling efficiency will supersede the EER-rated requirement.[3](#_bookmark2) Hence for larger equipment classes (≥ 65 kBtuh), the minimum IEER requirements should be met.

|  |  |
| --- | --- |
| Statewide Offering ID for NR/AR/NC | Measure Description |
| SWHC046A/ SWHC046O/ SWHC046AC | Commercial Packaged Heat Pump, 1-stage < 65 kBtu/h, SEER>=15, HSPF>=8.2 |
| SWHC046B/ SWHC046P/  SWHC046AD | Commercial Packaged Heat Pump, 2-stage < 65 kBtu/h, SEER>=15, HSPF>=8.2 |
| SWHC046C/ SWHC046Q/ SWHC046AE | Commercial Packaged Heat Pump, < 65 kBtu/h, SEER>=16, HSPF>=8.5 |
| SWHC046D/ SWHC046R/  SWHC046AF | Commercial Packaged Heat Pump, < 65 kBtu/h, SEER>=17, HSPF>=9.0 |
| SWHC046E/ SWHC046S/ SWHC046AG | Commercial Split Heat Pump, < 65 kBtu/h, SEER>=15, HSPF>=8.7 |
| SWHC046F/ SWHC046T/ SWHC046AH | Commercial Split Heat Pump, < 65 kBtu/h, SEER>=16, HSPF>=9.0 |
| SWHC046G/ SWHC046U/  SWHC046AI | Commercial Split Heat Pump, < 65 kBtu/h, SEER>=17, HSPF>=9.4 |
| SWHC046H/ SWHC046V/ SWHC046AJ | Commercial Split Heat Pump, < 65 kBtu/h, SEER>=18, HSPF>=9.7 |
| SWHC046I/ SWHC046W/  SWHC046AK | Commercial Packaged Heat Pump, 135 to <240 kBtu/h, IEER>=14.4, COP>=3.2 |
| SWHC046J/ SWHC046X/ SWHC046AL | Commercial Packaged Heat Pump, 135 to <240 kBtu/h, IEER>=15.4, COP>=3.2 |
| SWHC046K/ SWHC046Y/ SWHC046AM | Commercial Packaged Heat Pump, >240 kBtu/h, IEER>=12.3, COP>=3.2 |
| SWHC046L/ SWHC046Z/  SWHC046AN | Commercial Packaged Heat Pump, >240 kBtu/h, IEER>=12.8, COP>=3.2 |
| SWHC046M/ SWHC046AA/ SWHC046AO | Commercial Packaged Heat Pump, 65 to <135 kBtu/h, IEER>=14.1, COP>=3.4 |

2 California Public Utilities Commission (CPUC). 2019. *Decision 19-08-009 in the Order Instituting Rulemaking Concerning Energy Efficiency Rolling Portfolios, Policies, Programs, Evaluation, and Related Issues (R.13-11-005).* Issued August 5. OP 1

3 [10](https://www.achrnews.com/articles/142042-rooftop-manufacturers-are-ready-for-2023-efficiency-standards) CFR Part 431 US DOE Docket Numbers EERE–2013–BT–STD–0007 and EERE–2013–BT–STD–0021. Energy Conservation Standards for Small, Large and Very Large Air-Cooled Commercial Package Air Conditioning and Heating Equipment and Commercial Warm Air Furnaces.

|  |  |
| --- | --- |
| Statewide Offering ID for NR/AR/NC | Measure Description |
| SWHC046N/ SWHC046AB/ SWHC046AP | Commercial Packaged Heat Pump, 65 to <135 kBtu/h, IEER>=14.8, COP>=3.4 |

# BASE CASE DESCRIPTION

The base case for above-code savings is a commercial packaged or split-system air-conditioning unit with electric (dx) cooling and gas heating meeting the code requirements prevailing in 2020.

The base case for above-existing savings is a commercial packaged or split-system air-conditioning unit with gas heating meeting the code requirements prevailing in 2010. The selection of the 2010 code for existing baseline is discussed in Code Requirements.

# CODE REQUIREMENTS

Applicable state and federal codes and standards for air-sourced heat pumps are specified below. The table also shows codes for baseline equipment (air-cooled air conditioners and gas heating systems).

Applicable State and Federal Codes and Standards

|  |  |  |
| --- | --- | --- |
| Code | Applicable Code Reference | Effective Date |
| CA Appliance Efficiency Regulations – Title 20 (2019) | Section 1605.1(c)(1) Table C-4,  Section 1605.3(e)(1)(A) Table E-8 Section 1605.1(e)(2) Table E-5 | January 1, 2019 |
| CA Appliance Efficiency Regulations – Title 20 (2010) | Section 1605.1(c)(1) Table C-3 and Section 1605.1(e)(1)(A) Table E-6 Section 1605.1(e)(2) Table E-4 | January 23, 2006 |
| CA Building Energy Efficiency Standards – Title 24 (2019) | Section 110.2 Table 110.2-A, 110.2-B | January 1, 2020 |
| CA Building Energy Efficiency Standards – Title 24 (2008) | Section 112 Table 112-A | January 1, 2010 |
| Federal Standards (Title 10) | 10 CFR 431.97 Table 3 | January 1, 2018 |

Since most commercial applications will be installed with three-phase circuits, the authors have elected to exhibit only the code requirements for three-phase systems where there are alternate requirements for equipment powered by single-phase circuits.

California Appliance Efficiency Regulations (Title 20 - 2019)[4](#_bookmark3) Section 1605.1(c)1 Table C-4 has standards for commercial package air-conditioning and heating equipment and air-source heat pumps. The relevant equipment types are replicated in the table below.

4 California Energy Commission (CEC). 2019. *California Code of Regulations Title 20 Public Utilities and Energy.* CEC-140-2019-

002. January. Table C-4

Title-20 2019 requirements for packaged air-conditioners and heat pumps

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Equipment Type | Cooling Capacity | Sub- Category | Efficiency Levelsi | Compliance date: Equipment manufactured starting on |
| Small Commercial Package Air-Conditioning and Heating Equipment (Air-Cooled, 3-Phase, Split-System) | < 65,000  Btu/h | AC | SEER=13.0 | June 16, 2008 |
| HP | SEER=14.0 HSPF=8.2 | January 1, 2017 |
| Small Commercial Package Air-Conditioning and Heating Equipment (Air-Cooled, 3-Phase, Single-Package) | < 65,000  Btu/h | AC | SEER=14.0 | January 1, 2017 |
| HP | SEER=14.0 HSPF=8.0 | January 1, 2017 |
| Small Commercial Packaged Air Conditioning and Heating Equipment (Air-Cooled) | ≥ 65,000  Btu/h and  <135,000  Btu/h | AC | IEER=12.7 | January 1, 2018 |
| HP | IEER=12.0 COP=3.3 | January 1, 2018 |
| Large Commercial Packaged Air Conditioning and Heating Equipment (Air-Cooled) | ≥ 135,000  Btu/h and  <240,000  Btu/h | AC | IEER=12.2 | January 1, 2018 |
| HP | IEER=11.4 COP=3.3 | January 1, 2018 |
| Very Large Commercial Packaged Air Conditioning and Heating Equipment (Air-Cooled) | ≥ 240,000  Btu/h and  <760,000  Btu/h | AC | IEER=11.4 | January 1, 2018 |
| HP | IEER=10.4 COP=3.2 | January 1, 2018 |

i All IEER values shown are for heat pump heating and does not include equipment with electric resistance heating and no heating.

California Appliance Efficiency Regulations (Title 20 - 2019)[5](#_bookmark4) Section 1605.1(e)1 Table E-5 has standards for commercial gas-fired central furnaces. The table is replaced below:

Title-20 2019 requirements for large central gas furnaces

|  |  |  |  |
| --- | --- | --- | --- |
| Appliance | Rated Input (Btu/hr) | Minimum Thermal Efficiency | |
| January 1, 1994 | January 1, 2023 |
| Gas Central Furnaces | ≥225,000 | 80 | 81 |

California Appliance Efficiency Regulations (Title 20 - 2019)[6](#_bookmark5) Section 1605.3(e)1 Table E-8 has standards for gas-fired central furnaces <225,000 Btu/hour. The table is replaced below:

5 California Energy Commission (CEC). 2019. *California Code of Regulations Title 20 Public Utilities and Energy.* CEC-140-2019-

002. January. Table E-5.

6 California Energy Commission (CEC). 2019. *California Code of Regulations Title 20 Public Utilities and Energy.* CEC-140-2019-

002. January. Table E-8.

Title-20 2019 requirements for small central gas furnaces

|  |  |  |
| --- | --- | --- |
| Appliance | Application | Minimum Thermal Efficiency |
| Central furnaces with 3-phase electrical supply  < 225,000 Btu/hour | All applications except mobile homes | 78 AFUE or 80 Thermal Efficiency (at manufacturer's option) |

California Building Energy Efficiency Standards (Title 24 - 2019)[7](#_bookmark6) Section 110.2 Table 110.2-A and 110.2-B have minimum efficiency requirements for air-cooled air-conditioners and air-source heat pumps. While these table have the EER and IEER requirements, IEER requirements only apply to equipment with capacity control which are not a requirement for the measures in this workpaper. The relevant information from the referred tables are listed below.

Title-24 2019 requirements for air conditioners and heat pumps

|  |  |  |
| --- | --- | --- |
| Equipment Type | Size Category | Minimum Efficiencyii,iii,iv |
| Air conditioners, air cooled both split system and single package | ≥ 65,000 Btu/h and  < 135,000 Btu/h | 11.2 EER  12.9 IEER |
| ≥ 135,000 Btu/h and  < 240,000 Btu/h | 11.0 EER  12.4 IEER |
| ≥ 240,000 Btu/h and  < 760,000 Btu/h | 10.0 EER  11.6 IEER |
| ≥ 760,000 Btu/h | 9.7 EER  11.2 IEER |
| Heat pumps - Air Cooled (Cooling Mode), both split system and single package | ≥ 65,000 Btu/h and  < 135,000 Btu/h | 11.0 EER  12.2 IEER |
| ≥ 135,000 Btu/h and  < 240,000 Btu/h | 10.6 EER  11.6 IEER |
| ≥ 240,000 Btu/h | 9.5 EER  10.6 IEER |
| Air Cooled (Heating Mode) Split system and single package | ≥ 65,000 Btu/h and  < 135,000 Btu/h | 3.3 COP |
| ≥135,000 Btu/h | 3.2 COP |

ii The heating mode COP values correspond to 47 °F db/43 °F wb outdoor air

iii IEERs are only applicable to equipment with capacity control

iv Deduct 0.2 from the required EERs and IEERs for units with a heating section other than electric resistance heat

7 California Energy Commission (CEC). 2018. *2019 Building Energy Efficiency Standards. Title 24. Part 6.* CEC-400-2018-020-CMF.

December. Effective January 1, 2020.

2018 DOE Appliance Efficiency Regulations[8](#_bookmark7) provide efficiency requirements for air-cooled air conditioning and heat pumps units over 65 kBtuh which exactly match with Title 20 requirements listed above.

For code baseline, which is the baseline used for Normal Replacement (NR) measures, measure implementation must comply with both the minimum EER and IEER requirements from Title-24 2019 for larger units (>65 kBuh) and minimum SEER from Title-20 2019 for smaller units (<65 kBuh).

To determine the existing baseline efficiency, previous CA Title 20 and Title 24 codes were consulted. Since the RUL for Accelerated Replacement (AR) measure application for this measure is ≤5 years (and equipment life is 15 years, for the baseline equipment type), the equipment should have been installed before 2010 to have a 5-year RUL in 2020. Hence, equipment efficiencies from CA Title 24 and Title 20 applicable in year 2010 are considered for determining existing baseline efficiency.

California Building Energy Efficiency Standards (Title 24 - 2008)[9](#_bookmark8) Section 112 Table 112-A provides the efficiency requirements for packaged ACs ≥ 65 kBtu/h manufactured before 1/1/2010.

Similarly, California Appliance Efficiency Regulations (Title 20 - 2010)[10](#_bookmark9) Section 1605.1(c)(1) Table C-3 provides the efficiency requirements for packaged ACs < 65 kBtu/h effective 1/1/2010.

# NORMALIZING UNIT

Tons of cooling capacity (Cap-tons).

# PROGRAM REQUIREMENTS

*Fuel Substitution Test*

Per CPUC Decision 19-08-009 Rulemaking 13-11-005 “Decision Modifying the Energy Efficiency Three- Prong Test Related to Fuel Substitution”, for all fuel substitution measures, the measure must ‘not increase total source energy consumption when compared with the baseline comparison measure available utilizing the original fuel’. [11](#_bookmark10) Also, the measure ‘must not adversely impact the environment compared to the baseline measure utilizing the original fuel. Fuel substitution calculations were conducted using CPUC’s “Fuel Substitution Calculator” to confirm the measures in this workpaper pass Parts One and Two of the Fuel Substitution Test.

*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

8 [10](https://www.achrnews.com/articles/142042-rooftop-manufacturers-are-ready-for-2023-efficiency-standards) CFR Part 431 US DOE Docket Numbers EERE–2013–BT–STD–0007 and EERE–2013–BT–STD–0021. Energy Conservation Standards for Small, Large and Very Large Air-Cooled Commercial Package Air Conditioning and Heating Equipment and Commercial Warm Air Furnaces.

9 California Energy Commission (CEC). 2008. *Title 24. Part 6.* 2008 *Building Energy Efficiency Standards.* CEC-400-208-001-cmf.

December. Effective January 1, 2010.

10 California Energy Commission (CEC). 2010. *2010 Appliance Efficiency Regulations.* CEC-400-2010-012.

11 California Public Utilities Commission (CPUC). 2019. “Decision 19-08-009 Rulemaking 13-11-005 Decision Modifying the Energy Efficiency Three-Prong Test Related to Fuel Substitution”. August 5.

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

|  |  |  |
| --- | --- | --- |
| Measure Application Type | Delivery Type | Sectora |
| Normal replacement | DnDeemDI | Com |
| Normal replacement | DnDeemed | Com |
| Normal replacement | UpDeemed | Com |
| New construction | DnDeemDI | Com |
| New construction | DnDeemed | Com |
| Accelerated replacement | DnDeemDI | Com |
| Accelerated replacement | DnDeemed | Com |
| Normal replacement | DnDeemDI | Ag |
| Normal replacement | DnDeemed | Ag |
| Normal replacement | UpDeemed | Ag |
| New construction | DnDeemDI | Ag |
| New construction | DnDeemed | Ag |
| Accelerated replacement | DnDeemDI | Ag |
| Accelerated replacement | DnDeemed | Ag |
| Normal replacement | DnDeemDI | Ind |
| Normal replacement | DnDeemed | Ind |
| Normal replacement | UpDeemed | Ind |
| New construction | DnDeemDI | Ind |
| New construction | DnDeemed | Ind |
| Accelerated replacement | DnDeemDI | Ind |
| Accelerated replacement | DnDeemed | Ind |

a For Ag and Industrial building types, the unitary heat pumps used solely for space comfort conditioning such as serving office spaces with-in the agriculture or industrial building are eligible.

*Required Documentation for Normal and Accelerated Replacement in Downstream and Direct Install Delivery*

For downstream deemed and downstream direct-install delivery types, in addition to the standard information such as building type, climate zone, and capacity of the units, the following data must be submitted with each project application by the project developer:

* What is the existing fuel type for space heating?
* Did the site require any electric infrastructure upgrades for the proposed electrification measure? If yes, provide the itemized invoices with infrastructure upgrade costs.
* Did the owner install any other electrification measures at this site? If yes, list the measures and provide the itemized invoices with infrastructure upgrade costs (if any).

*Required Documentation for Normal Replacement in Upstream and Mid-Stream Delivery*

For upstream/mid-stream delivery method, the participant baselines are unknown and the spillover effects are unknown. The manufacturer or distributor doesn’t know whether the purchased measure is

replacing a gas or an electric baseline appliance. Claimed savings for these delivery types will be adjusted using the ratio of baseline gas appliance to total baseline appliances.

For Midstream delivery, the implementer shall survey 10% of the mid-stream baseline existing conditions and fuel type to determine actual gas/electric baseline proportions and the program administrator shall adjust claimed savings based upon these survey results.

For upstream delivery, the implementer should provide the retailer or distribution location where the product was sold, rated capacity, proposed commercial building type or space where the product will be installed, and cooling and heating efficiency.

*Eligible Products*

This measure involves fuel substitution and must replace an existing less efficient packaged or split AC and natural gas furnace. The existing furnace equipment must be removed and disposed of rather than refurbished and sold. Existing gas line(s) serving removed gas equipment must be capped off and removed refrigerant must be handled and disposed in accordance with all state and local regulations including but not limited to CA Energy Standards, CA Building Code, CA Pluming Code, and NEC.

All the packaged or split heat pumps must exceed the minimum efficiency requirements indicated in measure case description section.

Existing equipment incentivized under AR must be fully operational and serving intended application under qualified building type. Non-operational and/or broken equipment cannot be incentivized under AR and must be incentivized under NR.

*Eligible Building Types and Vintages*

This measure is applicable for new construction and existing commercial building types of any vintage.

*Eligible Climate Zones*

This measure is applicable in all California climate zones.

*Required Documentation for Accelerated Replacement*

Preponderance of evidence (POE) must be documented. Notably, programs shall document if measure was replaced as a direct result of information, recommendations, and support provided by the Program Administrator, and programs shall require the collection and submission of documentation to ensure proper conformance to eligibility and implementation requirements. The following are the types of information that will be required for all projects:

* Customer/site information
* Specifications of existing equipment
* Proof that the existing air conditioner and gas furnace are still operating as intended
* Existing air conditioner and gas furnace nameplate data with manufacturer date to confirm remaining useful life
* Replacement central heat pump information

To document POE, the provided Preponderance of Evidence (POE) survey[12](#_bookmark11) or similar, should be completed.

12 SWHC046-01 Com Unitary POE Survey.docx

*Required Documentation for New Construction (applicable for ALL downstream and downstream DI measures and only sample midstream measures)*

Implementer should confirm and provide required documentation to verify that measure implementation meets one of the following conditions:

* measures are installed in new areas of an existing building,
* measures are installed in a major renovation of an existing building, or
* measures are installed in capacity expansions of existing systems to serve existing and/or new load retrofits that require a new energy service.

Required documentation can include ONE of the following:

* Existing utility bills for the building,
* City approved permitting,
* City approved Mechanical, or Electrical, or Architecture site drawings, or
* Title-24 compliance report

*Incentive Amounts*

Fuel substitution measures face market barriers, including consumer market failures and supplier market failures.[13](#_bookmark12) Deployment of the program may require rebates or financial incentives to participants that exceed the measure cost. The program may pass the TRC test, but fail the PAC test. Incentives or rebates that exceed the TRC cost for a measure may be requested in workpaper submissions, to be approved by Commission Staff.[14](#_bookmark13)

# PROGRAM EXCLUSIONS

This measure is not eligible when there is no natural gas to electricity fuel substitution for heating and/or when the measures includes a non-regulated fuel. New construction measures are only eligible under certain conditions listed below. These are defined as new services in *Fuel Substitution Technical Guidance for Energy Efficiency*. [15](#_bookmark14) Ground up constructions are not eligible.

* measures are installed in new areas of an existing building,
* measures are installed in a major renovation of an existing building, or
* measures are installed in capacity expansions of existing systems to serve existing and/or new load retrofits that require a new energy service.

13 Energy+Environmental Economics. April 2019. “Residential Building Electrification in California <https://www.ethree.com/wp-content/uploads/2019/04/E3_Residential_Building_Electrification_in_California_April_2019.pdf> Consumer economics, greenhouse gases and grid impacts”.

14 Originally defined in D.92-09-080, the dual test was last modified in D.05-04-051

15 California Public Utilities Commission (CPUC), Energy Division. 2019. *Fuel Substitution Technical Guidance, Version 1.1*. October

31. Page 3.

# DATA COLLECTION REQUIREMENTS

Baseline equipment type and fuel source must be verified, for downstream and direct install measures.

Per CPUC Decision 19-08-009[16](#_bookmark15), building infrastructure costs which include panel upgrades or gas line installations/upgrades required to facilitate these fuel substitution measures shall be collected for all downstream and direct install measures.

# USE CATEGORY

HVAC

# ELECTRIC SAVINGS (KWH)

The unit energy savings (UES) of this measure were derived as the difference of baseline and measure case unit energy consumption (UEC) derived from simulations with DOE-2.3/ eQUEST 3.65 energy modeling software. Prototypes from the Database for Energy Efficient Resources (DEER) 2020 were used for the simulations. MASControl3, an updated version of the measure analysis software for DEER2020, was used to generate the energy savings values for all measure offerings. The following Tech IDs from MASControl3 were used to determine the existing, baseline, and measure energy consumption.

|  |  |  |
| --- | --- | --- |
| Existing Baseline Description and Tech ID | Code/ Standard Baseline Description and Tech ID | Measure Description and Tech ID |
| PkgAC1Sp-S13/ AirEcono- OATemp | PkgAC1Sp-S14 / AirEcono- OATemp | PkgHP1SpCom-S15-H8.2 / AirEcono-OATemp PkgHP2SpCom-S15-H8.2 / AirEcono-OATemp PkgHP2SpCom-S16-H8.5 / AirEcono-OATemp PkgHP2SpCom-S17-H9 / AirEcono-OATemp |
| SplitAC1Sp-S13/ AirEcono- OATemp | SplitAC1Sp-ge45-S14 / AirEcono-OATemp | SplitHP1SpCom-S15-H8.7 / AirEcono-OATemp SplitHP2SpCom-S16-H9 / AirEcono-OATemp SplitHP2SpCom-S17-H9.4 / AirEcono-OATemp SplitHP2SpCom-S18-H9.7 / AirEcono-OATemp |
| PkgAC1SpH-65to135-E10.3 | PkgAC2SpP-65to135-E11.2 | PkgHP2SpP-65to135-E11.5-C3.4 PkgHP2SpP-65to135-E12-C3.4 |
| PkgAC1SpH-135to240-E9.7 | PkgAC2SpP-135to240-E11 | PkgHP2SpP-135to240-E11.5-C3.2 PkgHP2SpP-135to240-E12-C3.2 |
| PkgAC1SpH-240to760-E9.3\* | PkgAC2SpP-240to760-E10 | PkgHP2SpP-240to760-E10.5-C3.2 PkgHP2SpP-240to760-E10.8-C3.2 |

\*The existing baseline efficiency which is referred from Title-24 2008 has EER requirement of 9.5 which is 2% higher than the 9.3 EER in the prototype. This small difference will be overestimating the savings by

<2%.

These selected DEER technologies were run for all commercial building types, all California climate zones, and for median vintage 2007. Using the vintage 2007 is a simplification approach and is suggested as per Resolution E-4952[17](#_bookmark16) when age is not known.

16 California Public Utilities Commission (CPUC). 2019. “Decision 19-08-009 Rulemaking 13-11-005 Decision Modifying the Energy Efficiency Three-Prong Test Related to Fuel Substitution”. August 5.

17 CPUC Resolution E-4952. October 12, 2018. Page A-21.

MAScontrol3 generated the annual energy usage (electric and gas) and hourly energy usage (electric) for each of the three Tech IDs. Using the post processing files within MASControl3, the normalized UEC values were calculated by dividing the energy usage with the normalizing unit (cap-tons) which vary by climate zone for each building type. UES is the difference of the baseline and measure case UEC. For NR measures, the baseline is the code/ standard baseline described in the table above. For AR measures, the 1st baseline is the existing baseline and the 2nd baseline is the code/ standard baseline described in the table above. Because of the added electric load for heating in the measure case, there could be increase in kWh usage indicating kWh penalty. DEER prototypes for Heat Pump HVAC may have all other end uses such as domestic hot water also electrified. Hence only the energy usage from HVAC end use (cooling, heating, total ventilation, supplemental heating and auxiliary) were considered by calculating the energy usage.

Additionally, using the DEER2020 commercial building weights[18](#_bookmark17) for “median” era (vintage 2007 belongs to median era), the weighted average savings that could be used when the specific commercial type is not known were calculated (labeled with building type "Com"). These savings values could be used for upstream delivery when the building type information could not be gathered or for units used for space comfort conditioning in agriculture and industrial sector buildings not covered in the measure combinations.

The savings for eligible new construction measures are assumed to be same as normal replacement measures since both the measure application types uses code baseline efficiency and the vintage of building type is less sensitive parameter compared to the unit efficiency.

Please refer to the MASControl3 files[19](#_bookmark18) and the calculation file[20](#_bookmark19) for details.

To verify if this measure passes the fuel substitution test, part 1 and part 2 of the fuel substitution test, as required by fuel substitution technical guidance,[21](#_bookmark20) were performed using the approved fuel substitution calculator. All the measures and measure combinations pass the fuel substitution test. Please refer to the completed fuel substitution calculator[22](#_bookmark21) for details.

One would expect increase in electricity usage and hence negative kWh savings with fuel substitution electrification measures. However, there are few instances where the kWh savings are positive because the savings from cooling mode from high cooling efficiency dominate the increased kWh from heating mode.

Please note that, the gas furnace efficiency remained the same from 2010 (existing baseline) to the current code (code baseline). The therms savings for 1st and 2 baselines for AR measures slightly differ because of the interactive effects of the fan system with the heating load.

18 DEER2020-Building-Weights.xlsx

19 SWHC046-01 Model setup-results-processing.zip

20 SWHC046-01 Energy analysis.xlsx

21 Fuel Substitution Technical Guidance-v1.1

22 SWHC046-01 Fuel Sub Calculator-NR.xlsx and SWHC046-01 Fuel Sub Calculator-AR.xlsx

# PEAK ELECTRIC DEMAND REDUCTION (KW)

In accordance with the requirements of the CPUC Fuel Substitution Technical Guidance, for Energy Efficiency, October 31, 2019, there will not be any peak demand reduction or penalty towards peak demand goal achievement from fuel substitution measures.[23](#_bookmark22)

# GAS SAVINGS (THERMS)

The methodology described for the Electric Savings) also generated UES values for gas. There will be therms savings since the base case has gas heating and the measure case does not use any gas fuel.

# 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 RUL is only applicable to the first baseline period for a retrofit or accelerated replacement measure with an applicable code baseline. The methodology to calculate the RUL conforms with Version 5 of the Energy Efficiency Policy Manual, which recommends “one-third of the effective useful life in DEER as the remaining useful life until further study results are available to establish more accurate values.”[24](#_bookmark23) This approach provides an RUL estimate without the requiring any a priori knowledge about the age of the equipment being replaced.[25](#_bookmark24)

The EUL and RUL specified for this measure are presented below. The estimated lifetime can be traced to values adopted for the California PY 2001 programs and was adopted for commercial AC measures for DEER 2005.

23 California Public Utilities Commission. 2019. “Fuel Substitution Technical Guidance for Energy Efficiency”.

24 California Public Utilities Commission (CPUC), Energy Division. 2013. *Energy Efficiency Policy Manual Version 5*. Page 32.

25 KEMA, Inc. 2008. "Summary of EUL-RUL Analysis for the April 2008 Update to DEER." Memorandum submitted to Itron, Inc.

Effective Useful Life and Remaining Useful Life

|  |  |  |
| --- | --- | --- |
| Parameter | Value | Source |
| EUL (yrs) | 15.0 | Pacific Gas and Electric Company (PG&E), San Diego Gas & Electric (SDG&E), Southern California Edison (SCE), Southern California Gas Company (SCG), California Energy Commission (CEC), Office of Ratepayer Advocates (CPUC ORA), and Natural Resources Defense Council (NRDC). 1998. *Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings from Demand-Side Management Programs.* Revised March 1998 and March 1999. Appendix F.  Pacific Gas and Electric Company (PG&E), San Diego Gas & Electric (SDG&E), Southern California Edison (SCE), Southern California Gas Company (SCG). 2000. “Proposed Effective Useful Life for Measures for PY2001 Program Elements. Report Issued Prior to Public Meeting. Response to Ordering Paragraph #8, Discussion Paper 2.” September 5.  Itron, Inc. 2005. *2004-2005 Database for Energy Efficiency Resources (DEER) Update Study - Final Report*. Prepared for Southern California Edison. Table 11-1.  California Public Utilities Commission (CPUC), Energy Division. 2008. “EUL\_Summary\_10-1-08.xls.” |
| RUL (yrs) | 5.0 | EUL/3 |

# BASE CASE MATERIAL COST ($/UNIT)

For equipment > 65 kBtu/h, the base case material costs for packaged AC units were derived from data collected through a survey of equipment distributors. Data were based upon the 2016 efficiency tiers and interpolated to the DEER 2020 tiers. For material costs for gas furnaces were obtained from RSMeans Online.[26](#_bookmark25)

For equipment ≤65 kBtu/h, the base case material costs were gathered from several online sources. These costs include the cost of gas furnaces with-in packaged or split unit. The data was organized into efficiency tiers and equipment type (split or packaged). Using the rated capacity, the normalized cost per ton was calculated. When data was available from several sources, the average cost per ton was calculated.

Please refer to cost calculation file[27](#_bookmark26) for details.

# MEASURE CASE MATERIAL COST ($/UNIT)

For equipment > 65 kBtu/h, the measure case material costs for packaged heat pumps units were derived from data collected through a survey of equipment distributors. Data were based upon the 2016 efficiency tiers and interpolated to the DEER 2020 tiers.

26 Gordian. 2019. *RSMeans Online*. Mechanical Costs.

27 SWHC046-01 Com Heat Pump HVAC Fuel Sub Cost Analysis.xlsx

For equipment ≤65 kBtu/h, the measure case material costs were gathered from several online sources. The data was organized into efficiency tiers and equipment type (split or packaged). Using the rated capacity, the normalized cost per ton was calculated. When data was available from several sources, the average cost per ton was calculated.

Please refer to cost calculation file[28](#_bookmark27) for details.

# BASE CASE LABOR COST ($/UNIT)

The base case labor costs include the cost of installing the AC system and the gas furnace. The labor cost for the AC and gas furnace were obtained from RSMeans Online.[29](#_bookmark28) These costs were normalized to the rated capacity and grouped into the capacities matching the measures. While grouping, average labor cost per ton was calculated when there is more than one labor cost per ton data point available. Please refer to cost calculation file[30](#_bookmark29) for details.

# MEASURE CASE LABOR COST ($/UNIT)

The measure case labor costs include the cost of installing the heat pump system and electrician charges to access and upgrade the electrical panel if required for the added electrical load from supplemental heating. The labor cost for installing the heat pump and the electrician rate was obtained from RSMeans Online.[31](#_bookmark30) Based on field experience, it is assumed that 2 hours of an electrician will be required to access and upgrade the electrical panel if required.

# 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. The NTG for fuel substitution measures was stipulated in Decision 19-08-009, *Decision Modifying the Energy Efficiency Three-Prong Test Related to Fuel Substitution,* issued by the California Public Utilities Commission (CPUC).[32](#_bookmark31) “When a fuel substitution measure passes the Fuel Substitution Test, it shall be included in the cost-effectiveness analysis of the portfolio with a net-to-gross (NTG) ratio assumption of 1.0, until such time as evaluated NTG information is available, when the assumption shall be updated on a prospective basis.”

Net-to-Gross Ratios

|  |  |  |
| --- | --- | --- |
| Parameter | Value | Source |
| NTG – All Fuel Substitution Measures | 1.0 | California Public Utilities Commission (CPUC). 2019. *Decision 19-08-009 in the Order Instituting Rulemaking Concerning Energy Efficiency Rolling Portfolios, Policies, Programs, Evaluation, and Related Issues (R.13-11-005).*  Issued August 5. Page 42. |

28 SWHC046-01 Com Heat Pump HVAC Fuel Sub Cost Analysis.xlsx

29 Gordian. 2019. *RSMeans Online*. Mechanical Costs.

30 SWHC046-01 Com Heat Pump HVAC Fuel Sub Cost Analysis.xlsx

31 Gordian Group, Inc. (n.d.) "RSMeans Data Online." Residential Costs 2019.

32 California Public Utilities Commission (CPUC). 2019. *Decision 19-08-009 in the Order Instituting Rulemaking Concerning Energy Efficiency Rolling Portfolios, Policies, Programs, Evaluation, and Related Issues (R.13-11-005).* Issued August 5. OP 1.

# 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 Rates

|  |  |  |
| --- | --- | --- |
| Parameter | GSIA | 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 benefits for this measure have not been quantified.

# DEER DIFFERENCES ANALYSIS

DEER Difference Summary

|  |  |
| --- | --- |
| DEER Item | Comment / Used for Workpaper |
| Modified DEER methodology | No |
| Scaled DEER measure | No |
| DEER Base Case | Yes (DEER2020 prototypes) |
| DEER Measure Case | Yes (DEER2020 prototypes) |
| DEER Building Types | Yes |
| DEER Operating Hours | Yes |
| DEER eQUEST Prototypes | Yes |
| DEER Version | 2020 |
| Reason for Deviation from DEER | Measure does not exist in DEER |
| DEER Measure IDs Used | N/A |
| NTG | Source: DEER2020. The NTG of 01.0 is associated with NTG ID: *FuelSubst- Default* |
| GSIA | Source: DEER2011. The GSIA of 1.0 is associated with GSIA ID: *Def-GSIA* |
| EUL/RUL | Source: DEER2014. The value of 15 years is associated with *EUL\_ID: HVAC-airHP* |

# REVISION HISTORY

Measure Characterization Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| Revision Number | Revision Complete Date | Primary Author, Title, Organization | Revision Summary and Rationale for Revision Effective Date and Approved By |
| 01 | 2019-12-02 | Akhilesh Reddy Endurthy and Nicholas | New Workpaper |

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | Fette, Solaris-Technical, LLC |  |
| 05/19/2020 | Jesse Manao SCE | Added PGE & SDGE Implementation IDs in Implementation tab.  Additional Changes are Noted in "SWHC046-01 EAD Changes Info 051920.docx" |
|  | 11/30/2021 | Akhilesh Endurthy, Solaris-Technical, LLC. | Addendum to report refrigerant avoided cost calculations in compliance with Resolution E-5152. |